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How Environmental Awareness and Knowledge Affect Urban Residents' Willingness to Participate in Rubber Plantation Ecological Restoration Programs: Evidence from Hainan, China

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Abstract: The rapid expansion of rubber plantations in Asian countries has led to various environmental problems. Therefore, local governments are implementing rubber plantation ecological restoration (RPER) programs as an essential solution. However, such programs can be implemented only if residents are intensely involved. Based on a survey of 521 urban households in Hainan Province, China, this study investigates the effect of environmental awareness and knowledge on residents' willingness to participate in RPER programs. We employ a double-hurdle (DH) model to estimate residents' participation in two stages. First, we determine whether residents wish to participate or not (PN). Then, we measure residents' degree of willingness to participate (DWP). The results show that residents' environmental awareness has a significant positive effect on whether they wish to PN but has no impact on their DWP. By contrast, residents' environmental knowledge has a significant positive effect on whether they wish to PN and their DWP. The moderating effect shows that residents' environmental knowledge significantly weakens the positive effects of their environmental awareness on whether they wish to PN. Moreover, residents' age, educational level, employment, and place of residence substantially influence their DWP. The findings in this study can provide useful insights for policymaking on improving rubber plantation ecosystems.

Keywords: environmental awareness; environmental knowledge; ecological restoration; willingness to participate; rubber plantation; double-hurdle model

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1. Introduction

Since the 1960s, rubber plantations have been rapidly expanding in developing Asian countries, with the total planting area of rubber trees increasing by 196% from 3.57 million ha in 1961 to 10.57 million ha in 2018 [1]. The development of the natural rubber industry has contributed to economic growth in some regions with low economic development levels. However, the rapid expansion of rubber plantations has damaged local tropical rainforest ecosystems and led to various ecological and environmental problems, such as a weakened climate-moderating capacity, biodiversity loss, and soil erosion [2,3]. Consequently, restoring and protecting the ecosystems threatened by natural rubber plantations have become urgent issues in Asian rubber-planting countries [4,5].

As a natural rubber-producing country, China also faces severe ecological and environmental problems due to rubber plantation expansion. In this context, the Chinese government is implementing rubber plantation ecological restoration (RPER) programs as an essential solution to these issues. RPER programs can effectively improve the ecological functions of plantations, enrich biodiversity, and improve ecological processes by harmonizing the relationship between rubber production activities and the external environment [6,7]. However, because of limited funding and technology, as well as the influence of relevant policies, regulations, and other factors, government-led RPER programs have not been implemented effectively [8].

The practical implementation of ecological restoration programs requires the participation of multiple stakeholders [9,10]. In addition to the government, rubber farmers are important actors in improving rubber plantation ecosystems, and the roles of these farmers have received some scholarly attention. For instance, Min et al. analyzed the willingness of rubber farmers in Xishuangbanna Prefecture, Yunnan Province, to participate in activities designed to improve rubber plantation ecosystems and found that they had a relatively positive attitude toward such participation. It was also observed that wealth accumulation and environmental awareness have significant positive effects on willingness to participate [11]. In relevant studies, scholars have found that farmers often refrain from initiating ecosystem improvement activities due to their poor economic conditions, which leads to slow progress in the implementation of ecological restoration programs [12–14]. Externality theories suggest that ecological restoration activities enable rubber farmers to generate obvious external and social-ecological benefits pursued by external beneficiaries (e.g., urban residents) [15,16]. Hence, the attitudes and desires of external beneficiaries need to be considered when the government is trying to win public support for ecological restoration policies and measures. However, existing studies on RPER have mostly focused on two types of actors, i.e., the government and farmers, and neglect external beneficiaries.

Ecological restoration programs can effectively improve residents' quality of life and promote the environmental condition of neighboring regions. Therefore, as the beneficiaries of ecological restoration programs, neighboring residents are encouraged to participate in such programs [17,18]. Several studies have shown that public participation can effectively facilitate ecological restoration programs, including those related to water environment restoration, waste recycling reuse, public service provision, and ecological tourism resources [19–24]. In addition, factors such as individual characteristics and wealth have been verified to influence the public's willingness to participate [25,26]. Significantly, as critical driving factors of residents' pro-environmental behaviors, environmental awareness and knowledge have gradually attracted widespread scholarly attention [27–30]. In this regard, it can be assumed that public participation in RPER programs is also affected by environmental awareness and knowledge. However, the ecological and environmental problems caused by rubber planting are usually not as easy to perceive and comprehend as other regular problems (such as water pollution, desertification, and air pollution). During our field survey, we found that the respondents had different perceptions of the ecological problems stemming from rubber tree planting. Some of them lacked awareness of the ecological and environmental problems stemming from rubber tree planting. For instance, some respondents believed that rubber plantations are "green" and "environmentally friendly," while others even thought that the government should reward rubber-planting farmers for growing carbon sinks in their rubber tree planting activities. Therefore, the influence of the public's awareness and knowledge on its willingness to participate in RPER programs may be different from the conclusion of existing studies. Thus, this study focuses on the impacts of environmental awareness and knowledge on residents' willingness to participate in RPER programs.

Environmental awareness is an individual's understanding and consciousness of ecological and environmental problems [31–34]. Individuals who are aware of environmental issues and the impacts of environmental change are more likely to reduce environmental damage [35]. Previous studies have examined the relationship between individuals' environmental awareness and their willingness to take ecological restoration actions. For instance, Eiswerth et al. (2001) investigated how environmental awareness affects the public's participation in invasive species management programs for lakes [36]. They found that people with a high educational level or frequent contact with lakes are mostly conscious of the damage that invasive species can cause to lake ecosystems and are more likely to support invasive species management programs. Kamaruddin et al. (2016) assessed the environmental awareness level of some communities. They concluded that the public is aware of various environmental problems. However, its participation is low due to lack of time and interest [37]. In general, individuals with a higher degree of environmental

awareness often have more proactive attitudes toward the environment and are more inclined to engage in pro-environmental behaviors [38]. Although there is no literature on the impact of environmental awareness on residents' participation in RPER programs, we expect that residents who have environmental awareness of the ecological problems caused by natural rubber cultivation will be more inclined to support RPER programs [39].

Meanwhile, environmental knowledge is an individual's perception and understanding of ecosystem structures, functions, and improvement programs [29]. Some empirical studies have shown that environmental knowledge has a positive effect on individuals' willingness to participate in ecosystem improvement and environmental protection activities [27,40]. For example, Pothitou (2016) found that residents who are more knowledgeable about the environment are more willing to take environmental protection actions [41]. Gifford et al. (2014) argued that environmental knowledge is an essential but insufficient condition for environmental actions [42]. Ogbeide et al. (2015) showed that consumers with more knowledge of green products are more likely to pay for environmentally friendly products [43]. In general, it is easier for individuals with environmental knowledge to overcome mental barriers such as a lack of awareness, fear, or misunderstanding. In contrast, individuals who lack environmental knowledge have difficulty making wise participation decisions [44–46]. Therefore, we expect that residents with a greater understanding of RPER programs will be more willing to participate in them.

Although most studies indicate that both subjective environmental awareness and objective environmental knowledge can promote a person's participation in ecological restoration programs, there are different understandings of the relationship between environmental awareness and experience and their influence on a person's willingness to participate. Some scholars argue that environmental knowledge is part of environmental awareness and should be treated as its perceptual component [47]. Otto and Pensini (2017) found that environmental knowledge determines only 2% of a person's environmental behaviors [48]. In addition, Kollmuss and Agyeman (2002) noted that environmental knowledge indirectly influences people's environmental protection behaviors [49]. Steg and Vlek (2009) suggested that environmental knowledge leads to improved awareness of environmental problems [50]. Bassi et al. (2019) discovered that when relevant knowledge is absent, the public's awareness of general environmental problems is more substantial than its awareness of specific environmental problems [30]. Despite their different opinions, most scholars agree that environmental knowledge influences an individual's environmental awareness and behaviors (e.g., it may have some moderating effect on an individual's environmental awareness and actions). Hence, we assume that residents' environmental knowledge affects the relationship between their environmental awareness and their willingness to participate in RPER programs.

The primary objective of this study is to investigate the impacts of environmental awareness and knowledge on residents' willingness to participate in RPER programs. This study is expected to make three contributions to the literature. First, hierarchical regression is applied to test the moderating effect of environmental knowledge on the relationship between residents' environmental awareness and their willingness to participate, thus revealing the mechanism by which environmental knowledge and understanding influence the willingness to participate. Second, to further elucidate these influencing mechanisms, residents' participation decision-making is examined based on two aspects: Whether they wish to participate or not (PN) and the degree of willingness to participate (DWP). Then, a double-hurdle (DH) model is used to examine the influence on each aspect. Meanwhile, we use a combined analysis to assess the moderating effect on these two aspects simultaneously to avoid potential estimation errors. Third, this study fills the existing gap regarding the role of external beneficiaries in rubber plantation ecosystem improvement actions and provides a theoretical and empirical reference for policymaking on RPER.

The structure of this paper is as follows. In Section 2, we describe the econometric analysis model of residents' willingness to participate in ecological restoration. Section 3 introduces the study area and data collection process and gives a statistical profile of the

sample residents. We then discuss and present the analytical results in Section 4, including the explanatory variables, the control variables, and the influence of the moderating effects. We also analyze the marginal effects and conduct a robustness test on the modeling results. In the final section, we summarize the study and make some policy recommendations.

2. Econometric Model

2.1. DH Model

A DH model is a two-stage estimation method that is widely applied in studies of individual behavior. It divides the decision-making process into two stages, each of which can have a different determining mechanism [51–53]. In this study, we divided residents' willingness to participate into two stages. The first stage is the wish to PN, and the second stage is the DWP. In the first stage, the dependent variable is a dummy variable (that takes the value of only 1 or 0, indicating participation or not, respectively). In the second stage, the dependent variable is continuous. Hence, if a fair number of residents do not participate in ecological restoration (the value of the dependent variable is 0), multiple sample values will be 0, which in econometrics is known as a corner solution. Since the 0 value represents the rational choice of individuals, the Heckman selection model is inapplicable [54,55]. In this paper, we used the DH model to handle corner solutions.

Specifically, in the first stage, residents decide to participate based on the random utility framework [56,57]. In the formula, d_i^* represents the difference between the utility of participating (U_{iP}) and the utility of not participating (U_{iN}) in an ecosystem improvement project. If $d_i^* = U_{iP} - U_{iN} > 0$, a resident chooses to participate in the ecological restoration project. However, these two utilities are subjective and unobservable. They can be expressed as latent variables, and their values are a function of the observable variables in the model. Hence, the model for stage 1 is as follows:

$$d_i^* = \alpha X_i + u_i; u_i \sim N(0, 1) \text{ and } d_i = \begin{cases} 1 & \text{if } d_i^* > 0 \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

where i represents respondent i , and d_i^* is the latent variable of d_i . A value of $d_i = 1$ means that a resident chooses to participate in RPER, while $d_i = 0$ means nonparticipation.

The model for the second stage takes the following form:

$$y_i = \beta Z_i + v_i; v_i \sim N(0, \sigma^2) \text{ and } y_i = \begin{cases} y_i^* & \text{if } y_i^* > 0 \text{ and } d_i = 1 \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

where y_i is resident's DWP in RPER; y_i^* is the latent variable of y_i , and X_i and Z_i are vectors containing the explanatory variables, including the main explanatory variables (environmental awareness, environmental knowledge, and their interactive item) and the control variables (the individual characteristic variables, the area dummy variables, etc.). The explanatory variables of the two stages can be different. α and β are correlation coefficients, and u_i and v_i are random errors.

Based on Equations (1) and (2), we created the following log-likelihood function based on the DH model:

$$L(y_i | x_i, \theta) = \prod_{y_i=0} [1 - \Phi(x_i\alpha/\sigma_u)] \Phi(z_i\beta/\sigma_v)^* \prod_{y_i>0} \Phi(x_i\alpha/\sigma_u) \Phi(z_i\beta/\sigma_v) \times \frac{\phi[(y_i - z_i\beta)/\sigma_v]}{\sigma_v \Phi(z_i\beta/\sigma_v)} \quad (3)$$

where ϕ and Φ are the probability density function and the cumulative distribution function of a normal distribution, respectively; σ_u is the standard deviation of u_i ; and σ_v is the standard deviation of v_i . The form of $[1/\Phi(z_i\beta/\sigma_v)]$ guarantees that the density is integrated as $y_i > 0$. Function (5) allows us to compute the values of α , β , and σ^2 based on the maximum likelihood estimates.

2.2. Assessing the Moderating Effect

We applied a moderating effect model to assess the influences of environmental knowledge on the relationship between residents' environmental awareness and willingness to participate. When the moderating effect is considered, it is often necessary to normalize the independent variables and the moderators [58]. In this paper, the model of the moderating effect on residents' willingness to participate was as follows:

$$P_i = \chi EA_i + \gamma EK_i + \eta EA_i \cdot EK_i + \lambda X_i + \sigma \quad (4)$$

where P_i is the willingness to participate (including the wish to PN and the DWP) of resident i ; EA_i and EK_i represent the environmental awareness and environmental knowledge of resident i , respectively, X_i is the control variables, e.g., the individual characteristic variables and area dummies; and χ , γ , η , and λ are regression coefficients; and σ is the error. Equation (4) can be changed into the following form:

$$P_i = \gamma EK_i + (\chi + \eta EK_i) EA_i + \lambda X_i + \sigma \quad (5)$$

where the regression coefficient $(\chi + \eta EK_i)$ measures the relationship between the willingness to participate and the environmental awareness of resident i , which is a function of EK_i ; and η measures the moderating effect of resident i 's environmental knowledge on the relationship between that resident's environmental awareness and willingness to participate.

2.3. Marginal Effect Analysis

The correlation coefficients of the variables in the DH model can explain only part of the relationship between environmental awareness and knowledge and residents' willingness to participate. In this paper, we also used Burke's (2009) method and calculated the marginal effects of the explanatory variables on residents' willingness to participate in the two stages to better understand the influences of environmental awareness and knowledge on residents' willingness to participate [54]. First, we estimated the PN probability of each individual resident i :

$$P(d_i^* > 0 | x_i) = \Phi(x_i \alpha) \quad (6)$$

Then, we estimated the resident's conditional DWP (i.e., willingness to participate in ecological restoration):

$$E(y_i | y_i > 0, z_i) = z_i \beta + \sigma \times \lambda(z_i \beta / \sigma) \quad (7)$$

In Equation (7), $\lambda(z_i \beta / \sigma)$ is the inverse Mill ratio:

$$\lambda(z_i \beta / \sigma) = \varphi(z_i \beta / \sigma) / \Phi(z_i \beta / \sigma) \quad (8)$$

Based on Equations (6) and (7), we estimated the marginal effect of the independent variables in the first stage and the conditional average partial effect (CAPE) of the independent variables in the second stage of the DH model.

3. Data

3.1. Data Collection

The data used in the study came from a household survey conducted in Hainan Province, China, in July 2019. Hainan is located in the southernmost part of China and is its most crucial rubber tree production base. In 2018, the rubber tree planting area in Hainan was 528,000 ha, accounting for 45.7% of China's total rubber tree planting area [1,59]. Since the 1950s, large-scale rubber tree planting has replaced the virgin tropical rainforest on Hainan Island and has caused severe environmental problems [60–62]. We collected data via stratified random sampling. First, we randomly selected four cities: Haikou (northern Hainan Island), Sanya (southern), Danzhou (central), and Wanning (southern) (for details, see the study area in Figure 1).

Figure 1. Study area.

These four cities have different economic development levels (gross domestic product (GDP)) and geographic features (status of rubber tree planting). The details are shown in Figure 2. Then, we selected residents of different districts of each city through random sampling. Specifically, the samples included 181 households in the Xiuying, Qiongshan, Meilan, and Longhua Districts of Haikou; 115 households in the Jiyang, Haitang, and Tianya Districts of Sanya; 104 households in Danzhou; and 121 households in Wanning (Danzhou and Wanning are cities at the county level and do not have districts). Thus, we randomly selected households based on the subdistricts of 2 cities and surveyed 521 households. For the survey, we used a structured questionnaire prepared in Chinese. The data collected by the questionnaire included residents' socioeconomic characteristics, their knowledge and awareness of environmental change, their understanding of RPER programs, and their willingness to participate. Before the survey, we provided professional training to all of the investigators to guarantee that the interview approaches and coverage were consistent and to minimize the errors caused by the subjective opinions of the investigators. We then conducted a preliminary test on the questionnaire through an online survey in June 2019 and modified the questionnaire based on the test. Finally, we performed face-to-face interviews with the sampled residents in the study area in July 2019.

Figure 2. The rubber output, planting area, and gross domestic product (GDP) of all regions in Hainan Province.

3.2. PN and DWP

We measured residents' willingness to participate in RPER programs at two stages. First, we determined whether residents wish to PN. Then, we measured their DWP. PN is a binary variable, and we measured it by asking the interviewed residents whether they were willing to participate in RPER programs. DWP is a continuous variable, measured as residents' willingness to pay (WTP) for RPER programs. To assess residents' WTP, we applied the conditional valuation method (CVM), a survey approach designed to value nonmarket values, revealing the public's WTP for specified changes in the quantity or quality of nonmarket goods [63]. Through the design of the questionnaire in this study, we described the particular scenario (rubber expansion has caused some ecological and environmental problems) to the survey respondents and made the presented RPER programs public goods. We then let the respondents give their payments in elicitation formats.

In the CVM survey, elicitation formats are critical: They directly determine the accuracy of WTP evaluation. Elicitation formats such as open-ended (OE) and payment cards (PCs) are widely applied in CVM studies because they are simple and straightforward [64,65]. However, in practice, these two approaches also pose some obstacles. For instance, respondents may find it challenging to answer OE questionnaires. Although the PC approach can dramatically reduce such difficulties, it tends to generate some starting point deviations [66]. Therefore, in this paper, we followed the example of Whittington et al. (2002) and used both the OE and PC approaches to design the CVM questionnaire to collect data on the respondents' WTP [67].

In our CVM questionnaire, we provided respondents with the following virtual market scenarios: "In RPER programs, rubber plantations will differ from traditional plantations by treating rubber trees as part of a complex ecosystem with multiple species, multiple layers of plants, and a sound biological environment. This change can help improve biodiversity and the ecological functions of rubber plantations. Promoting RPER programs will help improve the local ecological environment, but such activities are expensive and may require your family to pay some fees (equivalent to buying ecological environmental products). Please consider your family's actual circumstances and decide whether you are willing to participate." The options for the question were "1 = yes, 0 = no." If the interviewed residents answered "yes," we proceeded to stage 2 of the WTP survey. The problem in stage 2 read as follows: "All the fees you pay will be used for RPER programs. Please indicate the maximum amount you are willing to pay." For the elicitation formats, we first asked the respondents an OE question. When it was difficult for the respondents to specify a WTP amount, we provided them with multiple PCs as different options. We designed the PC options based on the studies by Solomon (2009) and Sardana et al. (2019) [68,69]. Based on the preliminary online survey results, we roughly estimated the scope of respondents' WTP for RPER programs and determined the specific amounts to put on the PCs ("0, 5, 10 ... 900, 1000, more than 1000 RMB").

3.3. Statistical Profile of the Variables

As shown in Table 1, 429 of the 521 respondents, i.e., 82.34%, were willing to participate in RPER programs, indicating residents' high willingness to participate. Furthermore, among the 429 respondents, 27.84% of the residents had a WTP for RPER programs of less than RMB 50, 28.6% had a WTP between RMB 50 and 100, 29.74% were willing to pay between RMB 100 and 200, and 16.32% were willing to pay more than RMB 200.

This paper's core independent variables are environmental awareness and environmental knowledge. Environmental awareness refers to whether residents are aware of the environmental problems caused by natural rubber plantations. To measure their environmental awareness, we asked residents the following question: "Do you agree that rubber plantation hurt Hainan's ecosystem?" The respondents were asked to choose from the following options: "5 = strongly agree," "4 = agree," "3 = uncertain or unsure," "2 = disagree," and "1 = strongly disagree." In total, the residents' average environmental awareness was 2.775, with a standard deviation of 1.227, showing that the environmental awareness of

residents of Hainan Province was at a medium level. Environmental knowledge reflects residents' understanding of knowledge about the ecological environment, such as RPER programs' mechanisms for preventing biodiversity reduction, controlling soil erosion, and so on. To measure residents' environmental knowledge, we asked them the following question: "Do you know about some RPER programs that have been implemented and how they work?" The response options included the following: "5 = very much," "4 = much," "3 = average," "2 = a little," and "1 = hardly any." The statistical results indicate that the average environmental knowledge was 1.681, with a standard deviation of 0.862, which means that the residents of Hainan Province generally had a low level of knowledge about RPER.

Table 1. Willingness to pay (WTP) distribution.

WTP/Yuan	Frequency	Percent/%	Cum.
WTP = 0	92	17.66	17.66
0 < WTP ≤ 50	145	27.84	45.49
50 < WTP ≤ 100	149	28.6	74.09
100 < WTP ≤ 200	155	29.74	83.69
200 < WTP ≤ 500	36	6.91	90.60
WTP > 500	49	9.41	100.00
Total	521	100	/

In addition, considering that residents' characteristics may affect their willingness to participate in ecological restoration programs, we took their gender, age, educational level, employment, and family burden as control variables. Moreover, to control for the influences of regional differences, we included the study region as a control variable in the model. We used the number of years of school education to measure residents' educational level. Additionally, we used whether the head of household had a job to access the respondents' employment. Furthermore, we used the dependency ratio (the number of members not of labor-force age versus the number of labor-force members in a household) to determine family burden. The statistical results indicate that the majority (56%) of the respondents were male, the average age was 32.8 years, the average educational level was 12.66 years, the employment rate was 93.5%, and the average family burden (dependency ratio) was 0.98. The descriptive statistics of the total variables were shown in Table 2.

Table 2. Descriptive statistics of the variables.

Variables	Definitions	Mean	Std. Dev.
<i>Dependent</i>			
PN	The respondents' willingness to participate (1 = yes; 0 = otherwise)	0.823	0.382
DWP	The degree of willingness to participate, measured by the respondents' WTP (yuan)	174.129	291.326
<i>Independent</i>			
En-awareness	The environmental awareness of the interviewed residents (1–5)	2.775	1.227
En-knowledge	The respondents' knowledge of RPER programs (1–5)	1.681	0.863
EA × EK	The interaction of environmental awareness and environmental knowledge	0.138	1.089
<i>Control</i>			
Gender	The gender of the respondents (1 = male; 0 = female)	0.56	0.497
Age	The age of the respondents (years)	32.804	10.558
Education	The educational level of the respondents (years)	12.658	3.416
Work	Whether the respondents are employed (1 = yes; 0 = otherwise)	0.935	0.247
Burden	The ratio of those of labor-force age to those not of labor-force age in the population	0.984	0.894
Sanya	Regional dummy variables	0.221	0.415
Danzhou	(1 = live in this area;	0.2	0.4
Haikou	0 = otherwise)	0.347	0.477

4. Estimation Results

4.1. Model Estimation Results

In this paper, we used a DH model to analyze the factors influencing residents' willingness to participate in RPER and conducts a stratified regression from Models 1 to 3. Model 1 examines the main effect of environmental awareness' on residents' willingness to participate (including their wish to PN and their DWP). Model 2 adds environmental knowledge to Model 1 for the main effect analysis. Model 3 adds the interactions between environmental awareness and knowledge to Model 2 to examine the moderating effects of environmental knowledge on the relationship between residents' environmental awareness and willingness to participate in RPER. As the independent and moderating variables were continuous, we used a stratified regression to analyze and test the moderating effects and normalized both the independent and moderating variables [58]. Table 3 shows the modeling results. The Wald chi-square tests in Models 1 and 3 were statistically significant at the 1% level, indicating an overall good degree of fit.

Table 3. Estimation results of the double-hurdle (DH) model.

Variables	Model 1		Model 2		Model 3	
	Hurdle I PN	Hurdle II DWP	Hurdle I PN	Hurdle II DWP	Hurdle I PN	Hurdle II DWP
En-awareness	0.199 ¹ *** (0.056) ²	16.727 (12.216)	0.176 *** (0.057)	14.351 (12.036)	0.389 *** (0.126)	6.291 (21.986)
En-knowledge			0.273 *** (0.091)	75.845 *** (19.955)	0.682 *** (0.244)	62.296 (43.836)
EA × EK					−0.143 * (0.075)	4.616 (12.817)
Gender	0.147 (0.142)	26.135 (29.923)	0.119 (0.143)	6.515 (30.099)	0.137 (0.145)	6.294 (30.154)
Age	−0.017 *** (0.006)	−3.121 ** (1.228)	−0.017 *** (0.006)	−2.457 ** (1.192)	−0.015 ** (0.006)	−2.476 ** (1.192)
Education	0.058 *** (0.021)	10.136 * (5.457)	0.051 ** (0.021)	8.285 (5.263)	0.048 ** (0.021)	8.344 (5.274)
Work	0.265 (0.319)	101.035 * (57.132)	0.182 (0.321)	84.855 (56.090)	0.182 (0.323)	85.157 (55.992)
Burden	0.055 (0.080)	18.482 (16.073)	0.052 (0.082)	16.621 (16.371)	0.046 (0.082)	16.865 (16.380)
Sanya	−0.002 (0.187)	−34.656 (44.086)	0.045 (0.191)	−21.071 (43.683)	0.041 (0.191)	−21.063 (43.793)
Danzhou	0.558 *** (0.215)	20.403 (45.104)	0.599 *** (0.218)	45.304 (44.976)	0.589 *** (0.218)	45.485 (45.048)
Haikou	0.340 * (0.180)	−9.397 (44.327)	0.390 ** (0.182)	18.788 (44.345)	0.380 ** (0.183)	18.780 (44.402)
Constant	−0.076 (0.424)	98.539 (102.109)	−0.388 (0.440)	−29.045 (96.710)	−0.984 * (0.549)	−6.041 (108.473)
Observations	521	429	521	429	521	429
Log-likelihood	−218.86754		−214.0078		−212.21946	
LR chi ² (9)	48.02 ***		57.74 ***		61.31 ***	

¹ *** $p < 0.01$, ** $p < 0.01$, * $p < 0.05$, * $p < 0.1$. ² Standard errors are in parentheses.

4.2. The Influences of Environmental Awareness and Knowledge on Residents' Willingness to Participate

Table 3 presents the estimated results of the effect of environmental awareness on residents' willingness to participate in RPER programs. In Hurdle I, environmental awareness had a significant (at the 1% level) impact on residents' wish to PN, but in Hurdle II, the impact of environmental awareness on residents' DWP was not significant. These results indicate that residents with strong environmental awareness are more willing to participate in RPER programs. However, environmental awareness does not directly affect their DWP.

Model 2, which includes environmental knowledge, shows that environmental knowledge positively affected residents' wish to PN and DWP in both hurdles, and this effect was statistically significant at the 1% level. The results indicate that when residents are more knowledgeable about RPER, they have a higher willingness to participate. Moreover, residents' knowledge about ecological restoration programs directly affects their participation degree. In summary, environmental awareness affected only residents' wish to PN, while environmental knowledge affected both residents' wish to PN and their DWP.

4.3. The Moderating Effects of Environmental Knowledge

Model 3 introduces the interaction between environmental awareness and environmental knowledge to examine whether environmental knowledge enhances or weakens the positive impact of environmental awareness on residents' willingness to participate. First, in Hurdle I, the results show that environmental knowledge negatively moderated the effect of environmental awareness on residents' wish to PN, and this effect was statistically significant at the 10% level, indicating that environmental knowledge affects the relationship between residents' environmental awareness and their wish to PN and that the moderating effect is negative. Second, in Hurdle II, the results show that environmental knowledge positively moderated the effect of environmental awareness on residents' DWP. The moderating effect was nonsignificant, indicating that environmental knowledge has little moderating impact on the relationship between residents' environmental awareness and their DWP.

To more clearly and intuitively illustrate the moderating effect in Hurdle I, we drew a diagram, as shown in Figure 3. When residents' environmental knowledge level is low, it is more likely that environmental knowledge will have a more substantial moderating effect on the correlation between residents' environmental awareness and their wish to PN (with a higher slope). In contrast, when their environmental knowledge level is high, its moderating effect will be smaller (with a smaller slope). The causes of such results are worth discussion. Specifically, environmental awareness and environmental knowledge can directly affect residents' willingness to participate in ecological restoration actions. However, participation decisions based on environmental awareness tend to be more subjective, while those based on environmental knowledge tend to be more objective. Residents with high environmental knowledge levels (i.e., those who know more about the ecological restoration programs) are more inclined to base their decisions on their environmental knowledge than to base their decisions on their subjective environmental awareness [48,53].

Figure 3. Moderating effect of environmental knowledge. EK represents residents' degree of environmental knowledge.

In contrast, residents with less environmental knowledge may rely only on their subjective environmental awareness to make decisions. Hence, environmental knowledge has adverse moderating effects on the relationship between environmental awareness and willingness to participate. Some previous studies on the moderating effects of environmental knowledge on individuals' behavior have reached similar conclusions. For instance, Haryanto's (2014) empirical research on Indonesian consumers found that environmental knowledge weakens the positive effects of a "green" brand on consumers' purchasing attitudes [70].

4.4. The Influences of the Control Variables

Among the control variables of the residents' characteristics, their age, educational level, and employment had significant positive effects on their willingness to participate in RPER programs. In Models 1 and 2, the respondents' age positively and significantly (at the 1% level) affected their wish to PN and negatively and significantly (at the 5% level) affected their DWP. In Model 3, the respondents' age negatively and significantly (at the 5% level) affected their wish to PN and their DWP. These results mean that older residents tend to have a lower willingness to participate, probably because older residents have less access to relevant information and less exposure to environmental awareness-raising materials and campaigns. Therefore, they have less environmental knowledge and weaker environmental awareness, which affects their participation. The respondents' educational level had a significant positive effect on their wish to PN (in Model 1, the effect was statistically significant at the 1% level, and in Models 2 and 3, the effect was statistically significant at the 5% level). In Model 1, educational level positively and statistically (at the 10% level) affected residents' DWP. In Models 2 and 3, educational level also positively affected residents' DWP. However, the effects were not significant. The results indicate that residents with better education have a higher DWP in ecological restoration actions. A reasonable explanation is that well-educated respondents know more about the importance of ecological-environmental protection. Thus, they are more willing to participate in ecological restoration actions. In Model 1, whether the respondents were employed positively and significantly (at the 10% level) affected their DWP, indicating that people with a job and a stable income have a high DWP in ecological restoration actions. Finally, in Models 1 and 3, the respondents' gender and family burden (dependency ratios) had no significant PN or DWP effects.

An analysis of the region control variable indicates that residents' willingness to participate in different areas had high heterogeneity. Specifically, in Models 1–3, living in Danzhou had a positive effect on the respondents' wish to PN, and this effect was statistically significant at the 1% level. In all three models, living in Haikou also positively affected residents' PN (in Model 1, the effect was statistically significant at the 10% level, while in Models 2 and 3, the effect was statistically significant at the 5% level). These results indicate that, across different regions of Hainan Province where the natural conditions, economic development level and local culture and customs show heterogeneity, residents' willingness to participate in ecological restoration actions significantly varies. There are two possible reasons for this result. First, as shown in Figure 2, Danzhou is the area with the highest rubber tree production in both planting and output volume. Hence, rubber is an important local industry that is closely related to residents' everyday lives. Therefore, the residents of Danzhou experience more environmental problems due to rubber planting and know more about rubber planting. Thus, they are more inclined to participate in RPER programs. Second, although rubber planting is not an essential industry in Haikou, it is the capital city of Hainan Province, and its educational level, urbanization rate, and economic development level are the highest among cities in Hainan Province. In 2019, Haikou city contributed over 30% of the provincial GDP [63]. Haikou residents have increased exposure to frequent awareness-raising materials and information on ecosystem protection due to their location. They have more vital environmental awareness than any other residents

in our study. Moreover, they have higher income levels than the residents of other cities. Hence, they are more willing to participate in RPER programs.

4.5. Marginal Effect Analysis

This paper assessed the marginal effects of the models (see Table 4) to reveal how strongly changes in the independent variables influence changes in the dependent variables compared to the regression coefficients. Our marginal effect analysis results show that a 1% increase in residents' environmental awareness can lead to a 4% increase in their wish to PN, and this result was statistically significant at the 1% level. This result also indicates that a 1% increase in residents' environmental knowledge can cause an increase of 7.3% in their wish to PN. The CAPE results suggest that among the residents who decide to participate in ecological restoration actions, a 1% increase in their environmental knowledge can increase their DWP by RMB 75.58, and this result was statistically significant at the 1% level. Increases in residents' environmental awareness and knowledge can improve their willingness to participate and their degree of participation in ecological restoration actions.

Table 4. Marginal effects for the DH model.

Variables	Hurdle I: PN		Hurdle II: DWP	
	Marginal effects	Std. Err.	CAPE	Std. Err.
En-awareness	0.040 ¹ ***	0.013	14.371	12.204
En-knowledge	0.073 ***	0.022	75.584 ***	17.077
Gender	0.031	0.033	6.294	30.165
Age	−0.003 **	0.001	−2.476	1.5118
Education	0.011 **	0.005	8.344 *	4.5451
Work	0.041	0.073	85.157	57.279
Burden	0.010	0.019	16.865	16.580
Sanya	0.009	0.043	−21.063	45.174
Danzhou	0.133 ***	0.049	45.485	44.778
Haikou	0.086 **	0.041	18.780	40.659
Observations	521		429	

¹ *** $p < 0.01$, ** $p < 0.01$, * $p < 0.05$, $p < 0.1$.

The control variable results show that a 1% increase in the respondents' age led to a 0.3% decrease in their wish to PN, and that a 1% increase in their educational level caused a 1.1% increase in their wish to PN. Living in Danzhou and Haikou increased the respondents' wish to PN by 13.3% and 8.6%, respectively. The CAPE results show that a 1% increase in the educational level of residents willing to participate led to a DWP increase of 8.34 RMB, and this result was statistically significant at the 1% level. Our marginal effect analysis results further confirm the effects of age and educational level on residents' willingness to participate in ecological restoration actions. Residents' PN had significant regional heterogeneity.

4.6. Robustness Test

To test the reliability of the empirical analysis, we conducted a robustness test using a regression on reduced sample size [71]. We randomly deleted 25% of the sample data (130 observations were randomly chosen and then dropped). After that, we re-estimated the remaining samples. Table 5 presents the DH model assessment results of environmental knowledge, environmental awareness, and the interaction between them after the randomly chosen 25% of sample data were excluded. Although the coefficient values somewhat changed, the directions of the main explanatory variables and the interaction coefficients remain unchanged. The effect remains significant (Table 5), indicating that the study's conclusions are robust.

Table 5. Robustness checks of the estimation.

Variables		En-Awareness (Coef. ²)	En-Knowledge (Coef.)	EA× (Coef.)
Original model	Hurdle I	0.176 ¹ ***	0.273 ***	−0.143 *
	Hurdle II	14.351	75.845 ***	4.616
Deleted sample ³	Hurdle I	0.459 ***	0.936 ***	−0.188 **
	Hurdle II	18.638	96.020 *	1.718

¹ *** $p < 0.01$, ** $p < 0.01$, * $p < 0.05$, * $p < 0.1$; ² Coef. = coefficient; ³ We use the “randomtag” command in the Stata software to randomly delete 25% of the sample data and re-estimate the remaining samples. After repeating the above processes, the estimation results remained stable. This table shows one of the estimation results.

5. Conclusions

It is essential to gain public support and participation in RPER programs to protect and restore the ecosystem functions of rubber tree-planting regions. In this study, we divided willingness to participate into two stages. First, we determined whether residents wish to PN. Then, we measured their DWP. We surveyed 521 urban households in Hainan Province, China. We used a DH model to assess the effects of environmental awareness and knowledge on residents’ willingness to participate in ecological restoration actions. We also examined the moderating effects of environmental knowledge on the relationship between residents’ environmental awareness and their willingness to participate, further assessed the marginal effects of the model, and tested the robustness of the model.

In general, both environmental awareness and knowledge had significant positive effects on residents’ willingness to participate in ecological restoration actions. This finding means that appropriately raising public awareness can effectively win public support for implementing RPER programs. The analytic results of the moderating effects showed that environmental knowledge weakened the positive impact of environmental awareness on residents’ willingness to participate. As residents’ environmental knowledge increases, their environmental awareness had a weaker positive effect on their willingness to participate in ecosystem-improvement actions. The DH model assessment results indicate that environmental knowledge and awareness have different effects on the two stages in residents’ decision to participate in RPER. Environmental awareness affected only residents’ wish to PN in stage 1. In contrast, environmental knowledge affected residents’ willingness to participate in both stages (their wish to PN and their DWP). This finding suggests that more advanced environmental knowledge encourages residents to participate in ecological restoration and raises their degree of participation.

Based on the results above, we recommend that policymakers should pay attention to the importance of environmental knowledge and awareness in ecological restoration programs. They should promptly inform the public about the implementation background, targets, operational mechanism, and expected effects of such programs so that residents can have sufficient access to information about such programs. The government should further optimize the means of promoting environmental protection. Protecting the ecological environment is a responsibility shared by society but promoting it should be tailored to different residential groups and the specific characteristics of regions. The government should strategically select the critical points of campaigns and their promotional materials to raise residents’ environmental awareness and increase their knowledge about ecological restoration programs to improve public participation and effectively facilitate ecosystem program implementation.

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