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ICT Use on Residents' Willingness to Participate in Environmental Protection: Micro Evidence from Waste Classification and Disposal in China

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Abstract: Using CLDS (2018) micro survey data, this paper empirically investigates the impact of information and communication technology (ICT) use on residents' willingness to participate in environmental protection and its mechanism from the unique perspective of waste classification and disposal. The results show that ICT use significantly increases residents' willingness to participate in environmental protection, and this result still holds after conducting robustness tests in multiple ways. The mechanism analysis shows that ICT use can improve residents' environmental supervision consciousness and social interaction level, and then positively affect residents' willingness to participate in environmental protection. Heterogeneity analysis shows that ICT use has a greater impact on the willingness to participate in the environmental protection of young and middle-aged people, groups with low human capital level and high material capital level. This study provides a new explanation for understanding residents' environmental behavior from a micro perspective and provides some empirical evidence for the formulation of public policies on environmental protection.

Keywords: ICT Use; Willingness to Participate in Environmental Protection; Waste Classification and Disposal; Environmental Supervision Consciousness; Social Interaction

I. Introduction

Since the reform and opening up, China's economic development has made great achievements that have attracted worldwide attention, with its GDP ranking second in the world. However, this rapid economic growth has been achieved to a large extent at the expense of environmental quality, and rough development has led to tightening constraints on resources and the environment, environmental pollution, and other problems. By 2035, the overall goal of China's development is: to widely form a green production and lifestyle, to reduce carbon emissions steadily after reaching the peak, to fundamentally improve the ecological environment, and to realize the goal of a beautiful China. It is thus clear that strengthening environmental protection and governance is of great significance in promoting green economic and social development and realizing harmonious coexistence between humans and nature.

As the main force of environmental protection governance, the government and social organizations actively participate in environmental protection through legislation, environmental supervision, and other measures, which have achieved the expected results. However, participation in environmental protection at the individual level is relatively lagging and has not yet given full play to its due role in environmental protection (Zhang, 2013). Meanwhile, according to

the Ecological Civilization Awareness Survey and Research Report, China's public recognition of ecological civilization construction is more than 70%, but the awareness is less than 50%, and the practice is only about 60%. Therefore, how to improve the individual's willingness to participate in environmental protection has become the focus of widespread concern in the academic community and the industry.

From the micro subject, reducing waste pollution has become a consensus for protecting the environment. Since 2004, China has been the world's largest producer of waste, and domestic waste pollution has gradually become a major challenge to environmental improvement and public health. Individual practice of waste classification and disposal behavior has become an important way to reduce domestic waste pollution. Waste classification and disposal is a significant manifestation of residents' daily participation in environmental protection, and is a direct expression of residents' real willingness to participate in environmental protection. In this regard, this paper systematically analyzes residents' willingness to participate in environmental protection from the perspective of waste classification and disposal.

Reviewing the established literature, scholars have researched residents' environmental protection participation from the aspects of age, education, socioeconomic factors, social network, role model effect, social norms, environmental governance ability and other factors (Wang, 2008; He et al., 2015; Fu and Huang, 2016; Cui et al., 2017; Shi et al., 2018; Liu and Zhang, 2022; Ma et al., 2022), which provides the research basis for this paper, but such studies have not considered the role of the actual factor of information and communication technology (ICT) use in residents' willingness to participate in environmental protection.

In recent years, China has implemented major strategies such as "Broadband China" and "Internet+", and the Internet penetration rate has increased from 34.3% in 2010 to 70.4% in 2020, while the number of Internet users has increased rapidly from 457 million to 989 million. The development of ICT is not only a technological revolution, but also a powerful social, economic, and cultural force, bringing fundamental changes to social development and residents' lives (Xie et al., 2017), and will certainly have a significant impact on residents' environmental protection behavior to a large extent. On the one hand, ICT use breaks through time and space limitations, greatly improves the efficiency and capacity of information transmission, and reduces the cost of information acquisition, which is more conducive to the individual through the network channel to obtain environmental protection information and knowledge, and can deepen the residents' understanding and awareness of environmental issues, and it will be conducive to the improvement of the willingness of individuals to participate in environmental protection. On the other hand, ICT use can enable individuals to accumulate more social capital, thus enhancing the intensity of individual social interaction. In fact, household waste as a direct by-product of human activities, and the environmental behavior of residents is more likely to be influenced by social capital with the attribute of interpersonal interaction. ICT use makes it easier for people to use instant messaging tools (QQ, WeChat, etc.) to expand their social circles, enhance social interactions, and make individuals' willingness to participate in environmental protection more influenced by the cohort effect, model effect, and demonstration effect.

At present, only a few studies have been conducted on the relationship between ICT use and residents' willingness to participate in environmental protection, but the micro-action mechanism as well as the heterogeneity have not been explored in depth. Based on this, this paper uses detailed micro data CLDS (2018) to empirically analyze it and conducts mechanism analysis from two dimensions of environmental supervision consciousness and social interaction; at the same time, this paper also carries out heterogeneity analysis from three dimensions of age, human capital level, and material capital level, to provide the basis for a comprehensive understanding of the deep logical relationship between the ICT use and residents' willingness to participate in environmental protection. This study not only provides new explanations for

understanding residents' environmental protection behavior but also can provide some empirical evidence for the formulation of public policies on environmental protection.

II. Methodology

2.1 Data Source

All data used in this paper are from the 2018 China Labor Dynamics Survey (CLDS) database. The CLDS establishes a database at the individual, household, and community levels by conducting biennial tracking surveys of urban and rural villages in China, which has a reasonable research methodology, a large sample size, and large and high-quality data dimensions, and is highly recognized in the field of micro research. The database not only investigates the labor force status, property status, production and operation, but also investigates the micro-environmental protection behavior of China's residents, which is an ideal database for studying individual environmental protection participation at the micro level, the database can meet the research needs of this paper. This paper mainly uses the database at the individual and household level, and after processing the indicators, 15,032 research samples are finally retained.

2.2 Variables

2.2.1 Explained Variable

The explained variable of this paper is residents' Willingness to participate in environmental protection. Referring to the variable selection ideas of Zuo et al. (2022), Li and Feng (2021), Liu et al. (2021), and Shi et al. (2018), this paper uses the question in the questionnaire "Whether or not your family is willing to participate in waste classification" to characterize residents' willingness to participate in environmental protection. The reason is: that domestic waste pollution has gradually become a major challenge to environmental improvement and public health, individual participation in waste classification and disposal has become the most frequent behavior of residents' daily environmental protection participation, so it is reasonable to use residents' willingness to participate in waste classification and disposal to represent residents' willingness to protect the environment. This variable is a binary variable, if residents are willing to participate in waste classification and disposal, it means that residents have the willingness to participate in environmental protection, and the value is 1; otherwise, it means that residents do not have the willingness to participate in environmental protection, and the value is 0.

2.2.2 Core Explanatory Variable

The core explanatory variable of this paper is ICT use. ICT use mainly refers to individuals' information activities such as surfing the Internet, information transmission, and information acquisition through the use of electronic products (Zhang et al., 2022). Based on this, concerning the indicator selection ideas and data availability of Zhang et al. (2022), Liu et al. (2021), Liu and Zhang (2022), the final use of "whether to surf the Internet" to characterize individual ICT use. This variable is a binary variable, when the value of the variable is 1, it means that the individual uses the Internet, indicating that he has the behavior of ICT use. When the value of the variable is 0, it means that the individual does not use the Internet, indicating that he has no behavior of ICT use. It should be noted that in the questionnaire of CLDS (2018), whether to use the Internet is set with four options, which are "only use computers to surf the Internet (including pad), only use mobile phones to surf the Internet, use both computers and mobile phones to surf the Internet, and do not surf the Internet". If one of the first three situations mentioned above occurs, it is considered that respondents have ICT use behaviors, and the value is 1. Otherwise, it is considered that respondents have no behavior of ICT use, and the value is 0.

2.2.3 Control Variables

Based on the variable selection ideas of Peng et al. (2019) and Liu et al. (2021), this paper selects control variables

from two dimensions: individual level and household level. Specifically, the individual characteristic variables are mainly gender, age, education status, whether married and health status. In the gender variable, 1 indicates male and 0 indicates female; the age variable indicates the actual age of the head of the household; meanwhile, in order to observe the nonlinear relationship between age and residents' willingness to participate in environmental protection, this paper adds the square of the age, which is treated as the square of the age divided by 100; the education status is divided into eleven levels, which are: no school, Primary school / private school, junior high school, general high school, vocational high school, technical school, technical secondary school, junior college, undergraduate, master 's degree, doctor 's degree, with the values from 1 to 11 in turn; married indicates whether the household head is married or not, with 1 indicating married and 0 indicating unmarried; health status is a sorting variable divided into five levels, which are very unhealthy, relatively unhealthy, general healthy, healthy and very healthy, with values from 1 to 5 respectively. The variables at the household level mainly include household size, household economic status (level), whether the household has debts, whether the household has cars, and living environment. Household size is the population of the household; household economic status is scored from 1 to 10, indicating 10 levels from very poor to very rich, and the larger the value means the better the economic status; whether the household has debt is a binary variable, with 1 indicating that the household has debt and 0 indicating that the household has no debt; whether there is a car is a binary variable, with 1 indicating that the household has a car and 0 indicating that the household does not have a car; this paper uses the "noise around the house" to represent the living environment, Score 1 to 10, which means very noisy to very quiet, and the larger the value, the smaller the surrounding noise, and the better the living environment of the household.

2.3 Descriptive Statistical Analysis

Table 1 shows the descriptive statistical results of the variables. It can be seen that the willingness of residents in China to participate in environmental protection is high, with 89.44% residents willing to participate in environmental protection; the average of ICT use is 0.7636, indicating that 76.36% of residents have ICT use behaviors; 47.53% of the survey samples are male; the average age of the head of the household is 47.4425 years old; the education level of the head of the household is generally not high, with a average of 3.4763, between junior high school and general high school; 84.69% of the survey sample is married; the health status of the head of household is relatively high, with an average of 3.5818, between general healthy and healthy; the average household size is 4.5402; the economic status of the household is medium, with an average of 5.6687; 30.71% of the households are in debt; 69.99% of the households own a car; and the condition of the living environment is general, with an average of 6.6117.

Table 1 Descriptive Statistical Analysis

Variables	N	Mean	Std	Min	Max
Willingness to participate in environmental protection	15032	0.8944	0.3074	0	1
ICT use	15032	0.7636	0.4249	0	1
Gender	15032	0.4753	0.4994	0	1
Age	15032	47.4425	13.6442	17	91
Age squared	15032	24.3694	12.4851	2.8900	82.8100
Education	15032	3.4763	2.2785	1	11

Married	15032	0.8469	0.3601	0	1
Health	15032	3.5818	1.0083	1	5.
Household size	15032	4.5402	2.0877	1	19
Economic situation	15032	5.6687	1.7376	1	10
Household debt	15032	0.3071	0.4613	0	1
Car	15032	0.6999	0.4583	0	1
Living environment	15032	6.6117	1.9074	0	10

Note: Age squared is actually age squared divided by 100, if there is no special account, this article is the same as below.

2.4 Model

Since the explained variable residents' willingness to participate in environmental protection is a binary variable of 0-1, this paper uses the Probit model for processing, and the model is set as follows:

$$Pro(EN_i=1)=\Phi\ (\alpha ICT_i+\beta Control_i+\mu_i) \quad (1)$$

In equation (1), EN is the Explained Variable of willingness to participate in environmental protection, ICT is the core explanatory variable of ICT use, Control is the control variable selected at the individual level and household level, μ_i is the random error term, and α β are the parameters to be estimated.

III. Empirical Analysis

3.1 Basic Regression Analysis

Table 2 shows the estimation results of the base regression, where columns (1) to (3) are the estimation results of the stepwise regression using the OLS model, and columns (4) to (6) are the estimation results of the stepwise regression using the Probit model, with the OLS model as the control model. As can be seen from column (1) of Table 2, without adding other control variables, ICT use has a significant positive effect on residents' willingness to participate in environmental protection, with a marginal effect of 0.0500, and with the addition of individual level variables and household level variables respectively, the effect of ICT use on residents' willingness to participate in environmental protection is still significantly positive and statistically significant at least at the 5% level. However their marginal effects are reduced to 0.0229 and 0.0144 respectively, which means that not adding individual level and household level control variables will overestimate the extent of the impact of ICT use on residents' willingness to participate in environmental protection. The results in columns (4) to (6) show that the effect of ICT use on residents' willingness to participate in environmental protection is significantly positive and statistically significant at least at the 10% level, regardless of whether only the core explanatory variables are included or the individual level and household level control variables are added in turn. From the results of columns (1) to (6), it can be seen that the gradual addition of variables, no matter which model is used, does not fundamentally change the results, ICT use can increase residents' willingness to participate in environmental protection.

In terms of the estimation results of the control variables, only column (6) is interpreted here because the estimation results do not change much. Gender has a negative effect on residents' willingness to participate in environmental protection, which indicates that men's willingness to participate in environmental protection is lower than women's, a result that is consistent with reality; the higher the education of the head of the household, the higher his willingness to

participate in environmental protection, and this estimation is statistically significant at the 1% level; the probability of residents' willingness to participate in environmental protection is higher for married residents, which is on average 3.11% higher than that for unmarried residents; the higher the health of the head of the household, the higher his willingness to participate in environmental protection, and this estimate is statistically significant at the 1% level; the larger the household size, the lower the willingness to participate in environmental protection; the better the economic condition of the household, the higher the motivation to participate in environmental protection, and this result is statistically significant at the 1% level. Variables such as age, age squared, whether the household has debts, whether the household has cars, and living environment status lacked statistical significance on residents' willingness to participate in environmental protection.

Table 2 Results of Basic Regression

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	OLS	**OLS**	**OLS**	**Probit**	**Probit**	**Probit**
ICT use	0.0500***	0.0229***	0.0144**	0.0461***	0.0186***	0.0106*
	(7.7086)	(3.2066)	(1.9901)	(8.2904)	(3.0482)	(1.7103)
Gender		-0.0098*	-0.0081		-0.0112**	-0.0096*
		(-1.9513)	(-1.6133)		(-2.2287)	(-1.9060)
Age		0.0004	-0.0005		0.0007	-0.0003
		(0.3451)	(-0.4184)		(0.5688)	(-0.2246)
Age squared		-0.0008	-0.0000		-0.0010	-0.0002
		(-0.5894)	(-0.0032)		(-0.7780)	(-0.1246)
Education		0.0115***	0.0088***		0.0148***	0.0120***
		(11.4189)	(8.1146)		(10.3112)	(8.0935)
Married		0.0326***	0.0329***		0.0317***	0.0311***
		(3.6999)	(3.6647)		(3.9738)	(3.8376)
Health		0.0142***	0.0096***		0.0133***	0.0090***
		(5.1105)	(3.3901)		(5.2148)	(3.4226)
Household size			-0.0054***			-0.0054***
			(-4.1747)			(-4.7352)
Economic situation			0.0124***			0.0114***
			(7.1842)			(7.0724)
Household debt			-0.0014			-0.0009
			(-0.2484)			(-0.1565)
Car			0.0012			-0.0037
			(0.2092)			(-0.6124)
Living environment			-0.0017			-0.0011
			(-1.1662)			(-0.8114)
R^2 /Pseudo R^2	0.0048	0.0156	0.0208	0.0067	0.0252	0.0326
N	15,032	15,032	15,032	15,032	15,032	15,032

Note: Marginal effects are reported in this paper, ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively, with t-values or z-values in parentheses. Unless otherwise specified, the same applies here.

3.2 Heterogeneity Analysis

Which groups are more affected by ICT use in their willingness to participate in environmental protection? This paper analyzes the heterogeneity of age, human capital level, and material capital level to distinguish the differences in the impact of ICT use on the willingness to participate in environmental protection of different groups, and then provide a basis for improving the targeting of public policies on environmental protection.

There are differences in information literacy among different age groups, and older groups generally face a serious digital divide compared to young and middle-aged groups. So this paper first analyzes heterogeneity from the perspective of age, defining those older than 60 years old as the elderly group, and vice versa for the young and middle-aged groups. The results show that ICT use has a significant promotion effect on the willingness of middle-aged and young people to participate in environmental protection, and is statistically significant at the 5% level, but lacks statistical significance on the willingness of the elderly group to participate in environmental protection, which suggests that the digital divide between the different age groups seriously restricts the role of ICT in the promotion of environmental protection participation, and is not conducive to the release of the digital dividend, so it is imperative to reduce the digital divide among the elderly population.

Second, individuals with different levels of human capital have different cognitive abilities, and there will be differences in terms of environmental awareness and willingness to participate in environmental protection, so this paper divides the sample into two groups, not received higher education and having received higher education, and compares the differences between the two groups. This paper finds that ICT use has a significant positive effect on the willingness to participate in environmental protection of residents with low human capital who have not received higher education, but lacks statistical significance for the group with high human capital, which suggests that ICT has a significant inclusiveness effect, which can compensate for the shortcomings of the individual's human capital, and thus significantly increase the willingness of residents to participate in environmental protection. The reason is that ICT use can be through browsing information, graphics, videos, and other unconsciously accepting environmental protection concepts, strengthening the awareness of the environmental crisis, thus enhancing the residents' willingness to protect the environment (Peng et al., 2019).

Furthermore, heterogeneity is analyzed from the perspective of material capital level. It is divided according to the economic tier to which the household belongs, where greater than or equal to rank 5 is defined as a high level of material capital and assigned a value of 1, Otherwise, it is a low level of material capital and assigned a value of 0. Based on this, group regression can be found that ICT use does not have any significant effect on the environmental protection participation willingness of the households with low material capital, but it has a significant positive effect on the environmental protection participation willingness of the households with high material capital. The reason for this is that households with good economic status are less likely to face the digital divide and can obtain environmental information and knowledge through ICT, thus promoting their environmental participation.

Through the analysis of heterogeneity, it can be found that the impact of ICT use on the environmental protection participation of residents is heterogeneous, and this difference will play a different role with the age, human capital accumulation status, and material capital status, which means that the use of network media for environmental

protection publicity needs to pay special attention to the heterogeneity of the group's willingness to participate in environmental protection, and to improve the relevance of environmental policy.

Table 3 Estimated Results of Heterogeneity Analysis

Variables	(1) Young and middle-aged	(2) Elderly	(3) Low human capital	(4) High human capital	(5) Low material capital	(6) High material capital
ICT use	0.0169**	0.0100	0.0128*	-0.0100	0.0018	0.0189**
	(2.2085)	(0.7047)	(1.8855)	(-0.4267)	(0.1831)	(2.2987)
Gender	-0.0075	-0.0076	-0.0078	-0.0193**	-0.0077	-0.0102*
	(-1.3719)	(-0.5681)	(-1.3782)	(-2.0996)	(-0.9255)	(-1.6795)
Age	-0.0004	0.0603*	-0.0012	0.0036	-0.0019	0.0009
	(-0.2113)	(1.6915)	(-0.8527)	(1.5074)	(-0.9927)	(0.6243)
Age squared	-0.0001	-0.0447*	0.0007	-0.0043	0.0010	-0.0009
	(-0.0594)	(-1.7179)	(0.4666)	(-1.5810)	(0.5145)	(-0.5912)
Education	0.0097***	0.0011	0.0108***	0.0140*	0.0154***	0.0091***
	(7.1756)	(0.2567)	(4.3213)	(1.7545)	(5.4607)	(5.7114)
Married	0.0353***	0.0197	0.0286***	0.0248*	0.0468***	0.0123
	(3.7899)	(0.8319)	(3.0815)	(1.7666)	(3.7848)	(1.1198)
Health	0.0130***	-0.0023	0.0092***	0.0086	0.0053	0.0117***
	(4.4427)	(-0.3354)	(3.1974)	(1.4943)	(1.2635)	(3.5485)
Household size	-0.0055***	-0.0054*	-0.0055***	-0.0046*	-0.0007	-0.0088***
	(-3.9092)	(-1.9069)	(-4.3649)	(-1.9217)	(-0.3798)	(-6.3488)
Economic situation	0.0100***	0.0220***	0.0128***	0.0029	0.0135***	0.0045
	(5.6287)	(5.1028)	(7.1823)	(0.9158)	(3.5773)	(1.3007)
Household debt	0.0025	-0.0204	-0.0003	-0.0038	-0.0135	0.0106
	(0.4265)	(-1.1887)	(-0.0479)	(-0.3556)	(-1.5208)	(1.5080)
Car	-0.0002	-0.0062	0.0011	-0.0202**	0.0010	0.0063
	(-0.0321)	(-0.3765)	(0.1597)	(-2.0484)	(0.0867)	(0.9450)
Living environment	-0.0002	-0.0075**	-0.0008	-0.0031	-0.0083***	0.0056***
	(-0.1238)	(-1.9921)	(-0.5211)	(-1.1456)	(-3.9512)	(3.1944)
R^2 /Pseudo R^2	0.0210	0.0197	0.0209	0.0616	0.0238	0.0335
N	12,212	2,820	13,147	1,885	6,844	8,188

IV. Mechanism Analysis and Robustness Tests

4.1 Mechanism Analysis

Referring to the mechanism test idea of Jiang (2022), this paper adopts direct regression to conduct the mechanism test. This paper argues that the effect of ICT use on environmental protection willingness is mainly realized by increasing residents' environmental supervision consciousness and the degree of social interaction.

Mechanism 1 Environmental supervision consciousness. This paper uses the CLDS (2018) "whether to take action against someone spitting or trampling on green space and flowers", which has three options: stopping it in person, reflecting it to the relevant departments, and taking no action. If the respondent chooses to stop it in person or react to the relevant department, it means that he has taken action against environmentally unfriendly behaviors, then he is considered to have environmental supervision consciousness, and assigned a value of 1, otherwise, he is considered to have no environmental supervision consciousness, and assigned a value of 0. As can be seen from the estimation results in Table 4, ICT use improves the environmental supervision consciousness of the residents at the 10% level. This is because ICT use can improve people's access to knowledge about environmental pollution or environmental protection, enhance people's recognition of the "gold mountain silver mountain is green hills" and the sense of ownership of environmental protection, and motivate individuals to participate more actively in environmental protection and daily environmental protection supervision, which inadvertently improves residents' willingness to participate in environmental protection.

Mechanism 2 Social interaction. Gift expenditures reflect the social relations of Chinese families' human interaction, with the essential attributes of social interaction, in this regard, this paper refers to the selection ideas of Yang et al. (2011), this paper uses the gift expenditures of the household as a proxy variable for social interaction, and the larger the value is, the higher the intensity of its social interaction, which is logarithmized in the empirical evidence. From the estimation results in Table 4, it can be seen that the effect of ICT use on social interaction is positive and statistically significant at the 1% level, and the marginal effect shows that individuals who use ICT have 29.13% higher social interaction than those who don't, and the social interaction mechanism in this paper is verified. This paper argues that ICT use can promote the willingness to participate in environmental protection through the enhancement of social interaction, the reason is that the residents of environmental protection behavior is more likely to be influenced by social capital with the attribute of interpersonal interaction, ICT use has made it easier for people to use instant messaging tools (QQ, WeChat, etc.) to expand their social circles and enhance social interactions, which makes individual environmental protection behaviors more influenced by the cohort and demonstration effects.

Table 4 Mechanism Test Results

Variables	**(1)** **Environmental supervision consciousness**	**(2)** **Social interaction**
ICT use	0.0245*	0.2913***
	(1.6480)	(3.4289)
Gender	0.0064	0.0524
	(0.6685)	(0.8065)
Age	0.0089***	-0.0077
	(3.6255)	(-0.4801)
Age squared	-0.0080***	-0.0049
	(-2.9986)	(-0.2849)
Education	0.0107***	-0.0220
	(4.7428)	(-1.2350)

Married	-0.0042	0.4436***
	(-0.2563)	(4.0210)
Health	0.0029	-0.1653***
	(0.5320)	(-4.8477)
Household size	0.0035	0.0644***
	(1.4215)	(3.9311)
Economic situation	0.0098***	0.0919***
	(3.0153)	(4.3289)
Household debt	0.0301***	0.6478***
	(2.8631)	(9.3062)
Car	-0.0062	-0.4968***
	(-0.5735)	(-6.5484)
Living environment	-0.0029	0.0193
	(-1.1415)	(1.1188)
R^2 /Pseudo R^2	0.0119	0.0214
N	6,877	14,987

4.2 Robustness Tests

The above paper has estimated the results using stepwise regression, which to some extent indicates the robustness of the results. Therefore, in the robustness test part of this paper, we focus on two aspects: firstly, use the PSM model to reduce the endogeneity of the model caused by selection bias. Secondly, use alternative variables. The details are as follows:

4.2.1 Using the PSM Model

Based on the probit model, this paper uses the Propensity Score Matching (PSM) method to construct a counterfactual causal framework to test the causal effect of ICT use and residents' willingness to participate in environmental protection. PSM divides the samples into an experimental group and a control group, making it similar to a natural experiment, to reduce the selection error and better observe its net effect. Before using PSM, sample matching and balance tests are conducted. After matching in this paper, the t-test results show that the vast majority of experimental and control groups do not have systematic differences, which satisfies the prerequisites for the use of the PSM model. The estimation results are shown in the table below, and this paper focuses on the net effect of ATT estimation. It can be found that the difference between the experimental group and the control group has a value of 0.0267, a standard error of 0.010, and a t-value of 2.64, which passes the significance test, indicating that ICT use can significantly increase residents' willingness to participate in environmental protection, and the basic regression result of this paper is still valid.

Table 5 Estimated Results of Propensity Score Matching (ATT)

Variables	Treated	Controls	Difference	S.E.	T-stat
Unmatched	0.9067	0.8562	0.0500	0.0059	8.49
ATT	0.9061	0.8794	0.0267	0.0101	2.64

ATU	0.8562	0.8681	0.0119
ATE			0.0232

Note: The matching method is radius (caliper) matching with the radius set to 0.1.

4.2.2 Use of Substitution Variable

This paper uses communication expenditure as a proxy variable for ICT use. The reason for this is that the more communication expenditures, the more information activities residents participate in, the higher the level of information literacy, and the stronger the ability to use ICT naturally. The regression results in Table 6 show that the effect of communication expenditures on residents' willingness to participate in environmental protection is significantly positive, indicating that the use of the new variable did not change the estimation results of the basic regression.

In summary, the findings of this paper are robust.

Table 6 Robustness Test Results Using Proxy Variables

Variables	**(1)**
Communications expenditure (log)	0.0067*** (2.8870)
Gender	-0.0064 (-0.9134)
Age	0.0001 (0.0425)
Age squared	-0.0005 (-0.2336)
Education	0.0093*** (5.6525)
Married	0.0132 (1.0785)
Health	0.0132*** (3.4020)
Household size	-0.0058*** (-3.3695)
Economic situation	0.0087*** (3.6232)
Household debt	0.0101 (1.2357)
Car	-0.0031 (-0.4201)
Living environment	0.0037*(1.8766)
R^2 /Pseudo R^2	0.0441
N	5,596

V. Conclusions and Policy Implications

5.1 Conclusions

This paper uses CLDS (2018) micro survey data to conduct a systematic study on the influential relationship, heterogeneity, and mechanism of ICT use and willingness to participate in environmental protection. First, after regression using the Probit model as well as robustness tests, this paper finds that ICT use can significantly promote residents' willingness to participate in environmental protection. Secondly, the heterogeneity analysis in terms of age, human capital level, and material capital level reveals that the impact of ICT use on residents' willingness to participate in environmental protection is group-differentiated, and the promotion effect is greater for young and middle-aged people, groups with low human capital level and high material capital level. ICT in environmental protection participation reflects a certain degree of inclusiveness, but there is also a digital divide, which restricts the role of ICT use

in environmental protection willingness of some groups to a certain extent, and is not conducive to the release of ICT digital dividends. Mechanism analysis found that there are two main mechanisms of ICT use on residents' willingness to participate in environmental protection, one is that ICT use strengthens the individual's environmental supervision consciousness, so that the sense of ownership of environmental protection participation is strengthened. The other is that ICT use improves the intensity of the individual's social interactions, and enhances the demonstration and exemplary effects of environmental protection behavior in the information media, thereby increasing the willingness of residents to participate in environmental protection. This study not only clarifies the relationship between ICT use and residents' willingness to participate in environmental protection from an empirical perspective, but also provides some empirical evidence for the formulation of public policies on environmental protection.

5.2 Policy Implications

The policy insights of this paper mainly include: (1) We should give full play to the role of the Internet and other new media as an information channel in residents' environmental protection participation. Vigorously promote environmental protection concepts and knowledge through online media, social tools, short video media and others to stimulate the willingness of micro individuals to participate in environmental protection, and form a synergistic effect with the society and the government's environmental governance; (2) We should accelerate the construction of network infrastructure, actively organize information training, publicize and popularize network knowledge, cultivate residents' information literacy, reduce the digital divide for "vulnerable groups" such as the elderly, and enhance the universality of information and communication technologies and the release of the digital dividend; (3) We should raise residents' environmental supervision consciousness, and stop and supervise the trampling of environmental protection behaviors in a timely manner, so as to jointly build a livable environment with green water and green mountains; (4) We should make full use of the Internet and other information and communication technologies to give full play to the advantages of the Internet platform for demonstrating environmental protection behaviors, guiding people to participate in environmental protection, and enhancing the initiative of individuals in environmental protection.

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