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Do Internet Skills Increase Farmers' Willingness to Participate in Environmental Governance? Evidence from Rural China

Qiang He, Xin Deng, Chuan Li, Zhongcheng Yan and Yanbin Qi *

College of Economics, Sichuan Agricultural University, Chengdu 611130, China;
heqiangklcf@stu.sicau.edu.cn (Q.H.); dengxin@sicau.edu.cn (X.D.); 2020108003@stu.sicau.edu.cn (C.L.); 2019108007@stu.sicau.edu.cn (Z.Y.)
* Correspondence: qybin@sicau.edu.cn; Tel.: +86-028-8629-0896

Abstract: Environmental pollution is threatening the sustainable development of rural areas. Increasing farmers' willingness to participate in environmental governance (FWPEG) can effectively reduce this threat. Fortunately, the internet can speed up the process. However, it is unclear whether and to what extent the mastery of internet skills will increase FWPEG. This study uses data from 3503 farmers in 30 provinces in mainland China. It uses the TE and IVQTE models to correct selection bias and quantitatively assess the impact of mastery of internet skills on FWPEG. The results show: (1) mastering internet skills can significantly increase FWPEG, and after correcting the endogenous deviation, the marginal benefit of farmers mastering internet skills is 0.124; (2) in the 34–81% quantile range, internet skills show a declining development trend in FWPEG, which is in line with "the law of diminishing marginal utility", and mastery of the impact of internet skills on FWPEG has "leaping" (33% → 34%)" and "sagging (81% → 82%)" characteristics; (3) compared to that of the east, internet skills in central and western regions have a more significant role in promoting FWPEG. In general, internet skills can effectively increase FWPEG, and the impact will be more pronounced in underdeveloped areas. The influence of internet skills on FWPEG will gradually weaken with the increase of FWPEG. The results of this research help to coordinate the relationship between government environmental governance and rural environmental autonomy and provide some new ideas for realizing global rural revitalization.

Keywords: internet skills; FWPEG; treatment effect model; rural China

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1. Introduction

As one of the three major global crises, environmental pollution hinders the sustainable development of the regional population, economy, and society [1–3]. Canipari et al. pointed out that environmental pollution would reduce fertility rate and people's fertility intention, which was not conducive to population growth [4]. Baroudi et al. believe that environmental pollution is one of the most serious problems facing ecosystems and biodiversity [5]. Qureshi et al. found that greenhouse gas emissions seriously affected agricultural production such as cotton, wheat, and rice [6]. Ting et al. pointed out that under the influence of spatial factors, haze pollution has a great inhibitory effect on economic development [7]. Zehra et al. found that environmental pollution mitigates the value of energy stock prices [8]. In addition, environmental pollution also has a negative impact on residents' happiness [9,10]. Environmental pollution became a universal concern all over the world, and many countries in the world are also actively exploring new ways to control environmental pollution. Public participation is one of them, and the ways and channels of public participation are constantly expanding and enriching [11].

The public has become an indispensable force in China's environmental governance, but this force was not effectively stimulated in rural areas. This may be due to the low willingness of farmers to participate in environmental governance [12]. Arnstein divided public participation into eight steps, from low to high: Manipulation, Therapy, Informing, Consultation, Placation, Partnership, Delegated Power, Citizen Control [13]. Therefore, this study believes that public participation is a process in which the masses directly participate in the government's public decision-making through formal or informal channels and continuously advance to a higher ladder. As stakeholders of environmental resources, the public became an important force to promote environmental governance [14]. Public participation is a necessary prerequisite for environmental governance [15–17]. For example, Lihua et al. found that there is also a synergistic effect between government environmental governance and public participation, and public participation can improve regional environmental quality [18]; Su et al. reported that public participation is an important way to improve the overall effect and social recognition of rural environmental governance in water source areas [19]. However, Soon et al., Awasthi et al., and Rathore et al. found that people's environmental governance behaviors remain ineffective [20–22]. In particular, Chinese residents' participation in environmental governance is still in its infancy [23], especially in rural areas. For example, Liu et al. pointed out that Chinese farmers are not willing to sort waste [24], while Han et al. found that the local economic development levels limit the willingness of Chinese farmers to participate in domestic waste management [25]. Ma et al. pointed out that the proportion of Chinese farmers using clean energy is low [26]. Notably, China is one of the largest developing countries globally [27], and there are currently more than 500 million people living in rural areas (about 1/16 of the world's total population). Therefore, the farmers' willingness to participate in environmental governance (FWPEG) may be directly related to the sustainable rural development process in China.

At present, China entered a new stage of development from low-income stage to middle- and high-income stages, and the public is increasingly willing to participate in environmental governance [28]. However, because the level of social development in rural areas lags behind that of urban residents, farmers' income, education, and cognition levels are lower than urban residents, making rural residents' environmental perception and willingness to participate in governance generally lower than urban residents [29–31]. Therefore, increasing FWPEG is vital to solving rural environmental pollution problems [32,33]. Furthermore, information is key to enhancing the public's willingness to participate in environmental governance. For example, Kim et al. pointed out that environmental information disclosure can increase public participation in environmental projects such as water resources management [34]. Mukhtarov et al. reported that information and communication technology (ICT) could help improve the effectiveness and efficiency of urban water governance [35], while Yu et al. pointed out that the government's provision of environmental information to the public can increase the public's willingness to participate in governance [36]. However, not everyone has the right-to-know information for developing countries, especially in rural areas, but the internet's emergence and popularization may change this status quo. For example, Aiken et al. pointed out that internet search information can estimate the disease activity of the epidemic and enable efficacious protections [37], while Zhang et al. reported that Chinese netizens pay more attention to environmental issues than non-netizens [38].

China's rural revitalization strategy accelerated the modernization of agriculture and rural areas, and environmental pollution in rural areas became increasingly serious, but the increase of internet penetration in rural areas may change the situation [39]. However, the economic development in rural areas of China pays more attention to the environmental pollution caused by economic development. Zhao et al. and Qiao et al. reported that because farmers are more sensitive to air pollution than urban residents, the risk of death caused by air pollution is generally higher in rural areas [40,41]. Yu et al. found that excessive sewage discharge from industrial and agricultural production and poor living habits of villagers are the main reasons for the deterioration of the rural water environment [42]. The lack of farmers' awareness of environmental pollution and their low willingness to participate in governance has hindered the modernization of China's agriculture and rural areas. As of 2020, the internet penetration rate in rural areas in China is 46.2%. Therefore, this study uses rural China as a case analysis sample to evaluate and analyze whether the popularization of the internet has increased the FWPEG and to what extent. The results of this study will help provide research support for China to coordinate government environmental governance and rural environmental autonomy and help improve the environmental pollution in rural China.

Public participation in environmental governance is an important issue in contemporary environmental field and a key concept in many interdisciplinary research fields such as politics, sociology, and environmental science. The public is an important subject of environmental governance, as well as an indispensable part of making up for the "failure" of government and market and promoting environmental fairness.

There is abundant research on public participation and environmental governance in academic circles, which provides the research basis for this study. Most scholars believe that public participation can effectively improve the effect of environmental governance. For example, Garmendia and Stagl found that public participation has many advantages for environmental governance, such as improving the understanding of Environmental events [43]. Through discussing the impact of public participation on the environment, Sun et al. found that involved stakeholders, the degree of participation, approach and timing has impact [44]. Yao et al. believe that collaborative public participation is a possible way to strengthen the effectiveness of public involvement within the Chinese context [45]. Zhang et al. pointed out that the impact of public participation policy and proposals on environmental governance is insane replaceable [46]. In addition, some scholars believe that the impact of public participation on environmental governance was exaggerated. For example, Tu et al. found that PITI information disclosure has a positive impact on pollution reduction, but existing literature may exaggerate the role of public participation in environmental improvement in China, and government administrative measures still play an important role at the present stage [47]. Newig et al. And Anna et al. pointed out that public participation cannot guarantee more effective decision-making, and when citizens without professional knowledge or experience participate, it may even lead to poor decision-making implementation [48,49].

The rural environmental mass incidents became one of the main factors affecting social stability in rural areas [50]. However, Munro found that rural residents were less likely to participate in environmental governance than their urban counterparts [51]. Farmers' participation in environmental governance is often passive, which will reduce farmers' enthusiasm in agricultural production and environmental governance. For example, Ma et al. found that perceived benefit and perceived cost are important perceived value factors affecting farmers' participation in waste sorting [52]. Wand et al. found that response costs had a significant negative impact on FWPEG [53]. McGurk et al. found that increasing the level of compensation could increase the participation rate of farmers in the agricultural environment schemes [54]. Su et al. pointed out that personal environmental awareness, environmental protection facilities, and environmental service quality have a significant impact on public participation in the use of rural MSW public collection points [19]. So, does the internet help increase farmers' willingness to participate in environmental governance?

The impact of the internet on the traditional concepts of farmers and the promotion of environmental protection knowledge may contribute to an effectively increased FWPEG. Firstly, the internet can allow farmers to raise awareness of environmental protection. Zhao et al. pointed out that the internet reduces pesticide use by improving farmers' awareness of green production [55]. Vilas et al. reported that a water quality information system based on the internet could improve farmers' environmental protection awareness [56]. Farmers will improve water quality by improving crop management. Drangert et al., Boz, and Chisanga et al. also associate the popularization of the internet with effectively improving FWPEG [57–59]. Simultaneously, Li et al. and Yang et al. pointed out that improving the efficiency of farmers' access to information and increasing the exchange and interaction between farmers can increase FWPEG [60,61]. Furthermore, the study found that farmers who often use the internet can improve their understanding and knowledge [62,63], increasing FWPEG. internet skills can improve the well-being of farmers and increase farmers' awareness of environmental protection, thereby increasing FWPEG.

2. Materials and Methods

2.1. Data

This study uses the original data from the Chinese Social Survey (CSS) conducted by the Chinese Academy of Social Sciences Institute of Sociology (Website: http://css.cssn.cn/css_sy/, accessed on 12 May 2021). CSS employs the sampling methods which are multistage cluster, stratified, and PPS sampling. CSS also uses the technology of computer assisted personal interviewing to household survey, which helped ensure data quality. CSS's respondents cover 604 villages (residential committees) in 151 counties in 31 provinces of mainland, and its survey contents cover the modules of family, employment, economic status, living conditions, social security, social values, and social evaluation, social and political participation, and voluntary services [64]. This study uses the 2019 CSS survey data, which are currently the latest data publicly available to the institution.

In addition, since the environmental governance behaviors of urban residents were well discussed, this study aims to discuss the impact of internet skills on FWPEG. Therefore, this study processed the original database as follows: firstly, this study only included rural household registration samples as the analysis object (that is, urban household registration samples were deleted); secondly, this study deleted samples with more missing data. In summary, 3503 sample farmers became the analysis data of this study.

2.2. Method

2.2.1. Dependent Variables

This study takes FWPEG as the dependent variable. Existing studies primarily examine farmers' willingness to pay for environmental costs to study FWPEG [65,66]. However, using a single dimension such as payment to examine the FWPEG is inevitably biased. Therefore, this research constructs the FWPEG evaluation index system from the farmers' environmental protection attitude, participation willingness and environmental protection knowledge. Firstly, farmers' attitude towards environmental protection is an important factor determining their participation in environmental governance. The more attention farmers attach to environmental protection, the more they will actively participate in environmental governance [67,68]. Secondly, this study included the willingness to participate in environmental protection at the single dimension level as an important factor in the FWPEG evaluation index system. Finally, farmers' environmental knowledge is also an important factor determining their participation in environmental governance. The more environmental knowledge farmers have, the more they can participate in environmental governance [69,70]. Based on this, this study believes that it is reasonable and necessary to construct FWPEG evaluation index system from farmers' environmental protection attitude, participation willingness and environmental protection knowledge. As shown in Table 1, the three-level indicators are the specific contents of the questionnaire. A total of five optional options are included in the analysis: fully consistent, relatively consistent, not quite consistent, completely inconsistent, and uncertain. The values assigned to these five optional options are: fully consistent = 5; relatively consistent = 4; Uncertain = 3; not quite consistent = 2 and completely inconsistent = 1. According to the studies of Zhu et al. [71], Deng et al. [72] and Huang et al. [73], this study uses the entropy weight method (EWM) to measure the FWPEG (The specific measurement process is shown in Appendix A), this study uses the entropy weight method (EWM) to measure the FWPEG. The weight and level of FWPEG are calculated by using EWM. The weight of FWPEG is shown in Table 1. The weight of environmental protection attitude is 0.341 and 0.207 respectively, the weight of willingness to participate in environmental protection is 0.353, and the weight of environmental protection knowledge is 0.099.

Table 1. Evaluation index system of farmers' willingness to participate in environmental governance.

One-Level Indicators	Two-Level Indicators	Three-Level Indicators	Attributes	Weights	Mean	S.D.
FWPEG	Awareness-1	For our country, economic development is more important than environmental protection	–	0.341	2.904	1.374
	Awareness-2	Protecting the environment is the responsibility of the government, and it has little to do with me	–	0.207	2.281	1.341
	Willingness	If I have time, I am very willing to join an environmental organization	+	0.353	4.144	1.063
	Knowledge	I don't understand environmental issues, and I don't have the ability to comment	–	0.099	2.908	1.467

2.2.2. Key Variables

The current study takes internet skills as the core explanatory variable. Most of the existing research focuses on the internet, with established measurement methods. For example, Whitacre et al. and Conley et al. use broadband access rates to measure internet usage [74,75]. This study considers that the research object is farmers and the use of the internet in rural areas lags behind the cities; furthermore, there may be situations in which internet broadband access is not used. Therefore, this article draws on the practice of Deng et al. and directly asks farmers whether they are online in the questionnaire as the core explanatory variable [76], namely, internet skills. This indicator is a 0-1 binary variable.

2.2.3. Control Variables

The purpose of this study was to examine the quantitative impact of internet skills on FWPEG. Refer to Wang et al., Xiao et al. and Wang et al. when investigating farmers' environmental governance behavior and willingness to participate, four aspects of personal characteristics, family characteristics, basic social security and living environment are introduced as control variables [77–79]. Therefore, this study also selected personal characteristics (gender, age, marriage, nationality, party, belief, education), family characteristics (size, fixed assets, income), basic social security and living environment, etc. Twelve variables in four aspects as control variables. At the same time, the instrumental variable is selected as the one-year communication expenditure of the farmer's entire family. In contrast, communication costs belong to the category of consumption. From a broad perspective, the internet also belongs to communication consumption, so the network usage habits in household communication expenditures will continue. Hence, endogenous variables in this study meet the relevant conditions. In theory, however, communication expenses will not directly affect farmers' willingness to participate in environmental governance. The model variables and summary statistics are described in Table 2.

Table 2. Definition and data description of variables in model.

Variables	Definition	Mean	S.D.
Dependent variable			
FWPEG [a]	The score of farmers' willingness to participate in environmental governance	0.583	0.237
key variable			
internet skills	1 if farmer surfing the internet, 0 otherwise	0.598	0.490
Control variables			
Gender	1 if interviewee is female, 0 otherwise	0.579	0.494

Table 2. *Cont.*

Variables	Definition	Mean	S.D.
Age	The age of interviewee (years)	45.417	14.110
Size	The number of members for interviewee family (num)	6.654	3.421
Marriage	1 if interviewee is not married, 0 otherwise	0.112	0.316
Education	1 if interviewee did not go to school, 2 if interviewee graduated from elementary school, 3 if interviewee graduated from junior high school, 4 if interviewee graduated from high school, 5 if interviewee graduated from college, 6 if interviewee graduated from a university or above	0.245	0.430
Nationality	1 if interviewee is Han nationality, 0 otherwise	0.908	0.290
Party	1 if interviewee is the Communist Party and Democratic Parties, 0 otherwise	0.070	0.256
Belief	1 if interviewee has religious beliefs, 0 otherwise	0.138	0.345
Fixed assets	Number of houses owned by farmers	1.181	0.575
Income	1 if annual family income below 5000, 2 if annual family annual income 5000 to 10,000, 3 if annual family income of 10,000 to 30,000, 4 if annual family income of 30,000 to 50,000, 5 if annual family income of 50,000 to 100,000, 6 if annual family income is more than 100,000 (RMB)	4.171	1.470
Pension	1 if interviewee buys endowment insurance, 0 otherwise	0.359	0.480
Living Environment	1 if interviewee is very dissatisfied; 10 if the interviewee is very satisfied (10 levels)	6.935	2.359
IV	1 if family's annual communication expenditure is greater than 1000, 0 otherwise (RMB)	0.730	0.444
Observation	3503		

Note: [a] See Appendix A for calculation process of FWPEG. To investigate correlation between variables in Table 2 and FWPEG indicators, three dimensions, Awareness, Willingness and Knowledge, were used as dependent variables to perform Ordinary Least Squares (OLS) estimation with variables in Table 2, and regression results are shown in Appendix B.

2.2.4. The Treatment Effect Model

There are differences between the treatment effect model and the ordinary regression model for the correlation between the variables studied. The treatment effect model studies the causal relationship between variables, allowing researchers to obtain accurate estimates of the causal relationship between variables under very weak assumptions, so it plays a very important role in microeconomic policy evaluation [80]. This analysis studies the impact of internet skills on FWPEG, and the possible endogenous problems of variables and their impact must be considered. The sources of endogeneity are mainly omitted variable bias, measurement error, and two-way causality [81]. Firstly, whether farmers master internet skills is a self-selection behavior, and there may be unobservable factors that affect both mastery of internet skills and FWPEG. Secondly, the improvement of FWPEG may prompt farmers to take the initiative to master internet skills. There may be a two-way causal relationship between FWPEG and whether the farmers mastered internet skills. Therefore, this study draws on the Treatment Effect (TE) model to solve the self-selection problem and correct the endogenous bias [82], as shown in Equations (1)–(3).

$$FWPEG_i^d = \alpha X_i + \beta Int\_skills_i + \gamma_i \quad (1)$$

$$Int\_skills_i^* = \delta Z_i + \mu_i \quad (2)$$

$$Int\_skills_i = \begin{cases} 0 Int\_skills^* > 0 \\ 1 Int\_skills^* \leq 0 \end{cases} \quad (3)$$

Equation (1) is the central equation of FWPEG, and Equations (2) and (3) are the determining equations of the endogenous variable internet. $FWPEG_i^d$ is a latent variable representing the willingness of farmers to participate in environmental governance.

$Internet_i$ represents whether farmers have mastered internet skills, X_i is other factors that affect farmers' willingness to participate in environmental governance; $Internet_i^*$ is the chance ratio of sample i, Z_i is a variety of exogenous factors that affect the variable interneti, and γ_i and μ_i are random disturbance terms.

2.2.5. The Instrumental Variable Quantile Treatment Effect Model

In addition to the endogenous issues, the unobserved heterogeneity may cause different marginal effects of farmers' acquisition of internet skills. The Quantile Treatment Effects Model (QTE) can deal with heterogeneity and correct endogenous problems. It can study the heterogeneous influence of internet skills on FWPEG at different quantiles and accurately estimate the causal relationship between variables. At the same time, this research is more concerned about the unconditional impact of the mastery of internet skills on the distribution of FWPEG, regardless of personal circumstances and family characteristics. Compared with conditional endogenous QTE, unconditional endogenous QTE sums the conditional effect on the whole sample, so the function form is one-dimensional, while conditional QTE is multidimensional, so its policy meaning is easier to convey to policy makers. However, treatment variables are generally considered to be endogenous, that is, whether an individual chooses to participate in treatment or not is related to the individual's expectation of the outcome of the policy. This makes it difficult to estimate treatment effects. It is necessary to use the instrumental variable estimation of the quantile in technical processing [83]. Therefore, this study draws on the practice of Frölich and Melly introduces instrumental variables and builds an instrumental variable quantile treatment effect model (IVQTE) based on the TE model [84], as shown in Equations (4) and (5).

$$FWPEG_i^{\tau d} = \alpha^{\tau} X_i + \beta^{\tau} Int\_skills_i + \gamma_i \quad (4)$$

$$Int\_skills_i = \eta^{\tau} X_i + \theta^{\tau} IV_i + \nu_i \quad (5)$$

where IV is an instrumental variable, other variables are consistent with the above TE model, τ represent the quantile, and ν_i depends on the ranking variable γ_i, and is unobservable information. The quantile treatment effect is $q_\tau(FWPEG_1) - q_\tau(FWPEG_0)$, $q_\tau(FWPEG_1)$, and $q_\tau(FWPEG_0)$, respectively, and this indicates the degree of willingness of *FWPEG* when $D = 1$ and $D = 0$, respectively.

The specific calculation is divided into three steps:

Firstly, to define the weight function W, calculate the nonparametric estimate $\hat{p}(\cdot)$ of the propensity score $p(X)$, $W = \frac{IV - p(X)}{p(X)(1 - p(X))}(2Int\_skills - 1)$;

Secondly, $\hat{p}(\cdot)$ will be substituted into the expression of W to obtain a consistent estimate of W: $\hat{w}_i = \frac{iv_i - \hat{p}(x_i)}{\hat{p}(x_i)(1 - \hat{p}(x_i))}(2Int\_skills_i - 1)$;

Finally, minimize $\frac{1}{n}\sum_{i=1}^{n}(\rho_\tau(fwpeg_i - \alpha - \beta Int\_skills_i) \cdot \hat{w}_i)$. Among the conditions for, $\rho_\tau(\phi) = \phi(\tau - 1(\phi < 0))$.

3. Results

3.1. Descriptive Results

3.1.1. Collinearity Test and Instrumental Variable Test

Before conducting empirical analyses, the investigation needs to assess the independent variables for collinearity and test for weak instrumental variables [81,85]. The test results are shown in Table 3. The VIF value of each variable is within 3, indicating that there is no collinearity among the variables. In addition, the ivreg2 command in stata16 is used to test the instrumental variables of this study. The test results verify that the instrumental variables are exogenous and not weak instrumental variables, and internet skills are endogenous variables.

Table 3. Collinearity test and weak instrumental variables test.

Collinearity Test							
Variables	Age	Education	internet skills	Marriage	Income	IV	Pension
VIF	2.63	1.96	1.73	1.63	1.29	1.19	1.15
Variables	Party	Gender	Nationality	Fixed assets	Belief	Living Environment	Size
VIF	1.12	1.11	1.06	1.04	1.02	1.01	1

Weak Instrumental Variables Test		
Kleibergen-Paap rk LM statistic	24.031	(0.000)
Kleibergen-Paap rk Wald F statistic	24.128	{16.38}

Note: p value is in parentheses; Stock-Yogo Weak Recognition Test 10% Critical Value is in big parentheses.

3.1.2. Mean Differences

The mean difference data analyzes the difference between farmers who have internet skills and those who do not. The test results of the mean difference are shown in Table 4. Except for variables gender, size, nationality, fixed assets, and living environment, all the other variables pass the significance test at the level of 5%. It shows a significant difference between the farmers who have internet skills and those who do not. Among them, the mean difference of FWPEG is −0.177, passing the significance test at the 1% level, indicating that farmers with internet skills are more willing to participate in environmental governance than farmers without internet skills. Therefore, this study must use the TE and the IVQTE models to explain the selection bias caused by the observed and unobserved factors.

Table 4. Mean differences in variables between.

	No Internet Skills		Internet Skills		Diff.	
FWPEG	0.477	(0.226)	0.654	(0.218)	−0.177	***
Gender	0.585	(0.493)	0.575	(0.494)	0.009	
Age	55.587	(9.048)	38.583	(12.716)	17.004	***
Size	6.616	(3.430)	6.680	(3.417)	−0.064	
Marriage	0.021	(0.144)	0.173	(0.379)	−0.152	***
Education	2.110	(0.865)	3.358	(1.216)	−1.247	***
Nationality	0.898	(0.302)	0.914	(0.281)	−0.015	
Party	0.056	(0.230)	0.080	(0.271)	−0.024	***
Belief	0.122	(0.328)	0.148	(0.355)	−0.026	**
Fixed assets	1.163	(0.517)	1.193	(0.610)	−0.029	
Income	3.554	(1.512)	4.585	(1.285)	−1.031	***
Pension	0.496	(0.500)	0.266	(0.442)	0.231	***
Living Environment	7.011	(2.538)	6.884	(2.231)	0.127	
IV	0.577	(0.494)	0.833	(0.373)	−0.256	***
Observation	1408		2095			

Note: Standard deviations are in parentheses; ** $p < 0.05$, *** $p < 0.01$.

3.2. Empirical Results

3.2.1. Empirical Results of the TE Model

The TE_MLE column in Table 5 shows that the Wald endogeneity test rejects the null hypothesis that the central equation and the determination equation are mutually independent at a significance level of 10%. The residual correlation (athrho_cons) is negative and passed the significance test, indicating a negative selectivity bias, that is, unobservable factors that affect FWPEG and unobservable factors that hinder farmers from mastering internet skills occur at the same time. Therefore, it is appropriate to conduct a TEM analysis on sample data in this study.

Table 5. Comparison of TE and OLS estimation results.

Variables	**OLS**			**TE_MLE**			**TE_2Step**		
Master Equation (FWPEG)									
Internet skills	0.063	(6.34)	***	0.124	(5.04)	***	0.141	(3.78)	***
Gender	−0.010	(−1.29)		−0.008	(−1.09)		−0.007	(−0.94)	
Age	−0.004	(−9.95)	***	−0.003	(−5.70)	***	−0.003	(−3.52)	***
Size	0.002	(1.46)		0.002	(1.47)		0.001	(1.47)	
Marriage	−0.055	(−4.02)	***	−0.044	(−2.98)	***	−0.035	(−2.07)	**
Education	0.044	(10.64)	***	0.040	(8.81)	***	0.037	(7.16)	***
Nationality	0.010	(0.66)		0.011	(0.68)		0.010	(0.64)	
Party	0.053	(3.67)	***	0.051	(3.50)	***	0.049	(3.35)	***
Belief	0.004	(0.31)		0.003	(0.29)		0.003	(0.27)	
Fixed assets	0.009	(1.49)		0.009	(1.44)		0.009	(1.37)	
Income	0.004	(1.38)		0.002	(0.79)		0.001	(0.29)	
Pension	0.020	(2.43)	**	0.020	(2.43)	**	0.020	(2.44)	**
Living Environment	−0.003	(−1.89)	*	−0.003	(−1.88)	*	−0.003	(−2.03)	**
Province dummies		YES			YES			YES	
_cons	0.557	(13.98)	***	0.510	(11.17)	***	0.476	(8.77)	***
Determination Equation (Internet Skills)									
Age				−0.064	(−21.99)	***	−0.064	(−22.76)	***
Marriage				−0.510	(−2.80)	***	−0.518	(−3.19)	***
Education				0.480	(14.07)	***	0.478	(14.94)	***
Party				0.135	(1.15)		0.112	(1.01)	
Fixed assets				0.065	(1.30)		0.067	(1.33)	
Income				0.135	(6.97)	***	0.135	(6.92)	***
_cons				1.452	(7.32)	***	1.465	(7.51)	***
athrho_cons				−0.129	(−1.91)	*			
lnsigma_cons				−1.575	(−134.78)	***			
hazard lambda							−0.049	(−2.18)	**
lambda					−0.027				
rho					−0.128			−0.233	
chi2					3.670 *				
R^2		0.244							
Log pseudolikelihood					−872.11845			−1429.2943	
Observation		3503			3503			3503	

Note: *t*-values are in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Firstly, the TE_MLE column in Table 5 shows that the main explanatory variable (internet skills) coefficient is estimated to be 0.124 and has passed the significance test at the 1% level, indicating that mastering internet skills can significantly increase FWPEG. At the same time, the OLS regression in Table 5 shows that the coefficient of internet skills is estimated to be 0.063 and passed the significance test at the 1% level, indicating that the OLS regression underestimates the impact of internet skills on FWPEG. Therefore, after correcting the endogenous deviation, internet skills have a more prominent effect on increasing FWPEG.

Secondly, the master equation in the TE_MLE column in Table 5 shows that age, marriage, and living environment significantly negatively affect FWPEG. In contrast, education, party, and pension significantly positively affect FWPEG. In addition, the determination equation in the TE_MLE column in Table 5 shows that age and marriage significantly negatively affect farmers' mastery of internet skills, while education and income significantly positively affect farmers' mastery of internet skills.

Finally, comparing the estimation results of OLS and MLE, due to self-selection bias and endogenous problems, internet skills in the traditional OLS estimation results affect FWPEG and produce a downward biased estimate. In contrast, comparing the estimation results of the TE_MLE and TE_2Step columns, because the collinearity problem between the central equation and the variables of the decision equation cannot be avoided, the two-stage estimation method produces an upward biased estimate of the influence of internet skills on FWPEG. In general, the MLE estimates are robust and reliable, verifying that internet skills can increase FWPEG.

3.2.2. Empirical Results of the IVQTE Model

The TE model reveals the average FWPEG of internet skills. This study then uses the IVQTE model to estimate the "marginal effect" of internet skills and accurately determine the impact of internet skills on FWPEG. The communication cost expenditure is selected as the instrumental variable. The estimated results are shown in Table 6.

The IVQTE estimation results of the core explanatory variable, internet skills, show that at the 10%, 25%, 33%, 82%, and 90% points, the impact of internet skills on FWPEG has not passed the significance test. In the 34–81% quantile range, the influence of internet skills on FWPEG showed a declining development trend, which is in line with "the law of diminishing marginal effects". On the whole, internet skills have the characteristics of "leaping (33% → 34%)" and "sagging (81% → 82%)" in the influence of farmers' willingness to participate in environmental governance. In addition, the (quantile regression) QR estimation results of the core explanatory variable, internet skills, show that the influence of internet skills on FWPEG presents an inverted U-shaped development trend. Obviously, the IVQTE estimation results are more reliable. However, since variable endogeneity has not been considered, it is impossible to accurately judge the actual processing effect of internet skills and outcome on different groups.

Table 6. Comparison of QR and IVQTE estimation results.

Quantile	QR			IVQTE		
10%	0.037	(2.31)	**	0.259	(0.75)	
25%	0.076	(5.06)	***	0.380	(1.04)	
33%	0.079	(5.33)	***	0.451	(0.94)	
34%	0.078	(5.24)	***	0.473	(1.85)	*
50%	0.068	(5.83)	***	0.406	(1.78)	*
75%	0.069	(5.06)	***	0.250	(1.87)	*
81%	0.059	(4.70)	***	0.238	(1.70)	*
82%	0.059	(4.63)	***	0.225	(1.59)	
90%	0.044	(3.15)	***	0.134	(0.50)	
Observation		3503			3503	

Note: Only show coefficient estimates for internet skills; *t*-values are in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

3.2.3. Regional Heterogeneity

Further analysis of the differences in the influence of internet skills on FWPEG in different regions involves decomposing the sample based on the farmer households' regions. Regression analysis was done on the eastern, central, and western regions' subgroups, with the results shown in Table 7.

Firstly, comparing the estimation results of the eastern and central-western regions, the estimated coefficient of internet skills in eastern and central-western regions is 0.093 and 0.141, respectively, and passed the significance test at the level of 5% and 1%. Such data infer that internet skills in central and western regions have a more significant role in promoting FWPEG. Secondly, the estimation result coefficients of the remaining variables in the master equation column show that the eastern region's family size and marriage significantly affect the FWPEG. Fixed assets and pensions in the central and western regions significantly affected FWPEG. The influence of age and party in the eastern region on FWPEG is greater than that of the central and western regions. In comparison, the influence of education in the eastern region on FWPEG is less than that of the central and western regions. Finally, judging from the estimated result coefficients of the variables in the Determination equation column, the fixed assets in the central and western regions significantly affect the farmers' mastery of internet skills. Marriage and income in the eastern region have a greater impact on farmers' mastery of internet skills than in the midwest, while age and education have less impact on farmers' mastery of internet skills than in the midwest.

Table 7. Comparison of maximum likelihood estimation results in eastern and central-western China.

Variables	East Area			Midwest Area		
Master Equation (FWPEG)						
Internet skills	0.093	(2.36)	**	0.141	(4.56)	***
Gender	−0.019	(−1.57)		−0.000	(−0.04)	
Age	−0.004	(−4.35)	***	−0.003	(−4.04)	***
Size	0.004	(2.58)	***	−0.000	(−0.24)	
Marriage	−0.074	(−3.21)	***	−0.022	(−1.15)	
Education	0.034	(4.86)	***	0.046	(7.68)	***
Nationality	0.018	(0.62)		0.006	(0.30)	
Party	0.070	(3.41)	***	0.037	(1.80)	*
Belief	0.008	(0.53)		−0.002	(−0.15)	
Fixed assets	0.003	(0.31)		0.016	(1.86)	*
Income	0.002	(0.35)		0.003	(0.72)	
Pension	−0.000	(−0.01)		0.034	(3.26)	***
Living Environment	−0.003	(−1.17)		−0.003	(−1.47)	
Province dummies		YES			YES	
_cons	0.568	(7.20)	***	0.477	(8.35)	***
Determination Equation (Internet Skills)						
Age	−0.059	(−12.24)	***	−0.069	(−18.40)	***
Marriage	−0.629	(−2.22)	**	−0.411	(−1.77)	*
Education	0.434	(7.82)	***	0.504	(11.71)	***
Party	0.258	(1.33)		0.051	(0.36)	
Fixed assets	−0.006	(−0.09)		0.109	(1.66)	*
Income	0.165	(5.31)	***	0.110	(4.39)	***
_cons	1.354	(3.90)	***	1.635	(6.65)	***
athrho_cons	−0.039	(−0.36)		−0.180	(−2.12)	**
lnsigma_cons	−1.582	(−83.38)	***	−1.574	(−104.54)	***
lambda		−0.008			−0.037	
rho		−0.039			−0.178	
chi2		0.130			4.500 **	
Log pseudo-likelihood		−321.588			−531.212	
Observation		1385			2118	

Note: t-values are in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4. Discussion, Conclusions, and Implications

4.1. Discussion

The phenomenon of "boiling frogs in warm water" weakens farmers' perception of pollution and hinders the increase of FWPEG. It is one of the obstacles to the harmonious coexistence of man and nature in rural areas. Especially in rural areas in developing countries, FWPEG is generally low, and rural environmental autonomy and government environmental governance cannot effectively coordinate development [86,87]. Recently, the Chinese government introduced many rural environment management files to improve the rural environment (for example, in 2021 promulgated the "law of the People's Republic of China national economic and social development of the 14th compendium of the five-year plan and 2035 vision", one specifically mentioned in sections "to improve the rural living environment"). However, due to the low level of farmers' perception of pollution and their low willingness to cooperate with the government's environmental governance measures, many of the government's measures on rural environmental governance did not have the desired outcomes. However, this study found that the emergence of the internet can coordinate rural environmental autonomy and government environmental governance, thereby increasing FWPEG, which provides a reference for the Chinese government and other developing countries to build new environmental governance mechanisms.

The data from the current research encourages facilitating a relationship between the existing internet technology and environmental governance. The internet changed the world and our lives. The "Metcalf rule" of the internet has a more significant impact on developing countries. For example, Ma et al. found that the popularization of the internet is helpful to the exploration of sustainable agricultural practices in China [88]. Similarly, Godil et al. reported that the internet application could reduce Pakistan's carbon dioxide emissions [89]. This study further verifies that there are spatial differences in the impact of internet skills on FWPEG. The role of internet skills in developed rural areas in improving FWPEG is less than that in underdeveloped rural areas. Equally, in underdeveloped rural areas, FWPEG is lower than in developed rural areas, similar to the conclusions of Tourlioti et al. and Liu et al. [90,91].

Finally, the findings of this study are somewhat different from those of existing studies. Yang et al. found that the development of the internet is helpful to air pollution control [92], and Lin et al. reported that the internet could be used as a platform for environmental information disclosure, helping the public to participate in environmental governance [93]. However, there was less research on the impact of internet skills on environmental governance, with no previous research studies on the impact of internet skills on different levels of FWPEG. This study found that internet skills have no significant impact on FWPEG at the high and low quintiles. Internet skills can affect FWPEG only in the 34–81% quantile range, inferring that it is impossible to increase FWPEG by only popularizing the internet. Government departments should also popularize environmental protection knowledge. Only a "two-pronged approach" can achieve the desired outcome of increasing FWPEG.

This study finds that internet skills are helpful to break the "post-understanding" predicament in rural areas of developing countries and stimulate FWPEG. Such results provide empirical evidence for coordinating the relationship between government environmental governance and rural environmental autonomy and for the internet to affect the sustainable development of the environment positively.

In addition, there are some shortcomings in this research, which future research would need to address. The relationship between internet skills and FWPEG may be dynamic. Future research can build data panels that can be tracked continuously to analyze the dynamic inter-relationships. Also, since the Chinese government implemented the "broadband China" strategy in 2013, the internet penetration rate in rural areas of China has gradually increased. Future studies can further investigate whether the conclusions of this study apply to other developing countries.

4.2. Conclusions and Implications

With the rapid development of the internet, public participation through new media channels was widely used to enhance citizens' right to speak and enthusiasm for participation in the environment, especially in promoting policy agenda setting, reuniting stakeholder groups, and innovating the interaction and communication mechanism between the government and the public. The internet became an indispensable tool for public participation in environmental governance. This study uses survey data of Chinese farmers in 30 provinces of mainland China to quantitatively study the impact of internet skills on FWPEG. Consideration of the sample selection bias correction, the treatment of heterogeneity, and the correction of endogeneity, this study found that internet skills can improve FWPEG and have a heterogeneous impact on FWPEG at different subpoints, as follows:

(1) Internet skills can significantly improve FWPEG, and the marginal benefit of farmers mastering internet skills after correcting the endogenous deviation is 0.124.
(2) In the 34–81% quantile range, internet skills show a declining development trend in FWPEG, which is in line with "the law of diminishing marginal utility", and mastery of the impact of internet skills on FWPEG has "leaping" (33% → 34%)" and "sagging (81% → 82%)" characteristics.
(3) Compared to the east, internet skills in central and western regions have a more significant role in promoting FWPEG.

The validated conclusions outlined above can contribute and assist in emerging policy enlightenment. Firstly, internet skills can significantly increase FWPEG, and it is particularly important to popularize the internet in rural areas. One suggestion could be that the government differentially price internet broadband network fees, increasing urban internet broadband network fees to compensate for internet broadband network fees in rural areas. Such policy would lower the barriers to entry for the internet in rural areas and increase internet penetration in rural areas. Secondly, relevant government departments should increase financial support for underdeveloped rural areas to build local internet infrastructure. A corresponding policy may be that relevant government departments can allocate special financial funds to underdeveloped rural areas to build rural internet infrastructure, increase internet penetration, and regularly invite internet companies to carry out related internet popularization activities. Finally, internet skills have a heterogeneous impact on FWPEG at different points, and how to improve FWPEG is the key to stimulating internet skills. For example, environmental protection departments can hold regular activities to popularize environmental protection knowledge in rural areas, engaging farmers to understand the harm caused by environmental pollution, thereby increasing FWPEG and inspiring the promotion of internet skills.

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Appendix A

The EWM is to weight the index by judging the degree of dispersion of the index, and what it measures is a type of uncertainty. The larger the entropy value, the larger the amount of information it contains, and the smaller the uncertainty, the smaller amount of information. The EWM includes the following steps:

Steps (1): the indicators of farmers' environmental awareness, farmers' willingness to participate, and farmers' environmental attitude were standardized to achieve data homogenization and eliminate the influence of dimensions and levels of data on the evaluation results. Among them, farmers' environmental awareness and attitude were negative indicators, while farmers' participation willingness was positive. The specific formula steps are as follows:

Positive indicators: $z'_{ij} = \frac{z_{ij} - \min\{z_{1j}, \ldots, z_{nj}\}}{\max\{z_{1j}, \ldots, z_{nj}\} - \min\{z_{1j}, \ldots z_{nj}\}}$

Negative indicators: $z'_{ij} = \frac{\max\{z_{1j}, \ldots, z_{nj}\} - z_{ij}}{\max\{z_{1j}, \ldots, z_{nj}\} - \min\{z_{1j}, \ldots, z_{nj}\}}$

i = sample, j = relevant indicators, the standardized calculation method of each indicator is as follows:

The standardized value of the j index $= \frac{Z_j - Z_{\min(0)}}{Z_{\max(0)} - Z_{\min(0)}}$

Steps (2): calculate the proportion of the j-th sample value under the i-th index in the index:

$$p_{ij} = \frac{z_{ij}}{\sum_{i=1}^{n} x_{ij}}, i = 1, \ldots, n, j = 1, 2, 3, \ldots m \quad \text{(A1)}$$

Steps (3): calculate the entropy value of the jth index:

$$e_j = -k\sum_{i=1}^{n} p_{ij} \ln(p_{ij}), j = 1, \ldots, m, \text{ among them }, k > 0, k = 1/\ln(n), e_j \geq 0 \quad \text{(A2)}$$

Steps (4): calculate information entropy redundancy (difference):

$$d_j = 1 - e_j, j = 1, \ldots, m \quad \text{(A3)}$$

Steps (5): calculate the weight of each indicator:

$$w_j = \frac{d_j}{\sum_{i=1}^{m} d_j}, j = 1, \ldots, m \quad \text{(A4)}$$

Steps (6): calculate the comprehensive score of the sample:

$$FWPEG = w_1 z_{i1} + w_2 z_{i2} + w_3 z_{i3} + w_4 z_{i4}, \text{among them } z_i \text{ is the standardized data.} \quad \text{(A5)}$$

The calculated weights of the indicators of FWPEG are listed in Table 1.

Appendix B

From the estimated results in Table A1, internet skills are significant for the four basic indicators of FWPEG. Among them, the estimated coefficients of internet skills for Awareness-1, Awareness-2, and Knowledge are negative, and the estimated coefficients for Willingness are positive. This is mutually verified with the attributes set in Table 1. It is reasonable and correct to construct the FWPEG indicator system in three dimensions.

Table A1. OLS estimation results of 4 basic indicators.

Variables	Awareness-1			Awareness-2			Willingness			Knowledge		
internet skills	−0.186	(−2.97)	***	−0.393	(−6.52)	***	0.122	(2.51)	***	−0.268	(−4.33)	***
Province dummies		YES			YES			YES			YES	
Control variable		YES			YES			YES			YES	
_cons	2.61	(10.58)	***	2.544	(10.71)	***	3.879	(19.82)	***	3.240	(12.94)	***

Note: t-values are in parentheses; *** $p < 0.01$.

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