Determinants of Residential Solid Waste Management Services Provision: A Village-Level Analysis in Rural China

Dan Pan [1], Ruiyao Ying [2],* and Zuhui Huang [3]

[1] Institute of Poyang Lake Eco-Economics, Jiangxi University of Finance and Economics, Nanchang 330013, China; blesspanda@163.com

[2] College of Economics and Management, Nanjing Agricultural University, Nanjing 210095, China

[3] China Academy of Rural Development, Zhejiang University, No. 388 Yuhangtang Road, Hangzhou 310058, China; zhhuang@zju.edu.cn

* Correspondence: yry@njau.edu.cn; Tel.: +86-25-8439-6234

Abstract: Providing residential solid waste collection (RSWC) services is the first and most indispensable part of residential solid waste management and is crucial for rural environment protection. This paper seeks to analyze the determinants of RSWC services' provision at the village level, based on a latest survey data set of 150 villages in the Poyang Lake Eco-Economic Zone (PLEEZ) in Jiangxi Province. Using a Probit regression model and a Bivariate Probit regression model, our results indicated that: (1) The provision of RSWC services is not evenly distributed and richer villages have more RSWC services; (2) A showcasing phenomenon exists in the provision of RSWC services. Villages that are more populous, nearer to the township government, and located in the new countryside and old liberated areas saw an increase in the provision of RSWC facilities, services that will more easily showcase village leaders' political achievement, while the provision of RSWC workers and both RSWC facilities and workers, services that will less easily showcase village leaders' political achievement, do not increase in these villages; (3) Informal governance characteristics, such as the ratio of largest family clans, whether village leaders come from the village's largest family clans, and the number of people working in the upper-level government have strong predictive power over the provision of RSWC services, while formal governance characteristics, such as elections, do not matter in RSWC services' provision.

1. Introduction

Rural areas, which account for 90% of mainland China, are now faced with serious environmental problems caused by the increase in residential solid waste (RSW) [1]. Traditionally, most RSW in rural China was recycled onto agricultural land as organic fertilizer, and the environmental pollution from RSW was not serious [2]. However, with the steady development of rural living standards and a rapid rise in rural population, the quantity of RSW has increased dramatically [3]. It is estimated that the annual growth rate of RSW is about 8%–10% in rural China. In 2015, the officially estimated data showed that the total quantity of RSW in rural China is 150 million tons, which is 2.25 times the removal quantity of municipal solid waste; about half of RSW was discharged directly into environment [4].

Providing sufficient RSW management services to decrease the pollution from RSW is an important task for Chinese Government. In rural China, since the "Rural Tax Reform" in 2006, when village levies and direct fees were formally abolished, it is often the responsibility of villagers'

committees to determine and finance RSW management services. The provision of RSW management services is uneven across villages in rural China. The results of Wang et al. [5] show that in Jiangsu province, a relatively rich province in China, almost 90% of villages have RSW management services, while in Hebei province, a relatively poor province in China, only 20% of villages have RSW management services. What caused this great difference among villages in the provision of RSW management services?

Few studies have examined the determinants of RSW management services provision from the village-level perspective in rural China. Two exceptions are Ye et al. [6] and Wang et al. [5]. However, deficiencies remain in the extant studies. First, as the data used in Ye et al. [6] is from 2005 and the data used in Wang et al. [5] is from 2011. They are out of date and, thus, cannot reveal the latest progress of RSW management services in rural China. Second, the conventional factors supposed to determine the provision of RSW management services include village characteristics, such as village income, geographic location, village size, and village density; village leaders' characteristics, such as age, gender and education; and formal governance characteristics, such as elections. These factors have also been found to be important determinants of the provision of other public goods, such as roads, schooling, and electricity [7–9]. In addition, informal governance characteristics, such as clans and social capital, have been empirically confirmed to have great effect on public goods provision in general [10,11]. However, despite the evidence, to the best of our knowledge, no studies have yet investigated the effect of informal governance characteristics on the determinants of RSW management services provision in rural China.

The contributions of this work to current literatures are at least two ways. First, in addition to the conventional determinants of RSW management services provision, informal governance characteristics will also be considered. The need to consider informal governance characteristics in the provision of RSW management services is especially important for rural China, because the informal connections have thrived there over many years [12]. The second contribution is that our analysis is based on a latest data from 2015 in rural China. It is our belief that, with the great improvement of economic and social transformation, RSW management services in rural China have changed a lot. By using the latest data, we can reflect the real situation of RSW management services in rural China.

The main goal of this work is to analyze the determinants of RSW management services provision by using the latest data from 2015 in rural China. In general, according to the lifecycle of RSW, the process of proper RSW management services consists of three steps: RSW collection (RSWC), RSW transportation, and RSW disposal [13]. In this paper, we focus on the RSWC step. Our logic is that RSW must be properly collected before it can be transported and treated. In addition, as suggested by He [14] and Tai et al. [15], due to low densities of rural areas, the cost of RSWC accounts for up to 40% of the total cost of RSW management, which is almost twice of the RSWC cost of urban solid waste. Therefore, providing enough RSWC services will become increasingly important for the Chinese Government.

The rest of the paper is organized as follows: Section 2 introduces the background of RSW management in rural China. Section 3 specifies the empirical model. Section 4 describes the case study area and presents data descriptive statistics. Section 5 presents the baseline results of Probit regression and the Bivariate Probit regression results considering endogeneity. The final section concludes the paper.

2. RSW Management in Rural China

The Chinese Government has issued a succession of regulations to tackle the environmental problem caused by RSW. In 2010, ten departments in China, including the Ministry of Housing and Construction, the Ministry of Finance, and the Ministry of Environment Protection, enacted the "Guidance for Comprehensively Promoting Rural Garbage Management", which is the first guidance for RSW management. Government investment has also been increasingly allocated to RSW management. In 2008, the Chinese Government set up a "Rural Environmental Protection Special

Fund". It is estimated that, with the help of this fund, a total of 37.5 billion RMB (which is equal to 5.36 billion USD at a 7:1 exchange rate) was allocated to protect the rural environment, benefiting more than 80,000 villages in rural China [4]. However, although remarkable progress has been made in rural environmental protection, the provision of RSW management services is still poor and is far less than the people's need. As a result, illegal RSW discharge is pervasive in rural China. The phenomenon of "Garbage Besieging Villages" is often reported. Inadequate provision of RSW management services not only pollutes the ecological environment of rural areas, such as water, soil, and air [16], but also does great harm to the health of rural people [17]. It is estimated that inappropriate disposal of RSW has caused severe pollution of 24% of drinking water and 18% of lake water in China [2].

There are typically two different types of institutional arrangements in RSW management. Under the most popular arrangement, it is the responsibility of local government to provide RSW facilities and hire RSW workers. The upper-level government is the regulator of the quality of RSW services. The other is private provision arrangement which is less pronounced but still relevant. Under this arrangement, the local government usually assigns the RSW management work to private firms. Accordingly, the local government is the regulator of quality of RSW services. The privatization of RSW management has both advantages and disadvantages (see Simoes et al. [18] for a detailed discussion). The performance of public provision arrangement and private provision arrangement vary across different regions in rural China, depending on the political ideology, village characteristics, farmers' cooperation, among others [18,19].

The fundamental mode of RSW management in rural China is "household classification, village collection, township transfer and county treatment". In the RSWC stage, RSWC facilities, such as refuse chutes and outdoors trash cans, have been implemented widely. RSWC workers, who are responsible for transporting all the RSW in the village, have also been introduced in some developed rural areas. In the RSW transfer or transportation stage, the RSW is transported to county or above the county level for downstream treatment and disposal. In the RSW treatment stage, sanitary landfill, incineration and composting are the main treatment technologies, while sanitary landfill is the dominant treatment technology [20].

3. Methods

3.1. Probit Model

The dependent variable in our analysis is whether villages have provided RSWC services in 2015, which is a binary outcome variable. Thus, we employed a "binary choice model", specifically, a Probit model, to analyze the determinants of RSWC services. The model can be specified as follows:

$$RSWC = 1[\delta X + \mu > 0] \tag{1}$$

$$RSWC^* = \delta X + \mu \tag{2}$$

$$RSWC = \begin{cases} 1 & \text{if } RSWC^* > 0 \\ 0 & \text{if } RSWC^* < 0 \end{cases} \tag{3}$$

where RSWC is a binary variable, which is equal to 1 if the village provides RSWC services, and 0 otherwise; δ is the parameter vector; μ is the error term; and X is the vector of the determinants of RSWC services' provision.

Based on the theoretical analysis and literature review, the determinants of RSWC services' provision consist of two types of factors, including village characteristics and governance characteristics. The definition of these variables and the expected signs of the coefficients associated with these variables are presented in Table 1. *Income* is expected to have a positive impact because villages with higher income would have more financial resources that can be invested to provide RSWC services. *Population and Group* have positive expected signs because more populous villages will generate more RSW and have higher demand to treat RSW. *Density* is expected to have a negative impact because the

costs of providing RSWC services are higher in villages with higher density. *Distance* has a negative expected sign because villages nearer to the township government are often more richer and have more resources to provide RSWC services. *Ncountryside* is expected to have a positive impact because new-countryside villages can get more financial support from the upper-level government to invest in RSWC services. The expected effects of *Liberated* and *Mountain* are "unknown". The reason is that, on one hand, villages located in old liberated and mountain areas are often poorer and have fewer resources to provide RSWC services, on the other hand, in recent years, the Chinese government has been increasingly investing in the public projects in old liberated and mountain areas. *Elected* is expected to have a positive impact because elected village leaders are more likely to provide RSWC services in order to satisfy voters' demands. Informal governance characteristics, including *Rclans, Lclans and Hleaders,* are expected to have positive impacts because informal governance has thrived over many years in rural China and have great effect on public goods provision [11].

Table 1. Definition of the explanatory variables and their expected sign on dependent variable.

Variables	Definition	Expected Sign
Village characteristics		
Income	Per capita income in 2015 (thousand RMB)	+
Population	Total population in 2015 (thousand people)	+
Group	Number of small groups in a village	+
Density	The farthest distance between two households in the same small group of villages (km)	−
Distance	The distance from village committee to the township government (km)	−
Ncountryside	Dummy of new countryside area(yes = 1; no = 0)	+
Liberated	Dummy of old liberated area(yes = 1; no = 0)	unknown
Mountain	Dummy of mountain area(yes = 1; no = 0)	unknown
Governance characteristics		
Formal governance		
Elected	Dummy of elected leader (yes = 1; no = 0)	+
Informal governance		
Rclans	Ratio of the village's largest family clans (%)	+
Lclans	Whether the village leader comes from the village's largest family clans (yes = 1; no = 0)	+
Hleaders	Number of people working in the upper-level government (person)	+

Note: "+" means the variable has positive effect on RSWC services' provision; "−"means the variable has negative effect on RSWC services' provision;"unknown" means the expected effect of the variable on RSWC services' provision is not sure.

3.2. Bivariate Probit Model

If all the explanatory factors included in the X vector are exogenous, then the Probit regression results will be consistent. However, we may have a potential endogeneity problem because some explanatory factors included in the X vector could be endogenous. One of the explanatory factors found in the previous literature is whether the village leader is elected or not—the *Elected* variable [7]. First, there may be a reverse effect between the *Elected* variable and RSWC services' provision. For example, village leaders who provided more RSWC services during their terms of office will generate higher support from villagers and are more likely to be reelected in the next round of election. Meanwhile, villagers expect elected village leaders to provide more RSWC services and, therefore, villagers elect candidates for village leadership on the basis of the candidates' commitment to providing

more RSWC services. Second, both *Elected* and RSWC services' provision may be affected by some omitted variables. There will be a bias in the coefficient of the *Elected* variable if it is endogenous.

Two-stage least squares (2SLS) method is often used to tackle the endogenous problem. However, in our analysis, both the outcome variable (RSWC services provision) and the exogenous variable (*Elected*) are binary, 2SLS is no less appropriate [21]. Sajaia [22] pointed out that a Bivariate Probit model is appropriate to control endogeneity when dependent variable and exogenous variable are binary. By computing full-information maximum likelihood estimates, the Bivariate Probit model can produce unbiased and more efficient estimates compared to 2SLS estimators [22]. The Bivariate Probit model has been widely used in recent years [23,24]. Therefore, we employed a Bivariate Probit model to control endogeneity. The Bivariate Probit model can be written as:

$$\text{RSWC} = 1[\delta X + \alpha \text{Elected} + \mu > 0] \tag{4}$$

$$\text{Elected} = 1[\beta Z + \varepsilon > 0] \tag{5}$$

where Z is the vector of the determinants of *Elected*, β is the parameter vector, and ε is the error term. Z includes all the factors in the X vector of Equation (4). In addition, we also include an additional instrumental variable in Equation (5) to predict *Elected*.

4. Case Study and Data

4.1. Study Area

This paper took the Poyang Lake Eco-Economic Zone (PLEEZ) in Jiangxi Province as the study area. PLEEZ contains 38 counties, and more than 20 million people reside in this area (Figure 1). PLEEZ was officially approved by State Council of China as a national strategy in 2009 to become a comprehensive development model for China's other lake areas and large rivers. In recent years, pollution from RSW has imposed serious environmental degradation on PLEEZ. This includes eutrophication, deterioration of surface water and groundwater quality, and biodiversity losses. Reducing the pollution from RSW has become an extremely important issue in PLEEZ. To the best of our knowledge, no studies have analyzed the RSW management problem in PLEEZ.
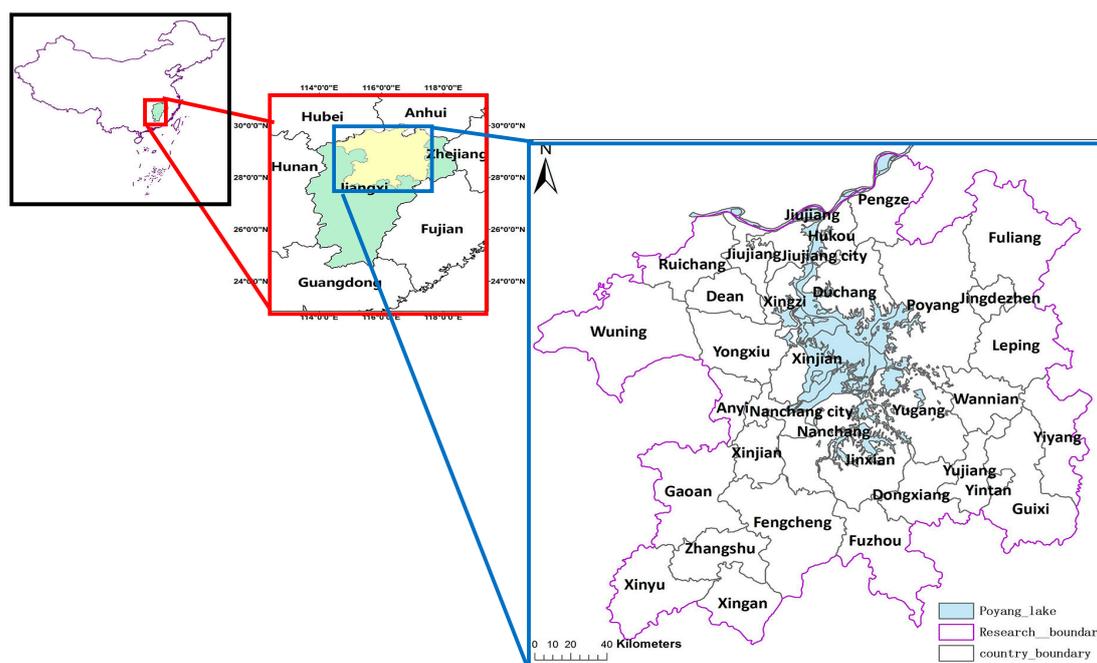

Figure 1. The Location of the Poyang Lake Eco-Economic Zone.

4.2. Data Source

Data were collected by the authors in March 2016, through face-to-face interviews with village leaders. As there are vast differences in economic development and RSWC services' provision among different areas of PLEEZ, we used a stratified random sampling method, based on the per capita gross value of industrial output (GVIO), to identify our sample villages. The GVIO is used as a basis because Rozelle [25] indicated that GVIO can predict peoples' living standards and economic development more accurately than can per capita income. The stratified random sampling procedures are as follows. First, we ordered and divided all the 38 counties in PLEEZ into 10 groups based on the condition of the GVIO, and one sample county was randomly selected from each group; Second, as per the county selection procedure mentioned above, five townships were randomly selected, according to the GVIO in each county from the counties identified in the first step. Third, we randomly chose three villages in each township, according to the GVIO. Thus, a total of 150 villages were included in our dataset.

A structured questionnaire was used to obtain the primary data. The questionnaire basically has two parts. The first part collected information about RSW management in each sampled village, including RSWC facilities and RSWC workers. The second part relates to the information regarding village characteristics and governance characteristics.

4.3. Descriptive Statistics

Variable descriptive statistics of the total sample villages are presented in Table 2. The per capita income of the surveyed villages in 2015 is 4.29 thousand RMB (which is equal to 614 USD at a 7:1 exchange rate). There are, on average, 5.48 small groups in a village. The farthest distance between two households in the same small group of village is 2.13 km, and the average distance from village committee to the township government is 4.86 km. Most surveyed villages are located in the old liberated areas and mountain areas. Almost all the village leaders are elected. The ratio of the village's largest family clans averages 54.76% and most of the village leaders come from the village's largest family clans. The number of people working in upper-level government is 6.64, on average.

Table 2. Variable descriptive statistics of the total sample villages.

Variables	Mean	Standard Deviation	Minimum	Maximum
Village characteristics				
Income	4.29	2.38	1.21	10.36
Population	2.69	1.76	0.78	6.35
Group	5.48	3.96	1.0	26.0
Density	2.13	1.59	0.15	4.76
Distance	4.87	3.21	0.32	7.85
Ncountryside	0.22	0.12	0.0	1.0
Liberated	0.56	0.28	0.0	1.0
Mountain	0.72	0.24	0.0	1.0
Governance characteristics				
Formal governance				
Elected	0.92	0.14	0.0	1.0
Informal governance				
Rclans	54.76	24.57	12.43	76.54
Lclans	0.58	0.39	0.0	1.0
Hleaders	6.64	13.56	0.0	21.0

Figure 2 shows the proportion of villages and the proportion of people in sampled villages with RSWC services. In our sample, 73.33% villages provided RSWC facilities. The proportion of villages with RSWC workers is lower than is the proportion of villages with RSWC facilities, which is 57.33%.

Only 46% villages in our sample provided both RSWC facilities and RSWC workers. In terms of the proportion of people with RSWC services, 65.35% people in our sampled villages have RSWC facilities, which is lower than the proportion of villages with RSWC facilities. This is because, under the budget constraint, a RSWC facility is jointly used by several farmers in rural China (our survey data showed that the maximum number of farmers jointly used a RSWC facility is 12, while the minimum number of farmers jointly used a RSWC facility is 1). By the same token, the proportion of people with both RSWC facilities and RSWC workers is much lower than the proportion of villages with both RSWC facilities and RSWC workers, which is only 38.94%. The proportion of people with RSWC workers is the same as the proportion of villages with RSWC workers. This is because RSWC workers serviced all farmers in the village.
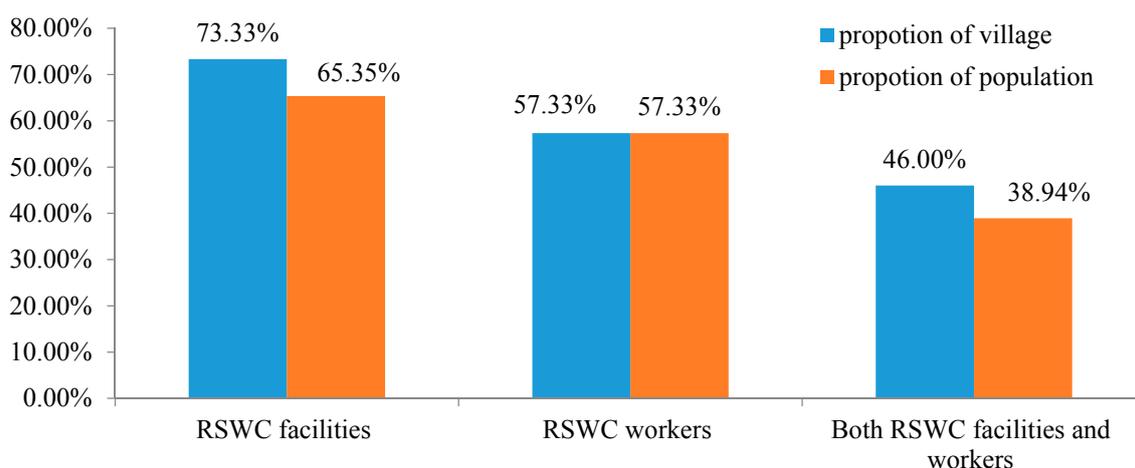
Figure 2. Proportion of villages with residential solid waste collection (RSWC) services.

Compared with the proportion of villages with RSWC services in previous literature, we can see that, even though our sample area is a low-income area of China, the proportion of villages with RSWC services in our sample is the highest (Table 3). This is mainly because the Chinese government has put RSW management as a policy priority since 2005; thus, increasing investment has been allocated to provide RSWC services. This indicates that the RSWC management services have seen a remarkable growth in recent years. The latest data in our paper allow us to reflect the real situation of RSW management services in rural China.

Table 3. Proportion of villages with RSWC services in previous literature.

Literature	Villages with RSWC Facilities	Villages with RSWC Workers	Survey Year	Sample Area
Ye et al. [6]	10%		2005	Jiangsu, Sichuan, Shaanxi, Hebei, and Jilin
Huang et al. [26]	52%		2009	Beijing, Jilin, Hebei, Anhui, Sichuan, and Yunnan
Wang et al. [5]	50%	45.5%	2011	Jiangsu, Sichuan, Shaanxi, Hebei, and Jilin

Table 4 compares the characteristics of villages with and without RSWC services. The results show that villages providing RSWC services have higher per capita income, greater total population, and a higher number of small groups. In addition, villages with a higher population density and that are nearer to the township government seem more likely to provide RSWC services. Villages located in the new countryside and old liberated areas provide more RSWC services. RSWC services are more likely

to be provided in villages that have a higher ratio of the village's largest family clans and where more village leaders come from the village's largest family clans. We also find that villages with a higher number of people working in the upper-level government are more likely to provide RSWC services.

Table 4. Comparison of villages with and without RSWC services.

Variables	RSWC Facilities		RSWC Workers		Both RSWC Facilities and Workers	
	Yes	**No**	**Yes**	**No**	**Yes**	**No**
Village characteristics						
Income	4.53	3.65	4.82	3.61	5.48	3.29
Population	2.88	2.19	3.04	2.23	3.09	2.36
Group	6.29	3.26	7.24	3.13	8.44	2.98
Density	2.04	2.37	2.00	2.31	1.82	2.39
Distance	4.75	5.21	3.96	6.09	2.42	6.94
Ncountryside	0.24	0.16	0.28	0.14	0.34	0.12
Liberated	0.59	0.48	0.62	0.48	0.73	0.42
Mountain	0.72	0.71	0.73	0.71	0.76	0.69
Governance characteristics						
Formal governance						
Elected	0.92	0.91	0.94	0.89	0.94	0.90
Informal governance						
Rclans	56.04	51.26	60.10	47.63	66.50	44.85
Lclans	0.61	0.51	0.65	0.48	0.76	0.43
Hleaders	6.99	5.68	7.08	6.05	8.42	5.14

5. Results

The descriptive statistics mentioned above do not take other factors into account. To further examine the determinants of RSWC services provision, we use two empirical regressions in this section. The first is the baseline Probit regression results. In this model, we assume that all the explanatory factors included in the X vector in Equation (1) are exogenous. The second is the Bivariate Probit regression results. In this model, we relax the exogenous assumption and assume that some explanatory factors included in the X vector in Equation (1) could be endogenous.

5.1. Probit Regression Results

The Probit regression results of the factors that influence RSWC services provision are shown in Table 5. The regression equations appear to perform well. The Prob > chi^2 values suggest that the models are statistically significant. The pseudo-R^2 values indicate that 27.82%, 28.76%, and 25.34% variation are included in the models for RSWC facilities, RSWC workers, and both RSWC facilities and workers, respectively. Although there are several exceptions, our results of the Probit analysis of the determinants of RSWC services provision are consistent with our general findings from the descriptive statistics in Table 4.

The coefficient of *Income* is positive and significant in all three models, indicating that in villages with higher per capita income, there is relatively more RSWC facilities' provision, RSWC workers' provision, and both RSWC facilities' and workers' provision. As we stated in the introduction section, funding for RSWC services' provision in China mainly comes from the village itself. Villages with higher per capita income have more financial resources to provide RSWC services. The importance of economic development in the provision of public goods has been verified in other studies; for example, Zhang et al. [27] and Luo et al. [28] also found that villages with higher income have more public projects investment.

The coefficients of *Population*, *Group* are positive and significant and the coefficient of *Density* is negative and significant in the model of RSWC facilities, which means that more populous villages tend to have more RSWC facilities. A larger village population will generate more RSW, which, in turn, induces government to provide more RSWC facilities. On the other hand, RSWC costs are higher in sparsely populated villages than in more populous villages. Thus, under the budget constraint, more RSWC facilities will be provided by village leaders in more populous villages. However, the coefficients of *Population*, *Group*, and *Density* are not significant in the models of RSWC workers and both RSWC facilities and workers, indicating that the provision of RSWC workers and both RSWC facilities and workers is not influenced by the size and density of villages. One explanation is plausible. Under the consideration of welfare, villages often hire people who are of low-income and unfit to be RSWC workers. In addition, on average, there is only one RSWC worker in each small group. Therefore, the relationship between the provision of RSWC workers and village size is not strong.

Table 5. Probit regression results of the determinants of RSWC services provision.

Variables	RSWC Facilities		RSWC Workers		Both RSWC Facilities and Workers	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Village characteristics						
Income	0.089 ***	0.032	0.035 ***	0.012	0.066 ***	0.024
Population	0.143 ***	0.051	0.076	0.087	0.102	0.095
Group	0.384 **	0.158	0.292	0.187	0.207	0.169
Density	−0.198 ***	0.047	−0.083	0.072	−0.174	0.126
Distance	−0.329 ***	0.126	−0.214	0.198	−0.263	0.187
Ncountryside	0.876 ***	0.293	0.632	0.564	0.603	0.495
Liberated	0.762 **	0.301	0.485	0.326	0.389	0.253
Mountain	−0.104	0.208	−0.186 ***	0.093	−0.087	0.066
Governance characteristics						
Formal governance						
Elected	1.654	1.149	1.043	0.965	1.396	0.985
Informal governance						
Rclans	0.063 **	0.026	0.075 **	0.031	0.054 **	0.025
Lclans	0.087 ***	0.023	0.079 **	0.033	0.063 ***	0.021
Hleaders	0.321 ***	0.108	0.295 ***	0.102	0.204 ***	0.076
Constant	−7.486	4.984	−9.841	6.532	−6.293	3.652
Pseudo-R^2	0.2782		0.2876		0.2534	
Prob > chi^2	0.000		0.000		0.000	

Note: *** and ** denotes significance level at 1% and 5%.

The coefficient of *Distance* is negative and significant and the coefficients of *Ncountryside*, *Liberated* are positive and significant in the model of RSWC facilities, which means that villages nearer to the township government and located in the new countryside and old liberated areas are likely to provide more RSWC facilities. Two possible explanations are as follows. First, as villages that are near township government and located in the new countryside area are often richer, government has enough funding to provide RSWC facilities. Second, village leaders can showcase their political achievements more easily by investing in villages that are near township government and are located in the new countryside areas. As we found in our survey data, two economically similar villages, one located in the new countryside areas, the other does not located in the new countryside areas. There are nearly five times as many RSWC facilities in the village located in the new countryside areas as are found in the village that does not. By the same token, by investing in villages located in the old liberated areas, village leaders can also showcase their political achievements more easily. However, the coefficients of *Distance*, *Ncountryside*, and *Liberated* are not significant in the models of RSWC workers and both RSWC facilities and workers, indicating that the provision of RSWC workers

and both RSWC facilities and workers are not influenced by *Distance*, *Ncountryside*, and *Liberated*. The reason for this is that, compared with RSWC workers and both RSWC facilities and workers, the benefits of providing RSWC facilities are more obvious. Thus, village leaders prefer RSWC facilities to showcase their political achievements.

Villages located in the mountain areas (*Mountain*) are shown to have a negative and significant correlation with the provision of RSWC workers. Mountainous areas are often in poor natural and geographical conditions, which will result in high transportation costs and greater difficulties for workers to collect RSW. This is in line with the findings of He et al. [29], who found that the relationship between natural terrain and public goods provision efficiency is negative.

The coefficient of the formal governance variable, *Elected*, is not significant in all three models, which means that village leaders who are directly elected do not provide more RSWC services than do those who are not directly elected. This is not consistent with previous studies on the role of formal governance in the provision of public goods. For example, the findings from Luo et al. [7] and Martinez-Bravo et al. [30] suggest that elections have strong predictive power over the provision of public goods. Two explanations are plausible. First, as formal governance improves, such as electoral rules and procedures, most of the villages in rural China are being directly elected by villagers, rather than being appointed by the upper-level government, and the homogeneity of elections reduces the impact of election on RSWC services' provision. Second, unlike the other public goods investments, such as in school construction, road and bridge construction, drinking water services construction, electricity construction, and irrigation construction, the provision of RSWC services cannot generate political achievement in the short term. Thus, village leaders lack adequate incentives to provide RSWC investment.

The coefficients of informal governance variables, *Rclans*, *Lclans*, *and Hleaders*, are positive and significant in all three models, indicating that villages with a higher ratio of largest family clans, where more village leaders come from the village's largest family clans, and where more people are working in the upper-level government, are more likely to provide RSWC services. With the help of the informal governance of large clans, the village leaders can get more levies from the villagers for public goods expenditure and are more able to mobilize resources needed for providing public goods. This is in line with previous studies regarding the role of informal governance on public goods provision. For instance, Tsai et al. [10] show that villages with informal groups, such as temple associations and village-wide lineage groups, are more likely to invest in public goods. Yao et al. [11] indicates that a large increase in public goods expenditure is highly associated with the presence of a village leader that comes from the two largest family clans. Villages with more people working in upper-level government seem to have a strong predictive power over the provision of RSWC services. This finding is consistent with the findings from Zhang et al. [31], who found that villages with more people working in upper-level government will favor their home village when allocating resources and will facilitate their own home villages' application for public goods investment. This finding is not surprising in rural China where informal connections (*guanxi*) have thrived over many years [12].

A comparison of the role of formal governance and informal governance on RSWC services' provision indicates that formal governance does not matter in RSWC services' provision. In contrast, informal governance becomes the primary factor influencing RSWC services' provision. The reasons may be that village election in rural China has become highly normative and universal, and the situation of formal governance is homogeneous in villages, with the result that the impact of formal governance on public goods provision has decreased. Conversely, the traditional informal governance matters more than formal governance.

5.2. Accounting for the Endogeneity:Bivariate Probit Regression Results

In this section, we employ a Bivariate Probit model to take account of the potential endogeneity of the variable *Elected*, because concerns of reverse causality and unobserved confounders remain.

Based on the findings of Luo et al. [7], we used the number of conferences convened by the upper government for election (*Conferences*) as an additional instrumental variable in Equation (5). The logic is that the more conferences are convened by the upper government for election, the more likely it becomes that county election protocol will happen in the process of election. Our data show that, on average, four conferences were convened for election. The correlation coefficient between *Conferences and Elected* was significant.

According to the suggestion by Wooldridge et al. [32], the instrumental variable should be related to the endogenous variable (*Elected*) but should not be related to the outcome variable (RSWC services provision). In theory, *Conferences* is considered to be a proper instrumental variable, since it is positively correlated with *Elected* but not with RSWC services' provision. Meanwhile, we also test the validity of *Conferences* through statistical analysis. Specifically, we test whether *Conferences* is correlated with other control variables. We divide our sample villages into two groups: those villages that have more than four conferences and those villages that have less than four conferences. The results from Table 6 indicate that the value of control variables is almost the same between the two groups. Therefore, the instrumental variable used in our paper is sound, both by logic and by statistical analysis.

Table 6. The relationship between instrumental variable and other control variables.

Variables	More Than 4 Conferences Convened by the Upper Government for Election	Less Than 4 Conferences Convened by the Upper Government for Election
Village characteristics		
Income	4.32	4.24
Population	2.71	2.65
Group	5.43	5.57
Density	2.07	2.24
Distance	4.79	5.01
Ncountryside	0.19	0.27
Liberated	0.58	0.52
Mountain	0.75	0.67
Governance characteristics		
Formal governance		
Elected	0.94	0.88
Informal governance		
Rclans	53.98	56.15
Lclans	0.59	0.56
Hleaders	6.53	6.84

Table 7 reports the Bivariate Probit regression results of the determinants of RSWC services' provision. Accordingly, a comparison of the coefficients associated with the variables in the Bivariate Probit and Probit regression model is presented in Table 8. We can find that most of the estimated coefficients are the same as Probit estimates. This finding convinces us that our results remain robust when considering endogeneity problems.

Table 7. Bivariate Probit regression results of the determinants of RSWC services provision.

Variables	RSWC Facilities		RSWC Workers		Both RSWC Facilities and Workers	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Village characteristics						
Income	0.075 ***	0.026	0.041 **	0.018	0.059 **	0.026
Population	0.137 **	0.055	0.082	0.083	0.114	0.099
Group	0.217 *	0.113	0.185	0.135	0.223	0.184
Density	−0.163 **	0.076	−0.067	0.046	−0.097	0.102
Distance	−0.315 **	0.132	−0.232	0.187	−0.189	0.125
Ncountryside	0.823 ***	0.254	0.543	0.431	0.597	0.421
Liberated	0.721 **	0.285	0.424	0.265	0.279	0.188
Mountain	−0.123	0.187	−0.193 **	0.087	−0.082	0.058
Governance characteristics						
Formal governance						
Elected	1.236	0.985	1.321	0.927	1.218	0.976
Informal governance						
Rclans	0.072 **	0.036	0.079 **	0.035	0.061 **	0.028
Lclans	0.091 ***	0.027	0.082 **	0.037	0.058 **	0.029
Hleaders	0.304 **	0.127	0.226 **	0.098	0.235 **	0.114
Constant	−9.385	5.231	−7.317	4.265	−11.327	7.276
Pseudo-R^2	0.2904		0.2945		0.2789	
Prob > chi^2	0.000		0.000		0.000	

Note: ***, **, and * denotes significance level at 1%, 5%, and 10%.

Table 8. Comparison of Bivariate Probit regression results and Probit regression results.

Variables	RSWC Facilities		RSWC Workers		Both RSWC Facilities and Workers	
	Bivariate Probit	Probit	Bivariate Probit	Probit	Bivariate Probit	Probit
Village characteristics						
Income	0.075 ***	0.089 ***	0.041 **	0.035 ***	0.059 **	0.066 ***
Population	0.137 **	0.143 ***	0.082	0.076	0.114	0.102
Group	0.217 *	0.384 **	0.185	0.292	0.223	0.207
Density	−0.163 **	−0.198 ***	−0.067	−0.083	−0.097	−0.174
Distance	−0.315 **	−0.329 ***	−0.232	−0.214	−0.189	−0.263
Ncountryside	0.823 ***	0.876 ***	0.543	0.632	0.597	0.603
Liberated	0.721 **	0.762 **	0.424	0.485	0.279	0.389
Mountain	−0.123	−0.104	−0.193 **	−0.186 ***	−0.082	−0.087
Governance characteristics						
Formal governance						
Elected	1.236	1.654	1.321	1.043	1.218	1.396
Informal governance						
Rclans	0.072 **	0.063 **	0.079 **	0.075 **	0.061 **	0.054 **
Lclans	0.091 ***	0.087 ***	0.082 **	0.079 **	0.058 **	0.063 ***
Hleaders	0.304 **	0.321 ***	0.226 **	0.295 ***	0.235 **	0.204 ***
Pseudo-R^2	0.2904	0.2782	0.2945	0.2876	0.2789	0.2534
Prob > chi^2	0.000	0.000	0.000	0.000	0.000	0.000

Note: ***, **, and * denotes significance level at 1%, 5%, and 10%.

6. Conclusions and Discussion

China has been facing an increasing challenge to properly manage a massive amount of RSW. Providing RSWC services is the first and most indispensable part of RSW management and is crucial for rural environment protection. Although there has been much effort by the Chinese Government to provide RSWC services in recent years, there is still huge insufficiency and remarkable variation

among regions in the level of RSWC services' provision, which poses a great threat to rural areas' long-term development. Based on the latest survey data set collected in PLEEZ in Jiangxi Province, this paper seeks to understand the determinants of RSWC services provision at the village-level. Our analysis, which uses a Probit regression model as the baseline estimation strategy and a Bivariate Probit regression model considering endogeneity as a robustness check, yields three important findings.

First, we find that villages that are richer are more likely to provide all the RSWC services, including RSWC facilities, RSWC workers, and both RSWC facilities and workers. This suggests that provision of RSWC services is not evenly distributed across different regions; Second, villages that are more populous, nearer to the township government, and located in the new countryside and old liberated areas have seen an increase in the provision of RSWC facilities, but not the provision of RSWC workers and both RSWC facilities and workers. This suggests that showcasing exists in the provision of RSWC services; Third, informal governance characteristics, such as the ratio of largest family clans, whether village leaders come from the village's largest family clans, and the number of people working in upper-level government, have strong predictive power over the provision of RSWC services, while formal governance characteristics, such as elections, do not affect RSWC services' provision. This suggests that, due to the steady improvements of the normative and universal of formal governance in China, traditional informal governance matters more than formal governance in the provision of public goods.

This study might provide some policy implications for the related policy-makers. First, the upper-level government should provide more fiscal support to the local villagers' committees to improve their financial capacities. Moreover, relatively underdeveloped rural areas, such as poorer and mountain areas, should get more support from the upper-level government in the future; Second, RSWC facilities should be constructed to optimize the route and decrease RSW management costs. To achieve this, related facilities need to be well designed and managed; Third, the showcasing phenomenon in the provision of RSWC services should be taken into account by officials in their works. This necessitates changes in the evaluation of local government performance in RSWC services provision. For example, not only the provision of RSWC facilities, but also the provision of RSWC workers should be evaluated. In addition, farmers' satisfaction of RSW management should also be considered. Fourth, the government should take into account the informal governance in different regions of rural China and let informal governance play a due role in promoting public goods' provision.

Finally, a note on the limitations of this study is in order. Nowadays, the funding of RSWC services' provision mainly comes from two channels: one is government finance, the other is monthly or yearly bills paid by rural people who enjoy RSWC services. Therefore, rural peoples' willingness to pay for RSWC services provision is a prerequisite for sustainable provision of RSWC services. However, this study only analyzes the determinants of RSWC services' provision at the village level. Thus, follow-up studies are needed to understand rural people's willingness to pay for RSWC services' provision.

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