Spillover effects of rural residents' past pro-environmental production behavior on their voluntary waste separation behavior

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Based on the survey data of rural residents in the National Ecological Civilization Pilot Area (Jiangxi), this paper empirically analyzes the spillover effect and mechanism of past pro-environmental production behavior on rural residents' voluntary garbage sorting behavior, and adopts the fsQCA to clarify the grouping paths and examines the interactive relationship among multiple factors. The results of the empirical study show that: firstly, past pro-environmental production behaviors can directly promote rural residents' voluntary garbage sorting behaviors; secondly, environmental self-identification and subjective norms have a partially mediating effect; thirdly, publicity and village regulations play a positive moderating effect. Further, the results of fsQCA analysis reaffirm the influence mechanisms, and reveal the multiple concurrent pathways through which past pro-environmental production behaviors drive the active waste sorting behaviors of rural residents. It's found that there is a substitution relationship between rural residents' past pro-environmental production behavior and publicity and education. This study enriches the theoretical explanation of the spillover of residents' pro-environmental behaviors, and provides useful ideas for stimulating rural residents' enthusiasm in active participation of rural residents in household waste sorting.

KEYWORDS

rural residents, past pro-environmental production behavior, household waste sorting behavior, behavioral spillover effects, fsQCA

1 Introduction

As global temperatures continue to rise, extreme weather changes such as heat waves, heavy rains and droughts are becoming more frequent and intense, putting human life and health and socio-economic development around the world at risk. The Climate Change 2023 report, released by the United Nations Intergovernmental Panel on Climate Change (IPCC), unequivocally asserts that human activities have been the primary drivers of global warming. According to Magazzino et al. (2020), source separation and reduction of domestic waste play a crucial role in effectively curbing greenhouse gas emissions, forming a significant component of climate change mitigation efforts. Residents are not only the implementers but also the direct beneficiaries of these waste management practices. Encouraging residents to voluntarily engage in waste separation has emerged as a pivotal point for intervention. Many scholars have paid attention to the influencing factors of residents' household waste classification behavior, with some studies focusing on psychological factors such as environmental awareness,

attitudes, and subjective norms, while others have elaborated on the important influence of situational factors such as publicity and education, recycling facilities, and social networks (Meng et al., 2019; Ao et al., 2022; Wang and Tan, 2022; Chen et al., 2023). Human behavior is dynamic and coherent, and the impact of past experiences on resident behavior cannot be ignored. However, existing studies have overlooked the important influence that past behaviors may have on residents' voluntary pro-environmental behavioral decisions.

Recent studies suggest that there may be positive spillover effects between residents' pro-environmental behaviors. For example, Yue et al. (2021) found that residents' low-carbon purchasing behaviors help motivate them to implement low-carbon usage behaviors, recycling behaviors, and waste sorting behaviors, and Stangherlin et al. (2023) showed that there is a positive spillover between residents' recycling behaviors and recycled product purchasing behaviors. However, negative spillovers between residents' pro-environmental behaviors have also been found (Nayum and Thøgersen, 2022). The government can get twice the result with half the effort by activating the positive spillovers of certain environmental behaviors of residents, which is an important guidance for behavioral public policy making, and thus more and more scholars pay attention to the phenomenon of spillovers of pro-environmental behaviors of residents. Scholars have explored the definition of spillover effect of pro-environmental behavior, spillover mechanism and influencing factors. Regarding the definition of spillover effect, Truelove et al. (2014) argued that the spillover effect of pro-environmental behaviors refers to the role of one pro-environmental behavior of a resident in reinforcing (positive spillover) or inhibiting (negative spillover) the implementation of other pro-environmental behaviors in the subsequent period of the resident's life; as for the mechanism of the spillover effect, the theories of "goal activation" and "behavioral congruence" are commonly used. In terms of spillover mechanisms, "goal activation" and "behavioral congruence" theories are often used to describe how positive spillovers from pro-environmental behaviors occur (Bem, 1967; Fishbach et al., 2006), while the most frequently cited theories for negative spillovers between pro-environmental behaviors are "mono-effect bias" and "moral licensing" theories (Bem, 2006). "Moral licensing" theory (Fishbach and Dhar, 2005; Miller and Effron, 2010) and pro-environmental behavioral spillover patterns are also influenced by specific conditions, such as intervention strategies, social norms, and environmental motivations (Eby et al., 2019; Ling, 2020). Existing pro-environmental behavior spillover studies mainly focus on the spillover effects between different behaviors in the field of environmental protection (e.g., green consumption, garbage classification, etc.), but rarely focus on the spillover effects of pro-environmental behaviors in the field of production. Existing literature has extensively studied pro-environmental behaviors in the field of production, mainly focusing on farmers as the object of study, involving the adoption of green technologies in agriculture, pesticide and fertilizer reduction, and other fields, examining their cognition, behavior to effects and other dimensions, focusing on their influencing factors and mechanisms and other antecedent links (Gao et al., 2020; Guo et al., 2022; Hu and Liu, 2024). It is rare to pay attention to the after-effects of pro-environmental behaviors in the production field, and it is even rarer to examine the spillover effects of past pro-environmental production behaviors on residents' voluntary waste classification behaviors.

China has a large agricultural sector (Zhang and Li, 2022), and by the end of 2023, the size of China's rural resident population will be as high as 477 million, accounting for 33.8% of China's total population. The Chinese government attaches great importance to the green development of agriculture, and the No. 1 Document of the Central Committee issued by the Chinese government in 2024 explicitly mentions "solidly promoting the reduction of chemical fertilizers and pesticides to increase efficiency, and the resourceful treatment and utilization of organic waste from agricultural production." According to official data, rural residents in China have a practice rate of more than 90% in agricultural production behaviors such as soil testing and fertilizer application, straw return to the field, and agricultural film recycling. Rural residents are both practitioners and production decision makers in waste classification. Against this background, this paper explores the spillover effects of rural residents' past pro-environmental production behaviors on their voluntary household waste classification behaviors, taking China as an example, with a view to providing theoretical references and practical new ideas for advancing the green transformation of rural production and lifestyle.

Combining the above analysis of the actual situation and review of the literature, with the purpose to explore whether the past pro-environmental production behavior of rural residents have an impact on their current voluntary household waste sorting behavior, and how does the specific mechanism of the spillover effect of these pro-environmental behaviors occur, based on research data from China's National Ecological Civilization Pilot Area (Jiangxi Province), using the mediated model and fsQCA, this study examines the spillover effect of rural residents' past pro-environmental production behaviors on their proactive garbage sorting behaviors and the spillover mechanism. The marginal contributions of this study are threefold: (1) From the spillover perspective, different domains of rural residents' pro-environmental behaviors (pro-environmental production behaviors and garbage sorting behaviors) are included in the same research framework, which provides a new perspective for examining rural residents' proactive garbage sorting behaviors, and enriches the existing theoretical research on residents' pro-environmental behaviors. (2) We investigated the transmission mechanism of environmental self-identification and subjective norms in the spillover of rural residents' pro-environmental behaviors, as well as the moderating roles of publicity, education and village regulations, which helped clarify the spillover mechanism and boundary conditions of residents' pro-environmental behaviors in cross-sectoral areas. (3) Adopting the fsQCA method, the interaction between rural residents' past pro-environmental production behaviors and active waste sorting behaviors is further examined to deepen the understanding of the complex mechanism of spillover.

2 Theoretical framework

2.1 Rural residents' past pro-environmental production behavior and their voluntary domestic waste classification behavior

Drawing on the study of Yue et al. (2021), this paper defines rural residents' voluntary domestic waste classification behavior as rural residents actively and proactively classifying domestic waste at source

in their daily lives under the harmony between human and nature. Behavioral consistency theory suggests that individuals will infer their own attitudes or tendencies from their past behaviors, and in order to avoid the psychological discomforts such as anxiety and stress triggered by the inconsistency between attitudes and behaviors, they will maintain behavioral consistency in their subsequent decision-making (Bem, 1972). Most scholars' findings support the existence of a positive spillover effect between residents' pro-environmental behaviors, i.e., one behavior increases the likelihood of the occurrence of another behavior (Maki et al., 2019). For example, Thomas et al. (2016) found that residents' willingness to participate in six other environmental behaviors increased significantly after they supported the policy of charging for single-use plastic bags. Stangherlin et al. (2023) pointed out that there is a positive spillover between individuals' recycling behaviors and purchasing of recycled products, and that the positive spillover of recycling behaviors on purchasing of recycled products is stronger than the positive spillover of purchasing recycled products on recycling behaviors. Spillover. As a result, this paper proposes hypothesis H1.

> *H1:* Rural residents' past pro-environmental production behavior has a positive spillover effect on their active waste separation behavior.

2.2 The mediating role of environmental self-identity and subjective norms

Environmental self-identity describes the extent to which an individual identifies with the social identity of an environmentalist (Liu and Ng, 2023). Self-perception theory proposes that people rely on their past behaviors to infer their attitudes, which motivates them to adopt behaviors that are consistent with their self-perceptions (Bem, 1972). Identity Motivation Theory further suggests that individuals' significant past experiences motivate them to identify with the social identity they play, and that this identity, once established, motivates them to practice the corresponding behaviors in order to maintain their environmental image (Festinger, 1962). Van der Werff et al. (2014) suggest that people recall past pro-environmental behaviors and develop an internal attribution of past Liu and Ng (2023) reconfirmed that recalling past pro-environmental behaviors helps to enhance residents' environmental self-identity. In addition, a large number of studies have shown that a strong environmental self-identity motivates people to practice environmentally friendly behaviors. Floress et al. (2022) noted that stronger environmental self-identity corresponds to higher beliefs about environmental protection, which increases the likelihood that individuals will engage in sustainable consumption behaviors. Individuals who view themselves as caring for the environment and willing to participate in recycling are more likely to engage in waste collection behaviors (Nigbur et al., 2010). These studies suggest that environmental self-identity has a mediating role in the positive spillover of pro-environmental behaviors. As a result, this paper proposes hypothesis H2.

> *H2:* Environmental self-identity mediates the effect of rural residents' past pro-environmental production behavior on their proactive waste sorting behavior.

Subjective norms are derived from the theory of planned behavior, which articulates the social pressures associated with particular behaviors (Ajzen, 1991), and reflects the individual's pursuit of ethical norms and community values. Goal self-regulation theory suggests that people can infer their intrinsic goal preferences by observing initial behavior (Susewind and Hoelzl, 2014; Geng et al., 2016). Individuals reviewing past good performance of environmental behaviors with a goal commitment perspective tend to view following ethical norms as their stable intrinsic preference, and they perceive that they should actively participate in environmental protection, forming strong subjective norms for environmental protection (Ye et al., 2022). Regarding the relationship between subjective norms and individual environmental behavior, rich theoretical and empirical experiences support that subjective norms are a key factor in motivating individual environmental behavior. TPB theory proposes that subjective norms are a direct determinant of actual behavior (Ajzen, 1991). Many scholars have demonstrated the positive influence of subjective norms in motivating residents to implement pro-environmental behaviors such as household food waste behavior and garbage sorting behavior (Razali et al., 2020; Van Tonder et al., 2023; Gao et al., 2024). Accordingly, hypothesis H3 is proposed.

> *H3:* Subjective norms mediate the effect of rural residents' past pro-environmental production behaviors on their active waste sorting behaviors.

2.3 Regulatory role of publicity and education and village rules and regulations

The influence of residents' past pro-environmental behavior experience on subsequent pro-environmental behavior is context-dependent, and the pro-environmental behavior spillover pattern of residents varies in different contexts, i.e., there may be a moderating role of contextual factors in pro-environmental behavior spillover (Truelove et al., 2014; Maki et al., 2019). Meanwhile, contexts are diverse, and institutional factors play an important role in them as typical contextual variables (Ling and Xu, 2021). Persuasion theory proposes that a persuader's dissemination of information about a particular aspect affects the receiver's behavioral decisions (Hovland, 1959). Publicity and education is a typical formal system in rural areas, in which the government and related media popularize the environmental pollution caused by indiscriminate and mixed household waste disposal and promote the significance and importance of individual behavioral actions on waste separation through various means such as distributing initiative letters, posters and household publicity. This type of strategy helps to help rural residents develop internal attribution, speculate that they have implemented pro-environmental production behaviors in the past in order to improve the environment, and understand the ecological benefits of garbage sorting, and then they may also behave more positively in garbage sorting behaviors. Accordingly, hypothesis H4 is proposed.

> *H4:* There is a moderating effect of publicity and education in the influence of rural residents' past pro-environmental production behavior on their active waste classification behavior.

Village rules and regulations are a kind of informal institutional factors, which are the behavioral norms jointly formulated and jointly observed by the collective villagers of the village, and can create a good atmosphere for protecting the environment by setting up a typical example and blaming public opinion. In areas where waste classification is incorporated into village rules and regulations, rural residents realize that pro-environmental behaviors are highly recognized by the society, and they are more willing to disseminate environmental protection concepts and share environmental information, which prompts rural residents to deeply root the concept of green development in their hearts and put it into practice, and also consciously regulate the behavior of waste classification after protecting the production environment. Based on the above analysis, hypothesis H5 is proposed.

> *H5:* There is a moderating effect of village rules and regulations in the influence of rural residents' past pro-environmental production behavior on their active waste classification behavior.

In summary, this paper constructs a theoretical model, as shown in Figure 1.

3 Methodology

3.1 Study area

The sample of this study comes from Jiangxi Province, which is located in the southeast of China, on the south bank of the middle and lower reaches of the Yangtze River, and lies between 24°29′14″ ~ 30°04′43″ N and 113°34′18″ ~ 118°28′56″E. Jiangxi Province was selected as the study area for the following two reasons: on the one hand, Jiangxi Province is one of the 13 major rice producing areas in China, and its rice planting area and total output rank among the top in the whole country. In order to promote the green development of agriculture, the provincial agricultural department has issued the "Implementation Plan for the Zero Growth of pesticide Use in Jiangxi Province by 2020," which comprehensively promoted green production technologies to rural residents, such as soil testing and formula fertilization, increased application of organic fertilizer, green manure planting, straw returning to the field and so on. As early as 2019, the comprehensive utilization rate of straw in the province reached more than 90%, which made remarkable achievements in guiding rural residents to carry out green agricultural production. On the other hand, Jiangxi Province was selected as the first batch of national ecological civilization experimental zones in China in

2016. By 2022, 14 pilot counties (cities, districts) for rural waste classification were set in the province, and the Regulations on Household Waste Management in Jiangxi Province was implemented in March 2022, which is representative in guiding rural residents to practice household waste classification. Therefore, it is representative to choose Jiangxi Province as the study area to discuss the spillover effect of rural residents' pro-environment production behavior on their voluntary garbage sorting behavior.

3.2 Data collection

The data in this paper are derived from the field questionnaire survey conducted by our research group on rural residents in Jiangxi Province from June to October 2022. According to the social and economic development of Jiangxi Province and the division of demonstration counties, the stratified sampling method was used to determine the sample rural residents. Rural residents who had carried out pro-environmental production behavior in 2021 and did not participate in garbage sorting in 2021 were selected.

To ensure data quality, the research steps include the following phases: First, based on existing literature, a preliminary questionnaire is designed and a pre-survey is conducted. Considering the economic conditions and the implementation of waste classification pilot programs in various regions of Jiangxi Province, a stratified random sampling method is used to distribute questionnaires through an online survey system, resulting in a total of 160 samples. Second, after conducting reliability and validity tests on the scale, variables that did not pass the tests are eliminated, and related items are adjusted, resulting in the final questionnaire that is officially adopted. Finally, in the formal research phase, questionnaires were obtained through random visits, face-to-face interviews and online questionnaires, and finally 427 questionnaires were obtained, and 304 valid questionnaires were obtained that met the study's requirements, resulting in an efficiency rate of 72.38%. To ensure effective capture of the spillover effect of rural residents' past pro-environmental production behaviors on their household waste sorting behaviors, the sample rural residents were all those who had implemented pro-environmental production behaviors without household waste sorting in the past year, according to the order of time before and after to reduce the estimation result error, in order to scientifically investigate the causal relationship of pro-environmental behaviors across domains.

In terms of sample characteristics, the gender distribution reveals a male-to-female ratio of 104.4, indicating a slight male predominance. Regarding income distribution, 61.52% of the sample earn an annual

FIGURE 1
Theoretical model.
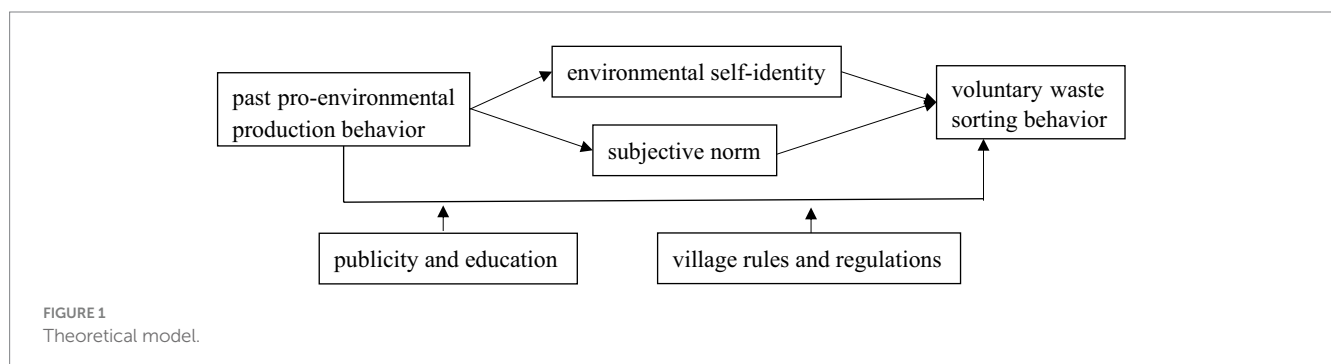
income of 30,000 yuan or less, while 22.37% fall within the 30,000 to 50,000 yuan bracket, 8.87% within the 50,000 to 80,000 yuan range, and 7.24% earn over 80,000 yuan (Table 1).

3.3 Questionnaire design

The questionnaire involves latent variables and manifest variables. The questionnaire includes three latent variables: rural residents' voluntary waste sorting behavior, past pro-environmental production behavior and subjective norms. Based on the existing research (Floress et al., 2022; Jia and Zhao, 2020; Leeabai et al., 2023; Liu and Ng, 2023; Teng et al., 2022; Wang, 2015; Wu, 2017; Yue et al., 2022), the specific measurement methods for each variable can be seen in Table 2.

Likert scale was used, with 1–5 indicating complete disagreement to complete agreement, in measuring past environmentally-friendly production behaviors, 1 = Never, 2 = Almost Never, 3 = Sometimes,

4 = Often, 5 = Always; in other cases, 1–5 represents strongly disagree to strongly agree. The results of reliability and validity of latent variables show that the factor load of each item is above 0.806, and the minimum KMO value is 0.767, which is suitable for factor analysis. The minimum values of AVE and CR are 0.707 and 0.925 respectively, which are higher than the standard values, indicating that the construction has good reliability and validity.

3.4 Model setting

Drawing on the test method of mediating effect and moderating effect of Wen et al. (2006), this paper discusses the influence of rural residents' past pro-environmental production behavior on their active garbage sorting behavior, the intermediary role of environmental self-identity and subjective norms, and the moderating effect of publicity and education and village regulations. The model is set as follows:

$$Y = \alpha_0 + \alpha_1 X + \alpha_2 Con + \varepsilon_1 \tag{1}$$

$$M_i = \beta_0 + \beta_1 X + \beta_2 Con + \varepsilon_2 \left(i = 1,2\right) \tag{2}$$

$$Y = \gamma_0 + \gamma_1 X + \gamma_2 M_i + \gamma_3 Con + \varepsilon_3 \left(i = 1,2\right) \tag{3}$$

$$Y = \theta_0 + \theta_1 X + \theta_2 W_j + \theta_3 X \times W_j + \theta_4 Con + \varepsilon_4 \left(j = 1,2\right) \tag{4}$$

TABLE 1 Description of the basic characteristics of the rural population of the sample.

Variable	Category	Frequency	Percentage
Sex	Male	155	50.99
	Female	149	49.01
Inc	<30,000	187	61.52
	30,000-50,000	68	22.37
	50,000-80,000	27	8.87
	>80,000	22	7.24

TABLE 2 Variable measurement methods.

Variable	Measurement method
Gender	Male =1, female =0
Age	Years old
Health status	Very bad = 1; Bad = 2; General = 3; Good = 4; Very good = 5
Annual income in 2021(unit: yuan)	Less than 10,000 = 1, 10,000–30,000 = 2, 30,000–50,000 = 3, 50,000–80,000 = 4, 80,000 or more =5
Voluntary garbage sorting behavior	In daily life, I always sort household waste out of habit.
	I can actively participate in public welfare activities related to household waste sorting organized by the village.
	I hope to attend meetings organized by the village related to household waste sorting.
	I hope to participate in the formulation of village policies and standards concerning household waste sorting.
Past pro-environmental production behavior	In the past year, the frequency of your use of pest-resistant seeds
	In the past year, the frequency of your adoption of reduced tillage or no-tillage techniques
	In the past year, the frequency of your use of biological pesticides in agricultural production
	In the past year, the frequency of your application of organic fertilizers in agricultural production
	In the past year, the frequency of your adoption of straw returning technology
	In the past year, the frequency of your recycling of agricultural film
Subjective norm	Classifying household garbage is more in line with my status
	My family believes that household waste should be sorted.
	My neighbors believe that household waste should be sorted.
Environmental self-identity	Protecting the environment is more in line with my identity
Publicity and education	The government's publicity and education on waste classification has a great influence on my household waste classification
Village regulations	Does your village require the classification of domestic waste? (Yes = 1, No = 0)

In Formula 1–4, Y represents the voluntary garbage sorting behavior of rural residents; X denotes the past pro-environmental production behavior; M_i (i = 1,2) are mediating variables, including environmental self-identity and subjective norms; $W_j (j = 1,2)$ represent moderating variables, including publicity and education and village regulations; Con denotes the set of all control variables, including health status, gender and income. α_0, β_0, γ_0 and θ_0 are constant terms, $\varepsilon_1, \varepsilon_2, \varepsilon_3$ and ε_4 random error terms.

4 Results

In order to avoid the multicollinearity between variables affecting the research results, VIF test is carried out with Stata software. According to the test results, the vif values of all variables are less than 2, indicating that there is no serious multicollinearity problem between variables.

4.1 Main effect test of past pro-environment production behavior

The results are shown in Table 3. In model (1), the past pro-environmental production behavior of rural residents is helpful to encourage them to voluntarily classify household waste (α =0.362, $p < 0.001$), assuming that H1 is supported.

4.2 The intermediary effect test of environmental self-identity and subjective norms

The mediating effect test results of environmental self-identification and subjective norms are shown in Table 3. According to model (2)–(3) in Table 1, rural residents' past pro-environment production behavior helps to strengthen their subjective norms (β =0.289, $p<0.001$), and rural residents with strong subjective norms

are more likely to voluntarily separate garbage (γ =0.236, $p<0.001$). Combined with model (1), the main effect is significantly positive, indicating that subjective norms play a partial mediating role in the positive impact of rural residents' past pro-environment production behavior on their voluntary garbage sorting behavior, and hypothesis H2 is valid.

In model (4)–(5) of Table 3, rural residents' past pro-environment production behavior enhances their environmental self-identification (β =0.348, $p < 0.001$), and strong environmental self-identification encourages them to actively participate in garbage classification (γ =0.515, $p < 0.001$). The results show that environmental self-identity plays a partial mediating role in the positive effects of rural residents' past pro-environment production behavior on their voluntary garbage sorting behavior, and hypothesis H3 is supported.

To further test the significance of the above-mentioned mediating effect, following Preacher and Hayes (2004), the Bootstrap method was employed to test the significance of mediation effects. The results of the regression for the indirect effect (mediating variable—voluntary waste sorting behavior of rural residents) are shown in Table 4. It can be observed from Table 4 that the confidence intervals for the relevant effects do not include 0, indicating the significant presence of the mediating effect and robust results.

4.3 Test of the moderating effect of publicity and education and village regulations

The test results of the moderating effects of publicity and education and village regulations are shown in Table 5. In model (2) of Table 5, the interaction between rural residents' past pro-environmental production behavior and publicity and education has a significant positive impact on their voluntary waste sorting behavior (θ =0.086, $p < 0.05$), which shows that the government's publicity and education helps to enhance the positive impact of rural residents' past pro-environmental production behavior on their

TABLE 3 Test results of main effect and intermediary effect.

	Model(1)	Model(2)	Model(3)	Model(4)	Model(5)
	Voluntary waste sorting behavior	Subjective norms	Voluntary waste sorting behavior	Environmental self-identity	Voluntary waste sorting behavior
Past pro-environmental production behavior	0.362***	0.289***	0.294***	0.348***	0.183***
	(7.51)	(5.72)	(5.96)	(6.35)	(4.38)
Subjective norms			0.236***		
			(4.39)		
Environmental self-identity					0.515*** (12.50)
Control variables	Yes	Yes	Yes	Yes	Yes
Constant	1.865***	−1.228***	2.152***	1.584***	1.049***
	(6.14)	(−3.86)	(7.12)	(4.58)	(4.12)
N	304	303	303	304	304
Adj-R^2	0.184	0.095	0.231	0.149	0.463
F	18.116	8.914	19.168	14.265	53.284

***, ** and * are significant at the level of 1, 5 and 10% respectively; The values in parentheses are t-values.

TABLE 4 Bootstrap test results.

Mediating variable	Coefficient	Std. err.	T-value	p-value	BootLLCI	BootULCI
Environmental self-identity	0.179	0.031	5.830	0.000	0.119	0.240
Subjective norms	0.068	0.023	2.920	0.003	0.022	0.114

***, ** and * are significant at the level of 1, 5 and 10%, respectively.

TABLE 5 Test results of moderating effect.

	Model(1)	Model(2)	Model(3)
	Voluntary waste sorting behavior	Voluntary waste sorting behavior	Voluntary waste sorting behavior
Past pro-environmental production behavior	0.222***	0.204***	0.275***
	(5.46)	(4.95)	(5.60)
Publicity and education	0.543***	0.561***	
	(12.42)	(12.70)	
Past pro-environmental production behavior × Publicity and education		0.086**	
		(2.21)	
Village regulations			−0.636***
			(−5.27)
Past pro-environmental production behavior × Village regulations			0.274**
			(2.32)
Control variables	Yes	Yes	Yes
Constant	0.643**	0.551**	2.392***
	(2.42)	(2.06)	(7.72)
N	304	304	304
Adj-R^2	0.461	0.460	0.250
F	52.781	45.374	17.837

***, ** and * are significant at the level of 1, 5 and 10% respectively. The values in parentheses are t-values.

voluntary waste sorting behavior, and publicity and education plays a positive moderating role in it, and the hypothesis H4 has been confirmed. In the model (3) of Table 5, since village regulations belongs to 0–1 variable, it is treated as a virtual variable and then included in the model. The influence coefficient of the interaction between past pro-environmental production behavior and village rules and regulations is significantly positive (θ =0.274, $p < 0.05$), indicating that the inclusion of waste sorting in village rules and regulations will strengthen the promotion of rural residents' past pro-environmental production behavior on their voluntary waste sorting behavior, and village rules and regulations have a positive moderating effect in it.

Based on the above empirical analysis, past pro-environmental behaviors have a promoting effect on the active waste sorting behavior of rural residents, which verifies the main effect in the theoretical framework (Figure 1). Among them, subjective norms and environmental self-identity have significant mediating effects, confirming the influence mechanism in the theoretical framework. Furthermore, publicity and education, as well as village regulations, also play a positive moderating role, further confirming the scientific and rational nature of the theoretical framework initially constructed in this paper, providing a reference for the exploration of the complex mechanisms of the spillover effects of residents' environmental protection behaviors in the future.

4.4 Configuration analysis

In order to explore the rural residents' past pro-environmental production behavior and the role of mediator variables (environmental self-identity, subjective norms) and moderator variables (publicity and education, village rules and regulations) in promoting their high-level active waste sorting behavior, this study adopted fsQCA. Firstly, 75, 50 and 25% quantiles of sample descriptive statistics are selected as membership points, and the data are calibrated with the help of fsQCA3.0 software. The aggregate membership values are all 0.5 minus 0.001. Secondly, according to the suggestion of Du et al. (2021) the original consistency threshold is set to 0.8, the PRI consistency threshold is set to 0.75, and the case threshold is set to 7. Finally, 75% of the case samples are retained. The configuration results are shown in Table 6.

The results show that there are three equivalent paths (S1, S2 and S3) for rural residents' past pro-environmental production behaviors to trigger their high-level active waste sorting behavior. The overall consistency is 0.922, and the overall coverage rate is 0.614, indicating that the three configurations have 92.2% explanatory power for triggering rural residents' high-level active waste sorting behavior, and they can explain 61.4% of high-level waste sorting behavior sample cases. The above results suggest that the configuration results obtained by fsQCA are effective. In addition, the configuration result passed the robustness test.

TABLE 6 Configuration results.

Condition	S1	S2	S3	N1a	N1b
Past pro-environmental production behavior	●	·			⊗
Environmental self-identity		●	●	⊗	⊗
Subjective norms	·	●	●	⊗	⊗
Publicity and education	●		·	⊗	
Village regulations	·	·	·		⊗
Consistency	0.942	0.960	0.934	0.931	0.921
Raw coverage	0.451	0.446	0.555	0.642	0.305
Unique coverage	0.032	0.027	0.135	0.379	0.041
Overall consistency		0.922		0.921	
Overall coverage		0.614		0.683	

"●" Core casual condition (present). "·" Peripheral casual condition (present). "⊗" Core casual condition (absent). "⊗" Peripheral casual condition (absent). Blank spaces indicate "do not care".

Among the three configuration paths, S1 is dominated by pro-environmental production behavior (pro-environmental production behavior × subjective norms × publicity and education × village regulations). Under the guidance of public opinion on waste classification, rural residents infer that they are environmentally friendly and willing to follow environmental norms according to their past pro-environmental production behaviors, which urges them to adopt consistent behaviors and actively participate in waste classification. S2 is driven by intrinsic motivation (pro-environmental production behavior × Environmental self-identity × subjective norms × village regulations). In villages where waste sorting is included in village regulations, for rural residents who have behavior of pro-environmental production behavior in the past, their inherent social role and subjective norms of environmental protection are helpful to stimulate their belief in environmental protection and put it into practice. S3 is an interactive type of psychological situation (environmental self-identity × subjective norms × publicity and education × village regulations). Rural residents with strong environmental self-identity and subjective norms tend to actively participate in waste sorting under the dual regulation and guidance of publicity of waste sorting and village regulations, even if they have no previous behavior in pro-environmental production.

5 Discussion

This study found positive spillovers from rural residents' past pro-environmental behaviors in the production domain to their waste separation behaviors in the living domain, which extends existing studies on residents' environmental behavior spillovers and provides new evidence to confirm the existence of positive spillovers among residents' pro-environmental behaviors. Existing residential environmental behavior spillover studies have focused on exploring spillover effects between different environmental behaviors in different domains of life, such as waste sorting, green consumption, and household energy conservation (Thomas et al., 2016; Stangherlin et al., 2023). The present study found that spillover effects also existed between pro-environmental behaviors in different domains of residents. This may be due to the fact that the pro-environmental behaviors implemented by rural residents in the past in agricultural

production help to conserve resources and reduce pollution, and this good behavioral performance helps to increase their confidence in protecting the environment, and thus actively participate in waste separation behaviors in the living domain. This is consistent with the behavioral congruence theory, which enriches the existing research on the spillover theory of residents' pro-environmental behaviors, and also provides new ideas and insights for guiding rural residents to actively participate in garbage sorting. This research conclusion also holds significant practical implications. In regions where the level of agricultural green development is low, the government should first implement a series of environmental policies in the production field to encourage rural residents to adopt pro-environmental behaviors in agricultural production. On this basis, residential waste sorting policies should be applied to guide rural residents to actively engage in source separation of household waste.

Environmental self-identity and subjective norms play a mediating role in the spillover of pro-environmental behaviors of rural residents, which is similar to the findings of existing studies. As far as environmental self-identity is concerned, the research results of Lauren et al. (2019), Yue et al. (2021), and Liu and Ng (2023) all confirmed the key mediating role of environmental self-identity in the positive spillover of pro-environmental behaviors. As far as subjective norms are concerned, a large number of studies have examined the role of normative motives, such as social norms and environmental concern, in the spillover mechanism of pro-environmental behaviors (Ling et al., 2023). The indirect effects of environmental self-identity and subjective norms were also partially supported in the fsQCA grouping pattern (N2, N3 in Table 3), with both serving as core conditions to motivate high levels of proactive waste sorting behavior among rural residents. Thus, environmental self-identification and active norms are key to stimulate the positive influence of rural residents' past pro-environmental behaviors on their active waste sorting behaviors. Therefore, it is essential to fully leverage the promotive effect of rural residents' pro-environmental production experiences on their household waste sorting. In areas where rural residents have already engaged in pro-environmental behaviors in agricultural production, the government should vigorously publicize the contributions of these residents to the sustainable development of agriculture through channels such as publicity reports and meetings. This approach aims to strengthen rural residents' sense of

environmental protection and their sense of ownership, thereby guiding them to actively practice pro-environmental behaviors in their daily lives.

The results of this study suggest that village rules and regulations, as an informal regulatory strategy, help to enhance the promotion of rural residents' past pro-environmental behaviors on their garbage sorting behaviors. This is inconsistent with the findings of Ling and Xu (2021), who argued that social facilitation strategies induced negative spillovers. This discrepancy may stem from the fact that individuals tend to implement social norm-following behaviors for the purpose of obtaining social approval or avoiding social condemnation, and when individuals tend to attribute their behaviors to external social pressures rather than intrinsic environmental protection motives, then the social boosting strategy fails to help individuals internalize their policy compliance behaviors (Lalot et al., 2018). In contrast, the intervention strategy selected in this paper is the village rules and regulations, which elaborates that the villagers collectively incorporate the garbage classification policy into the self-governance rules and regulations out of their internalized compliance with the policy, and thus can effectively urge the rural residents who have the experience of pro-environmental production behaviors to actively implement the garbage classification behaviors, i.e., activating the positive spillover. fsQCA derived group paths show that the village rules and regulations appear as the auxiliary conditions, which once again verifies that the village rules and regulations positive role in guiding rural residents to consciously participate in garbage classification. Simultaneously, the government should also equip the necessary facilities for the sorting of household waste, such as providing categorized waste bins in natural villages, to ensure the construction of facilities for the sorting, collection, transportation, and disposal of household waste. This will provide the necessary conditions for rural residents to implement waste sorting effectively.

The findings suggest that publicity and education strategies can help rural residents realize that compliance with environmental policies is motivated by intrinsic environmental protection, which helps the behavioral consistency mechanism to occur, thus inducing positive spillovers of pro-environmental behaviors. As pointed out by Steinhorst and Matthies (2016), the government's publicity strategy helps to promote residents' active participation in subsequent environmental behaviors in order to express their environmental preferences, which has a positive impact on pro-environmental behavioral spillovers. In addition, scholars have examined the potential effects of different interventions on pro-environmental behavioral spillovers, such as social comparisons, monetary incentives, and punitive measures (Alt and Gallier, 2022). This paper tests the effects of two intervention modes, publicity and education and village rules and regulations, in residents' pro-environmental behavior spillover, further clarifies the boundary regulation of residents' behavior spillover, deepens and expands the existing theoretical research on the mechanism of residents' pro-environmental behavior spillover, and also provides new ideas for optimizing the government's pro-environmental behavior policy formulation.

6 Limitation

Climate change and environmental pollution are difficult problems shared by all countries in the world, and in the face of changing international forms and the status quo of agricultural development, the pro-environmental behavior of residents has become a key factor in improving the production and living environment. Therefore, in-depth understanding of the diversified decision-making of different residents' behavioral spillovers in different environments, and exploring differentiated strategies, will help countries around the world to formulate differentiated measures to activate positive spillovers of pro-environmental behaviors. The limitation of this paper's study is that it focuses only on China, and exploring the diversity of pro-environmental behavioral spillovers across domains in a global perspective is an area for future research to be expanded. In addition, psychosocial variables (cognition, social capital, and behavioral similarity, etc.) may also have an important impact on the spillover effect of residents' pro-environmental behaviors, and the questionnaire can be improved according to the specific issues of the study in order to further clarify the complex mechanism of residents' pro-environmental behavior spillover. In order to expand the regional scope of the survey and enhance the generalizability of the research conclusions, attempts can be made by extending the survey period, which can increase the sample size. At the same time, broadening the survey range to cover more areas can improve the representativeness of the sample and the generalizability of the research conclusions.

7 Conclusions and policy recommendations

Based on the survey data of China's National Ecological Civilization Pilot Zone (Jiangxi Province), this paper uses the mediation and moderation effect model and the fuzzy set qualitative comparative analysis method to explore the spillover effects of rural residents' past pro-environment production behaviors on their voluntary waste separation behaviors, and explores the transmission mechanism of environmental self-identity and subjective norms, as well as the boundary effects of publicity and education and village regulations. The configuration paths of rural residents' voluntary waste sorting behavior driven by pro-environment production behavior in the past are clarified.

The empirical results show that: first, the past environment-friendly production behavior can directly promote the voluntary garbage sorting behavior of rural residents; Environmental self-identity and subjective norms have partial mediating effects on the influence of past pro-environment production behavior on the rural residents' voluntary garbage sorting behavior. Publicity, education and village regulations play a positive moderating effect on the influence of the past environment-friendly production behavior on the rural residents' voluntary garbage sorting behavior. Further, the fsQCA analysis results show that environmental self-identity and subjective norms play an important role in stimulating the high-level voluntary garbage sorting behavior of rural residents, and village regulations appear as auxiliary conditions, which proves the test results of the mediation and moderation effect model. In the interaction relationship of antecedent configuration, there is a substitution relationship between rural residents' past pro-environment production behavior and publicity and education.

Based on the above research conclusions, the following policy recommendations are put forward: (1) Fully activate the positive spillover of cross-domain pro-environmental behaviors of rural residents. In areas where rural residents have already carried out pro-environmental behaviors in agricultural production, the contributions to the sustainable development of agriculture made by those rural residents who have carried out pro-environmental behaviors in agricultural production should be vigorously publicized, so as to strengthen their sense of identity and ownership of environmental protection and guide them to actively practice pro-environmental behaviors in their daily lives. In addition, the government also needs to combine the daily living habits and living location of rural residents, reasonably equip waste sorting bins, and organize volunteers or supervisors to help rural residents put household waste correctly. (2) Guide the villagers to incorporate the relevant contents of waste classification into the village regulations. The government can guide villagers to realize the many benefits of garbage classification, take the initiative to incorporate the requirements of garbage classification into village regulations, mobilize the leading and exemplary role of local township sages, integrate demonstration forces such as township sages, party member, volunteers and enthusiastic villagers, create a good atmosphere of garbage classification, and urge rural residents to actively practice garbage classification.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the patients/participants OR patients/participants legal guardian/ next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

YT: Conceptualization, Funding acquisition, Supervision, Writing – review & editing. NL: Investigation, Methodology, Software, Writing – original draft, Writing – review & editing. CL: Funding acquisition, Software, Visualization, Writing – original draft. JY: Conceptualization, Writing – review & editing. YC: Supervision, Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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