

Article

The Impact of Environmental Regulations and Social Norms on Farmers' Chemical Fertilizer Reduction Behaviors: An Investigation of Citrus Farmers in Southern China

Gang Cui ^{1,2}  and Zhicheng Liu ^{1,*}

¹ College of Business, Hunan Agricultural University, Changsha 410128, China; cuigang0313@hunau.edu.cn

² College of Water Resources & Civil Engineering, Hunan Agricultural University, Changsha 410128, China

* Correspondence: ecoscholar@hunau.edu.cn

Abstract: This study investigates how environmental regulations and social norms affect farmers' chemical fertilizer reduction behaviors (CFRBs) and investigates the mediating role played by social norms and the moderating role played by social networks. As the analysis tool, a structural equation model is employed to analyze the data collected from a questionnaire survey with 402 valid samples of Chinese citrus growers. This study reveals that (1) environmental regulations and social norms have a significant effect on farmers' CFRBs; (2) injunctive social norms are a partial mediator of the relationship between incentive-based environmental regulations and farmers' CFRBs; (3) social networks play a positive moderating role in the relationship between injunctive social norms and farmers' CFRBs; and (4) large-scale farmers' CFRBs are more susceptible to the impact of environmental regulations and social norms than small-scale farmers. The result of this study provides a significant scientific foundation for the Chinese agricultural sector to develop policies to combat soil pollution in agriculture.

Keywords: agricultural soil pollution; chemical fertilizer reduction behaviors (CFRBs); citrus growers; environmental regulations; social norms; social networks



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1. Introduction

China currently faces a severe problem of agricultural soil pollution, and chemical fertilizer over-use has been one of the primary causes of the problem [1]. Chemical fertilizers used excessively can result in soil nutrient imbalances and soil compaction, affecting the quality and yield of agricultural products [2]. Moreover, nitrogen and phosphorus loss from chemical fertilizers can contribute to water eutrophication and aggravate non-point source pollution. Such problems pose a serious threat to agricultural sustainability [3]. Chemical fertilizer reduction measures in the Chinese agricultural sector (the Ministry of Agriculture and the Ministry of Ecology and Environment) have been promoted, including soil testing and formulated fertilization, drip fertigation, and organic fertilizers. The results, nevertheless, are limited [4]. The China Rural Statistical Yearbook reports that the average chemical fertilizer application intensity in Chinese agriculture decreased from 361.99 kg/ha to 313.50 kg/ha from 2015 to 2020. Nevertheless, its 2020 value is still higher than the world average of 122.8 kg/ha [5] and exceeds the environmental safety upper limit of 225 kg/ha acknowledged by developed nations [6]. The problem of the over-application of chemical fertilizers in Chinese agriculture has not been fundamentally addressed because many farmers are unwilling to adjust their farming practices to reduce the use of chemical fertilizers [7]. Therefore, it is necessary to investigate factors that affect farmers' fertilizer application behavior and explore scientific methods to help guide farmers to reduce chemical fertilizer application to mitigate agricultural soil pollution in China.

Research on farmers' behavior from the past provides the basis for this study [8,9]. Farmer's behavior can be influenced by many factors, both internal and external. The

former mainly consist of farmers' livelihood endowments [10], perceptions [9,11], and risk preferences [12,13], whereas the latter mainly consist of agricultural policies [14], social norms [15], and market conditions [16]. There is no doubt that changing farmers' livelihood endowments is difficult in the short term [10], and intervening in the market via administrative means would be prohibitively expensive [17]. Therefore, the aforementioned approaches are unfeasible, and some researchers have discovered that executing reasonable institutions is an effective way to encourage farmers to adopt cleaner production technologies [14,15,18].

Literature on the relationship between institutions and farmers' behavior focuses mainly on two categories of problems: (1) the influence of formal institutions on farmers' behavior [14,19] and (2) the influence of informal institutions on farmers' behavior [20]. Currently, China's rural society is transitioning from a traditional society to a modern society. The formal institutions that are represented by environmental regulations are often ineffective at solving rural problems, and even the phenomenon of "institutional failure" may occur [21]. At the same time, informal institutions that are represented by social norms are readily accepted by farmers. These factors significantly influence farmers' behavior [15], and the social networks that farmers have may reinforce this effect. Nevertheless, few studies have investigated farmers' behavior from the perspective of double institutions (environmental regulations and social norms), and the impact of social networks has not been studied extensively.

Additionally, most of the existing literature on the use of chemical fertilizers by farmers focuses on grain producers [11,22] and vegetable growers [23]. However, fruit trees with long growth cycles, high technical requirements, and high fertilization intensity have received far too little attention, especially citrus in southern China. Citrus is an evergreen fruit tree that grows in the tropics and subtropics and is found from 16° to 37° N latitude [24]. In China, citrus is the largest planted fruit tree, mainly planted in 11 southern provinces (Zhejiang, Fujian, Jiangxi, Hubei, Hunan, Guangdong, Guangxi, Chongqing, Sichuan, Guizhou, and Yunnan). The China Rural Statistical Yearbook reported that, from 2010 to 2020, the total citrus production in the above mentioned 11 southern provinces of China increased from 25,788,700 tons to 50,326,000 tons, with an average annual growth rate of 6.91%, reaching 98% of domestic production. The cost-benefit analysis of agricultural products in China shows that citrus has a much higher chemical fertilizer application intensity than grains and vegetables, so citrus is a key target for China's chemical fertilizer reduction initiatives. As a result, this study focuses on citrus growers in southern China.

The goal of this study is to investigate farmers' fertilization behaviors from the perspective of double institutions (environmental regulations and social norms). The research object in this study was citrus growers in southern China. In this study, a structural equation model was employed to analyze the impact of environmental regulations and social norms on farmers' chemical fertilizer reduction behaviors (CFRBs). Additionally, this study investigates the mediating effect of social norms and the moderating effect of social networks.

The study contributes to current research in four ways. Firstly, this study scrutinizes the effects of environmental regulations and social norms on farmers' fertilizer use patterns. Moreover, this study scrutinizes the mediating effect of social norms and the moderating effect of social networks, expanding previous studies on the relationships between institutions and farmers' behaviors. Secondly, this study provides empirical evidence for the study of farmers' CFRBs by surveying citrus growers in four provinces of southern China. The collected data show that this trend will barely meet China's target for chemical fertilizer reduction initiatives. Moreover, little is known about the chemical fertilizer application behaviors of citrus growers in southern China, and it is not clear what factors will influence those behaviors. Consequently, this study will fill the gap in the study of the chemical fertilizer application behavior of citrus growers in southern China. Thirdly, this study compares smallholder and large-scale citrus farmers in China, which will help to better understand the differences in fertilizer application behavior between the two types of citrus

farmers. Lastly, the findings will be helpful for policymakers seeking to reduce the use of chemical fertilizers.

The following of the paper is organized as follows. Section 2 contains an extensive review of the literature and a theoretical framework for the research hypothesis. Section 3 presents sample selection, variable measurement, and research model. Section 4 shows the results. Section 5 discusses these results. Section 6 concludes and suggests future research.

2. Literature Review and Hypotheses Development

North [25] argued that all economic activities are rational acts undertaken by people under the constraint of institutions to maximize their benefits. Based on how they bind people, North [24] classified institutions as formal or informal. Constitutions, laws, and property rights fall under the former category, while sanctions, taboos, customs, traditions, and codes of conduct fall under the latter category. The rational economic behavior of farmers is often guided, stimulated, and restrained by relevant institutions. In China today, environmental regulations are among the formal institutions that influence farmers' behavior. In contrast, the informal institutions that shape farmers' behavior are influenced by several social norms [14,18]. Therefore, this study uses environmental regulations to describe formal institutions and social norms to describe informal institutions.

2.1. The Effect of Environmental Regulations on Farmers' Behaviors

As a class of agricultural cleaner production technologies, chemical fertilizer reduction technologies help reduce agricultural non-point source pollution, which has positive externalities. This, however, requires farmers to invest additional capital and time as well as take on the risk of possible yield loss [12]. As such, the trade-off between environmental benefits and economic costs is of critical importance when designing agri-environmental regulatory policies [26]. Consequently, government guidance and economic incentives are vital to encourage farmers to adopt cleaner production practices [14]. Based on the available literature, three types of environmental regulation policies exist for chemical fertilizer reduction: Firstly, guidance-based regulations promote environmental awareness among farmers by highlighting the dangers of over-fertilization [27]. Secondly, incentive-based environmental regulations provide farmers with financial and material subsidies as well as free technical assistance to motivate them to reduce their use of chemical fertilizers [18]. Lastly, farmers are penalized for excessive fertilizer application through restraint-based environmental regulations. However, the Chinese government does not have restraint-based regulations for two reasons: on the one hand, the conditions to monitor farmers' fertilizer application behaviors, and, on the other hand, it may discourage farmers from working [28]. In addition, previous studies have indicated that environmental regulations have varying effects based on context. Based on a study of European Union agri-environmental schemes, Niskanen et al. [29] discovered that different farmers respond differently to environmental regulations. Pan [30] argued that policies such as technology regulation, sewage charges, media information provision, and biogas subsidies have different effects on livestock farmers of different sizes. According to mentioned literature, environmental regulations can facilitate farmers' adoption of cleaner production technologies, and the following hypotheses are formulated:

Hypothesis 1a (H1a). *Guidance-based environmental regulations positively impact farmers' CFRBs.*

Hypothesis 1b (H1b). *Incentive-based environmental regulations positively impact farmers' CFRBs.*

2.2. The Effect of Social Norms on Farmers' Behaviors

According to the new institutional economics theory, informal institutions often have a stronger binding force than formal institutions because informal institutions are more readily accepted and disseminated [31]. Therefore, informal institutions cannot be ignored when formal institutions fail to effectively govern environmental problems [32]. Regulatory power is relatively weak in rural China, and the people's ideology is conservative. To

solve the environmental problems in rural areas, it is necessary not only to rely on formal institutions but also on informal institutions [20]. The informal institutions represented by social norms play an important role in the production, life, and interpersonal communication of farmers through the “villagers’ self-governance system” [33] and “acquaintance society” [34]. Social norms are regulations and standards that are understood by group members in a specific context in response to certain events or behaviors. Although they fail to have legal effects and cannot be employed to control people’s words and actions through coercion, they can be employed to guide and regulate group members’ behavior [35]. Cialdini et al. [36] argued that social norms can be divided into two types: descriptive norms, which describe typical behaviors that most people are doing, and injunctive norms, which specify what people should do from a moral standpoint. People’s behavior can be directly influenced by both of these social norms, but their mechanisms are different. A descriptive social norm influences a person implicitly through typical examples of behavior while an injunctive social norm guides people to make behavioral choices based on the moral judgment of the majority and promises informal sanctions to reinforce restraint [37]. Additionally, descriptive social norms can only trigger healthy behavior in environments where most people act in socially acceptable ways. In contrast, injunctive social norms can promote good behavior in most situations [38]. The findings of Qiu et al. [21] suggest that social norms can influence farmers’ perceptions of value, risk confidence, and skills towards farmland conservation. The study by Li and Wu [15] discovered that social norms can influence rice farmers’ use of organic fertilizer. In rural China, social norms still play a crucial role in determining farmer behavior. Accordingly, the following two hypotheses are proposed:

Hypothesis 2a (H2a). *Descriptive social norms positively impact farmers’ CFRBs.*

Hypothesis 2b (H2b). *Injunctive social norms positively impact farmers’ CFRBs.*

2.3. The Effect of Environmental Regulations on Social Norms

According to Lai et al. [39], intrinsic social norms can be affected by extrinsic incentive regulations. Qin and Shogren [40] discovered that both monetary and non-monetary incentive regulations can encourage more effort from the “green” firm, and they defined the social norm as the typical firm’s attempt to protect the environment. Scholars in agriculture have identified a similar phenomenon. By promoting advocacy efforts, Xia et al. [33] and Du et al. [14] suggested that guidance-based environmental regulations can make most farmers aware of the importance of cleaner production technologies so that social norms conducive to technology diffusion will gradually emerge. Shi and Zhang [28] and Fei et al. [27] argued that if rural grassroots organizations and village elites support incentive-based environmental regulations, these regulations will serve as an effective demonstration and will encourage further farmers to embrace fertilizer reduction. As a result, environmental regulations and social norms are intertwined. The following four hypotheses are proposed:

Hypothesis 3a (H3a). *Guidance-based environmental regulations positively impact descriptive social norms.*

Hypothesis 3b (H3b). *Incentive-based environmental regulations positively impact descriptive social norms.*

Hypothesis 3c (H3c). *Guidance-based environmental regulations positively impact injunctive social norms.*

Hypothesis 3d (H3d). *Incentive-based environmental regulations positively impact injunctive social norms.*

2.4. The Mediating Effect of Social Norms

Some scholars argue that formal institutions can benefit from being socially acceptable and compatible with informal ones. Grzymala-Busse [41] claimed there is a limited scope of influence of any formal institution, and they can only form a social restraint system by relying on the complementary nature of different informal institutions. Li and Huang [42] pointed out that the cause of “institutional failure” in agro-environmental policy is the contradiction between policies that prioritize long-term social benefits and farmer behavior that prioritizes short-term economic gains. The study by Li et al. [18] discovered that social norms, as local institutions formed in long-term farming practices, can compensate for the lack of environmental regulation in terms of supervision and restraint. According to Xia et al. [33], environmental regulations can influence farmers’ behavior directly as well as indirectly through social norms. Ertor-Akyazi [43] concluded that social norms can change the decision-making environment of fishers by providing cues about socially acceptable desirable behaviors, so economic incentives designed to target small-scale fisheries will have more impact on their behavior. According to the literature and the analysis in Section 2.3, those environmental regulations could influence farmers’ CFRBs through social norms. The following four hypotheses are proposed:

Hypothesis 4a (H4a). *Descriptive social norms play a mediating role in the effect of guidance-based environmental regulation on farmers’ CFRBs.*

Hypothesis 4b (H4b). *Descriptive social norms play a mediating role in the effect of incentive-based environmental regulation on farmers’ CFRBs.*

Hypothesis 4c (H4c). *Injunctive social norms play a mediating role in the effect of guidance-based environmental regulation on farmers’ CFRBs.*

Hypothesis 4d (H4d). *Injunctive social norms play a mediating role in the effect of incentive-based environmental regulation on farmers’ CFRBs.*

2.5. The Moderating Effect of Social Networks

Social embeddedness theory reveals that people are inevitably influenced by the social networks in which they are embedded when making economic decisions [44]. Throughout rural China, where kinship ties and local ties still dominate, social networks play a significant role in influencing farmers’ livelihood decisions [45]. The social network consists of social relationships among specific individuals [46]. China’s rural society is characterized by scattered resources and independent farming, which means that an individual farmer’s capacity to withstand risks is limited, and the responsibility for cooperation and mutual assistance lies naturally with families with local ties [34]. Kinships and local ties are still the primary social relationships that rural Chinese villagers identify with and rely on today [47]. In recent years, the market economy has inevitably led to farmers’ occupational differentiation, and farmers’ occupational relationships have developed around agricultural production and operation [48]. Videras et al. [49] claim that the views and behaviors of relatives, neighbors, agricultural technicians, and village elites may influence the pro-environmental behaviors of farmers. Lyu et al. [45] measured the breadth, strength, and tightness of farmers’ social networks. The entropy method was used by Lyu et al. [45] to calculate the composite score of the social network owned by farmers based on these three indicators. Through empirical research, Lyu et al. [45] found that the higher the composite score of the social network owned by farmers, the less likely they would overuse chemical fertilizers. Bunkus et al. [50] reported that the more frequently farmers interacted with one another, the faster their behaviors were influenced by social norms. In their study, Brown et al. [51] discovered that social networks are more able to facilitate the effects of social norms on farmers’ environmental behavior than government agencies. Based on the previous analysis, the following two hypotheses were developed:

Hypothesis 5 (H5a). *Social networks positively moderate the relationship between descriptive social norms and farmers' CFRBs.*

Hypothesis 5 (H5b). *Social networks positively moderate the relationship between injunctive social norms and farmers' CFRBs.*

This study attempts to study the influences of environmental regulations and social norms on farmers' CFRBs (H1a,b and H2a,b), examining the relationship between environmental regulations and social norms (H3a,b,c,d), exploring social norms' mediating effects (H4a,b,c,d) and the moderating effects of social networks (H5a,b). By doing so, it provides a new perspective on factors affecting farmers' CFRBs. The framework of the assessment model is described in Figure 1.

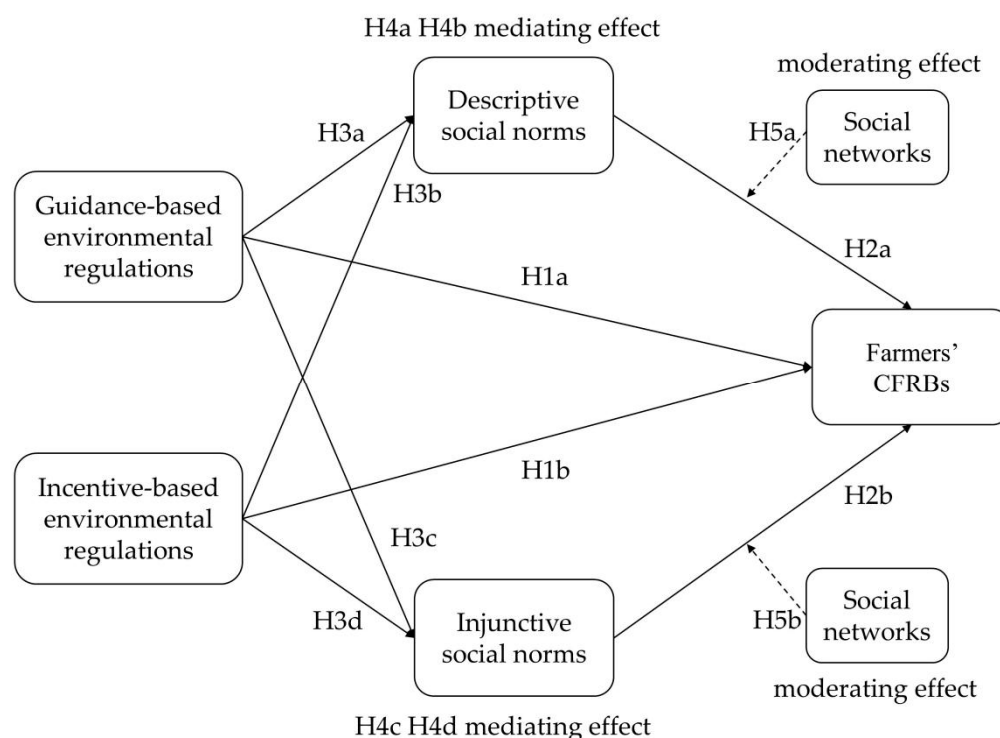


Figure 1. The framework of the assessment model.

3. Methodology

3.1. Data Sources

In the fourth paragraph of Section 1, citrus is mainly grown in 11 southern provinces of China. However, due to financial and staffing constraints, this study can only cover four representative provinces in southern China (Hunan, Guangxi, Sichuan, and Fujian, see Figure 2). These four provinces are important citrus-producing areas located in four different geographical regions in southern China. The study collected data from citrus growers in these four provinces. To ensure the reliability and validity of the survey, stratified random sampling and simple random sampling were employed. We conducted a pre-survey before conducting the formal survey. First, three villages were selected in Hunan Province. Second, 20 citrus growers from each village were randomly selected, and 60 citrus growers were invited to complete the questionnaire. Based on the results of the pre-survey, we found that some of the questions in the questionnaire were unreasonable, and then we revised these questions and used the revised questionnaire in the formal survey. During the formal survey, first, the production of citrus was examined in each county in these four provinces (Hunan, Guangxi, Sichuan, and Fujian); based on this information, ten counties from each province were selected, representing different latitudes, cultivars, climatic conditions, economic development, and social customs. Second,

40 villages were selected in a similar fashion. Finally, ten to twenty citrus growers were randomly selected from each village. Investigators collected pertinent information face-to-face from all respondents, who were heads of families. Four hundred and sixty-five questionnaires were collected between July and September 2021, and after examining and selecting, invalid questionnaires were eliminated, resulting in 402 valid questionnaires with a response rate of 86.45%.

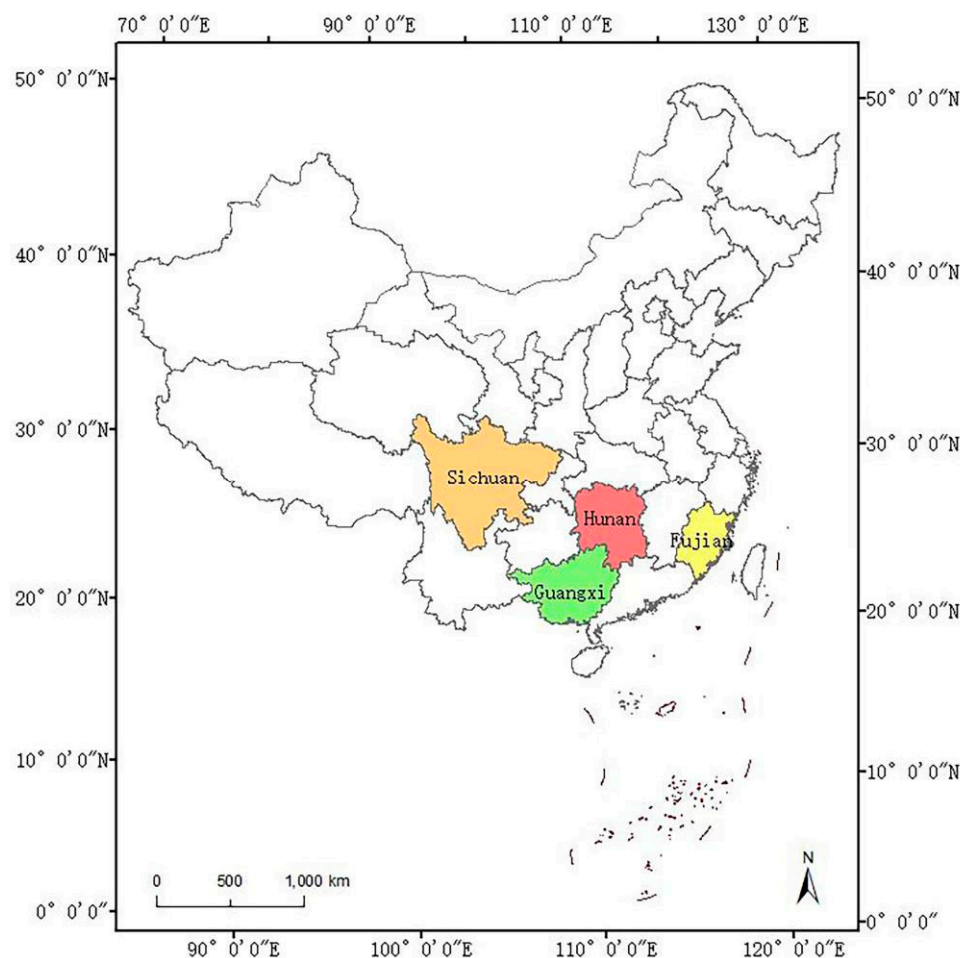


Figure 2. Areas surveyed.

In Table 1, this study presents its primary data. Male respondents predominate, 78.86% of citrus growers are over 40 years old, only 27.87 percent have at least a high school education, and over half earn more than RMB 50,000 a year. At the same time, more than half of the respondents had orchards of less than 3.33 ha. Data characteristics in this study are similar to those reported in Xiao et al. [52] and He and Qi [53], suggesting that the survey in this study is in line with the actual situation of Chinese citrus growers, and the sample is representative.

3.2. Variable Settings

New measurement items are created based on theoretical analysis and a review of the available literature (see Table 2). Based on adequate and valid data from the existing literature, a scale is developed. The revised measure items are derived from the suitable previous scales. Farmers' CFRBs in this study include four technical measures to minimize the amount of chemical fertilizer applied (see Table 2). Two kinds of environmental regulations, two kinds of social norms, and the social networks held by farmers are measured. The variables are quantified using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Table 2 contains detailed information about each item.

Table 1. Basic data about the survey participants.

Item	Characteristics	Frequency	Percent (%)
Gender	Male	308	76.62
	Female	94	23.38
Age	18–29	23	5.72
	30–39	62	15.42
	40–49	104	25.87
	50–59	98	24.38
	Above 60	115	28.61
Education	Primary School and below	137	34.08
	Junior High School	153	38.06
	Senior High School/secondary vocational school	84	20.90
	Vocational College	8	1.99
	Bachelor’s degree or above	20	4.98
Annual family income	Low-income families (less than 50,000 RMB)	172	42.79
	High-income families (more than 50,000 RMB)	230	57.21
Area of citrus orchards operated	Small-scale growers (less than 3.33 hectares)	215	53.48
	Large-scale growers (more than 3.33 hectares)	187	46.52
Province	Hunan	126	31.34
	Guangxi	149	37.06
	Sichuan	82	20.40
	Fujian	45	11.19

Table 2. Measurement of variables.

Latent Variable	Measurement Item	Mean (SD)	References
Farmers’ chemical fertilizer reduction behaviors (CFRBs)	You often use soil testing and formulated fertilization technology (CFRBs ₁).	3.71 (0.957)	Du et al. [14]
	You often use drip fertigation system technology (CFRBs ₂).	3.61 (0.963)	Zhu et al. [54]
	You often use commercial organic fertilizer (CFRBs ₃).	3.69 (0.976)	Xie et al. [55]
	You often use farm manure, such as plant straw, animal, and poultry manure (CFRBs ₄).	3.67 (0.995)	Xie et al. [55]
Guidance-based environmental regulations ¹ (GER)	Government awareness campaigns on the dangers of excessive chemical fertilizer application have affected you (GER ₁).	3.67 (0.970)	Jaraite and Kazukauskas [19]
	Government awareness campaigns on farmland quality protection have affected you (GER ₂).	3.64 (0.972)	Xue et al. [9]
	Government awareness campaigns on ensuring the quality and safety of agricultural products have affected you (GER ₃).	3.65 (0.975)	Xue et al. [9]
	Government awareness campaigns on agricultural waste recycling have affected you (GER ₄).	3.70 (0.945)	Xue et al. [9]
Incentive-based environmental regulations ² (IER)	You are satisfied with the technical services and subsidies provided by the government for soil testing and formulated fertilization (IER ₁).	3.65 (0.937)	Du et al. [14]
	You are satisfied with the technical services and subsidies provided by the government for the drip fertigation system (IER ₂).	3.88 (1.038)	Zhu et al. [54]
	You are satisfied with the subsidies provided by the government for purchasing commercial organic fertilizer (IER ₃).	3.70 (0.962)	Xie et al. [55]
	You are satisfied with the technical services and subsidies provided by the government for agricultural waste recycling (IER ₄).	3.71 (0.961)	Xie et al. [55]

Table 2. Cont.

Latent Variable	Measurement Item	Mean (SD)	References
Descriptive social norms (DSN)	People around you have adopted soil testing and formulated fertilization technology (DSN ₁).	3.2 (1.102)	Cialdini et al. [36]; Guo et al. [56]
	People around you have adopted drip fertigation system (DSN ₂).	3.06 (1.045)	Cialdini et al. [36]; Guo et al. [56]
	People around you have adopted commercial organic fertilizer (DSN ₃).	3.16 (1.097)	Cialdini et al. [36]; Guo et al. [56]
	People around you have adopted farm manure (DSN ₄).	3.2 (1.070)	Cialdini et al. [36]; Guo et al. [56]
Injunctive social norms (ISN)	People around you think farmers should adopt soil testing and formulated fertilization technology (ISN ₁).	3.65 (1.221)	Cialdini et al. [36]; Guo et al. [56]
	People around you think farmers should adopt drip fertigation system (ISN ₂).	3.63 (1.116)	Cialdini et al. [36]; Guo et al. [56]
	People around you think farmers should adopt commercial organic fertilizer (ISN ₃).	3.52 (1.099)	Cialdini et al. [36]; Guo et al. [56]
	People around you think farmers should adopt farm manure (ISN ₄).	3.7 (1.243)	Cialdini et al. [36]; Guo et al. [56]
Social networks (SNK)	Many relatives and friends visit your home during the Spring Festival (SNK ₁).	3.46 (1.292)	Jiang et al. [57]
	You have great trust in your relatives and friends (SNK ₂).	3.40 (1.222)	Xie et al. [55]
	You communicate regularly with people in your village (SNK ₃).	3.36 (1.200)	Lyu et al. [45]
	You have a good relationship with the people in your village (SNK ₄).	3.44 (1.216)	Lyu et al. [45]

¹ For instance: the policy of zero growth action of chemical fertilizers, and the policy of organic fertilizer instead of chemical fertilizer for fruit, vegetable and tea. ² For instance: the agricultural machinery purchase subsidy policy and the commodity organic fertilizer subsidy policy.

3.3. Analytical Method

SEM (structural equation model) is widely employed in social sciences and is effective in dealing with latent variables that cannot be directly observed [58]. In this study, environmental regulations, social norms, and social networks are latent variables that must be measured indirectly by multiple observed variables. Covariance-based SEM can simultaneously process latent and observed variables and allow for errors between latent and observed variables [59]. This study applied this method for its empirical analysis.

An SEM includes a measurement model and a structural model. The measurement model reflects the link between the latent and the observed variables. Latent variables can be specified by observed variables in the measurement model; the structural model illustrates the relationship between latent variables [60]. Here are the equations of the measurement model and structural model and their interpretations:

Measurement model:

$$X = \Lambda_X \xi + \delta \quad (1)$$

$$Y = \Lambda_Y \eta + \varepsilon \quad (2)$$

Structural model:

$$\eta = B\eta + \Gamma \xi + \zeta \quad (3)$$

In particular, ξ and η represent the exogenous and endogenous latent variables, separately. X represents the observed variables of ξ ; Y represents the observed variables of η . Λ_X is the coefficient linking X and ξ ; Λ_Y is the coefficient linking Y and η . δ and ε represent the error terms of X and Y , separately. B represents the regression coefficients of η , Γ represents the regression coefficients of ξ , and ζ represents the residual error [55].

4. Results

4.1. Test of Reliability and Validity

4.1.1. Test of Reliability

Using Cronbach's coefficient, this study analyzes the reliability of the measurement model. The reliability test was conducted using SPSS version 23.0 software, and Table 3 shows the results. The Cronbach's α value for each latent variable is higher than 0.7 in Table 3. Based on these results, this scale's internal consistency and the measurement model's reliability are satisfactory. As a result, the questionnaire for this study is highly reliable.

Table 3. Results of convergent validity test.

Latent Variable	Indicator	Standardized Factor Loading	Cronbach's α	Composite Reliability	Average Variance Extracted	KMO	Bartlett Sphericity Test
CFRBs	CFRBs ₁	0.827	0.893	0.894	0.68	0.801	0.000
	CFRBs ₂	0.801					
	CFRBs ₃	0.765					
	CFRBs ₄	0.899					
GER	GER ₁	0.824	0.847	0.851	0.592	0.786	0.000
	GER ₂	0.677					
	GER ₃	0.671					
	GER ₄	0.884					
IER	IER ₁	0.77	0.868	0.869	0.624	0.825	0.000
	IER ₂	0.783					
	IER ₃	0.826					
	IER ₄	0.779					
DSN	DSN ₁	0.781	0.818	0.819	0.531	0.805	0.000
	DSN ₂	0.659					
	DSN ₃	0.721					
	DSN ₄	0.749					
ISN	ISN ₁	0.85	0.88	0.882	0.652	0.832	0.000
	ISN ₂	0.751					
	ISN ₃	0.758					
	ISN ₄	0.863					
SNK	SNK ₁	0.82	0.847	0.848	0.582	0.814	0.000
	SNK ₂	0.726					
	SNK ₃	0.746					
	SNK ₄	0.757					

4.1.2. Test of Validity

The confirmatory factor analysis method is employed in this study to test the validity of the measurement model by assessing its convergent validity and discriminant validity.

SPSS version 23.0 software and AMOS version 23.0 software are employed to evaluate the measurement model's convergent validity using Standardized Factor Loading, Composite Reliability (CR), and Average Variance Extracted (AVE). The Kaiser–Meyer–Olkin (KMO) value for each latent variable is greater than 0.7, and the significance level of the test result is below 0.05, which indicates that this study is an excellent candidate for factor analysis. Additionally, the Standardized Factor Loading value of each indicator is more significant than 0.7, the CR value of each latent variable is more significant than 0.7, and the AVE value of each latent variable is more significant than 0.5, which demonstrates high convergent validity for the measurement model.

The AVE value is utilized to assess the discriminant validity of a measurement model. Consider the case where the square root of the AVE value for each latent variable is greater than the absolute value of the correlation coefficient between this latent variable and other latent variables. Thus, the measurement model could be considered to have a high degree

of discriminant validity [61]. In Table 4, the values on the diagonal are greater than the other values in the same row and in the same column as them, which represents that the square root of the AVE value of each latent variable is greater than the absolute value of the correlation coefficient between the latent variable and other latent variables. These results indicate high discriminant validity for the measurement model.

Table 4. Results of the discriminant validity test.

Variable	GER	IER	DSN	ISN	SNK	CFRBs
GER	0.769 ¹					
IER	0.483	0.789				
DSN	0.107	0.117	0.728			
ISN	0.22	0.423	0.217	0.807		
SNK	0.231	0.333	0.134	0.594	0.763	
CFRBs	0.476	0.566	0.188	0.425	0.286	0.824

¹ The bold values represent the square root of the AVE value of each latent variable.

4.2. Model Fitness and Hypothesis Test

4.2.1. Test of Model Fitness

AMOS version 23.0 software is utilized in this study to conduct the model fitness test and hypothesis test. Table 5 shows indicators that evaluate the fitness of the SEM. The values of all indicators indicate a good fit and usability of the research model.

Table 5. Model fitting degree.

Index	Judgment Standard	Value	References
CMIN/DF	<3	1.494	Scott [62]
GFI	>0.9	0.944	Scott [62]
AGFI	>0.8	0.927	Scott [62]
RMSEA	<0.08	0.035	MacCallum et al. [63]
NFI	>0.9	0.946	Scott [62]
IFI	>0.9	0.981	Scott [62]
CFI	>0.9	0.981	Scott [62]
NNFI	>0.9	0.978	Scott [62]

4.2.2. Test of Direct Effect

The estimated results for the direct effects are shown in Table 6 and Figure 3. According to the results, guidance-based environmental regulations (GER), incentive-based environmental regulations (IER), and injunctive social norms (ISN) all have positive and significant effects on farmers' CFRBs. As measured by the Standardized Path Coefficient, the degree of influence is high to low: IER > GER > ISN, such that H1a, H1b, and H2b are supported. Direct effects of descriptive social norms (DSN) on farmers' CFRBs fail to pass the significance test, and H2a is not supported. IER has a positive and significant effect on ISN and H3d is supported. The effects of IER on DSN and GER on both types of social norms failed to pass the significance test, so H3a, H3b, and H3c are not supported.

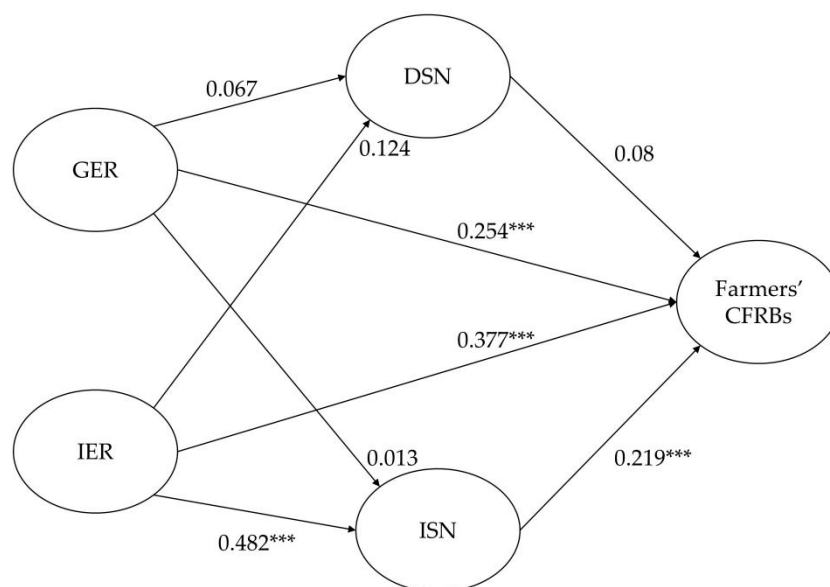
4.2.3. Test of Mediating Effect

According to the analysis in Section 2.4, environmental regulations can affect farmers' CFRBs directly and indirectly through social norms [64]. Social norms could act as a mediator variable [65]. The bootstrap method is utilized to scrutinize the mediating effect of social norms. According to Table 7, incentive-based environmental regulations (IER) can promote farmers' CFRBs indirectly through injunctive social norms (ISNs), so H4d is supported. In the relationship between IER and farmers' CFRBs, ISN plays a partially mediating role. The indirect effect of IER on farmers' CFRBs is smaller than its direct effect, indicating that it primarily promotes farmers' CFRBs through its direct effect. H3a, H3b, and H3c are not supported, so the mediating effects on the paths they represent are not available. As a result, H4a, H4b, and H4c are not supported.

Table 6. Direct-effect test results.

Hypothesis	Path	Standardized Path Coefficient	p-Value	Conclusion
H1a	GER → CFRBs	0.254 ***	0.000	Supported
H1b	IER → CFRBs	0.377 ***	0.000	Supported
H2a	DSN → CFRBs	0.08	0.076	Unsupported
H2b	ISN → CFRBs	0.219 ***	0.000	Supported
H3a	GER → DSN	0.067	0.356	Unsupported
H3b	IER → DSN	0.124	0.088	Unsupported
H3c	GER → ISN	0.013	0.843	Unsupported
H3d	IER → ISN	0.482 ***	0.000	Supported

Note: $n = 402$, *** $p < 0.001$.

**Figure 3.** Model path and estimated parameter results. Note: $n = 402$, *** $p < 0.001$.**Table 7.** Indirect-effect test results.

Type	Hypothesis	Path	Standardized Path Coefficient	p-Value	Conclusion
Total Effect	-	IER → CFRBs	0.493 **	0.005	-
Direct Effect	H1b	IER → CFRBs	0.377 ***	0.000	Supported
Indirect Effect	H4d	IER → ISN → CFRBs	0.116 **	0.005	Supported

Note: $n = 402$, ** $p < 0.01$, *** $p < 0.001$.

4.2.4. Test of Moderating Effect

SPSS version 23.0 software is utilized in this study to conduct a hierarchical regression analysis to assess the moderating role of social networks (SNK) in the effect of injunctive social norms (ISN) on farmers' CFRBs. For analysis, the mean score of the question items under each latent variable is substituted into the regression model. Firstly, the ISN and SNK are centralized and then substituted into the regression model to produce Models 1 and 2. Secondly, the product term of the centralized ISN and SNK is substituted into the regression model to produce Model 3. According to Wen et al. [66], if the determination coefficient in Model 3 is significantly greater than that in Models 1 and 2, or if the regression coefficient for the product term of ISN and SNK passes the significance test, this indicates that SNK moderates the impact of ISN on farmers' CFRBs. Table 8 reveals that Model 3 has a higher coefficient of determination than Models 1 and 2, and that the product term of ISN and SNK has a significant and positive regression coefficient, indicating that SNK acts as a positive moderator of the effect of ISN on farmers' CFRBs. Thus, the more robust farmers' social networks, the more injunctive social norms influence their CFRBs, and H5b is supported.

Since H2a is not supported in Table 6, the moderating effect on the path it represents will not exist. Therefore, H5a is not supported.

Table 8. Moderating effect test results.

Item	Model 1	Model 2	Model 3
ISN	0.425 **	0.395 **	0.420 **
SNK		0.051	0.106
ISN \times SNK			0.172 *
R ²	0.181	0.183	0.207
F-value	88.419 **	44.602 **	34.640 **

Note: $n = 402$, * $p < 0.05$, ** $p < 0.01$.

4.3. Multiple-Group Test

The results for the subgroup sample (Table 9) are similar to those for the total sample (Table 6). This indicates that the results of the empirical analysis are generally robust [55].

Table 9. Multiple-Group test results.

Hypothesis	Path	Small-Scale Citrus Growers ($n = 215$)			Large-Scale Citrus Growers ($n = 187$)		
		Standardized Path Coefficient	p -Value	Conclusion	Standardized Path Coefficient	p -Value	Conclusion
H1a	GER \rightarrow CFRBs	0.333 ***	0.000	Supported	0.198 **	0.007	Supported
H1b	IER \rightarrow CFRBs	0.299 **	0.001	Supported	0.43 ***	0.000	Supported
H2a	DSN \rightarrow CFRBs	0.037	0.541	Unsupported	0.167 *	0.026	Supported
H2b	ISN \rightarrow CFRBs	0.222 **	0.002	Supported	0.178 *	0.014	Supported
H3a	GER \rightarrow DSN	0.15	0.147	Unsupported	−0.021	0.834	Unsupported
H3b	IER \rightarrow DSN	−0.083	0.422	Unsupported	0.403 ***	0.000	Supported
H3c	GER \rightarrow ISN	0.001	0.988	Unsupported	0.026	0.771	Unsupported
H3d	IER \rightarrow ISN	0.511 ***	0.000	Supported	0.462 ***	0.000	Supported

Note: $n = 402$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

In spite of this, there are some differences between the two groups: first, the standardized path coefficients of H1a and H1b are significantly different between the two groups; second, the standardized path coefficients of H2a and H3b are significant only in the large-scale group, but not in the small-scale group.

5. Discussion

The results illuminate the impact of environmental regulations and social norms on farmers' CFRBs.

According to the results in Table 6, guidance-based environmental regulations and incentive-based environmental regulations are positive influences on farmers' CFRBs, in agreement with Du et al. [14] and Shi and Zhang [28]. As a result, H1a and H1b are supported. Most citrus growers have extensive skills and experience. As such, they are often willing to accept new technologies. Guidance-based environmental regulations can make citrus growers aware of chemical fertilizer reduction technologies, and incentive-based environmental regulations can reduce the cost of adopting chemical fertilizer reduction technologies for citrus growers. Therefore, both environmental regulations can effectively encourage citrus growers' adoption of chemical fertilizer reduction technologies.

In terms of social norms, Table 6 clearly shows that injunctive social norms have a positive impact on farmers' CFRBs and support H2b. These results are in agreement with those reported by Zeng et al. [11], Guo et al. [56], Qiu et al. [21], and Li et al. [15]. Chinese farmers are accustomed to obeying authority, which may explain these results. As a result, once activated, injunctive social norms can substantially influence farmers' behavior. It is surprising that CFRBs are not affected by descriptive social norms, and H2a is not supported. A possible explanation for this could be that the social environment

conducive to chemical fertilizer reduction has not yet been developed in rural China, so descriptive social norms cannot work.

The regression results in Table 6 support H3d. This is consistent with Shi and Zhang [28], who found that incentive-based environmental regulations have a positive influence on injunctive social norms. The results from Table 6 fail to support H3b. These results could be explained by the fact that the government may not have been able to create a social environment conducive to chemical fertilizer reduction in rural areas by relying solely on incentive-based environmental regulations. Moreover, the findings from Table 6 fail to support H3a or H3c. A possible explanation for these results could be that in today's rural China, the advocacy methods used by guidance-based environmental regulations are too rigid and not understood by the majority of farmers, so guidance-based environmental regulations may not be able to promote the formation of social norms that are conducive to reducing chemical fertilizer use.

Table 7 suggests that injunctive social norms partially mediate the relationship between incentive-based environmental regulations and farmers' CFRBs. Accordingly, H4d is supported. These findings are consistent with the study of Zeng et al. [11], who discovered that both external incentives and social norms can affect the environmental behavior of grain growers, and that external incentives can also indirectly affect farmers' environmental behavior through the activation of social norms. In the study, Li et al. [15] argued that governments could help farmers to deepen their understanding of organic fertilizer technology and apply it through the creation of positive social norms. These findings reveal that favorable social norms can significantly support the implementation of environmental regulations. H4b is not supported. This is in agreement with Reno et al. [38]. This could be due to the fact that incentive-based environmental regulations have little influence in rural China today. Most smallholders are not aware of incentive-based environmental regulations. Consequently, incentive-based environmental regulations cannot lead to the formation of descriptive social norms or enhance farmers' CFRBs through descriptive social norms. H4a and H4c are also not supported. These results can be explained by the fact that environmental protection advocacy in today's rural China is not evident. Using this type of advocacy, guidance-based environmental regulations cannot activate descriptive or injunctive social norms, nor can they improve farmers' CFRBs through these two kinds of social norms.

In Table 8, this study tests whether social networks moderate the relationship between injunctive social norms and farmers' CFRBs. These results in Table 8 indicate that injunctive social norms are more influential on farmers' CFRBs when their social networks are more robust. Therefore, H5b is supported. This is in agreement with Wang et al. [67] and Lyu et al. [45]. These results could be explained by the fact that Chinese farmers with robust social networks are more likely to obey authority. Consequently, incentive-based environmental regulations have a greater influence on them. In addition, H5a is not supported. This outcome is consistent with those of a study conducted by Zhang et al. [68], which discovered that social networks cannot influence farmers' pro-environmental behavior. Nevertheless, it contradicts both Wachenheim et al. [69] and Abdulai et al. [70]. These results could be explained by the lack of a social environment in China's rural areas conducive to chemical fertilizer reduction, so descriptive social norms are ineffective. Because of this, even farmers with robust social networks are not greatly affected by descriptive social norms.

The analysis results for the two sample groups differ in the multiple-group test. Firstly, while both types of environmental regulations have significant and positive effects on farmers' CFRBs in both groups of farmers, incentive-based environmental regulations have a much stronger impact than guidance-based environmental regulations on large-scale citrus farmers. On the other hand, the two types of regulations produce similar effects in the small-scale group. Some explanations for this can be discovered in the fact that current incentive-based environmental regulations are more favorable to large-scale growers, allowing them to enjoy more benefits than guidance-based regulations can provide.

By comparison, smallholders are restricted by policy conditions and can gain fewer benefits from incentive-based environmental regulations. Secondly, the impact of descriptive social norms on farmers' CFRBs is insignificant for the small-scale group and significant for the large-scale group. These findings can be explained by the fact that most large-scale farmers recognized and adopted CFRBs as well as formed an excellent social environment within their social circles, thereby facilitating the formation of descriptive social norms. Almost all of the large-scale citrus growers surveyed in this study were affected by this phenomenon. In their surveys, Qiu et al. [21] and Guo et al. [56] found a similar situation. In contrast, most small-scale citrus growers do not recognize CFRBs, so this phenomenon rarely occurs among them. Finally, incentive-based environmental regulations fail to have a significant effect on descriptive social norms in the small-scale group. However, it is significantly positive in the large-scale group. A possible explanation for this could be that the government, through incentive-based environmental regulations, creates a social environment that encourages large-scale farmers to reduce chemical fertilizer use. In contrast, since most smallholders do not have access to financial subsidies, the government is unable to create such a social environment for small-scale farmers. Ju et al. [71] discovered a similar situation when conducting their surveys.

6. Conclusions and Policy Implications

Institutions are considered crucial to influencing the production behavior of farmers. Environmental regulations and social norms are utilized as formal and informal institutions in this study. This study investigates how environmental regulations and social norms affect farmers' CFRBs using data from a survey of 402 citrus growers in four southern provinces of China. Moreover, it compares the effects of environmental regulations and social norms on CFRBs for citrus farmers of different sizes. These findings are summarized as follows. Firstly, guidance-based environmental regulations, incentive-based environmental regulations, and injunctive social norms have a significant impact on farmers' CFRBs. Secondly, injunctive social norms partially mediate the relationship between incentive-based environmental regulations and farmers' CFRBs. Social networks play a positive moderating role in the relationship between injunctive social norms and farmers' CFRBs. Thirdly, incentive-based environmental regulations affect large-scale farmers' CFRBs more than other factors. However, it does not have such an advantage for small-scale farmers. Finally, the impacts of descriptive social norms on farmers' CFRBs and incentive-based environmental regulations on descriptive social norms are significantly positive in the large-scale farmer group. In addition, neither effect is significant in the small-scale farmer group.

Below is an analysis of the theoretical contribution of the study. Firstly, this study analyzes farmers' CFRBs from a dual-institution perspective (environmental regulations and social norms), which amplifies the existing literature and gives a deeper understanding of the mechanisms that shape farmers' CFRBs. Secondly, the analytical model in this study explores the moderating role of social networks held by farmers, which has received relatively little attention in previous studies. Finally, this study can serve as a foundation for future research exploring Chinese agriculture-related institutions and their effect on farmers' productivity.

This study provides management and policymakers with practical suggestions for reducing agricultural chemical fertilizer use.

The Chinese agri-environmental regulators must recognize that the current conditions for applying incentive-based environmental regulations are too high for smallholders to benefit from them. For example, in Sichuan, China, farmers who grow more than 3.33 ha of citrus are eligible to apply for drip fertigation system subsidies. On the other hand, more than 90% of farmers grow citrus on less than 3.33 ha, so they are not eligible for this subsidy [52]. To increase smallholders' motivation to participate in agricultural chemical fertilizer reduction initiatives, policymakers should lower the threshold for applying incentive-based environmental regulations.

The grassroots government administrators should use environmental advocacy methods that farmers can easily understand to create a social environment conducive to chemical fertilizer reduction initiatives in rural areas. For example, Sichuan Province has a long culture of opera arts. Maybe they can arrange opera arts performances in the content of policy publicity. This policy publicity would facilitate the emergence of descriptive social norms, which, once established, might lead to farmers accepting CFRBs implicitly.

It is essential for grassroots government managers to recognize the significant role that social networks play in Chinese rural society when implementing chemical fertilizer reduction initiatives in agriculture. The government could, for instance, set up demonstration farmers for chemical fertilizer reduction in each village, hire full-time technicians to guide farmers in fertilization, and hold regular technology exchange sessions. Through these measures, the ties between farmers and agricultural technicians would be strengthened, the moderating role of social networks would be utilized, and the positive influence of social norms on farmers' CFRBs would be reinforced.

There are some limitations to this study. Firstly, the research subjects of this study are only citrus growers in southern China. Nevertheless, this research could be expanded in the future to include other cash crops such as tea and watermelon. Secondly, some scholars believe the share of non-farm income in total household income significantly influences farmers' behaviors [72,73]. Due to limited data resources, this study fails to scrutinize the differences in CFRBs of farmers with different levels of household non-farm income; therefore, future studies should explore these differences.

To make up for the limitations of this study, the authors of this paper will conduct additional studies in the future. Because chemical fertilizers pollute not only soil but water and air, in further studies the farmers' perceptions of the overall impact caused by excessive chemical fertilizers must be assessed, as well as their willingness to reduce the fertilizer use. Moreover, similar approaches need to be tested for other main crops such as tea and watermelon, and the chemical fertilizer reduction behaviors of farmers with different non-farm income levels should be compared to suggest strategies for promotion.

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