sustainability

MDPI

Article

Research on Government Regulations, Cognition and Farmers' Willingness of Straw-to-Field

Hong Chen, Haoyan Wang * and Yanqiu Li

College of Economics and Management, Northeast Forestry University, Harbin 150040, China; chenhong@nefu.edu.cn (H.C.); liyanqiu@nefu.edu.cn (Y.L.)
* Correspondence: wanghaoyan@nefu.edu.cn

Abstract: Contemporarily, the promotion and application of straw-to-field technology plays an important role in developing high-quality green agriculture, alleviating agricultural non-point source pollution and realizing the double carbon target. As the main subject of straw-to-field, a farmers' willingness directly determines their straw-to-field behavior. To explore the influencing factors of farmers' straw-to-field willingness and to improve the comprehensive utilization level of straw, this paper researches the relationship between government regulation, farmers' subject cognition and straw-to-field willingness based on the survey data of 733 farmers in Heilongjiang province, and it examines the mediating role of farmers' cognition in the process of government regulation affecting farmers' willingness of straw-to-field. The results evidence that policy incentives and administrative constraints affect farmers' willingness of straw-to-field by influencing ecological and technical cognition. However, farmers' cognition of the cost and benefit of straw-to-field is biased; thus, this factor cannot effectively transform the willingness of straw-to-field into action.

Keywords: straw-to-field; path analysis; cognition; government regulation

Citation: Chen, H.; Wang, H.; Li, Y. Research on Government Regulations, Cognition and Farmers' Willingness of Straw-to-Field. *Sustainability* **2023**, *15*, 9823. https://doi.org/10.3390/su15129823

Academic Editor: Michael S. Carolan

Received: 7 May 2023
Revised: 16 June 2023
Accepted: 17 June 2023
Published: 20 June 2023

1. Introduction

Scientific implementation of straw-to-field is harmless and is able to reduce greenhouse gas emissions, increase soil carbon inventory, and improve the regional atmospheric environment. Therefore, it is a significant instrument in effectively responding to global climate change, achieving dual-carbon goals, and developing green agriculture. According to practical experience, among the "five transformations" of straw (fertilizer, feed, base material, fuel and raw material), straw-to-field accounts for the largest proportion. It is also the most effective and realistic mode of straw resource utilization by farmers [1]. However, the straw-to-field market mechanism has not yet been formed because it has positive externalities and needs the guidance and support of the government. Countries worldwide have introduced a series of policies and regulations to encourage straw-to-field. Since 2018, the Indian government has implemented the "Zero Straw Burning" campaign. By providing loans, subsidies and mechanical equipment to farmers, farmers are encouraged to treat crop residues in a more environmentally friendly way, including actions such as straw-to-field and composting, so as to reduce environmental pollution and health hazards. Some American states and cities have passed legislation to prohibit or restrict farmers from burning straw. For example, California policymakers prohibit burning straw in most areas and encourage farmers to take more environmentally friendly measures. In 2015, Germany promulgated the policy of agricultural measures for reducing ammonia emissions and for protecting water quality, which encouraged farmers to implement straw-to-field, reduce burning and smoke pollution, improve soil quality and protect water quality. China is one of the largest agricultural countries in the world, and the resource of crop straw is constantly increasing. However, there are some problems in straw reuse, such as high recycling cost and low economic benefit, that need to be studied and solved as a whole. Since 2008, the government of China has successively issued a series of related policies to promote the

comprehensive utilization of straw, such as the implementation of straw-to-field. In 2022, the "Selected National Policies and Measures for Strengthening Agriculture, Benefiting Farmers and Enriching Farmers" was issued, encouraging farmers to take measures such as realizing straw-to-field, subsoiling soil preparation, reducing the amount of chemical fertilizers and pesticides, and applying organic fertilizers. In addition, subsidy funds were directly paid to households.

As the subject of straw-to-field, farmers' willingness directly affects the efficiency of straw-to-field; thus, the research on straw-to-field willingness and behavior has been widely concerned by scholars. The existing research is mainly focused on the influence of institutional, economic, social and technological exogenous factors on farmers' willingness for straw resource utilization. Firstly, the influence of mandatory government regulation, policy support, economic subsidies and other policy tools on farmers' straw-to-field technology adoption and its mechanism were studied [2–5]. Secondly, the effect of straw-to-field technology from the perspective of cost and benefit was explored [6–8]. Thirdly, the influence of social and environmental habitual systems on farmers' straw-to-field willingness and behavior, such as a social network [9–13], institutional trust [14], and neighborhood effect [15,16], were topics of focus regarding farmers' straw-to-field technology adoption behavior and willingness. On the other hand, the behavior and willingness of straw resource utilization were studied regarding their endogenous factors. Firstly, based on the theory of planning behavior, the formation mechanism of straw resource utilization behavior of the farmers [17,18] was analyzed from the aspects of the farmers' attitude, subjective norms, perceived behavior control and moral responsibility. Secondly, the characteristics of farmers, resource endowment, income change, land scale and farmland rights determination were studied [19–21]. Thirdly, the shadow of farmers' risk preference and risk perception on the adoption behavior of straw recycling technology were studied [22–24].

Throughout the existing literature, scholars have obtained rich research results on farmers' straw-to-field willingness and on the application of straw-to-field technology, among which most of the studies on government behavior directly affect farmers' technology adoption behavior. However, there is still room for expansion in the deficiency of path analysis of farmers' straw-to-field willingness. Accordingly, government regulation, subject cognition and farmers' straw-to-field willingness are incorporated into a unified analysis framework in this paper, which takes into account government behavior and farmers' cognitive factors to supplement existing research deficiencies, reveals the functional path of government behavior, and improves the analysis framework of farmers' straw-to-field behavior. Secondly, according to the social cognition theory as well as the two aspects of outcome expectation and self-efficacy, this paper builds a farmer's subject cognition system with four dimensions of cognition: ecological, technical, cost and benefit. Further, the influence of the government's demonstration, subsidies and punishment constraints on farmers' straw-to-field willingness was further discussed, and the effective path of government regulation on farmers' straw-to-field willingness to farmland was tested by influencing farmers' subject cognition. Thus, this paper reveals the functional mechanism of policy incentives and administrative punishment constraints on farmers' straw-to-field willingness and provides useful reference for improving farmers' straw-to-field willingness, implementing local government straw-to-field policy support, and expanding policy effects.

2. Theoretical Analysis and Research Hypothesis

2.1. Government Regulation and Farmers' Straw-to-Field Willingness

Government regulation refers to the government's exercise of rights to restrict or restrain economic activities. Government regulation is divided into three dimensions, namely, incentive, constraint and guide [25]. At present, the government's regulation of straw-to-field is mainly incentive and restraint; thus, this paper discusses the influence of government regulation on straw-to-field from the two aspects of incentive and constraint regulation. Incentive regulation supports straw-to-field behavior through economic subsidies and other measures, internalizes the cost, and enhances the initiative of farmers.

Constraint regulation raises the cost of violation through administrative punishment and other measures, forcing farmers to implement straw-to-field.

The theory of planned behavior (TPB) was proposed by Ajzen (1991) on the basis of the theory of reasoned action, which holds that behavioral attitude, subjective norms and perceived behavioral control affect behavioral willingness and decision making. Generally speaking, behavioral attitude is the subjective judgment of the object of behavior. The doer adheres to the principle of "pursuing advantages and avoiding disadvantages" and tends to bring about "good" changes. Subjective norms are the perception of social pressure. Individual decision making is affected by the pressure of the surrounding environment, including public opinion and policy incentives and constraints. Perceived behavior control is a judgment of the degree of difficulty to implement behavior, and there is more will to adopt technology that is easy to master. Based on the theory of planned behavior, many scholars have discussed the behavioral willingness of farmers, such as the study on farmers' willingness to participate in understory economy [26], the study on the influence of farmers' willingness to withdraw from homestead [27], the willingness of agricultural insurance [28] and the willingness of sewage treatment [29].

According to TPB, the government's policy incentives and administrative constraints constitute social pressure, and social pressure as an exogenous factor affects the willingness and decision of behavior. In the process of promoting straw-to-field projects, the government can guide farmers to conform to the policy guidance by means of publicity and subsidies. The government organizes straw-to-field publicity and training to guide farmers, which can help farmers to fully understand the policies and technologies, help farmers to overcome the obstacles in the process of straw-to-field, and reduce the energy and cost consumed by farmers in the process of mastering and adopting the technology. Subsidies can reduce the economic cost burdens of straw-to-field activities for the farmers, thus motivating farmers. Moreover, government supervision and punishment of straw burning can interfere with straw-to-field behavior through administrative coercion to curb the negative externalities. Based on the above analysis, this paper proposes the following hypothesis:

H1: *Policy incentives have a significant positive impact on farmers' straw-to-field willingness.*

H2: *The subject cognition of farmers has a significant positive effect on straw-to-field willingness.*

2.2. Subject Cognition and Farmers' Straw-to-Field Willingness

American psychologist Bandura introduced social cognitive theory (SCT) on the basis of traditional behaviorism personality theory. Based on social cognition theory, scholars build a cognitive influence factor model, interpret farmers' subject cognition from different perspectives, and analyze organic fertilizer implementation behavior [30], farmers' land circulation willingness [31], farmland share cooperation willingness, etc. [32]. According to SCT, subject cognition includes outcome expectation and self-efficacy. The interaction between subject cognition and social environmental factors affects the behavioral willingness and decision making of farmers. Based on the social cognition theory, this paper builds the subject cognition system from the two aspects of outcome expectation and self-efficacy.

Result expectation is the favorable or unfavorable prediction that the individual may take the result of a certain behavior, and that prediction affects the decision of willing behavior. The expectation of straw-to-field behavior results, on the one hand, is reflected in the expectation of external results. Specifically, farmers make a judgment on whether the ecological environment is improved after straw-to-field based on the understanding of the ecological environment, ecological science and green production, which are defined as ecological cognition in this paper. From the perspective of ecological cognition, compared with straw burning and disposal, straw-to-field can improve the ecological environment, reduce air pollution, and reduce fertilizer input, all with positive externalities. Farmers also have "ecological rationality" in production and operation; thus, ecological friendliness also promotes the willingness of straw-to-field.

As rational production subjects, relative to external outcome expectation, internal outcome expectation is the prediction that farmers weigh the cost and benefit. Cost cognition and benefit cognition are the farmers' recognitions of the expected result of straw-to-field technology adoption and the farmers' balance of benefits and losses on straw-to-field. In the process of straw-to-field, mechanical use and manual input constitute the cost structure. The stronger the farmers' cognition of cost payment, the weaker their willingness to use it. As expected benefits, the returned subsidies, the improvement of organic crop yield and the soil fertility level after straw-to-field are expected benefits.

In social cognitive theory, self-efficacy is defined as "the judgment of an individual's self-ability to carry out a behavior". Combined with farmers' straw-to-field behavior, farmers' judgment of their understanding and mastery of straw-to-field technology is the embodiment of self-efficacy. Technical cognition is embodied in farmers' information acquisition, training guidance and mastery of straw-to-field technology. From the perspective of technological cognition, the more farmers know about the technology of straw-to-field, the more available, applicable and easy it is to master it, and the more active they are in adopting it.

In summary, based on SCT, this paper builds a farmer's cognition system from the aspects of outcome expectation and self-efficacy, including four dimensions of ecological cognition, cost–benefit cognition and technological cognition, and it proposes the following hypothesis:

H3: *Subject cognition has a significant positive impact on farmers' willingness of straw-to-field.*

2.3. Government Regulation, Subject Cognition and Farmers' Straw-to-Field Willingness to Farmland

Based on SCT, on the one hand, farmers' subject cognition is affected by the external environment. Through observation and learning, farmers' belief in their own ability, namely self-efficacy, is strengthened, and self-efficacy directly affects the willing behavior. On the other hand, willingness behavior is influenced by goal setting and outcome expectation [33]. Self-efficacy promotes farmers' pro-environment behavior [34]. Good outcome expectation can promote green production, such as rational fertilization and enhancement of conservation tillage willingness [35]. At the same time, farmers' subject cognition in straw-to-field decisions will also change through external and internal interaction effects. Generally speaking, as external environmental factors, the stronger the role of policy incentives and administrative constraints, the stronger the impact on farmers' cognitive levels in all dimensions, i.e., policy incentives and administrative constraints may directly affect farmers' straw-to-field willingness to the land but also may affect farmers' subject cognition. Considering the aforementioned arguments, this paper proposes the following hypothesis:

H4: *Subject cognition (ecological cognition, technology cognition, cost cognition and benefit cognition) is the intermediary variable between government regulation and straw-to-field willingness.*

Based on the above hypothesis, the research framework is constructed as shown in Figure 1.

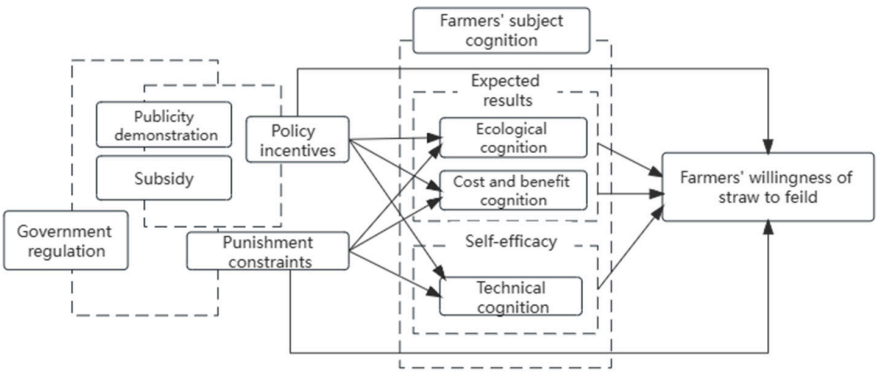

Figure 1. Research framework.

3. Data Sources, Description of Variables, and Model Selection

3.1. Variable Setting

For the willingness of farmers to straw-to-field, this paper sets the question "are you willing to participate in straw-to-field" in the questionnaire. The government regulation is mainly reflected in two aspects: policy incentive and administrative constraint, among which the policy incentive includes project publicity and financial subsidy. The subject cognition of farmers includes self-efficacy and outcome expectation. From the four dimensions of ecological, technical, cost and benefit cognition, 1–3 questions are measured through the scale form, and the weighted average of each dimension and the total score of the subject cognition of farmers are calculated by the entropy weight method. The specific variable settings are shown in Table 1.

Table 1. Variable setting and value assignment.

	Variable Name	Definition and Assignment	Mean	Standard Deviation
	Farmers' willingness of straw-to-field	Are you willing to participate in straw-to-field: willing = 1; unwilling = 0	0.597	0.491
Government regulation	Policy incentives	Do you know anything about the straw-to-field subsidy? Know = 1; not knowing = 0	0.842	0.370
		How are you satisfied with the straw comprehensive utilization policy subsidy? Satisfied = 3; general = 2; dissatisfied = 1	2.397	0.782
		Has any information about straw-to-field been obtained from government sources? Yes = 1; No = 0	0.877	0.328
	Administrative constraints	Has the local government imposed severe penalties for burning straw? Yes = 1; No = 0	0.774	0.419
Self-efficacy	Technical cognition	Do you know the corn straw-to-field operation method? Yes = 1; No = 0	0.895	0.740
		Do you know the rice straw-to-field operation method? Yes = 1; No = 0	0.992	0.646
Expected result	Ecological cognition	What are the changes in the surrounding ecological environment after straw-to-field? Get better = 3; Constant = 2; Poor = 1	2.694	0.514
		What are the changes in disease resistance of land after straw-to-field? Get better = 3; Constant = 2; Poor = 1	2.556	0.629
		What are the changes in fertilizer after straw-to-field? Less = 3; less = 2; more = 1	2.425	0.677
	Cost cognition	What are the costs of straw-to-field, such as labor costs, agricultural machinery costs and other costs (per mu)?	37.979	51.453
	Benefit cognition	What are the changes in land disease resistance after straw-to-field? Change = 3; constant = 2; Poor = 1	2.563	0.569
		What are the changes in organic crop yield after straw-to-field? More = 3; constant = 2; less = 1	2.569	0.618

3.2. Data Source

The data used in this study were collected from 60 villages and towns in Harbin, Suihua, Jiamusi and Qiqihar in Heilongjiang province from March to May 2022. Heilongjiang province is China's important commodity grain base, with fertile black soil, and it is the "ballast stone" of national food security. In June 2021, *The Implementation Plan of National Land Protection Project (2021–2025) has issued*, which emphasized the protection of black land in suitable areas in Northeast China through straw crushing and deep-turning. The 60 villages investigated in this paper are the key grain production areas in Heilongjiang province, which can reflect the overall agricultural production characteristics of Heilongjiang province and have certain regional representativeness and typicality. The contents of the survey mainly included the basic information of farmers, their families, their willingness of straw-to-field, and their subject cognition, etc. A total of 820 questionnaires were issued. Excluding the rejected or invalid questionnaires (when any item is missing in the returned questionnaires, they are defined as invalid questionnaires), 733 valid questionnaires were collected, with an effective recovery rate of 89.39%.

According to the questionnaire data, the respondents were mainly men, accounting for more than 80% of the agricultural production, mostly in family units. It can be seen that men as the main labor force are the decision makers of agricultural production. The age of the surveyed farmers was concentrated between 40 and 50 years old, accounting for 47.2%, and those over 50 years old accounted for 36.4%. The educational level of the respondents was low, with 82% of them having attained a junior high school education or lower. The number of family members was mostly three or less, accounting for 71.8%. In terms of income, the annual household income was mostly concentrated between 50,000 and RMB 100,000 (considering an exchange rate of 1 USD to 7 RMB, and the income ranged from USD 7142 to 14,258). The survey findings demonstrate a high degree of correspondence with the data of the actual situation of the study area, and the research results are scientific and referential (Table 2).

Table 2. Basic characteristics of the sample farmers.

Statistical Index	Classification Index	Frequency	Percent (%)	Statistical Index	Classification Index	Frequency	Percent (%)
Gender	Female	102	13.9	Age	Under 30	27	3.7
	Male	631	86.1		31–40	94	12.8
Education level	Primary school and below	76	10.4		41–50	346	47.2
	Junior high school education	525	71.6		51–60	215	29.3
	Junior college or above	61	8.3		61 years old and above	52	7.1
	High school degree	72	9.8	Family annual income/yuan	20,000–50,000	308	42.0
Number of family members	Three or less	527	71.8		20,000 and less	19	2.5
	Four to six	205	28.0		50,000–100,000	339	46.2
	Seven or more	2	0.2		More than 100,000	68	9.3

3.3. Model Setting

The structural equation can deal with both latent variables (ideas that cannot be directly measured) and observed variables, and it is suitable for modeling abstract concepts such as personal attitude and personal norms and wishes and has been widely used in recent years. The structural equation model is a data analysis method for establishing, estimating, and testing causality models that are mostly used in economic, social and psychological research. Scholars have used structural equations to study the ecological service system and farmers' production behavior [36]. In this study, structural equations were used to express the causal relationship between farmers' willingness of straw-to-field, government regulation and farmer subject cognition. We conducted the path analysis

according to the latent variables, verified the model fit, and explored the optimization path. The structural model expression is as follows:

$$\eta = B\eta + \Gamma\xi + \zeta, \quad (1)$$

where ξ is the matrix of exogenous variables; η is the endogenous variable matrix; B is the structural coefficient matrix, representing the influence of the endogenous variable matrix η; Γ is the structural coefficient matrix, representing the influence of the exogenous variable matrix ξ on the endogenous variable matrix η; and ζ is the residual matrix.

4. Results Analysis

4.1. Reliability and Validity Test

To test whether the questionnaire information is suitable for extracting information, the internal consistency of the questionnaire scale was measured with the Cronbach's α coefficient, using the KMO value and the Bartlett spherical test to test the validity of the questionnaire. The test results showed that the Cronbach's α coefficient of each item was greater than 0.6, indicating that the reliability quality of the data was acceptable. Validity was verified using KMO and Bartlett tests, the results showed KMO values greater than 0.7, and the study data were suitable for extracting information with good validity.

4.2. Government Regulation, Subject Cognition and Willingness of Straw-to-Field

In order to test the effect path of government regulation of external factors and subject cognition of internal factors on farmers' willingness of straw-to-field, a structural equation containing government regulation, subject cognition of farmers and their willingness of straw-to-field was first constructed, and path regression analysis was conducted. The regression coefficient is shown in Table 3, where it is evident that policy incentives and subject cognition have significant effects on farmers' willingness of straw-to-field. It can be seen that policy incentives such as straw-to-field policy publicity and fiscal subsidies can affect farmers' willingness of straw-to-field, which is consistent with the expectation, verifying hypothesis H1. Subject cognition, as an endogenous factor, also plays a significant role in straw-to-field willingness, which verifies hypothesis H3. The effective path of administrative constraints on straw-to-field willingness is not significant, which can be understood as that. Although administrative constraints and punishment restrict farmers' behaviors such as straw burning and abandonment with coercive force, the coercive constraint does not improve farmers' straw-to-field willingness. The underlying rationale can be explained by the fact that, on the one hand, the straw-to-field willingness depends on the consciousness and self-discipline formed by deep cognition, while the effect of other rules is not good. On the other hand, farmers themselves do not understand the implementation rules of the policy, and the straw-to-field understanding is not sufficient.

Table 3. Pathway coefficient estimation results.

Path	Standardized Path Coefficient	*p* Value	Hypothesis
Policy incentives --> Straw-to-field willingness	0.128 **	0.015	H1
Administrative constraints --> Straw-to-field willingness	0.128 **	0.171	H2
Subject cognition --> Straw-to-field willingness	0.128 **	0.000	H3

Note: GFI = 1.000, RMSEA = 0.000, CFI = 1.061, NFI = 1, TLI = 1.092; the model has a good fit. ** shows that the coefficient values are significant at 5%.

4.3. Cognition of the Mediating Effect of Policy Incentives on Farmers' Straw-to-Field Willingness

In order to further examine the mechanism of exogenous factors and endogenous factors on straw-to-field willingness and the mediating role of endogenous factors' subject cognition, this paper constructed a structural equation of policy incentive, subject cognition and willingness of straw-to-field. Firstly, the influence path was initially constructed according to the theoretical model, and then, the model was modified according to the MI

index combined with the theory. After the modification, the fit degree of the model was greatly improved, and the final path analysis results are shown in Table 4 and Figure 2.

Table 4. Results of pathway analysis estimation.

Path	Standardized Path Coefficient	*p* Value	Path	Standardized Path Coefficient	*p* Value	Hypothesis
Policy incentives --> Technology cognition	0.198 ***	0.000	Technical cognition --> Straw-to-field willingness	0.162 ***	0.001	H3, H4
Policy incentives --> Ecological cognition	0.250 ***	0.000	Ecological cognition --> Straw-to-field willingness	0.102 *	0.058	H3, H4
Policy incentives --> Cost cognition	−0.065	0.194	Cost cognition --> Straw-to-field willingness	0.056	0.262	H3, H4
Policy incentives --> Benefit cognition	0.216 ***	0.000	Benefit cognition --> Straw-to-field willingness	0.074	0.181	H3, H4

Note: χ^2/df = 3.402, GFI = 0.980, RMSEA = 0.078, CFI = 0.920, NFI = 0.896, AGFI = 0.931; the model has a good fit. ***, * shows that the coefficient values are significant at 1% and 10%, respectively.

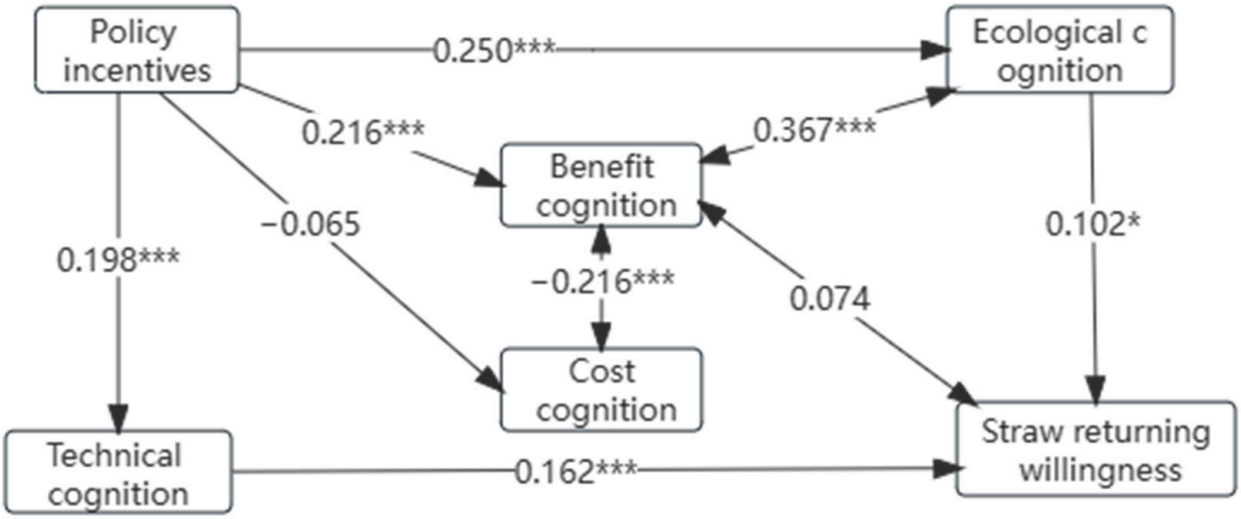

Figure 2. Pathway analysis chart of policy incentives affecting straw-to-field willingness. Note: → Indicates the influence relationship and ←→ indicates the relevant relationship. ***, * shows that the coefficient values are significant at 1% and 10%, respectively.

The path coefficients of ecological cognition and technological cognition of farmers' main cognition as intermediary factors are significant (Figure 2). Specifically, the path of policy incentives --> ecological cognition --> straw-to-field willingness is significant, which indicates that the hypothesis that policy incentives have an effect on farmers' willingness by guiding the formation of farmers' ecological cognition is established. The stronger the policy incentives, the stronger the promoting effect on the formation of farmers' ecological cognition, and the stronger the ecological cognition can significantly promote the improvement of straw-to-field willingness. The path of policy incentive --> technology cognition --> straw-to-field willingness is significant at the 1% level, which indicates that the government's publicity and subsidy behavior can help improve technology cognition and thus the willingness of straw-to-field, and the policy incentive can guide farmers to understand the technology of straw-to-field. The mediating effect of cost cognition and benefit cognition between policy incentives and farmers' straw-to-field willingness is not significant. The underlying rationale that is attributable to farmers' correct understanding of policy incentives and straw-to-field has yet to be formed. At the present stage, farmers cannot reasonably estimate the cost and correctly view the expected benefits of straw-to-field regarding their own agricultural production and management. The cognitive

bias results are such that the cognition of cost and benefit cannot be converted into the straw-to-field willingness.

4.4. Mediation Effect of Cognition on Farmers' Straw-to-Field Willingness under Administrative Constraints

Government regulation includes two aspects: incentive and punishment. The purpose of administrative constraint, as a punishment mechanism, is to restrain the behavior of farmers' straw resource utilization. In the above basic model, the direct effect of administrative constraint on the straw-to-field willingness is not significant. However, it may still have influence on the cognition of farmers and then the straw-to-field willingness. In order to verify the intermediary role of farmers' cognition, in this paper, a path analysis model was constructed again. The results are shown in Table 5 and Figure 3.

Table 5. Pathway analysis results.

Path	Standardized Path Coefficient	*p* Value	Path	Standardized Path Coefficient	*p* Value	Hypothesis
Administrative constraints --> Ecological cognition	0.110 ***	0.003	Ecological cognition --> Straw-to-field willingness	0.170 ***	0.000	H3, H4
Administrative constraints --> Benefit cognition	0.263 ***	0.000	Benefit Cognition --> Straw-to-field willingness	−0.076	0.036	H3, H4
Administrative constraints --> Technical cognition	−0.080 ***	0.000	Technical Cognition --> Straw-to-field willingness	0.393 ***	0.000	H3, H4

Note: $\chi^2/df = 4.928$, GFI = 0.987, RMSEA = 0.073, CFI = 0.952, NFI = 0.941; the model has a good fit. *** shows that the coefficient values are significant at 1%.

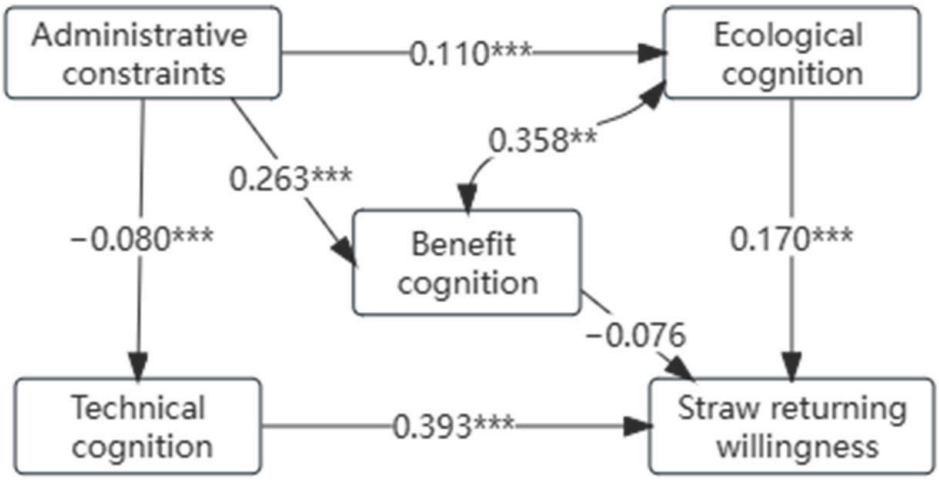

Figure 3. Pathway analysis diagram of administrative constraints affecting the willingness of straw-to-field. ***, ** shows that the coefficient values are significant at 1%, 5% respectively.

It can be seen that although administrative constraints have no direct impact on straw-to-field willingness, they affect the straw-to-field willingness through ecological cognition and technical cognition. The path of administrative constraint --> ecological cognition --> straw-to-field willingness was significant, which indicates that administrative constraint promoted the formation of farmers' cognition about the ecological impact of straw-to-field to farmland through coercive force, and the formation of cognition was conducive to the enhancement of willingness of straw-to-field. The method of administrative coercive force restrains farmers' behavior of burning and discarding straw and makes farmers change their cognition of the benefit of straw-to-field. The path of administrative constraints --> technical cognition --> straw-to-field willingness is significant at the 1% level, and the impact of administrative constraints on technical cognition is significantly negative. It can be understood that farmers pay more attention to whether their behaviors

are compliant and ignore the technical characteristics of land return technology itself under the government regulation constraints. However, with the deepening of farmers' cognition of straw-to-field technology, farmers' willingness of straw-to-field will be significantly improved. In addition, in the face of government administrative constraints, "economically rational" farmers paid more attention to economic benefits such as increased organic crop yield and improved soil fertility after straw-to-field, but the cognition of economic benefits failed to be effectively converted into the willingness of straw-to-field, which can be seen from the expected effect of farmers on straw-to-field. There are still cognitive biases in the understanding and feeling of application value.

5. Discussion

Promoting straw-to-field is an effective way to achieve carbon neutrality and a necessary measure to improve agricultural non-point source pollution and to promote green development [37]. The straw of crops is rich in carbon, and adding straw to farmland will increase soil organic carbon [38]. Straw-to-field can also offset greenhouse gas emissions [39,40]. Both policy incentives and administrative intervention will affect farmers' willingness of straw-to-field [41]. As the direct decision maker of straw treatment, it is of great significance for farmers to explore their willingness of straw-to-field and its influencing factors. Clarifying the path of government regulation, farmers' cognition and willingness of straw-to-field is helpful for implementing the policy accurately and for improving the policy efficiency. Based on the theory of planned behavior and social cognition, this paper reveals the action path of exogenous factors such as government regulation on farmers' willingness of straw-to-field, verifies the path of government regulation (incentive and punishment --> technology and ecological cognition --> willingness of straw-to-field), and reveals the endogenous and exogenous factors of farmers' willingness of straw-to-field.

According to the above analysis, we can see that government incentives and administrative constraints have an impact on farmers' willingness of straw-to-field through two intermediary variables: ecological cognition and technical cognition. From the perspective of ecological cognition, on the one hand, policy incentives guide farmers to correctly understand the ecological value of straw-to-field, which is helpful for enhancing the willingness of straw-to-field. The improvement of the ecological environment, the reduction of chemical fertilizer and other green production that are in conformity with the characteristics of ecological rationality of farmers, and their willingness of straw-to-field will increase with the deepening of their cognition. On the other hand, as a binding government regulation, punishment not only restricts farmers' behavior of straw-to-field, but also restricts farmers' incorrect ecological cognition, which drives and guides farmers to form correct ecological cognition.

Technological cognition is also an important intermediary variable. From the perspective of production theory, technology changes the production function and improves the production efficiency of labor and capital. According to the rational behavior theory, the optimal decision of farmers is to maximize profit, and a comprehensive and in-depth understanding of the information related to straw-to-field technology can help farmers grasp the important value of straw-to-field, including the expansion of their own benefits and the positive impact on the outside, and thus promote the improvement of straw-to-field willingness.

This paper enriches the theoretical application of planned behavior theory and social cognition theory in the field of agricultural economy and provides a theoretical basis for the government to take targeted measures to promote straw-to-field. In consideration of the limitation of article length, there are some shortcomings in this study, which should be expanded in future research. Firstly, because the samples were selected from 60 towns and villages in key agricultural production areas in Heilongjiang province, although the investigation procedures were strictly followed, the survey objects were selected in a narrow range, which did not cover the major grain-producing provinces or producing areas in China. Accordingly, the research conclusion has certain limitations when it is widely

applied to other similar regions in China. In addition, in terms of policy incentives to the selection of policy intervention indicators, it is possible to refine the indicators, which is the direction of future research.

6. Conclusions and Enlightenment

Based on the survey data of 733 farmers in Heilongjiang province, this paper analyzes the path by constructing a structural model, reveals the influence mechanism of policy incentives and administrative constraints on farmers' willingness of straw-to-field, and focuses on the intermediary effect of farmers' subject cognition in the process of government regulation affecting farmers' willingness of straw-to-field.

The study found that, firstly, policy incentives have a significant role in promoting farmers' willingness of straw-to-field, and the government's publicity, training and subsidies can effectively enhance farmers' willingness of straw-to-field. Secondly, farmers' subject cognition plays an intermediary role between policy incentives and willingness of straw-to-field, in which policy incentives can effectively guide the formation of farmers' ecological cognition and technical cognition and then promote the willingness of straw-to-field. Thirdly, although administrative constraints do not directly have a significant impact on farmers' willingness of straw-to-field, they affect farmers' willingness of straw-to-field through their subject cognition, among which administrative constraints promote farmers' willingness of straw-to-field through influencing ecological cognition. In addition, farmers' cognition of cost and benefit is biased, which has not been effectively translated into the willingness of straw-to-field.

Based on the above research conclusions, this paper draws the following enlightenments: focusing on the implementation of straw-to-field policies; taking ecological cognition, technical cognition and farmers' benefit cognition as important policy references to promote straw-to-field; and paying attention to the improvement of farmers' main cognitive level to provide precise, effective and effective policy support for straw-to-field. Firstly, we combined the actual needs of farmers and the actual situation of the countryside to carry out straw-to-field publicity. For example, we used the form of "small hand pulling big hand" to allow straw-to-field publicity into the campus, and we allowed the children to guide the family to improve the cognition of straw-to-field. Secondly, new media such as WeChat, short videos and public WeChat accounts should be used to widely publicize straw-to-field technology and its technical advantages, give full play to the advantages of rural interpersonal network, and learn knowledge related to comprehensive utilization of straw and environmental protection by organizing groups of neighbors and relatives to guide farmers to improve their cognition level of ecological environment protection and to understand the endogenous driving force of improving ecological benefits of straw-to-field. Thirdly, the technical training of the straw-to-field project should be strengthened to enhance the technical cognition of farmers on the comprehensive utilization of straw, so that they can fully realize the operability and advantages of straw-to-field in technology, guide farmers to understand the value of straw-to-field objectively and fully, evaluate the cost and benefit of straw-to-field correctly, and then make a scientific and accurate choice. Instead of taking punishment as the ultimate goal, it is necessary to overcome the single administrative restraints such as hard rules and economic punishment, and give play to the role of villagers' autonomous organizations. We explored the village collective use of public opinion pressure to strengthen supervision and punishment, praised farmers who have made good progress in straw-to-field and organize learning in the village, and improved the knowledge level and self-discipline of farmers related to straw-to-field.

Author Contributions: Conceptualization, H.C. and H.W.; methodology, Y.L.; software, Y.L.; validation, H.C., H.W. and Y.L.; formal analysis, H.C.; investigation, H.W.; resources, H.C.; data curation, H.W.; writing—original draft preparation, H.W.; writing—review and editing, Y.L.; visualization, Y.L.; supervision, H.C.; project administration, H.C.; funding acquisition, H.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National Social Science Foundation of China (22BJY089), Philosophy and Social Sciences Research Foundation of Heilongjiang Province (21JYB149), Central University Special Foundation of China (2572022DE01), and Key Open Project of Think Tank of Colleges and Universities in Heilongjiang Province (Think Tank of Modern Forestry and Carbon Sink Economic Development): Study on the Kinetic Energy Conversion Mechanism and Realization Path of Green Grain Production in Heilongjiang Province.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Chen, Y.; Xia, X.; Yang, L. Straw-to-field is a realistic way to achieve straw resource utilization. *Soil Fertil. China* **2020**, *6*, 299–307.
2. Gai, H.; Yan, T.; Zhang, J. Study on the willingness of farmers' environmental friendly technology adoption based on the hierarchical perspective—Take straw to field to the field as an example. *J. China Agric. Univ.* **2018**, *23*, 170–182.
3. Yao, K.; Chen, L.; Liu, Z. The influence of peasant household endowment, policy factors and crop types on straw to field technology adoption decisions. *Agric. Technol. Econ.* **2018**, *12*, 64–75.
4. Hellin, J.; Schrader, K. The incentives for alternative approaches to better use of straw in Swede. *Ecosyst. Environ.* **2003**, *21*, 237–245.
5. Mueller, W. The effectiveness of recycling policy options: Waste diversion or just diversions? *Waste Manag.* **2013**, *29*, 508–518. [CrossRef]
6. Stiglitz, J. Growth with Exhaustible Natural Resources: Efficient and Optimal Growth Paths. *Rev. Econ. Stud.* **1974**, *41*, 123–137. [CrossRef]
7. Simon, J.L. *The Economics of Population Growth*; Princeton University Press: Princeton, NJ, USA, 1977.
8. Zhang, Y.; Su, L. Benefit analysis of straw to field from cost-benefit perspective. China Population. *Resour. Environ.* **2022**, *32*, 169–176.
9. Qu, J.; Geng, M.; Wan, R.; Liu, X.; Chen, H.; Fu, G. Factors influencing the profitability of maize straw incorporation in northeast China. *Agron. J.* **2018**, *110*, 180–190.
10. Chen, J.; Li, J.; Luo, J.; Li, X.; Yuan, L. Social network analysis of farmer knowledge sharing on integrating crop straw to field with chemical fertilizer application in China. *Sustainability* **2019**, *11*, 6778.
11. Illa, C.; Robert, H.; Dennis, L.; Larry, M.; John, M.; Gibbe, P.; William, W. *Report of the Advisory Committee on Alternatives to Rice Straw Burning [R]*; Diane Publishing Company: Collingdale, PA, USA, 1997.
12. Jiang, W.; Yan, T. Study on Consistency of farmers' willingness and behavior of straw to field under dual wheel drive of ability and Opportunity: A case study of Hubei Province. *J. Huazhong Agric. Univ. (Soc. Sci. Ed.)* **2020**, *1*, 11.
13. Zhang, T.; Yan, T.; He, K. Effect of capital endowment on farmers' investment intention in green production: A case study of straw to field China Population. *Resour. Environ.* **2017**, *27*, 78–89.
14. Wang, X.; He, K.; Zhang, J. Analysis of farmers' willingness to adopt environment-friendly technologies and their heterogeneity: A case study of Hubei Province. *J. China Agric. Univ.* **2018**, *23*, 197–209.
15. Elahi, E.; Abid, M.; Zhang, H.; Cui, W.; Hasson, S.U. Domestic water buffaloes: Access to surface water, disease prevalence and associated economic losses. *Prev. Vet. Med.* **2018**, *154*, 102–112. [CrossRef]
16. Wang, Y.; Wang, P. Study on farmers' willingness to adopt straw to field based on planned behavior theory. *J. Henan Agric. Univ.* **2022**, *56*, 133–142.
17. Ajzen, I. The theory of planned behavior. *Organ. Behav. Hum. Decis. Process.* **1991**, *50*, 179–211. [CrossRef]
18. Zhi, J.; Yan, T. Technology perception, risk avoidance and farmers straw to field technology adoption behavior: Based on a survey of 1490 farmers in Hubei, Anhui and Hebei Provinces. *J. Arid. Land Resour. Environ.* **2021**, *35*, 74–80.
19. Lu, H.; Hu, L.X.; Zheng, W.W.; Yao, S.; Qian, L. Impact of household land endowment and environmental cognition on the willingness to implement straw incur—poration in China—ScienceDirect. *J. Clean. Prod.* **2020**, *262*, 121479. [CrossRef]
20. Gebrezgabher, S.A.; Meuwissen, M.P.M.; Kruseman, G.; Lakner, D.; Oude Lansink, A.G.J.M. Factors influencing adoption of manure separation technology in the Netherlands. *J. Environ. Manag.* **2015**, *150*, 1–8. [CrossRef]
21. Qiu, H.; Su, L.; Zhang, Y.; Tang, J. Risk preference, risk perception and farmers' adoption of conservation tillage technology. *China Rural Econ.* **2020**, *7*, 59–79.
22. Giannoccaro, G.; Gennaro, B.D.; Meo, E.D.; Prosperi, M.J.E.E. Assessing farmers' willingness to supply biomass as energy feedstock: Cereal straw in Apulia (Italy). *Energy Econ.* **2017**, *61*, 179–185. [CrossRef]
23. Bruijnis, M.; Hogeveen, H.; Garforth, C.; Stassen, E. Dairy farmers' attitudes and intentions towards improving dairy cow foot health. *Livest. Sci.* **2013**, *155*, 103–113. [CrossRef]
24. Zhang, J.; Yong, H. Research on the mechanism of government regulation on farmers' willingness to recycle plastic film—Based on the mediating effect of perceived value. *J. Arid. Land Resour. Environ.* **2022**, *36*, 90–98.
25. Cheng, Y.; Zeng, W.; Hu, Y. Analysis of Influencing Factors of farmers' willingness to participate in understory economy Based on Planned behavior theory. *Rural Econ.* **2021**, *11*, 62–69.

26. Niu, X.; Zhou, H.; Yu, Z.; Wu, G. Study on the Influence of Environmental perception on farmers' homestead withdrawal Intention from the perspective of Planned Behavior Theory: Based on the survey of farmers in the agriculture-related suburbs of Shanghai. *Chin. J. Agric. Resour. Reg. Plan.* **2022**, *43*, 141–149.
27. Sun, L.; Chen, S. Study on Insurance Intention, Insurance Behavior and Consistency of Agricultural Insurance—Based on deconstructed plan behavior theory. *Rural Econ.* **2021**, *11*, 70–77.
28. Wei, T.; Jin, L. The Influence of cognition on farmers' willingness to participate in the management and protection of domestic sewage treatment facilities: Based on the survey of farmers in the water source area of the middle route of South-to-North Water Transfer Project. *J. China Agric. Univ.* **2022**, *27*, 290–300.
29. Sang, X.; Luo, X.; Huang, Y.; Tang, L. Policy incentives, ecological cognition and farmers' organic fertilizer application behavior: A moderated mediation effect model. *Chin. J. Eco-Agric.* **2021**, *29*, 1274–1284.
30. Wu, M.; Gan, C.; Ren, L.; Chen, Y. Research on the Influencing factors of farmers' land transfer intention under the framework of distributed cognition theory: An empirical analysis of typical areas in Wuhan Urban Circle based on SEM model China Population. *Resour. Environ.* **2016**, *26*, 62–71.
31. Zhang, Y.; Gan, C.; Mei, Y. Analysis on the Influencing factors of Farmers' Participation in farmland stock Cooperative System Based on Social Cognition Theory: A Case study of Wuhan City. *Circ. Resour. Dev. Mark.* **2019**, *35*, 762–768.
32. Xu, X.; Lu, M. Research on purchasing behavior of Internet financial products based on Social cognition theory. *Soft Sci.* **2017**, *31*, 108–113.
33. Guo, Q.; Li, H.; Li, S. Analysis on the psychological driving factors of farmers' pro-environment behavior. *J. Arid Land Resour. Environ.* **2022**, *36*, 56–64.
34. Xiao, Y.; Qi, Z.; Yang, C.; Liu, Z. Social capital, ecological cognition and farmers' rational fertilization behavior: An empirical analysis based on Structural equation model. *J. China Agric. Univ.* **2021**, *26*, 249–262. (In Chinese)
35. Li, W.; Wang, G. Effects of social capital and technology cognition on the adoption behavior of farmers' conservation tillage technology in black soil region. *Chin. J. Eco-Agric. (Engl. Chin.)* **2022**, *30*, 1675–1686.
36. Liu, D.; Chen, H.; Zhang, H.; Shi, Q.; Geng, T. Impacts of ecosystem services on human well-being and population differences in Loess Hilly-gully region. *Geogr. Res.* **2022**, *41*, 1298–1310.
37. Yin, H.; Zhao, W.; Li, T.; Cheng, X.; Liu, Q. Balancing straw returning and chemical fertilizers in China: Role of straw nutrient resources. *Renew. Sustain. Energy Rev.* **2018**, *81*, 2695–2702. [CrossRef]
38. Kumar, A.; Nayak, A.K.; Sharma, S.; Senapati, A.; Mitra, D.; Mohanty, B.; Prabhukarthikeyan, S.R.; Sabarinathan, K.G.; Mani, I.; Garhwal, R.S.; et al. Rice straw recycling: A sustainable approach for ensuring environmental quality and economic security. *Pedosphere* **2023**, *33*, 15. [CrossRef]
39. Yang, Y.; Liang, S.; Yang, Y.; Xie, G.; Zhao, W. Spatial disparity of life-cycle greenhouse gas emissions from corn straw-based bioenergy production in China. *Appl. Energy* **2022**, *305*, 117854. [CrossRef]
40. Shi, W.; Fang, Y.R.; Chang, Y.; Xie, G. Toward sustainable utilization of crop straw: Greenhouse gas emissions and their reduction potential from 1950 to 2021 in China. *Resour. Conserv. Recycl.* **2023**, *190*, 106824. [CrossRef]
41. Li, G. Farmers' willingness to accept and influencing factors of straw-to-field: An empirical research based on cox proportional hazards model. *J. Agro-For. Econ. Manag.* **2018**, *17*, 54–62.