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Driving Mechanism of Farmers' Utilization Behaviors of Straw Resources—An Empirical Study in Jilin Province, the Main Grain Producing Region in the Northeast Part of China

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Abstract: In recent years, the unsustainable behaviors of straw utilization have led to waste straw being one of the sources of agricultural non-point source pollution. Studying the resource utilization of crop straw is conducive to expediate the development of ecological and green agriculture. More importantly, it has long-term significance for the recycling of agricultural waste, improving the quality of rural life, and the employment of farmers. Based on the theory of planned behavior (TPB), taking the representative survey questionnaire of farmers in Jilin Province, China as the sample, the structural equation model (SEM) was constructed to study the main factors that drive the utilization behaviors of straw resources of farmers and to explore the driving mechanism of the farmers behaviors in Jilin Province. The results show that the behavioral attitude and subjective norms of farmers in Jilin Province not only indirectly affect their actual behaviors through behavioral willingness, but also has significant direct effects on their behaviors. The most critical factors that affect the willingness of farmers to utilize the straw resources in Jilin Province are subjective norms and moral responsibilities. The subjective norms of farmers have a direct and significant positive impact on their willingness and behaviors. Behavioral attitude and perceived behavior control have a significant positive impact on their willingness. The behavioral willingness has a significant positive impact on their actual behaviors. This study provides guidance for the utilization of straw resources policy implications.

Keywords: farmer behavior; utilization of straw resources; driving mechanism; SEM

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1. Introduction

In traditional farmers' perspective, straw, as a by-product of crops, is a form of crop residue that is often used as kitchen fuel or to be burned directly. This view leads to a serious waste of resources, and it poses a threat to the environment and human health. The effective utilization of straw resources is an ecological project to reduce pollution and achieve sustainable development of agriculture [1]. Therefore, the sustainable usage of crop straw has already attracted worldwide attention.

Crop straw is mainly used as soil amendment, fertilizer, fodder, industrial raw materials, bio-gas, and for power generation in China [2]. At present, crop straw is mainly used as biofuels in four ways: power generation, gasification, liquefaction, and densification into briquette fuel [3,4]. The Chinese government aims to use 20% of the national crop straw waste for bioenergy production by 2030 [3]. By the end of 2019, the comprehensive utilization rate of straw resources reached 85.45% in China, in which the utilization rate of 10 provinces was over 90%, 9 provinces were over 85%, and nearly 50% of counties were over 90%. Farmers' utilization behavior of straw resources is affected by government policies, production habits, planting structure, the participation of rural official organizations, and other factors. Most farmers tend to utilize straw resources as fuel and feed [5,6]. In the Northeast part of China, corn stalks are crushed and returned to the fields to protect the black earth. However, since the amount of government subsidies is less than farmers' willingness to pay, the return rate of corn stalks is considerably low nationwide [7].

As a large country relying heavily on agriculture, India generates a large quantity of crop residue every year after harvest. Due to the high cost of sustainable treatment, a large amount of crop straw has been burned, which poses a serious threat to the environment and human health [8]. Restricted by the planting structure, the impact of burning corn straw is less than that of rice, wheat, and sugarcane in India [9,10]. The carbon emissions from agriculture account for nearly 75% in Ethiopia [11]. Most of the crop straw was burnt on the field, and the major methods of recycling the remaining straws in Ghana are as livestock feeds, fertilizers, cooking fuels, and as a substrate for mushroom planting [12,13].

The utilization rate of straw in developed countries is higher than that in most of the developing countries. American scholars have found that biobutanol is an alternative fuel that can be derived from corn straw. A large amount of collectible residues can be provided in the mid-West of the United States. It is estimated that the amount of biobutanol that can potentially be produced from corn residue is equivalent to 11.8% of its total domestic gasoline consumption [14]. Some scholars have also studied the optimization of biofuel production from both economic and environmental aspects and found that the bioethanol production from corn straw has the lowest cost and the least carbon emissions [15]. In Australia, wheat straw, oaten hay, and corn silage are used to produce biogas due to their rich content of lignocellulosic [16].

Scholars around the world have carried out comprehensive research on the efficient utilization of straw. Among them, the research on producing biofuels from corn straw is the most extensive. Corn stalk can be used to produce furfural and fermentable glucose for bioethanol production, which greatly reduces the reliance on fossil fuels in bioethanol production. Moreover, it is beneficial for environmental protection and sustainable development [17–21]. It was found that the hard reticular structure of corn straw lignin is the main issue that hinders the conversion of straw into biofuels [22]. Steam-assisted alkaline pretreatment and dilute acid, along with intensified thermal pretreatment, can improve the ethanol yield of corn stalk [23–25]. Under high temperature conditions, the extraction efficiency of ethanol fermentation from corn straw is the highest when an inoculum size of 5% has been used [20,26,27]. Corn straw fermentation can produce methane that can be used as fuel [28]; a coal briquette of corn straw blended with coal can reduce the ignition temperature and decrease combustion residues [29]. The combustion of corn straw blending with poultry manure or municipal sewage sludge can be made into biofuels with high economic value, significantly reducing the content of carbon, nitrogen, and sulfur oxides in pollutant emissions, which is of great significance for environmental protection [30–33].

Corn straw can be used to extract biomass composite fiber, which provides a simple and effective way for industrial production of new cellulose materials [34,35]. The block corn stalk with honeycomb structure is used as a green reducing agent and stabilizer, and the antibacterial block corn stalk can be used as interlayer filling material to produce environmentally friendly plywood [36]. Straw can also be used to produce biomass brick and fiber-cement. The composite building materials made from straw not only have the characteristics of good thermal insulation, they also minimize the reliance on natural building materials [37–41].

Straw can also be made into tubular cellulose material, which is used to replace thermal pasteurization to filter *Saccharomyces cerevisiae* and *Lactobacillus casei* in liquid food so as to avoid potential damage from heat treatment [42]. The corn residues after Lignocellulose production from straw fermented with *Trichoderma reesei* might be a good fertilizer to improve soil characteristics [43]. Straw, as an expansion agent in manure composting, increases the content of antibiotic resistant bacteria, increasing the temperature of manure fermentation reactor, and adjusting the ratio of carbon to nitrogen of fermentation degree which contributes to the efficacy of composting [44,45]. Mixed silage fermentation of sweet corn straw and lucerne can improve the quality of ensile [46]. Straw can also be used to produce activated carbon, which has good application potentials in the adsorption of volatile mixtures and hexavalent chromium [47–49]. The mixture of pyrolysis straw ash and melamine can be used to synthesize a catalyst for water electrolysis, which is of great significance to the development of new energy in the future [50].

Although straw has wide application prospects, straw is only the by-product of crops, and its final usage is directly affected by farmers' behaviors. Straw is usually burned directly in the field by farmers to reduce farming operations and to increase soil fertility [13,51]. In Ukraine, where agriculture is highly developed, renewable energy generation using crop residues as fuel is still less than 10% of the total generation [52]. The straw disposal behaviors of farmers are indirectly reflecting the decision-making cognition formed in the process of long-term adaptation and co-evolution between farmers and the surrounding objective environment [6]. Insufficient understanding of straw utilization alternatives, arable land area, farming system, government subsidies, cost-effectiveness of straw utilization, technologies of straw utilization, family income, etc., have significant impact on comprehensive utilization of straw [7,13,53–55].

In Apulia region (Southern Italy), farmers are more willing to sell their cereal straw on the feedstock market. The increasing demands with financial subsidies will raise the farmers' expectations on straw selling price [56]. The Chinese government provides compensation equivalent to 0.95% to 1.62% of the average family annual income to encourage farmers to participate in the energy utilization of straw. Moreover, the subsidies work better nowadays since farmers have higher monetary sensitivity [57,58]. The social media and interactions also have a significant impact on the willingness of farmers to accept the straw energy utilization, with both of them inter-linked with each other [5,57–59]. Krishna designed a uniform-price reverse auction and real payment system to incentivize the avoidance of open-field burning of rice straw by farmers in Nepal. He found that 86% of farmers agreed to refrain from burning rice straw with an average payment of $78.76/ha for paddy farm, which is equivalent to $13.17/ton in terms of reduction in carbon emissions [60].

At present, research on straw has been mainly focused on innovative applications in the chemical industry with less research on straw in the field of social science, and most of them focus on the research of farmers' willingness to adopt the sustainable utilization of straw resources. This paper introduces the theory of planned behavior (TPB) in social psychology and innovatively introduces moral responsibility as a latent variable to study the driving mechanism of farmers' behaviors of utilization of straw resources. Taking farmers in Jilin Province of China as the research object, this paper uses a structural equation model (SEM) to analyze the influencing mechanism of various factors on farmers' behaviors of utilization of straw resources and constructs a driving mechanism model of farmers' behaviors. The purpose of this paper is to identify the factors that restrict the utilization of straw resources and to provide theoretical guidance for the promotion and adoption of straw resources utilization policies.

2. Materials and Methods

2.1. Sample

This research is based on data collected through structural questionnaires, which were conducted from January to February in 2020 over a period of estimated 20 days. Questionnaires were randomly distributed to farmers from several representative cities and counties, e.g., Changchun, Liaoyuan, and Songyuan in Jilin Province, China, and the survey coverage was relatively wide, which covered our survey area. The behavior characteristics of farmers in each area were basically similar. A total of 140 field survey questionnaires were collected, and 101 valid questionnaires were obtained after those with incomplete information were identified as invalid questionnaires. The effective questionnaire rate reached 72.14%. From the valid questionnaires, the samples were well representative.

2.2. Hypothesis and Framework

First, before constructing the questionnaire in this paper, we analyzed and summarized the related variables that affect the utilization of straw resources of farmers through literature review. Based on the theoretical framework of theory of planned behavior (TPB), the driving model of the utilization behaviors of straw resources of farmers in Jilin Province was preliminarily constructed, as is shown in Figure 1. Based on the model, we selected several variables, and a preliminary questionnaire, covering specific items to be studied, has been formed.

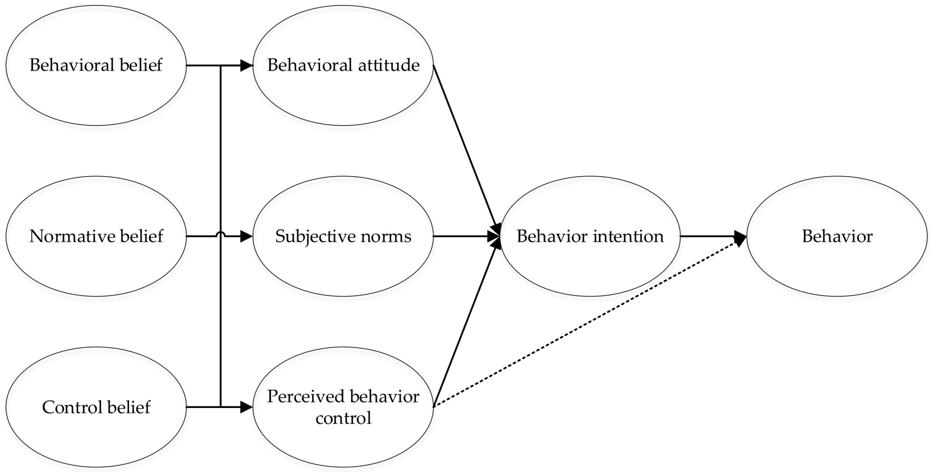

Figure 1. Theoretical framework of theory of planned behavior (TPB).

In order to obtain actual, comprehensive, and realistic data reflecting the actual situations of farmers, a pilot test was conducted with the preliminary questionnaire in Changchun and Liaoyuan in Jilin Province. Through in-depth interviews and the pilot test, latent variables of moral responsibility were introduced to the initial model, and the relationship among the variables was appropriately finetuned, as is shown in Figure 2.

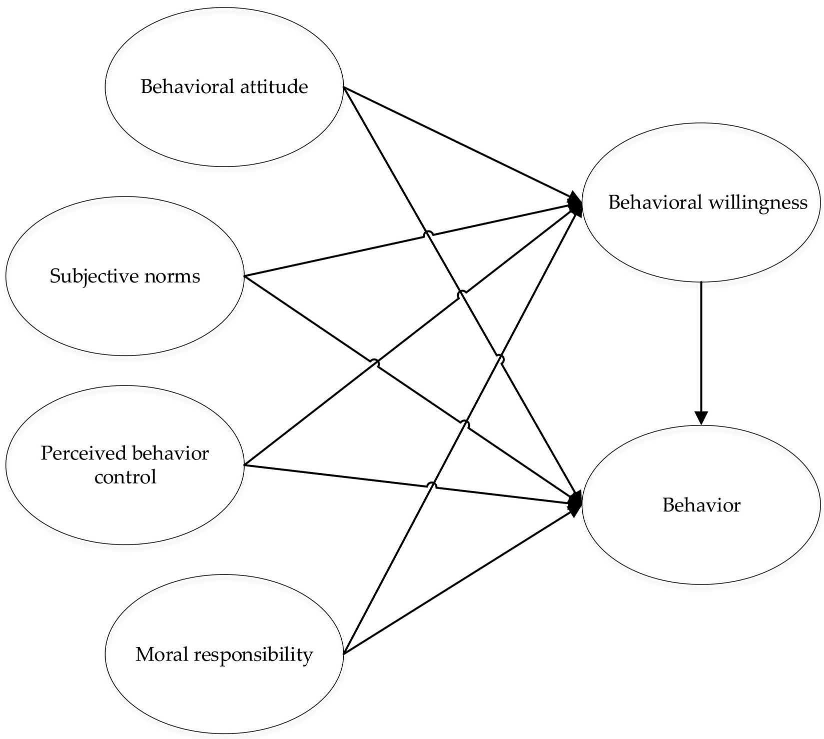

Figure 2. The driving mechanism of utilization behaviors of straw of farmers.

In Figure 2, in addition to the existing five latent variables, namely, behavioral attitude, subjective norms, perceived behavior control, behavioral willingness, and behavior, in the theory of planned behavior (TPB), we learned, through the interviews, that farmers' behavioral willingness and behaviors are also related to their moral responsibilities. Therefore, this paper introduced an additional latent variable of moral responsibility. In addition, behavioral attitude, subjective norms, perceived behavior control, and moral responsibility will not only affect farmers' willingness to adopt the utilization of straw resources, they also affect their actual behaviors.

Based on above and combined with the research hypotheses of TPB, the following hypotheses are proposed:

Hypothesis (H1). *Behavioral attitude of farmers will positively affect their willingness of utilization of straw resources.*

Hypothesis (H2). *Subjective norms of farmers will positively affect their willingness of utilization of straw resources.*

Hypothesis (H3). *Perceived behavior control of farmers will positively affect their willingness of utilization of straw resources.*

Hypothesis (H4). *Moral responsibility of farmers will positively affect their willingness of utilization of straw resources.*

Hypothesis (H5). *Behavioral attitude of farmers will positively affect their behavior of utilization of straw resources.*

Hypothesis (H6). *Subjective norms of farmers will positively affect their behavior of utilization of straw resources.*

Hypothesis (H7). *Perceived behavior control of farmers will positively affect their behavior of utilization of straw resources.*

Hypothesis (H8). *Moral responsibility control of farmers will positively affect their behavior of utilization of straw resources.*

Hypothesis (H9). *Willingness of farmers' utilization of straw resources will positively affect their behavior.*

2.3. Model Construction

Based on the theory of planned behavior (TPB), this paper selected the structural equation model (SEM) to systematically analyze the driving mechanism of farmers' utilization behaviors of straw resources in Jilin Province, China. The SEM can be divided into measurement equations and structural equations. The interaction between latent variables and indicators can be described with measurement equations, as shown in Equations (1)–(6).

$$x_i = \alpha_i x_i F_1 + e_i, i = 1,2,3 \tag{1}$$

$$x_i = \alpha_i x_i F_2 + e_i, i = 4,5,6 \tag{2}$$

$$x_i = \alpha_i x_i F_3 + e_i, i = 7,8,9 \tag{3}$$

$$x_i = \alpha_i x_i F_4 + e_i, i = 10,11,12 \tag{4}$$

$$y_i = \alpha_j y_i F_5 + e_j, i = 1,2,3; j = 13,14,15 \tag{5}$$

$$z_i = \alpha_j z_i F_6 + e_j, i = 1,2,3; j = 16,17,18 \tag{6}$$

where $x_1 \sim x_{12}, y_1 \sim y_3, z_1 \sim z_3$ denote 18 observed variables, respectively; $\alpha_1 \sim \alpha_{18}$ denote the load coefficients of the corresponding observed variables, respectively; $F_1 \sim F_6$ denote behavioral attitude, subjective norms, perceived behavior control, moral responsibility, behavioral willingness, and behavior, respectively; $e_1 \sim e_{18}$ denote the residual errors of 18 observed variables, respectively.

The relationship between latent variables can be described with structural equations, as shown in Equations (7) and (8).

$$F_5 = \beta_1 F_1 + \beta_2 F_2 + \beta_3 F_3 + \beta_4 F_4 + e_{23} \tag{7}$$

$$F_6 = \gamma_1 F_1 + \gamma_2 F_2 + \gamma_3 F_3 + \gamma_4 F_4 + \gamma_5 F_5 + e_{24} \tag{8}$$

where $\beta_1 \sim \beta_4, \gamma_1 \sim \gamma_5$ denote the path coefficients of the latent variables, respectively; e_{23} and e_{24} denote the residual errors of the latent variables F_5 and F_6, respectively. The structural equation model structure is shown in Figure 2.

2.4. Measurements

In order to analyze the psychology of farmers and to formulate corresponding encouraging policies, a five-point Likert scale ranging from 1 to 5 was used to describe the social psychology measurement indicators in Table 1, measuring the supporting or opposing degree of different farmers to the corresponding indicators.

Table 1. Variable selection and measurement indicators.

Type	Measurement Indicators	Items	Level Definition	Source
Behavioral attitude	Certainty	Be certain that straw resources can be comprehensive utilized.	1 = completely uncertain; 2 = a little uncertain; 3 = neutral; 4 = a little certain; 5 = completely certain	[61–64]
	Necessity	It is necessary that straw resources can be comprehensive utilized.	1 = completely unnecessary; 2 = a little unnecessary; 3 = neutral; 4 = a little necessary; 5 = completely necessary	
	Controllability	Think that utilization of straw resources is easy to operate and control.	1 = very difficult; 2 = a little difficult; 3 = neutral; 4 = a little easy; 5 = very easy	
Subjective norms	Media influence	Knowledge from newspapers, TV or radio is useful for the utilization of straw resources.	1 = completely useless; 2 = a little useless; 3 = neutral; 4 = a little useful; 5 = very useful	[61,63,65]
	Government influence	Government policies related to the utilization of straw resources are useful.	The same as x_4	
	Relatives' and neighbors' influence	Advice of relatives and neighbors on the utilization of straw resources is useful.	The same as x_4	
Perceived behavior control	Capital	Sufficient capital for the utilization of straw resources.	1 = none at all; 2 = limited capital; 3 = neutral; 4 = just enough; 5 = sufficient capital	[61,64,65]
	Labor	Sufficient labor for the utilization of straw resources.	1 = none at all; 2 = limited labor; 3 = neutral; 4 = just enough; 5 = sufficient labor	
	Time	Sufficient time for the utilization of straw resources.	1 = none at all; 2 = limited time; 3 = neutral; 4 = just enough; 5 = sufficient time	

Table 1. *Cont.*

Type	Measurement Indicators	Items	Level Definition	Source
Moral responsibility	Resource inheritance	The impact of the utilization of straw resources on future generations.	1 = harmful; 2 = a little harmful; 3 = neutral; 4 = a little beneficial; 5 = beneficial	[65–67]
	Social impact	The impact of the utilization of straw resources on others and society.	The same as x_{10}	
	Ecological impact	The impact of the utilization of straw resources on the ecological environment.	The same as x_{10}	
Behavioral willingness	Active publicity	Publicize the benefits of the utilization of straw resources actively.	1 = definitely not; 2 = maybe not; 3 = neutral; 4 = maybe; 5 = sure	[61,64,65]
	Drive others	Drive others to utilize straw resources.	The same as y_1	
	Willing to continue	Willing to continue to utilize straw resources.	The same as y_1	
Behavior	Active understanding	Having studied related knowledge of the utilization of straw resources.	1 = never; 2 = occasionally; 3 = sometimes; 4 = often; 5 = always	—
	Using behavior	Having utilized straw resources.	The same as z_1	
	Stop misbehavior	Having prevented or reported misbehaviors like the direct burning behavior of straw resources.	The same as z_1	

The variable measurement indicators in Table 1 were used for the design of measurement scale items. Detailed items used to measure each research construct are also shown in Table 1. After the interviews and pilot test, we modified and finetuned the items on the preliminary questionnaire, based on which the final questionnaire was formed.

Based on the above theoretical analysis and variables description, we defined the latent variables and their corresponding observed variables. $F_1 \sim F_6$ represent behavioral attitude, subjective norms, perceived behavior control, moral responsibility, behavioral willingness, and behavior, respectively. Variables are shown in Table 2 for details.

Table 2. Variable definition and descriptive statistics.

Type	Variable	Measurement Indicators	Mean	SD
Behavioral attitude (BA)	x_1	Certainty	2.8877	0.8690
	x_2	Necessity	2.9723	0.9236
	x_3	Controllability	2.7327	1.0799
Subjective norms (SN)	x_4	Media influence	3.3168	1.3195
	x_5	Government influence	3.7129	1.2613
	x_6	Relatives' and neighbors' influence	3.4455	1.2062
Perceived behavior control (PBC)	x_7	Capital	2.1386	0.9337
	x_8	Labor	2.3861	0.9644
	x_9	Time	2.4851	0.9710
Moral responsibility (MR)	x_{10}	Resource inheritance	4.2970	1.0103
	x_{11}	Social impact	4.1881	1.0217
	x_{12}	Ecological impact	4.2970	1.0767
Behavioral willingness (BW)	y_1	Active publicity	4.1584	0.9516
	y_2	Drive others	3.8218	1.0845
	y_3	Willing to continue	3.8515	1.1466
Behavior (BE)	z_1	Active understanding	3.4950	1.0111
	z_2	Using behavior	2.3564	1.0678
	z_3	Stop misbehavior	1.7822	0.9185

3. Results and Discussion

3.1. Descriptive Analysis

The basic characteristics of the samples are illustrated in Table 3. The age groups of the farmers being interviewed in this survey were mainly from 20 to 59 years old and their educational level was more at junior high school and senior high school level. During the Spring Festival, more migrant workers go back to their hometown, resulting in the age groups of those interviewed under 59. According to the distribution of crops during the time of the interview, it is seen that the main crops were corn, rice, and soybeans in Jilin Province, which is in line with the actual situation. In addition, the straw treatment method is still mainly focusing on open-field burning, supplemented by fertilizer conversion, fodder conversion, and energy conversion. Few farmers adopted fiber conversion, which is not a widespread treatment method in Jilin Province considering the local conditions.

Table 3. Basic characteristics of the sample.

Characteristics	Variables	Frequency	Proportion (%)
Sex	Male	45	44.55
	Female	56	55.45
Age	20–29	21	20.79
	30–39	29	28.71
	40–49	22	21.78
	50–59	25	24.75
	≥60	4	3.96
Educational level	Did not study	7	6.93
	Primary school	13	12.87
	Junior high school	43	42.57
	Senior high school or technical secondary school	25	24.75
	College or above	13	12.87
Main crops	Wheat	8	7.92
	Corn	84	83.17
	Rice	57	56.44
	Soybeans	30	29.70
	Cotton	3	2.97
	Others	6	5.94
Straw treatment method	Burning	53	52.48
	Fertilizer conversion	27	26.73
	Fodder conversion	30	29.70
	Energy conversion	39	38.61
	Fiber conversion	2	1.98
	Pile up	8	7.92

3.2. Reliability and Validity Test

3.2.1. Reliability Test

Reliability is the consistency of a certain measurement. It is considered reliable (in the sense of test-retest reliability) when it produces consistent outcomes under consistent conditions. In this paper, SPSS 22.0 was used to test the reliability of 6 latent variables and 18 observed variables, including behavioral attitude, subjective norms, perceived behavior control, moral responsibility, behavioral willingness, and behavior. The most used measure of reliability is the internal consistency coefficient, Cronbach's α. To be specific, values of Cronbach's α between 0.60 and 0.70 are acceptable, while values between 0.70 and 0.90 can be considered as satisfactory [68]. Through calculation, the overall consistency coefficient of the scale was 0.866 and the consistency coefficient of each variable was greater than 0.60, indicating that the scale exhibited a satisfactory degree of reliability.

3.2.2. Validity Test

Validity refers to the degree to which the observed variables accurately reflect the latent variables. Generally, a validity test includes a validity test and a construction validity test. In terms of content validity, based on the existing research and theory in combination with practical problems and situations, a five-point Likert scale was formulated, which has good content validity.

Construct validity includes convergent validity and discriminant validity. Confirmatory factor analysis is mainly used to test construct validity. AMOS 17.0 was used for confirmatory factor analysis of the scale and the test results are shown in Table 4. The results show that $\chi^2/df = 1.221$, which is considered acceptable since it's less than 5 [69]; $RMSEA = 0.047$, which is less than 0.06, is also considered acceptable [70], with the values of IFI, CFI, and TLI show a good fit with values of 0.90 or higher [71].

Table 4. Various fit index.

χ^2/df	RMSEA	IFI	CFI	TLI
1.221	0.047	0.982	0.981	0.975

We performed a convergent validity test. Hair et al. (2006) suggested that there are three criteria for evaluating convergent validity as follows: (1) ideally all standardized factor loadings are greater than 0.5 and above 0.7; (2) composite reliability (CR) is greater than 0.7; and (3) average variance extracted (AVE) is greater than 0.5 [72]. The result of the convergent validity test of confirmatory factor analysis is shown in Table 5. The results show that all standardized factor loadings and CR were above 0.7, and each AVE was above 0.5, indicating that the scale used in this paper had good convergent validity.

Table 5. Convergent validity test of confirmatory factor analysis results.

Path			Estimate	AVE	CR
X1	←	Behavioral attitude (F1)	0.949	0.923	0.973
X2	←	Behavioral attitude (F1)	0.982		
X3	←	Behavioral attitude (F1)	0.951		
X4	←	Subjective norms (F2)	0.747	0.656	0.851
X5	←	Subjective norms (F2)	0.862		
X6	←	Subjective norms (F2)	0.816		
X7	←	Perceived behavior control (F3)	0.817	0.544	0.780
X8	←	Perceived behavior control (F3)	0.716		
X9	←	Perceived behavior control (F3)	0.672		
X10	←	Moral responsibility (F4)	0.712	0.668	0.857
X11	←	Moral responsibility (F4)	0.908		
X12	←	Moral responsibility (F4)	0.820		
Y1	←	Behavioral willingness (F5)	0.780	0.682	0.865
Y2	←	Behavioral willingness (F5)	0.848		
Y3	←	Behavioral willingness (F5)	0.848		
Z1	←	Behavior (F6)	0.973	0.535	0.762
Z2	←	Behavior (F6)	0.630		
Z3	←	Behavior (F6)	0.510		

We also performed a discriminant validity test. Hair et al. (2006) suggested that the criterion of discriminant validity is to compare whether the arithmetic square root of AVE is above the correlation coefficients of factors [72]. The results of the discriminant validity test are shown in Table 6. It is seen that the arithmetic square root of the AVE of each factor is above its correlation coefficient with other factors, and the correlation coefficients between the factors are all at the significance level of 1%, indicating the discriminant validity of the scale is satisfactory.

Table 6. Discriminant validity test results.

	BA	SN	PBC	MR	BW	BE
BA	0.923					
SN	0.192 *	0.656				
PBC	0.154 *	0.336 **	0.544			
MR	0.264 **	0.407 **	−0.140 *	0.668		
BW	0.126 *	0.539 ***	0.113 *	0.429 ***	0.682	
BE	0.107 *	0.551 ***	0.178 *	0.166 *	0.246 *	0.535
AVE square root	0.961	0.810	0.738	0.817	0.826	0.731

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, BA = Behavioral attitude, SN = Subjective norms, PBC = Perceived behavior control, MR = Moral responsibility, BW = Behavioral willingness, BE= behavior.

Based on the results from Tables 4–6, the scale has good convergent validity and discriminant validity, indicating that the scale has passed the confirmatory factory analysis test.

3.3. Structural Equation Model Analysis

AMOS 17.0 was used to test the overall fitness of the model. The test results are shown in Table 7. The results show that each fitness index meets the requirements of critical value, indicating that the model presented an adequate fit to the data.

Table 7. Model fit index test results.

Fit Index	χ^2/df	NFI	NNFI	CFI	IFI	GFI	AGFI	RMSEA
Judging criteria	<5	>0.90	>0.90	>0.90	>0.90	>0.90	>0.90	<0.06
Actual fit	1.221	0.907	0.975	0.981	0.982	0.871	0.811	0.047

After testing the overall fitness of the model, we verified the model hypotheses and obtained the standardized path coefficients and fitting results among latent variables of the model, which is shown in Table 8. As shown from the results in Table 8, the standardized path coefficients of null hypotheses H1, H2, H3, H4, H5, H6, and H9 are significantly positive at the significance level of 10%, 1%, 10%, 1%, 10%, 1%, and 5%, respectively, indicating that the hypotheses test was supported. The standardized path coefficients of null hypotheses H7 and H8 are positive but they both fail to pass the significance test, indicating that the hypotheses test was not supported.

Table 8. Structural model fitting results.

Path	Variable Relationships	Standardized Path Coefficients	C.R.	Hypothesis Check
F5←F1	BW←BA	0.126 *	1.989	H1 (Supported)
F5←F2	BW←SN	0.593 ***	5.177	H2 (Supported)
F5←F3	BW←PBC	0.113 *	1.880	H3 (Supported)
F5←F4	BW←MR	0.429 ***	4.275	H4 (Supported)
F6←F1	BE←BA	0.107 *	1.826	H5 (Supported)
F6←F2	BE←SN	0.551 ***	5.893	H6 (Supported)
F6←F3	BE←PBC	0.078	0.971	H7 (Not supported)
F6←F4	BE←MR	0.066	0.784	H8 (Not supported)
F6←F5	BE←BW	0.246 **	2.855	H9 (Supported)

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, BA = Behavioral attitude, SN = Subjective norms, PBC = Perceived behavior control, MR = Moral responsibility, BW = Behavioral willingness, BE = behavior.

In order to understand the driving mechanism of farmers' utilization behaviors of straw resources more intuitively, according to Table 8, we drew the path analysis figure of the driving model of the utilization behaviors of straw resources of farmers in Jilin Province, China, as shown in Figure 3.

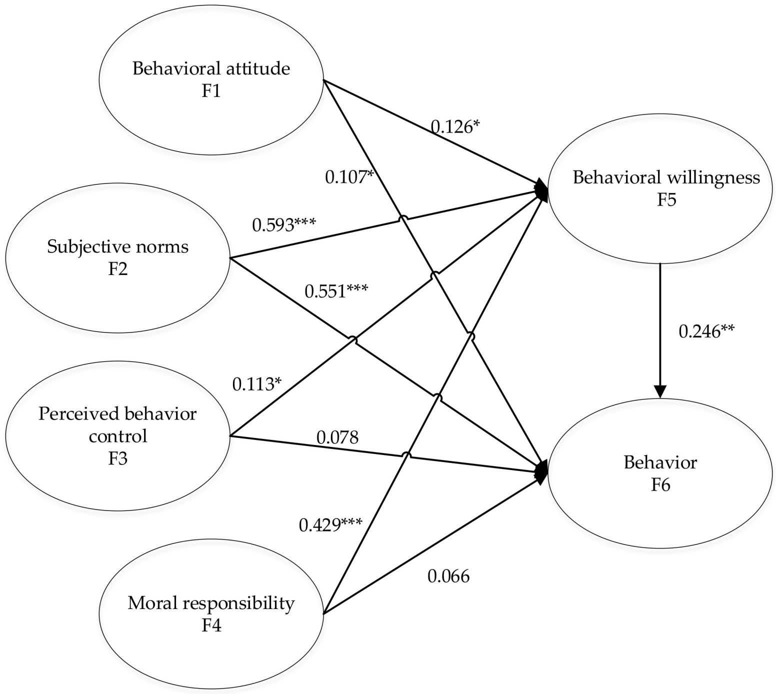

Figure 3. Structural equation model path analysis result. (Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$).

According to the results, each hypothesis is discussed, as follows:

The standardized path coefficient between behavioral attitude of farmers and their willingness of utilization of straw resources is $\beta_1 = 0.126$ $(p < 0.10)$, indicating that behavioral attitude of farmers has a significant positive impact on their willingness of straw utilization, thus supporting Hypothesis H1.

The standardized path coefficient between behavioral attitude of farmers and their willingness of utilization of straw resources is $\beta_2 = 0.539$ $(p < 0.01)$, indicating that subjective norms of farmers have a significant positive impact on their willingness of straw utilization, thus supporting Hypothesis H2.

The standardized path coefficient between perceived behavior control of farmers and their willingness of utilization of straw resources is $\beta_3 = 0.113$ $(p < 0.10)$, indicating that the perceived behavior control of farmers has a significant positive impact on their willingness of straw utilization, thus supporting Hypothesis H3.

The standardized path coefficient between moral responsibility of farmers and their willingness of utilization of straw resources is $\beta_4 = 0.429$ $(p < 0.01)$, indicating that moral responsibility of farmers has a significant positive impact on their willingness of straw utilization, thus supporting Hypothesis H4.

The standardized path coefficient between behavioral attitude of farmers and their behavior of utilization of straw resources is $\gamma_1 = 0.107$ $(p < 0.10)$, indicating that behavioral attitude of farmers has a significant positive impact on their behavior of straw utilization, thus supporting Hypothesis H5.

The standardized path coefficient between subjective norms of farmers and their behaviors of utilization of straw resources is $\gamma_2 = 0.551$ $(p < 0.01)$, indicating that subjective norms of farmers have a significant positive impact on their utilization behaviors of straw resources, thus supporting Hypothesis H6.

The standardized path coefficient between perceived behavior control of farmers and their utilization behaviors of straw resources is $\gamma_3 = 0.078$ $(p = 0.170 > 0.10)$, indicating that perceived behavior control of farmers has no significant impact on their behaviors of straw utilization, thus Hypothesis H7 was not supported. It is possible that there are more important perceived behavior control factors other than capital, labor, and time that promote farmers' utilization behaviors of straw resources so that perceived behavior control of farmers has no direct significant impact on their utilization behaviors of straw resources.

The standardized path coefficient between moral responsibility of farmers and their utilization behaviors of straw resources is $\gamma_4 = 0.066$ $(p = 0.233 > 0.10)$, indicating that moral responsibility of farmers has no significant impact on their behaviors of straw utilization, thus Hypothesis H8 was not supported. This could be because the samples selected in this paper are not well educated and have limitations in accepting new things. The samples did not fully understand the contribution of utilization of straw resources to society, ecology, environment, etc., which leads to moral responsibility of farmers having no direct significant impact on their utilization behaviors of straw resources.

The standardized path coefficient between behavioral willingness of farmers and their utilization behaviors of straw resources is $\gamma_5 = 0.246$ $(p < 0.05)$, indicating that behavioral willingness of farmers has a significant positive impact on their behaviors of straw utilization, thus supporting Hypothesis H9.

4. Conclusions and Policy Implications

4.1. Conclusions

Based on the theory of planned behavior (TPB), in combination with existing related research topics, this paper constructs the theoretical model and analyzes the behavioral willingness and behaviors of farmers' utilization of straw resources. Hence, the driving mechanism of farmers' utilization behaviors of straw resources has been established through the structural equation model (SEM). The main conclusions are as follows:

Farmers' behavioral attitude, subjective norms, perceived behavior control, and moral responsibility have a significant positive impact on their willingness of utilization of straw resources. In the meantime, willingness of farmers also has a significant positive impact on their behaviors. The behavioral attitude and subjective norms of farmers have a significant positive direct impact on their utilization behaviors of straw resources. The perceived behavior control and moral responsibility have no direct impact on their utilization behaviors of straw resources. However, they have a significant positive impact on their willingness of utilization of straw resources, and indirectly affect their behaviors through the willingness of farmers.

4.2. Policy Implications

Due to the increasing opportunity cost of labor, the gradual separation of animal husbandry and planting, and the immature utilization technology of straw resources, many farmers are reluctant to utilize the straw resources, and the phenomenon of illegal burning or discarding them at will has continued for a long time [73,74]. Current practical problems exist in the processing of the utilization of straw resources. There is no ecological compensation mechanism to promote the utilization of straw resources. The utilization of straw resources is mostly actively promoted by the government, while other entities have not participated in it [75]. Combined with the current status and empirical analysis, several relevant policy implications can be derived, as follows:

First, measures should be taken, through influencing farmers or related people, to strengthen the subjective norms of the utilization behavior of straw resources. Farmers tend to be strongly influenced by media, government, relatives, and neighbors in the decision-making process about utilization of straw resources. Therefore, in terms of affecting the subjective norms of farmers, the government needs to strengthen the policy's publicity and have important figures related to farmers use their positive influence so farmers can turn their decision-making from blind to rational.

Second, it is important to enhance farmers' sense of moral responsibility through improving their educational level. The empirical results show that the farmers' behavioral willingness and behavior of utilization of straw resources are greatly affected by moral responsibility. Moral responsibility of farmers can be strengthened through basic education and training, which further affects their willingness and behavior of utilization of straw resources.

Third, it is necessary to enhance farmers' behavioral attitude and perceived behavior control through improving their income. At present, the low level of farmers' income in Jilin Province, China, on the one hand, leads to the negative behavioral attitude towards the utilization of straw resources. Only by ensuring the income of farmers can we change their attitude and promote their active participation in the utilization of straw resources. On the other hand, the low income of farmers gives them lower risk tolerance and causes them to doubt their ability in utilization of straw resources. While increasing the income of farmers, letting farmers believe that the utilization of straw resources is profitable can enhance farmers' behavioral attitude and perceived behavior control and promote their utilization behavior of straw resources.

Fourth, the government needs to formulate more reasonable subsidy policies to actively guide farmers to the utilization of straw resources. At present, the government has few compensatory measures for farmers' straw recycling behavior, farmers are dissatisfied with the subsidy policy, and a gap exists between investment and income of farmers, which directly affects farmers' behavior of straw recycling. When farmers utilize straw resources, it means that they may increase their agricultural production budget and bear higher risks. Therefore, the government should establish a reasonable evaluation mechanism for the utilization behavior of straw resources of farmers and issue subsidies based on the evaluation results to encourage farmers to actively participate in the utilization of straw resources.

5. Limitations and Future Research

There are some limitations in this article. First, although this paper has referred to a large amount of relevant literature while selecting measurement indicators, and the characteristics of farmers' own utilization behaviors of straw resources have been taken into consideration, it does not cover all the factors that affect the driving mechanism of farmers' utilization behaviors of straw resources and, therefore, needs to be further improved and supplemented. Second, only 101 valid questionnaires were collected in this article, which leads to limitations in the even distribution of results. The sample size and even distribution of the samples need to be improved.

Moving forward, additional aspects should be considered. First, more variables should be introduced to the model through semi-structured in-depth interviews to improve the theoretical framework and to make a more comprehensive analysis and discussion on the influencing factors of farmers' utilization behaviors of straw resources. Second, the scope of acquisition of samples should be expanded. We need to make in-depth investigations on farmers in different provinces in China with different climate conditions, social environment, and economic levels so as to understand the driving mechanism of utilization behaviors of straw resources of farmers in different regions and to improve the even distribution of the results.

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