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Original Research

Analysis of the Behavioral Intention and Influencing Factors of Farmers Replacing Coal with Electricity in the Context of Carbon Neutrality: the Case Study in Yulin City

Yutong Zhao[1], Zengguang Xu[1]*, Yangyang Liu[2, 3], Tianqing Chen[2, 3]

[1]State Key Laboratory of Eco-hydraulics in Northwest Arid Region of China, Xi'an University of Technology, Xi'an 710048, China
[2] Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi'an 710075, China
[3]Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co., Xi'an 710075, China

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Abstract

Exploring the formation mechanism of farmers' behavioral intention to adopt electricity to replace coal (INT-CE) is important for adjusting energy policies in the context of passive energy transition. Based on the integrated framework of Theory of Planned Behavior (TPB) and Normative Activation Model (NAM), taking farmers in Yulin City, Shaanxi Province as the research sample, the formation mechanism of INT-CE is empirically analyzed using partial least squares structural equation modeling (PLS-SEM). INT-CE was influenced by both self-interested and altruistic motives, with self-interested motives having a greater impact. The results show that: (1) Subjective attitudes and perceived behavior control have significant positive effects on low-income farmers' transformation intention, the influence coefficients are 0.170 and 0.331, respectively. (2) Perceived behavior control has a significant positive impact on the transition intention of middle - income farmers, the coefficient is 0.155. (3) Subjective norms have significant positive impacts on the energy transition intention of high-in- come farmers, the coefficient is 0.261. Attitude has the greatest influence on INT-CE. The effect of past habits on INT-CE was not significant, but was controlled by attitudes and perceptual behaviors. Outcome awareness and responsibility attribution indirectly enhance INT-CE through personal norms. The government should consider farmers' self-interest and altruistic motives when motivating INT-CE. On the one hand, positive concepts of energy conservation should be fostered and farmers' knowledge of energy conservation should be enhanced. On the other hand, the education of farmers should be strengthened to make them realize the ecological damage caused by non-clean energy. At the same time, the influence of relevant groups on INT-CE should be further emphasized to play the role of demonstration and leadership,

*e-mail: xuzengguang@xaut.edu.cn

to enhance farmers' environmental awareness and to cultivate a sense of social responsibility to protect the ecological environment.

Keywords: energy transformation, behavioral intention, coal to electricity, energy, PLS-SEM

Introduction

According to the global burden of disease (GBD), nearly 600,000 premature deaths in China are attributed to domestic air pollution, accounting for 9.44% of all premature deaths in China [1]. Yulin, Shaanxi Province, as a heavy industrial province, is one of the areas heavily polluted by hazy weather. Bulk coal burning and winter coal heating are important reasons for the frequent occurrence of heavy haze weather in autumn and winter seasons [2]. Replacing coal combustion with electricity would be an effective means to improve air quality. In response to the national strategy of "carbon neutral, carbon peaking", the study area has issued a clean energy replacement program for coal for residential use, and the replacement of coal by electricity (hereafter collectively referred to as "coal to electricity") has been implemented in the area. As one of the coal-producing regions in Shaanxi Province, coal is the main energy source for local consumption, so the implementation of "coal to electricity" in the study area is very representative. However, we found that the implementation of this policy is difficult, and the intention of people is generally low, and the efficiency of policy implementation is low.

According to the "energy ladder" theory, people's energy preferences will change from traditional biomass and coal to more advanced and less polluting energy sources as their income increases [3], and the upgrading of residential energy consumption is a spontaneous process [4]. If the government promotes energy transition uniformly for all residents, people will have to pay more for energy use that they do not need urgently, which will put great cost pressure on households whose living standards do not meet the transition standard. Therefore, from the perspective of the "energy ladder" theory, the household income level is the only factor and the main driver that determines the intention of farmers to make the energy transition.

The "energy ladder" theory is not perfect, and the farmers' behavior is not only an economic behavior, but also a social behavior. The theory of planned behavior is widely accepted because it is the classical theory of human behavioral intention in social psychology [5]. According to the theory of planned behavior, intention is determined by psychological indicators such as personal attitudes, subjective norms, and perceived behavioral control. Income is only an external influence on farmers' intention to switch to energy, and even though the policy implementation is accompanied by subsidies, the implementation is still inefficient because this "one-size-fits-all" policy does not take into account farmers' psychological characteristics. Existing studies on behavioral intentions have also been deficient in the study of "soft indicators" such as farmers' own subjective attitudes, social norms, and perceived implementation pressure. We extended the theory of planned behavior (TPB) by introducing norm activation model (NAM) into the theory of planned behavior and proposed an integrated TPB-NAM model. Two factors, awareness of Consequence and Attribution of Responsibility, are added for integrated research. Meanwhile, based on the established influence of income, we study the main influencing factors of farmers' intention of different income groups to enhance farmers' intention of energy transformation, and also provide strong evidence for the need of more targeted government energy transformation subsidy policies.

Therefore, this study integrates the theoretical frameworks of TPB and NAM based on research data from January 2020 to December 2021 in Yulin City, Shaanxi Province, introduces the integrated TPB-NAM model constructed by previous habits, and examines the formation mechanism of behavioral intention to adopt electricity to replace coal (INT-CE) from two dimensions: individual economic rationality and social moral rationality. Specifically, this study proceeds from the following three aspects: (1) using the integrated TPB-NAM to explain the formation mechanism of INT-CE; (2) exploring the structural relationship between TPB and NAM; and (3) exploring the paths and ways of self-interest and altruistic motives on the formation of INT-CE. Thus, it provides theoretical references and policy references for relevant government departments to improve relevant policies and supporting measures to enhance INT-CE.

Theoretical Analysis and Hypothesis

Theory of Planned Behavior (TPB)

TPB (Theory of Planned Behavior, TPB) is a classic theory used in the field of social psychology to explain and predict individual behavior, which Originally is proposed by Ajzen in 1991 [6]. Numerous studies have been conducted to apply TPB to personal health, environmental behavior, and policy adoption [7,8], and a large number of results have been obtained. The theory suggests that individual behavioral intentions (INT) are determined by three main factors, which are Attitude (ATT), Subjective Norms (SN), and Perceived Behavior Control (PBC). TPB has a strong openness and inclusiveness, and the introduction of other relevant variables that have a significant impact on intention can further enhance the explanatory strength of the

model based on the traditional model. For example, the study by Bamberg et al. (2003) [9] demonstrated that past behaviors have a importance influent on individuals' intention to perform similar behaviors, Conner and Armitage (1998) [10] further pointed out that the inclusion of past behaviors in TPB increased the explanatory strength of intention by 7%. Based on these studies, this study extends the traditional TPB to explore how the inclusion of past habits would affect individual attitudes, perceived behavioral control, and intention formation.

Attitude refers to an individual's perception and evaluation of whether a particular behavior is favorable or unfavorable. In general, the higher the cognition and positive evaluation of INT-CE, the higher the intention of farmers to adopt INT-CE; Conversely, their subjective intention to adopt INT-CE will be reduced [11]. Rezaei et al. (2019) [12] study manifested that the attitude and view of farmers to integrated pest management technology is the most important factor affecting the adoption of technology. Hou and Hou (2019) [13] found that farmers' perceptions significantly increased the intention to adopt emission reduction technologies, and each unit increase in perceived ability contributed 25.5% to the adoption of low-carbon technologies. Theoretically speaking, the application of INT-CE can help realize the comprehensive and effective utilization of resources, reduce environmental pollution, produce ecological benefits, but also can produce pollution-free, high-quality green products, bring economic benefits for farmers, with the dual attributes of ecological benefits and economic benefits. Therefore, farmers are more willing to adopt INT-CE when they think it is useful and can lead to positive results. Based on this, the following hypothesis is proposed.

Hypothesis (H1): ATT have a significant positive effect on INT-CE.

Perceived behavioral control refers to the degree of ease or difficulty of an individual in carrying out a specific behavior, which is an individual's subjective perception of factors that promote or hinder the occurrence of his or her behavior. This perception depends to a large extent on the individual's trade-off between costs and benefits (including financial costs, effort, and time) in the implementation process [14]. This indicates that when individuals perceive that a behavior is easier to perform, they have a higher perceived control of the behavior and a higher sense of self-efficacy, which in turn leads to a stronger intention to perform the behavior. A study by Wang et al. (2021) [15] on INT-CE found that perceived behavioral control had a significant effect on farmers' intention to adopt. Arunrat et al. (2017) [16] studied the responsive behavior of farmers' perceptions of two types of agriculture and found that farmers with higher ability, resources, or opportunities were more responsive to two types of agricultural behaviors. These facts can be extended to farmers' farmland conservation technologies, and when farmers believe they have sufficient knowledge, skills, and resources, they are more likely to form INT-CE. Based on this, the following hypothesis is proposed.

Hypothesis (H2): PBC has a significant positive effect on INT-CE.

Subjective norms are the pressure that an individual feels when performing or not performing a certain line, which mainly comes from individuals or groups that have an influence on their behavioral decisions. In other words, individuals generally prefer to conform to the expectations of the reference group. Usually, the more positive the individual or group with whom the individual is close to perform a behavior, the stronger the individual's intention to perform the behavior; on the contrary, it reduces the individual's intention to perform the behavior [17]. A study by George (2004) [18] showed that social expectations from friends and relatives or important colleagues had a significant positive effect on farmers' behavioral intention to reduce fertilizer application, which was confirmed by Arli et al. (2018) [19] in their study on the intention to purchase green products. In the practice of INT-CE, the INT-CE by village cadres and relatives and friends will produce demonstration effect due to the farmers' own knowledge and judgment ability, thus improving INT-CE. Based on this, the following hypothesis is proposed.

Hypothesis (H3): SN have a significant positive effect on INT-CE.

Past Habit (PH) refers to the idea that individuals will use the experience of behaviors that occurred in the past as a mental cognitive basis to inspire the implementation of similar behaviors in the future [20, 21]. A study by Greaves (2013) [22] on farmers' domestic waste disposal behavior proved that past behavior affects behavioral intentions. However, Kim et al. (2013) [23] regards perceived behavioral control as an intermediary variable between past habits and behavioral intentions, and believes that past habits affect farmers' behavioral intentions by influencing individuals' ability to control behaviors. In addition, Trafimow (2000) [24] argued that the predictive power of attitudes should be diminished if people have past habits [25], on the contrary, argued that attitudes are good predictor variables of behavioral intentions when people are not used to exhibit a certain behavior. Other studies have also found that adding an individual's past habits into TPB can be able to enhance the predictive strength of an individual's intention to behave [26]. Logically, farmers who have experience with INT-CE have higher awareness of INT-CE and perceive less difficulty in INT-CE, thus influencing their INT-CE; therefore, based on the above discussion, the inclusion of past habits in the TPB yields the following hypothesis.

Hypothesis (H4): PH have a positive influence on ATT.

Hypothesis (H5): PH have a positive influence on PBC.

Hypothesis (H6): PH have a positive influence on INT-CE.

Norm Activation Model (NAM)

The Norm Activation Model (NAM) was first proposed by Schwartz (1977) [27], which is mainly used to predict and explain individuals' altruistic behavior, and has been broadly used in various pro-social and pro-environmental domains, such as green travel mode choice [28] and farmers' adoption of ecological agricultural practices [12]. The core variables of the moral incentive theory model are composed of the Personal Norms (PN), the Awareness of Consequence (AC) and the Attribution of Responsibility (AR). Among them, personal norms are activated by the Awareness of Consequence and the Attribution of Responsibility. Personal norms are the self-expectations of individuals to perform specific behaviors in a specific situation, and is the social norms that internalized into the consciousness of self-moral obligation; Awareness of Consequence is the individual's perception of the possible positive or negative effects of his or her actions; and Attribution of Responsibility indicates the individual's sense of responsibility for the consequences of his or her behaviors [29].

According to the NAM, individuals with burning personal norms are more likely to realize their wishes or behaviors in their productive lives that conform to the requirements of their personal norms. When individuals follow their personal norms to implement specific behaviors, they will feel satisfied because their actual behaviors are consistent with their self-expectations, which in turn leads to self-affirmation, but when specific behaviors violate their personal norms, individuals may feel guilty inside because their actual behaviors are contrary to their expectations, which in turn leads to self-denial. A study by Mackerron et al. (2009) [30] on air travelers' intention to pay carbon offsets found a significant positive effect of personal norms on intention to pay carbon offsets, and Shi et al. (2017) [31] reached a similar conclusion in a study on urban residents' behavioral intention to participate in environmental governance. The implementation of environmentally friendly farmland conservation behavior by farmers is conducive to reducing agricultural pollution and protecting the environment, which is a pro-environmental behavior with altruistic attributes, and their behavior is consistent with farmers' self-expectations. Therefore, hypothesis 7 is proposed.

Hypothesis (H7): PN have a significant positive effect on INT-CE.

NAM believes that when individuals are aware that their actions may have a negative impact on the environment, they tend to take responsibility for the negative consequences of their actions; Conversely, if they are not aware that their actions have an impact on the environment, they are less likely to be held responsible for those consequences. This indicates that an individual's awareness of consequences is a crucial antecedent of responsibility attribution. Furthermore, if individuals are aware of the positive consequences of being pro-environmental and has the responsibility to protect the ecological environment, the higher the individual's personal norms will be and the stronger the intention to carry out pro-environmental behaviors will be. Esfandiar et al. (2020) [32] on pro-environmental intention of marine aquaculture enterprises found that consequence awareness has a significant positive effect on both personal norms and responsibility attribution, while responsibility attribution also positively affects managers' personal norms. In the implementation of pro-environmental behavior in ecological farming, when farmers realize that not implementing environmentally friendly agricultural protection technology will bring negative consequences, and believe that they have the responsibility to improve the farming environment, farmers' self-expectation and sense of moral obligation to implement pro-environment behavior will become stronger. It is worth noting that farmers are less likely to adopt environmentally friendly practices if they are not aware that environmentally friendly agricultural conservation techniques have important environmental impacts. Based on this, the following hypothesis was obtained.

Hypothesis (H8): AC has a significant positive effect on PN.

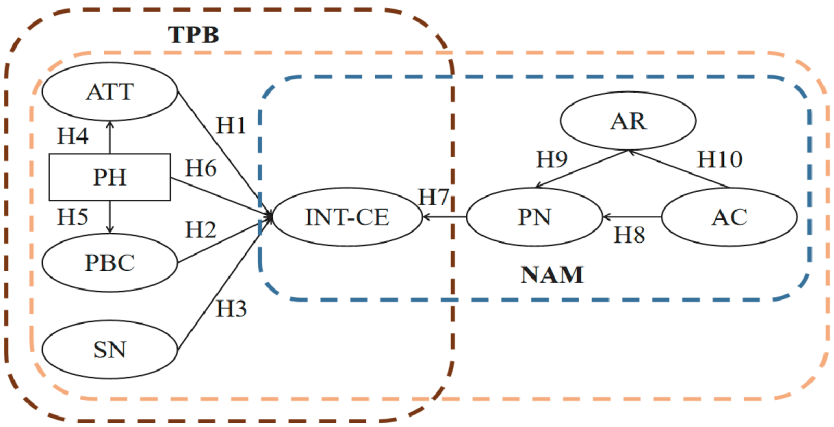

Fig. 1. Mechanism model for the study of farmers' behavioral intention to adopt electricity to replace coal.

Hypothesis (H9): AR has a significant positive effect on PN.

Hypothesis (H10): AC has a significant positive effect on AR.

Based on the above literature review and the proposed hypotheses, this paper constructs an extended TPB-NAM integration research framework, as shown in Fig. 1. From the perspective of individual economic rationality, the antecedent variables affecting farmers' intention to conserve farmland are: attitude, past habits, perceived behavioral control and subjective norms, while past habits affect attitude and perceived behavioral control; from the perspective of social moral rationality, awareness of consequences and attribution of responsibility indirectly affect farmers' intention to conserve farmland through individual norms, and awareness of consequences is an important antecedent variable of attribution of responsibility.

Materials and Methods

Sample

We conducted a field survey in Yulin City, Shaanxi Province, from January 2020 to December 2021, using a combination of participatory rural appraisal (PRA), questionnaires and access to local socioeconomic statistics to obtain data. A total of 325 households were surveyed by random sampling method, and 295 valid questionnaires were obtained, with an efficiency rate of 90.8%. Since energy consumption is household-based, the household income of all surveyed farm households was divided into five equal parts from highest to lowest according to the quintile classification standard of the National Bureau of Statistics for residents' income.

Survey Design

The questionnaire used in this study includes three parts: (1) demographic characteristics; (2) evaluation of INT-CE predictors; and (3) evaluation of INT-CE implications. Each dimension is based on literature review findings and theory, and each dimension is measured using validated research tools developed in previous studies (modified to fit the research context). A seven-point Likert scale was used to overcome measurement errors. The Likert scale ranges from "strongly disagree" (i.e., 1) to "strongly agree" (i.e., 7). Table A1 in the Appendix Survey items describes the used survey items.

Data Analysis Technique

A great deal of attention has been given to potential biases were considered in the survey, protocol design, and data analysis. Several approaches (e.g. direct contact by phone and assurance to share the results) were used to effectively ensure the highest response rate and avoid a non-response bias [33]. The partial least squares structural equation modelling (PLS-SEM) technique was adopted to analyze the data of our study. The reason why the study used this technique is that the process gives better results when analyzing this type of exploratory study. The PLS-SEM can also analyze those data that are not normally distributed [34]. There are no sample limits for this technique, and this process involves quantification of responses on a specific scale.

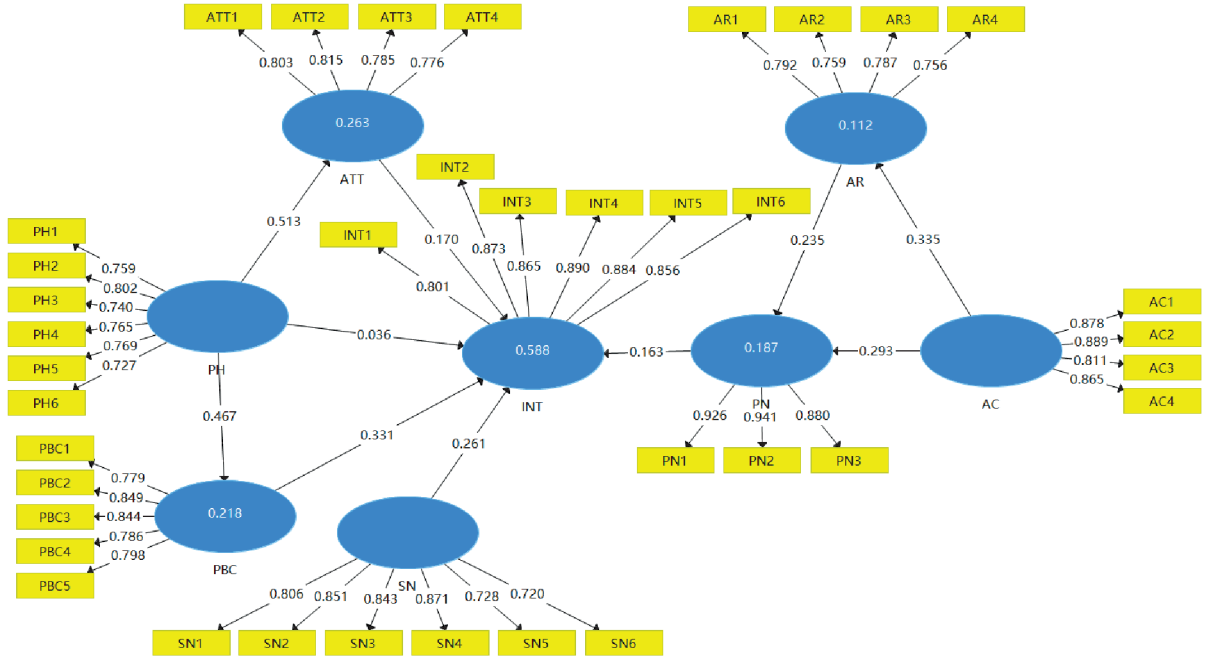

Fig. 2. Measurement model assessment.

Results

Measurement Model Assessment

The reflective constructs were validated by testing for internal consistency, composite reliability, convergent, and discriminant validity (Table 1 and Fig. 2). We verified that the value of Cronbach's alpha and composite reliability indices exceeded 0.7 [35], which validated the internal consistency and composite reliability of the constructs. This condition was valid for all the constructs. We verified that the average variance extracted (AVE) index was greater than 0.5, which is to test convergent validity. The lowest observed value (0.579) was substantially higher than this threshold. The discriminant validity of the reflective constructs was tested in three ways [36]. The correlation matrix proved that the AVE was greater than the square correlation between each pair of latent constructs. These results demonstrate the validity of the reflective constructs used in our analysis and the adequacy of the items used as construct indicators.

Structural Model Assessment

Table 2 and Fig. 3 report the results of the structural model from the PLS analysis, including standardized path coefficients with two-tailed t-tests for the hypotheses and the posthoc tests for testing the mediation effect. The results partially confirm the hypotheses proposed by the research model (Fig. 1). The path analysis confirms that ATT (H1: $\beta = 0.170$, $p<0.01$), PBC (H2: $\beta = 0.331$, $p<0.001$), SN (H3: $\beta = 0.261$, $p<0.001$), and PN (H7: $\beta = 0.163$, $p<0.01$) all positively impact INT-CE. The path analysis confirms that PH->ATT (H4: $\beta = 0.513$, $p<0.001$), PH->PBC (H5: $\beta = 0.467$, $p<0.001$), AC->PN (H8: $\beta = 0.293$, $p<0.001$), AR->PN (H9: $\beta = 0.235$, $p<0.001$), and AC->AR (H10: $\beta = 0.335$, $p<0.001$) are all significant. However, our results found no support for H6 (the effect of PH on INT). All the post-hoc test for the indirect effect is statistically significant for the path are significant. The structural model explained a variance rate of 0.112 for AR, 0.187 for PN, 0.218 for PBC, 0.263 for ATT and 0.588 for INT. These values can be considered as the predictive accuracy of the models among low, medium, and large [34]. The analysis of the composite-based standardized root mean square residual (SRMR) yielded a value of 0.065, below the 0.10 threshold, which confirms the robustness of the model [35].

Discussion

Discussion of the Analysis Results

The government implements the energy upgrading policy of replacing coal with electricity to promote the spontaneous transformation of farmers into passive

Table 1. Construct consistency, reliability, convergent and discriminant validity squared value of the AVE reported on the main diagonal of the correlation matrix.

Constructs	Composite Reliability	Cronbach's Alpha	Average variance extracted	AC	AR	ATT	INT	PBC	PH	PN	SN
AC	0.920	0.883	0.741	0.861	0.400	0.419	0.439	0.522	0.321	0.412	0.384
AR	0.856	0.777	0.599	0.335**	0.774	0.649	0.613	0.662	0.511	0.397	0.549
ATT	0.873	0.806	0.632	0.355**	0.516**	0.795	0.710	0.802	0.598	0.399	0.692
INT-CE	0.945	0.931	0.743	0.399**	0.521**	0.618**	0.862	0.750	0.456	0.511	0.687
PBC	0.906	0.871	0.659	0.460**	0.545**	0.671**	0.683**	0.812	0.525	0.495	0.648
PH	0.892	0.855	0.579	0.286**	0.431**	0.513**	0.415**	0.467**	0.761	0.207	0.452
PN	0.940	0.905	0.840	0.371**	0.333**	0.338**	0.473**	0.436**	0.190**	0.916	0.430
SN	0.917	0.890	0.649	0.340**	0.457**	0.582**	0.628**	0.574**	0.407**	0.391**	0.806

Note: AC - Awareness of Consequence; AR - Attribution of Responsibility; PN - Personal Norms; ATT - Behavioral attitude; INT-CE - Farmers' behavioral intention to adopt electricity to replace coal; PBC - Perceptual Behavioral Control; PH - Past Habit; PN - Personal Norms; SN - Subjective Norms. Significant level: p<0.10; *p<0.05; **p<0.01; ***p<0.001, Bold diagonal entries are square root of AVEs, Heterotrait-Montrait ratios (HTMT)(Underlined) are below 0.85

transformation. According to the energy ladder theory, passive energy transition is inevitably accompanied by policy subsidies. But the results show that even if the farmers alternative energy will increase with the increase of income, the subsidy after the implementation of the overall farmers intention is still low, only low-income farmers ability to pay the family is the main influence factors, medium and high income farmers intend to lower the dominant factor is not income, government subsidies for this part of the little intention to improve effect of farmers. Therefore, it is an inevitable choice to adjust the "one-size-fits-all" subsidy mode of coal to electricity policy and improve people's intention to choose.

1) Passive energy transition should not be implemented as a uniform subsidy standard for all farmers across the board, but rather the subsidy should be used to make up for the difference in farmers' intention to diversify the policies in order to maximize the subsidy effect. According to the calculation results, only low-income farmers are highly sensitive to the amount of subsidies [30]. Therefore, under the condition that the total amount of energy transition subsidies remains unchanged, the government should transfer the subsidies for high-income farmers to low-income people and increase the subsidies for low-income households to increase their energy transition capacity and improve their intention to choose. For middle-income farmers,

Fig. 3. Structural model assessment.

Table 2. Results of hypothesis testing.

Hypothesis	Effect	Path	Path coefficient	t-statistics	p-value	Decision
Main effects in the research model						
H1	Direct	ATT -> INT-CE	0.170	2.349	0.019**	Accept
H2	Direct	PBC -> INT-CE	0.331	4.486	0.000***	Accept
H3	Direct	SN -> INT-CE	0.261	3.785	0.000***	Accept
H4	Direct	PH -> ATT	0.513	10.991	0.000***	Accept
H5	Direct	PH -> PBC	0.467	9.690	0.000***	Accept
H6	Direct	PH -> INT-CE	0.036	0.683	0.495^{NS}	Rejected
H7	Direct	PN -> INT-CE	0.163	2.999	0.003**	Accept
H8	Direct	AC -> PN	0.293	4.367	0.000***	Accept
H9	Direct	AR -> PN	0.235	3.732	0.000***	Accept
H10	Direct	AC -> AR	0.335	5.613	0.000***	Accept
Post-hoc tests for the mediation						
	Indirect	AR -> PN -> INT-CE	0.038	2.480	0.013**	Accept
	Indirect	PH -> ATT -> INT-CE	0.087	2.434	0.015**	Accept
	Indirect	AC -> PN -> INT-CE	0.048	2.454	0.014**	Accept
	Indirect	AC -> AR -> PN -> INT-CE	0.013	2.330	0.020**	Accept
	Indirect	AC -> AR -> PN	0.079	3.502	0.000***	Accept
	Indirect	PH -> PBC -> INT-CE	0.155	4.429	0.000***	Accept

SRMR composite model = 0.065
$R^2_{AR} = 0.366$; $Q^2_{AR} = 0.063$
$R^2_{ATT} = 0.366$; $Q^2_{ATT} = 0.160$
$R^2_{INT\text{-}CE} = 0.366$; $Q^2_{INT\text{-}CE} = 0.429$
$R^2_{PBC} = 0.507$; $Q^2_{PBC} = 0.140$
$R^2_{PN} = 0.586$; $Q^2_{PN} = 0.139$
5000 bootstrap samples

Note: *** = $p<0.001$; ** = $p<0.01$; * = $p<0.05$; NS = $p>0.05$

the government should subsidize farmers according to their energy transformation needs to induce them to consider transformation on their own initiative. For high-income farmers, subsidies should be discontinued for them, and this group of farmers will spontaneously consider upgrading their energy to electricity.

2) Improve the policy service level during the implementation of the coal to electricity policy. Economic subsidy policy is not the only effective means to promote renewable energy consumption [23]. Through the analysis of influencing factors, it is found that the main factors to improve the will of low-income farmers are personal attitude and family capacity, and the key variables to improve the will of middle and high income farmers are family concept and public expectation respectively. Therefore, the government subsidy policy adjustment, but also need to strengthen the public service in the implementation of policy, organize relevant preferential policies and coal to electricity technology knowledge training, to help farmers to ecological government subsidies have more clear cognition, increasing the use of electrical technical ability, dispel fears about using electrical risk, promote conceptual change. At the same time, the local government should establish individual demonstration households, increase the publicity and education activities of the coal to electricity policy, change the public's concept, increase the sense of social respect for the implementation of the coal to electricity policy, and improve public expectations [37]. The energy use and sustainable development nexus have been important issues, as they may govern major policy decisions [38, 39]. Although traditional fossil fuel energies are widely adopted, they could result in some ecological problems, especially the massive greenhouse gas emissions [40, 41]. The public servants who carry out the policy can be more familiar with the policy content, so they should actively popularize the advantages of the policy to

their relatives and friends, so that peasant families can actively change their energy consumption and improve the public's intention to choose.

Research Implications

First, the government should take into account the self-interest and altruistic motives of farmers when motivating them to adopt INT-CE. On the one hand, it should cultivate positive attitudes of farmers to carry out INT-CE and strengthen their knowledge of farmers' INT-CE. For example, promote the idea that INT-CE can improve the quality of quality of life and obtain higher product premiums to increase economic returns. From the perspective of individual rationality, farmers should be encouraged to non-INT-CE in order to stimulate their self-interest motivation. On the other hand, education on ecological damage (e.g., soil pollution, water pollution, excessive pesticide residues, etc.) caused by non-INT-CE should be strengthened. For example, we should issue environmental protection manuals, announce in WeChat groups, and hold environmental protection seminars to enhance farmers' awareness of responsibility and perception of consequences for environmental protection, and stimulate farmers' altruistic motives and sense of responsibility for environmental protection. Inspire farmers' intention to adopt INT-CE from a socially rational perspective.

Second, whether related groups adopt INT-CE has a strong reference effect, so the government should attach more importance to the influence of related groups on farming behaviors, such as focusing on groups such as village cadres, villagers and wealthy leaders, focusing on coal to electricity of key demonstration households and enhancing the profitability of demonstration households through the model of demonstrating one driven group, so as to form a demonstration-driven effect among neighboring farmers and promote INT-CE in whole villages or whole towns (townships).

Third, it is time to improve the level of farmers' social networks and optimize the structure of farmers' resource endowment by category. In the aspect of social endowment, social institutions and social resources should be adopted to further strengthen the social network of farmers; in terms of economic endowment, government subsidies for coal to electricity should be strengthened to increase the economic benefits of farmers' adoption of coal to electricity, and enhance the attraction of coal to electricity; in terms of human endowment, the government and social institutions can provide free personnel to explain the means to enrich farmers' resource endowment, improve farmers' cognition of resource endowment, and enhance the control of farmers' perceptual behavior. By improving the level of various types of endowments of farmers to enrich their resources and enhance their risk resistance, farmers can improve their perceptual behavior control and exert the influence of subjective norms.

Conclusions

Based on the extended TPB-NAM integrated analysis framework, PLS-SEM was applied to analyze the influencing mechanisms of INT-CE from two perspectives: individual economic rationality and social moral rationality, and the main findings were as follows:

Firstly, in order to explain the formation mechanism of INT-CE from the perspective of both individual economic rationality and social moral rationality of farmers, we integrated TPB and NAM into a unified analytical framework. The study found that the formation of INT-CE is influenced by both self-interest and altruistic motives, and the self-interest motive is the stronger driving force.

Secondly, in TPB, attitudes, perceived behavioral control, and subjective norms all positively influence INT-CE, but the degree of impact is different. Attitudes have the greatest impact on intention, and subjective norms have a higher effect than perceived behavioral control.

Thirdly, this demonstrates the effectiveness of combining past habits with TPB, and provides a valuable attempt to further expand the TPB-NAM integrated analysis framework by incorporating other variables.

Fourthly, in the NAM, the awareness of consequences not only reinforces personal norms directly, but also positively affects personal norms indirectly through attribution of responsibility, which in turn increases INT-CE, indicating that farmers who are aware of the positive INT-CE will stimulate their sense of environmental responsibility and thus show stronger intention to adopt them.

Limitations and Future Research Directions

The specificity of the sample. The samples selected in this study are mainly from villages in Shaanxi, which is reasonable but has some limitations. For example, the sample lacks a survey of a wide range of farmers who do not use coal to electricity, and the sample does not fully represent the psychological dynamics of farmers' intention to adopt coal to electricity. Therefore, we need to continue to accumulate more valid samples, carry out a wider survey, and make the results more general and reliable.

In the future, this study will adopt the fuzzy set qualitative comparative analysis (fsQCA) method and technology-organization-Environment (TOE) framework to carry out complementary research, which will be carried out in the form of organizations in the current agricultural complex, and further explore the INT-CE of organizations and individuals in organizations.

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Conflict of Interest

The authors declare no conflict of interest.

Survey Items

Table A1. Items used to measure each survey construct and loadings.

Construct	Items	Loadings
Subjective Norms (SN), adapted from Zeweld et al. (2017)	SN1: How many times do you communicate with your relatives every year?	0.806
	SN2: How many times do you communicate with your friends every year?	0.851
	SN3: How many times do you communicate with the village chief every year?	0.843
	SN4: How many times do you communicate with the village elders every year?	0.871
	SN5: How many times do you communicate with the village committee every year?	0.728
	SN6: How many times do you communicate with your wife every year?	0.720
Behavioral attitude (ATT), adapted from Zeweld et al. (2017)	ATT1: I support the national regulations on the use of electricity to replace coal.	0.803
	ATT2: I support activities of electricity to replace coal in my village.	0.815
	ATT3: I am satisfied with electricity to replace coal currently applied.	0.785
	ATT4: I support the implementation of incentives for trying electricity to replace coal.	0.776
Perceptual Behavioral Control (PBC), adapted from Zeweld et al. (2017)	PBC1: Lack of information disclosure can hinder the use of electricity to replace coal.	0.779
	PBC2: Inadequate safeguards can hinder the use of electricity to replace coal.	0.849
	PBC3: Lack of expertise can hinder the use of electricity to replace coal.	0.844
	PBC4: Unreasonable compensation can hinder the use of electricity to replace coal.	0.786
	PBC5: Inadequate communication can hinder the use of electricity to replace coal.	0.798
Personal Norms (PN), adapted from [39]	PN1: I would feel guilty if I didn't use electricity to replace coal.	0.926
	PN2: My principle is to adopt electricity to replace coal.	0.941
	PN3: I think I have a moral obligation to adopt electricity to replace coal.	0.880
Awareness of Consequence (AC), adapted from [40]	AC1: Not adopting electricity to replace coal will damage the environment.	0.878
	AC2: Not adopting electricity to replace coal can have a negative impact on consumers.	0.889
	AC3: Crops that are not farmed using electricity to replace coal can disrupt consumer markets.	0.811
	AC4: Not adopting electricity to replace coal will affect the sustainable development of farming.	0.865
Attribution of Responsibility (AR), adapted from [40]	AR1: In order to reduce pollution to the environment, I feel it is my responsibility to adopt electricity to replace coal for farming.	0.792
	AR2: I have some responsibility for the environmental problems caused by not adopting electricity to replace coal.	0.759
	AR3: For sustainable agriculture, I feel I have a responsibility to adopt electricity to replace coal for farming.	0.787
	AR4: In support of the government's goal of developing high-quality farmland, I feel it is my responsibility to adopt green technologies for farming.	0.756

Table A1. Continued

Past Habit (PH), adapted from [21]	PH1: I often pay attention to changes in environmental dynamics that directly affect farming.	0.759
	PH2: In response to changes in farming, I was quicker than other villagers to use electricity to replace coal instead of traditional ones.	0.802
	PH3: I base my decision making behavior primarily on historical experience and available technology.	0.740
	PH4: It takes a long time to learn to use electricity to replace coal.	0.765
	PH5: It is a habit for me to use electricity to replace coal in accordance with the requirements of farmland protection.	0.769
	PH6: Using electricity to replace coal as required by the government is a habit for me.	0.727
Farmers' behavioral intention to adopt electricity to replace coal (INT-CE), adapted from Zeweld et al. (2017)	INT1: I would like to use electricity to replace coal instead of the production technology used now.	0.801
	INT2: I would like to learn electricity to replace coal.	0.873
	IANT: I would like to apply electricity to replace coal.	0.865
	INT4: I would like to promote electricity to replace coal.	0.890
	INT5: I am willing to give feedback on the effectiveness of electricity to replace coal.	0.884
	INT6: I would like the village to develop electricity to replace coal.	0.856

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