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Understanding Farmers' Behavior in Using Feed Additives: Self-Interest or Altruism?

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Abstract

Farmer decision making about feed additives and rational use is of great concern to policymakers. Overuse and misuse can lead to both environmental pollution and health threat. Following the Administrative Regulations on Feed and Feed Additives (ARFFA) can help to mitigate these impacts and improve farm incomes. This study aims to investigate farmers' behavior in using feed additives according to ARFFA. To this end, we adopt an integrated version of the theory of planned behavior and the norm activation model. We also apply the structural equation model to analyze survey data derived from 527 participants in the Jiangxi, Hubei, and Yunnan provinces in China. The results show that intention to rational use feed additives is primarily driven by attitude, followed by subjective norm and perceived behavioral control. Awareness of consequence is a positive predictor of ascription of responsibility, whereas ascription of responsibility significantly affects personal norm. We also find that both intention and personal norm have significant influence on farmers' behavior in rational use of feed additives, with intention having a greater effect. Overall, in addition to self-interest, altruism is also an integral part of influencing farmers' behavior in using feed additives according to ARFFA. The implications of these findings are discussed.

Keywords: sustainable agricultural practices; norm activation model (NAM); theory of planned behavior (TPB); farmer decision making

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Introduction

Fueled by the demand for animal products, feed additives are increasingly used by farmers around the world. The use of additives in agricultural practices provides many benefits to farmers, including enhancing the nutritional value of the base feed, improving animal performance, ensuring animal health, saving feed costs, and improving the quality of livestock products (e.g., Hamasalim, 2016; Hu and Cheng, 2016). However, the negative effects caused by the irrational use of feed additives are increasingly being recognized. The residues of antibiotics or hormones and the drug resistance resulting from the overuse and misuse of feed additives are posing serious threats to animal and human health (e.g., Wegener, 2003; Sapkota and Lefferts et al., 2007; Muhammad and Khan et al., 2020). The magnitude of the problem is now accepted, antimicrobial resistance (AMR) currently represents a major health threat and estimate to cost 10 million lives per year by 2050, much of the direct and indirect impact of AMR will fall on low and middle-income countries (Jim, 2016).

The view that feed additives can damage the environment has also been confirmed in previous studies. Lienert and Bürki et al. (2007) demonstrated that when antibiotic feed additives are consumed with feed by livestock and poultry, they are metabolized and excreted as prototypes in feces and urine by about 60% to 90%. Once manure containing antibiotic residues is used as fertilizer, it inevitably has an impact on the soil and the surrounding environment. Hu and Cheng et al. (2019) believed that feed additives excreted by animals could enter the environment through multiple pathways, thereby increasing the risk to ecosystems and creating a vicious cycle. According to the communique of China's Second National Pollution Source Census, the chemical oxygen demand of water pollutant emissions from livestock and poultry farming was over 10 million tons in 2017, accounting for 93.8% of the national pollution from agricultural sources. The amount of ammonia nitrogen and total phosphorus also exceeded 50% of the national agricultural source pollution. Livestock and poultry farming pollution has become the main source of agricultural surface pollution in China. Given the concerns raised about the environmental impact of feed additives, the Chinese government promulgated the Administrative Regulations on Feed and Feed Additives (ARFFA) to strengthen the management of feed additives. However, overuse and abuse are still prevalent (Larson, 2015; Yang and Paruch et al., 2019).

Because the proper use of feed additives can help improve the safety of animal products and maintain public health—in addition to providing long-term benefits to farmers—

clarification of the determining factors that drive farmers' behavior in using feed additives is imperative. Several studies have combined the theory of planned behavior (TPB) and the norm activation model (NAM) (e.g., Liu and Sheng et al., 2017; Zhang and Geng et al., 2017). TPB is considered to be a self-interest theory. Abrahamse and Steg et al. (2009) argued that TPB is a rational-choice model and that pro-environmental behavior is the result of individual cost-benefit analyses. However, altruistic motives also play important roles in predicting behavior (e.g., Chen, 2016; Gao and Wang et al., 2017; Oteng-Peprah and de Vries et al., 2020). Conversely, NAM is a robust model for explaining pro-social and pro-environmental behaviors, which ignores the role of self-interested motives in predicting behavior (Onwezen and Antonides et al., 2013). On the one hand, farmers always consider their interests, regardless of whether their use of feed additives is rational (Shi and Fan et al., 2017). On the other hand, when considering serious environmental pollution, farmers also keep in mind the altruistic nature of this behavior and try to act in ways that protect the environment (Shi and Fan et al., 2017). Therefore, to consider the perspectives of both self-interest and altruism, in this study, we integrated TPB and NAM to investigate the drivers of farmers' behavior related to the use of feed additives, according to ARFFA. This integrated model enables the provision of a more comprehensive insight into farmer decision making which can be used to inform policy that is designed to encourage farmers' rational use of feed additives.

The main objectives of this research are 1) to apply the integrated TPB-NAM model to explain farmers' behavior in the rational use of feed additives in agricultural practices; 2) to investigate the generation path of farmers' proper use of feed additives from self-interest and altruism perspectives. To accomplish these objectives, in the following section we review the literature and hypothesize the relationship between variables. Section 3 describes the methodology. Section 4 presents the estimation results. The final section presents conclusions, discusses policy implications.

Theory and hypotheses

Theory of Planned Behavior (TPB)

Icek Ajzen (1991) first developed TPB which extended the theory by adding perceived behavioral control to the theory of reasoned action model (Azjen, 1980). TPB explains how people change their behavior (Ajzen, 1991), and it has become one of the most commonly used models to predict human behavior (Ajzen, 2011). The theory suggests that three determinants can influence intention: attitude, subjective norm, and perceived behavioral control (PBC)

(Ajzen, 1991).

Attitude is explained as the degree to which an individual evaluates a behavior as favorable or unfavorable (Ajzen, 1991). In general, when individuals have a more positive attitude toward a behavior, they are more willing to perform that behavior (e.g., Zubair and Garforth, 2006; Khan and Manzoor et al., 2020). To be specific, Hou and Hou (2019) pointed out that the deeper perception farmers have and the more positively they evaluate low-carbon agriculture, the more likely they will be to engage in it. Farmers will intend to use feed additives following ARFFA if they believe the practice is meaningful and will make them feel good. We thus present the following hypothesis:

H1: Attitude will positively influence farmers' intention to use feed additives in accordance with ARFFA.

Subjective norm represents the social influence on individuals and refers to the social pressure individuals feel when they consider whether to perform a particular behavior (Ajzen, 1991). Individuals usually prefer to align themselves with the expectations of important organizations or important people, so the approval of behavior by an important person is sufficient to motivate an individual's intention to perform that behavior (e.g., Hu and Zillig et al., 2006; Wang and Yang et al., 2018). For example, Taghdisi and Amiri et al. (2018) suggested that focusing on subjective norms by paying attention to the individuals or organizations influencing the farmers is essential for promoting the intention to use pesticides optimally. Farmers are thus more likely to use feed additives rationally if that behavior is based on social pressure. Therefore, we propose the following hypothesis:

H2: Subjective norm will positively influence farmers' intention to use feed additives according to ARFFA.

PBC is defined as the perceived ease or difficulty of performing a behavior, and it reflects the individual's past experiences and expected impediments (Ajzen, 1991). Empirical findings suggest that PBC directly influences intention and that people are more likely to perform a behavior when they have high PBC (e.g., Adnan and Nordin et al., 2018; Wang and Gao et al., 2018; Farani and Mohammadi et al., 2019). For instance, Terano and Mohamed et al. (2015) indicated that farmers who have a positive PBC have stronger intentions to adopt sustainable agriculture practices. Therefore, when farmers believe they have the relevant knowledge, adequate technical support, and necessary funding, they are more likely to use feed additives based on ARFFA. It is worth noting that although Ajzen suggested the possibility of a direct effect of PBC on behavior in his original TPB model, a review of the relevant literature in the pro-environmental field revealed that the effect of PBC on behavior was not significant (e.g., Deng and Sun et al., 2016; Wang and Yang et al., 2018), and therefore this hypothesis is not made here. In summary, we conclude the next hypothesis:

H3: PBC will positively influence the intention of farmers to use feed additives according to ARFFA.

Moreover, intention reflects an individual's willingness to perform a particular behavior. It is assumed to be a direct antecedent of behavior (Ajzen, 2002). That intention directly influences behavior has been well established in previous studies (e.g., Adnan and Nordin et al., 2019; Despotović and Rodić et al., 2019; Bonke and Musshoff, 2020). Thus, we posit the following hypothesis:

H4: The intention of farmers to use feed additives according to ARFFA will positively affect their behavior.

Norm Activation Model (NAM)

NAM was originally proposed in the context of altruistic behavior and is primarily concerned with the sacrifice of personal interests for the welfare of others (Schwartz, 1977). NAM has three components: awareness of consequence, ascription of responsibility, and personal norm (Schwartz, 1977). Personal norm is the key to the NAM; it is defined as the self-expectation of a particular action in a particular situation (Schwartz, 1977), and it represents the moral obligation to perform a specific behavior (Schwartz and Howard, 1981). Ascription of responsibility represents people's feelings about whether they are responsible for the consequences of their behavior (Schwartz, 1977). When people are aware of the negative consequences of their behavior on others, they tend to assign responsibility for the consequences to themselves (Gao and Huang et al., 2017). Awareness of consequence refers to the person's tendency to relate their behavior to the welfare of others (Schwartz, 1977).

Researchers hold different perspectives on the relationships between the variables within NAM. The first view describes NAM as a mediator model, in which the awareness of consequence influences personal norm through the ascription of responsibility (e.g., Steg and De Groot, 2010; Onwezen and Antonides et al., 2013; Han, 2014). The second view sees NAM as a moderation model, in which both the awareness of consequence and the ascription of responsibility influence personal norm (e.g., Liu and He et al., 2018; Wang and Ali et al., 2020).

However, a series of studies by De Groot and Steg (2009) provided strong evidence for the first view. They compared these two interpretations in five studies and showed that personal norm significantly influences behavior and that the ascription of responsibility activates personal norm. Furthermore, people must be aware of the consequences of a behavior (awareness of consequence) before feeling responsible for it (ascription of responsibility). Therefore, the mediator model is used to establish the research model proposed in this study.

As mentioned earlier, farmers will tend to assign personal responsibility for the use of feed additives if they are aware that their reasonable use behavior has a positive impact on human health and the environment. Therefore, we apply NAM to the farmers' behavior in using feed additives according to ARFFA and formulate the following hypotheses:

H5: Awareness of consequence will positively affect the ascription of responsibility.

H6: Ascription of responsibility will positively affect personal norm.

H7: Personal norm will positively affect farmers' behavior in using feed additives in accordance with ARFFA.

The Proposed Model

Based on the above literature review and discussion, we proposed a conceptual model (**Figure 1**). Our theoretical framework involves seven latent variables, one explicit variable, and seven hypotheses. We combined the original TPB and NAM, which provided a more comprehensive understanding of farmers' behavior in using feed additives in accordance with ARFFA.

Methodology

Measures

We collected empirical data for this study through a structured questionnaire. The initial step in constructing the survey instrument was to review the relevant literature related to NAM and TPB. Based on this review, the construction of the questionnaire followed the instructions of Ajzen (2006) and used measurement scales and indicators established in previous studies by Han (2014) and Rezaei and Safa et al. (2019). We modified these adopted items in this study as appropriate to fit the requirements but followed the general style of these studies, and all measures were consistent with the common assessment practices in this field.

We divided the final questionnaire into two sections. The first section dealt with the sociodemographic information of the participants (including gender, age, education level, and annual household income). The second part had a total of 19 items. Three items each were used to measure attitude, subjective norm, awareness of consequence, and personal norm. Two items each were utilized to assess perceived behavioral control, intention, and the ascription of responsibility. These statements were anchored by 1 "do not agree at all" and 5 "strongly agree". One item was used for behavior. This statement was anchored by 1 "rarely" and 5 "often". **Table 1** reproduces the exact wording of the statements used in all scales.

Data Collection and Geographical Context

China is the largest producer and consumer of waterfowl farming in the world. In recent years, China's waterfowl industry has developed rapidly, people's demand for waterfowl products has increased year by year, and the quality and safety of waterfowl products has been increasingly emphasized. Therefore, we choose waterfowl farmers as the research object. We collected the data for this study in 2020. First, according to the National Waterfowl Industry Technology System, we conducted a survey on waterfowl production in the 21 main waterfowl-producing provinces in China and then randomly selected the target provinces as Jiangxi, Hubei, and Yunnan.

As shown in **Figure 2**, Jiangxi Province is located in southeast China and has the largest freshwater lake in China. This province has a long history of waterfowl breeding, which is the traditional production area of the national waterfowl industry. Hubei Province is located in central China. With its humid climate, suitable environment, and extremely rich water resources, Hubei Province is a well-known waterfowl production province in China and is also famous for its unique waterfowl processing products. Yunnan Province is located in southwest China. Known as the "animal kingdom", Yunnan features numerous featured products, including livestock and poultry. It is an important livestock-producing province in China. Moreover, Yunnan is one of the provinces with the richest genetic resources of livestock and poultry in China.

To ensure that the field research was carried out smoothly, we recruited 11 volunteers, and 50 questionnaires were distributed to each volunteer, for a total of 550 questionnaires. We provided presurvey training to volunteers, informing them about the key points and techniques of the face-to-face survey. The preferred participants were farmers or heads of farming enterprises and cooperatives with at least 5 years of farming experience, and they need to have some knowledge of the relevant aspects of ARFFA. We researched key farming areas along the rivers and lakes of each province as far as possible. A total of 537 questionnaires were completed. Of these participants, 527 remained for data analysis after removing misfiled questionnaires and extreme outliers.

Results

Data analysis

Least Significant Difference (LSD) analysis was conducted to examine whether there was any significant difference in responses across the three different provinces. No significant difference in participants' profile or measured constructs was found at $p < 0.05$. Thus, data from the three provinces were combined in all analyses that followed.

Structural equation modeling (SEM) in AMOS 24.0 was conducted to evaluate the proposed model and hypotheses. A desirable goal of sample size is to have a 20:1 ratio for the number of participants to the number of model parameters (Suhr, 2006), the ratio in this study is 24.0:1 that meets the requirement of sufficient sample size. A two-step procedure is adopted to test the research hypotheses. In the first step, confirmatory factors analysis (CFA) is conducted to test the fit of the measurement model and assess the reliability and validity of the constructs. In the second step, we use SEM to test the hypothetical model proposed above. As non-multivariate normal data will result in an inaccurate estimation, the model is estimated using the bootstrap method to adjust for non-multivariate normal with the maximum likelihood estimation method (Bollen and Stine, 1992).

Participants' Profiles

Table 2 presents the demographic characteristics of the participants. The participants ranged in age from 21 to 88 (SD = 14.69). Additionally, 67% of the participants were male and 33% were female. In terms of education level, 9.1% were illiterate. The groups of participants who had finished intermediate school (38.5%) and primary school (25.6%) were the largest groups, indicating that most of the participants were not well-educated. Nearly half (48.6%) reported an annual household income of 20,000–60,000 yuan (about 3114-9342 US dollars). The average number of poultry stocks for the participants from the years 2017, 2018, and 2019 was 1552.63 (SD = 7323.79), 2276.15 (SD = 10966.57), and 5083.98 (SD = 26041.04), respectively. According to the 2020 China Rural Statistical Yearbook, China's rural residents are generally older, more male, and less educated (50.8% of them were at intermediate school level), with an annual per capital disposable income of 16,020 yuan (about 2494.2 US dollars).

The distribution of the samples is largely consistent with the above indicators, indicating that the samples are somewhat representative.

As shown in **Table 1**, the mean values of intention (3.76), attitude (3.78), ascription of responsibility (3.79), and awareness of consequence (3.86) were relatively high. The mean score of personal norm (3.66) and subjective norm (3.59) were moderate whereas the mean value of behavior (3.22) and PBC (3.12) were low. These findings showed that most farmers had a favorable attitude towards the use of feed additives in accordance with ARFFA. Moreover, they were aware of the consequences of the misuse of feed additives and felt responsible for them. To a certain extent, they were easily restrained by themselves as well as others. However, they did not perceive enough control to use the feed additives properly. This may be because they did not have the required funds and skills to change the current situation. Also, although the participants had a strong intention of using feed additives in accordance with ARFFA (3.76), they did not show a correspondingly high level of behavior (3.22).

Reliability and Validity Testing

We assessed the internal consistency, convergent validity, and discriminant validity of the measurement model using CFA and the maximum likelihood estimation approach. **Table 3** provides a summary of the fit indices from the CFA. The results show that the measurement model is well adapted to the data according to Chen's (2007; 2016) indices.

As shown in **Table 4**, to assess internal consistency, we measured the composite reliability values. The values were greater than 0.8 for all variables, exceeding the minimum recommended value of 0.7 (Claes and David, 1981). This indicates that all the measurements of the variables included an acceptable level of consistency. We then further evaluated the convergent validity of the measurement model. The factor loadings of each latent variable were between 0.75 and 0.91, indicating that each measurement was highly representative of the corresponding latent variables (Hair and Black et al., 1998). And the average variance extracted (AVE) for each dimension was greater than 0.5 (Claes and David, 1981), confirming convergent validity.

Table 5 demonstrates that the measurement model established discriminant validity. There was a significant correlation between attitude and all the variables, including subjective norm, personal norm, awareness of consequence, perceived behavioral control, ascription of responsibility, intention, and behavior. In addition, the correlation coefficients were all smaller than the square root of the corresponding AVE, which means that the latent variables were correlated with each other and were distinguished from each other (Claes and David, 1981).

In order to ensure that common method bias (CMB) would not distort the results of this research, besides constructing the items, we informed the respondents that "the questionnaire is anonymous, there are no right or wrong answers, and the results of the questionnaire are not presented individually" in advance (Podsakoff and MacKenzie et al., 2003). This study also compared the standardized regression weights of the constrained and unconstrained models using the Common Latent Factor method. We subtracted the estimates without CLF from the estimates with CLF to get the differences in estimates. The results showed that the differences between them are all less than 0.2, indicating that CMB is not severe enough to affect the study results and the sample data pass the common method bias test (Afthanorhan and Awang et al., 2021).

Modeling Comparisons

The structural equation approach was used to test the proposed theoretical framework to predict farmers' behavior of using feed additives. To test the robustness of the integrated model, we conducted a rigorous theory-based stepwise test of the initial theoretical models and the integrated model based on a sample of 527 Chinese farmers. The results of the modeling comparisons are shown in **Table 6**.

First, the original TPB model was tested. Approximately 12.5% of the variance in behavior was explained by intention. Next, we tested the standard NAM. Only 8.4% of the variance in behavior was contributed by personal norm. Finally, the integrated model was tested. The results showed that the combination of intention and personal norm explained about 19.9% of the variance in behavior. It is also clear from other indicators that all three models have an acceptable fit, and the integrated model was superior to the other models in predicting farmers' behavior in using feed additives according to ARFFA.

Structural Equation Model Results

As presented in **Figure 3**, the original TPB constructs, which are attitude ($\beta = 0.61, p < 0.001$), subjective norm ($\beta = 0.21, p < 0.001$), and perceived behavioral control ($\beta = 0.14, p < 0.001$), were all significant predictors of the intention to use feed additives in accordance with ARFFA. Therefore, hypotheses 1, 2, and 3 were supported. Next, the path from intention to behavior was statistically significant, supporting H4 ($\beta = 0.54, p < 0.001$). Moreover, hypotheses 5, 6, and 7 proposed relationships among the original variables established in NAM.

The results showed that awareness of consequence had a positive influence on ascription of responsibility ($\beta = 0.83, p < 0.001$), ascription of responsibility had a significant impact on personal norm ($\beta = 0.83, p < 0.001$), and personal norm significantly affected behavior ($\beta = 0.28, p < 0.001$). These results supported hypotheses 5, 6, and 7. In summary, all the hypotheses were supported.

Discussion and implications

The study adds new knowledge to the research on factors influencing farmers' behavior in the use of feed additives according to ARFFA. It provides evidence on the validity of an integrated model using TPB and NAM in assessing farmers' rational feed additive use behavior. The findings suggest that while both the initial TPB and the initial NAM can effectively explain the behavior of regulated feed additive use, combining the two can improve its predictive power. Although farmers' behavior in regulating feed additive use is primarily driven by self-interest motives, this study also confirms that altruistic motives are also an integral part. Overall, the results of the study provide some insights for policymakers to make effective decisions regarding the rational use of feed additives. The theoretical and policy implications provided by the current study are discussed in detail below.

The empirical results showed that attitude, subjective norm, and PBC were all determinants that influence farmers’ intention to use feed additives according to ARFFA. That is, farmers with a favorable and positive attitude who were under social pressure and had sufficient resources and ability were more likely to use feed additives, according to the regulations. In addition, the intention had a significant effect on behavior, and the stronger the farmers’ intention to use feed additives according to the regulations, the more likely they were to exhibit appropriate behavior. Many previous studies have reported similar results (e.g., Adnan and Nordin et al., 2019; Bonke and Musshoff, 2020). However, the relative importance of structure differs from these studies.

According to the results, attitude made the largest contributions to the prediction of farmers’ intentions to use feed additives based on ARFFA. This result is consistent with the findings of Floress and de Jalón et al. (2017) and Maleksaeidi and Keshavarz (2019), who suggested that attitudes are usually the strongest predictors of farmers’ pro-environmental intentions. If governments prioritize the creation of favorable attitudes among farmers toward the rational use of feed additives, the likelihood of the farmers forming such an intention may increase, thereby directly influencing their behavior. Hence, it is recommended that the government make an effort to determine what shapes the favorable attitudes of farmers toward the rational use of feed additives. Also focus on incorporating the proper use of feed additives into farmers' mindset by formal communication (e.g., establishing appropriate mechanisms for monitoring responsibilities and rewards and penalties). Emphasize the ecological benefits of the rational use of feed additives in order to promote favorable attitudes among farmers.

Subjective norm was the second major factor in the original TPB. This is consistent with the previous research from Yadav and Pathak (2017). The pressure of subjective norms comes from the expectations of important people. Therefore, farmers should be supported by effective social support for the use of feed additives based on ARFFA. So, the government should develop an atmosphere for the rational use of feed additives by taking certain measures. It should also strengthen the role of demonstration, enhance farmers' understanding and trust in village cadres, strengthen the cohesiveness and appeal of village organizations, make full use of the social network of rural acquaintances, and promote farmers' rational use of feed additives through the guidance and demonstration of important people such as relatives, friends, and village cadres, thus enhancing subjective norm by increasing social pressure on farmers.

Consistent with previous studies (e.g., Shi and Fan et al., 2017; Wang and Gao et al., 2018), PBC was another factor that predicted farmers' intention to use feed additives based on ARFFA. In fact, most farmers do not have enough self-efficacy, including relevant resources such as knowledge, skills, time, and money (Rezaei and Safa et al., 2019). If farmers cannot overcome these difficulties, they are more likely to lose motivation and the intention to use feed additives, according to the regulation. It is important to improve farmers' PBC levels. The government should focus on building agricultural infrastructure, offering courses on relevant knowledge for farmers, encouraging them to attend these courses, and introducing more subsidized policies. All these actions are conducive to the development of high PBC among farmers, which further increases their intention to use feed additives rationally.

This study also confirmed that personal norm is influenced by the ascription of responsibility and that the ascription of responsibility is influenced by awareness of consequence. This finding provided some support for the original NAM (Schwartz and Howard, 1981). This means that, if farmers know the negative consequences that may be caused by their misuse of feed additives, and thus feel responsible for the consequences, they are more likely to develop personal norms for the rational use of feed additives. Personal norm had a significant impact on the farmers' behavior in using feed additives, according to ARFFA. Various studies have shown the role of the personal norm in predicting pro-environmental behavior (e.g., Han, 2014; Liu and Sheng et al., 2017; Shin and Im et al., 2018). Therefore, the government can increase the guidance of public opinion on the rational use of feed additives, raise awareness among farmers about the negative consequences caused by the misuse of feed additives, and promote their awareness that farmers are the main responsible for agricultural environmental protection so that farmers consciously use feed additives according to ARFFA in a subtle way. At the same time, education can also cause farmers to take more personal responsibility for their behavior to protect the environment. All the above measures will help activate farmers' personal norms and motivate them to use feed additives, according to ARFFA.

Limitations of the study should also be considered. First, although the sample size in this study (*n = 527*) was not problematic, it was relatively small. A larger sample size study would have more generalizable results. Second, the theoretical framework in this paper only assessed the farmers' use of feed additives in selected regions of China. Therefore, caution is recommended when generalizing the findings to farmers in other regions and to other behaviors. Future studies could test the proposed research model in different regions and compare the results with those of the current study. Third, although TPB was successfully integrated into NAM in this study, the decisions of farmers when engaging in pro-environmental behavior are significantly more complex than is evident in our framework. Further research efforts are needed to identify the other influential variables (e.g., perceived threat, habit) and to incorporate them into a proposed theoretical framework to provide a more complete understanding of farmers' pro-environmental behavior.

Author contributions

Xingdong Wang and Dan Pang were the principal investigators of the grants and wrote the first draft. Jin Tang revised the draft. Minglaing Wang analyzed the model and further revise and improve the paper. Xueping Gao contributed to research design, data collection. Wenmiao Liao and Zhenlin Weng completed the empirical analysis.

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TABLE 1 Mean, standard deviation of items and subsections (n = 527)

Subsections	Items	Mean score, standard deviation [A, B, C]
Attitude	Do you feel good about using additives for farming in accordance with the Administrative Regulations on Feed and Feed Additives (ARFFA)?	3.75 ±0.89^{a}
	Do you feel that it is meaningful to use additives for farming in accordance with ARFFA?	3.80 ±0.88^{a}
	Do you think you should farm in accordance with the relevant provisions of ARFFA?	3.79 ±0.89^{a}
	Subsection mean scores	3.78 ±0.89$^{\alpha}$
Subjective Norm	Most of the people who are important to me think I should use antibiotics as a standard when farming.	3.64 ±0.93^{a}
	Most of the people who are important to me favor me implementing standard antibiotic use for farming.	3.65 ±0.96^{a}
	Most people like me would implement standard antibiotic use for farming.	3.47 ±0.99^{b}
	Subsection mean scores	3.59 ±0.96$^{\beta}$
Personal Norm	I would feel guilty if I didn’t farm according to standard antibiotic use.	3.64 ±0.86^{a}
	My principle is to farm according to standard antibiotic use.	3.68 ±0.88^{a}
	I believe I have a moral obligation to farm according to standard antibiotic use.	3.67 ±0.87^{a}
	Subsection mean scores	3.66 ±0.87$^{\beta}$
Awareness of Consequence	Farming without standard antibiotic use can be harmful to human health.	3.94 ±0.88^{a}
	Farming without standard antibiotic use can have a negative impact on consumers.	3.91 ±0.84^{a}
	Products raised without following standard antibiotic use can disrupt consumer markets.	3.72 ±0.88^{b}
	Subsection mean scores	3.86 ±0.87$^{\delta}$
Perceived Behavioral Control	Do you think it is easy to implement standard antibiotic use practices?	3.17 ±0.97^{a}
	Do you believe you have a sufficient technical support team, funding, and so on to provide for the smooth implementation of standard antibiotic use?	3.07 ±1.04^{a}
	Subsection mean scores	3.12 ±1.01$^{\varepsilon}$
Ascription of	To reduce the risk to consumer health, I feel it is my responsibility to farm in accordance with standard	3.81 ±0.86^{a}

Responsibility	antibiotic use.	
	I should be responsible for consumer health problems that result from farming without following standard antibiotic use.	3.77 ±0.86[a]
	Subsection mean scores	3.79 ±0.86[α]
	Are you willing to use additives in accordance with ARFFA when you farm in the coming year?	3.74 ±0.98[a]
Intention	Are you willing to take some of the plots and farm them in accordance with the relevant regulations of ARFFA?	3.79 ±0.96[a]
	Subsection mean scores	3.76 ±0.97[α]
Behavior	Over the past year, how often did you use additives in full compliance with the relevant provisions of ARFFA?	3.22 ±1.31[a]

Note. A. Mean scores of the items superscripted by the same English alphabet are not significantly different from each other.

B. Mean scores of the subsections superscripted by the same Greek letter are not significantly different from each other.

C. At the 1% level of significance based on the Chi-square (χ^2) test.

TABLE 2 Demographic Characteristics of the Participants (n = 527)

Characteristics	Category	n	Percentage (%)	χ^2	Df	p
Age	21-29	55	10.4	291.1	4	0.06
	30-39	59	11.2			
	40-49	137	26.0			
	50-59	138	26.2			
	60 and above	138	26.2			
Gender	Male	353	67.0	60.8	1	0.50
	Female	174	33.0			
Highest Education	Illiterate	48	9.1	217.2	4	0.37
	Primary School	135	25.6			
	Intermediate school	203	38.5			
	High school or junior college	89	16.9			
	Academic degree	52	9.9			
Household Income (Yuan/ RMB) [a]	less than 20， 000	100	19.0	181.0	3	0.00
	20,000-60,000	256	48.6			
	60,000-100,000	125	23.7			
	more than 100,000	46	8.7			

[a] *Note.* An average of 6.425 China Yuan equals to 1USD at the time of survey.

TABLE 3 Model Fit Indices for Measurement Model

Fit index	Recommended value	Estimate value
Normed Chi-Square (χ^2 / df)	<3	2.15
Root-Mean-Square Error of Approximation (RMSEA)	<0.08	0.05
Goodness of-fit Index (GFI)	>0.9	0.95
Normed Fit Index (NFI)	>0.9	0.97
Comparative Fit Index (CFI)	>0.9	0.98
Incremental Fit Index (IFI)	>0.9	0.98
Tucker-Lewis Index (TLI)	>0.9	0.98

TABLE 4 Measurement Model Results

Measurements	Factor Loadings	Cronbachs' alpha	Composite Reliability	AVE
ATT 1	0.87			
ATT 2	0.89	0.91	0.92	0.79
ATT 3	0.90			
SN 1	0.91			
SN 2	0.89	0.91	0.91	0.78
SN 3	0.85			
PN 1	0.88			
PN 2	0.90	0.92	0.92	0.79
PN 3	0.89			
AC 1	0.86			
AC 2	0.88	0.87	0.87	0.69
AC 3	0.75			
PBC 1	0.88	0.85	0.86	0.75
PBC 2	0.85			
AR 1	0.89	0.86	0.86	0.76
AR 2	0.85			
INT 1	0.87	0.87	0.87	0.77
INT 2	0.88			

Note. ATT = Attitude; SN = Subjective Norm; PN = Personal Norm; AC = Awareness of Consequence; PBC = Perceived Behavioral Control; AR = Ascription of Responsibility; INT = Intention.

TABLE 5 Correlation coefficients between variables

	ATT	SN	PN	AC	PBC	AR	INT	BEH
ATT	0.89							
SN	0.76***	0.88						
PN	0.68***	0.67***	0.89					
AC	0.66***	0.63***	0.67***	0.83				
PBC	0.40***	0.50***	0.48***	0.38***	0.87			
AR	0.68***	0.65***	0.79***	0.76***	0.41***	0.87		
INT	0.79***	0.71***	0.59***	0.62***	0.46***	0.61***	0.88	
BEH	0.37***	0.42***	0.37***	0.31***	0.57***	0.33***	0.42***	/

Note. The bold numbers on the diagonal are the square root of AVE. p*<0.1, p**<0.05, p*** < 0.001.

TABLE 6 Estimated parameters and goodness-of-fit indices of the test models (n = 527)

Path	TPB model	NAM model	Integrated model
χ^2	292.66	272.05	490.32
χ^2 / df	7.50	10.463	3.50
p	< 0.001	< 0.001	< 0.001
RMSEA	0.11	0.13	0.07
CFI	0.94	0.92	0.96
NFI	0.93	0.92	0.94
IFI	0.94	0.92	0.96
TLI	0.92	0.89	0.95
GFI	0.91	0.89	0.91
Adjusted R^2			
AR	/	0.60	0.68
PN	/	0.51	0.66
Intention	0.51	/	0.68
Behavior	0.13	0.08	0.20

Note. RMSEA = Root-Mean-Square Error of Approximation; CFI = Comparative Fit Index; NFI = Normed Fit Index; IFI = Incremental Fit Index; TLI = Tucker-Lewis Index; GFI = Goodness of-fit Index; AR = Ascription of Responsibility; PN = Personal Norm.

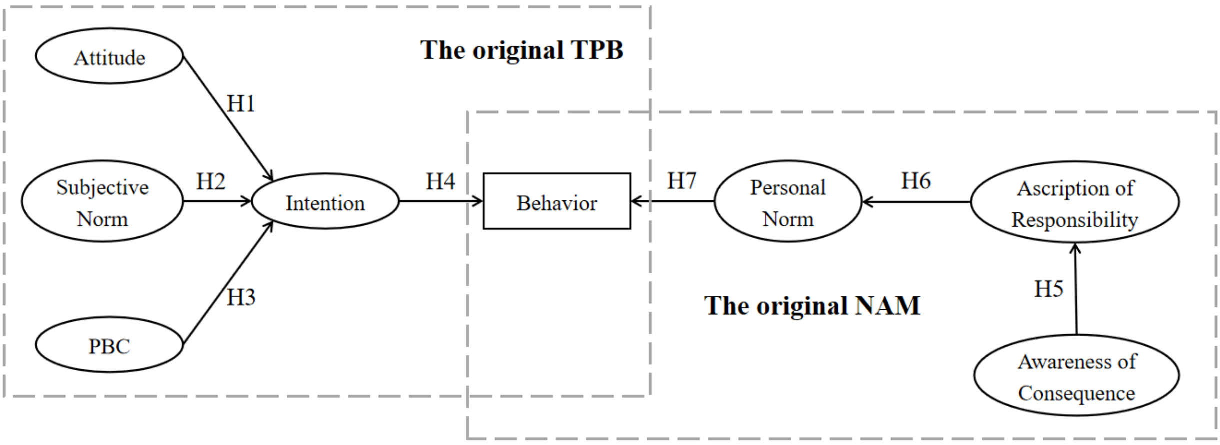

FIGURE 1 The proposed model

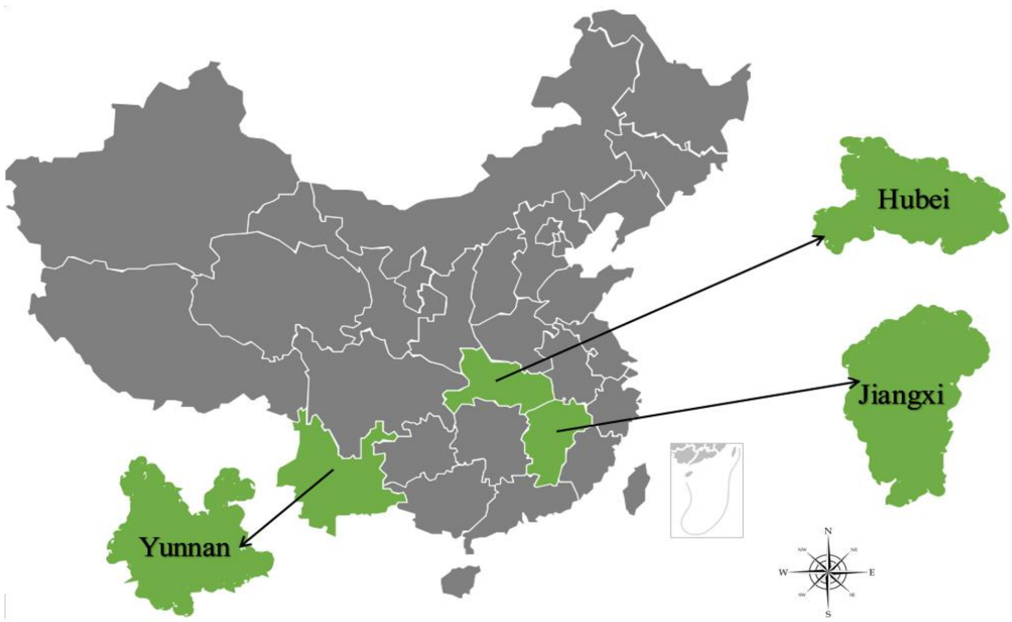

FIGURE 2 The survey area

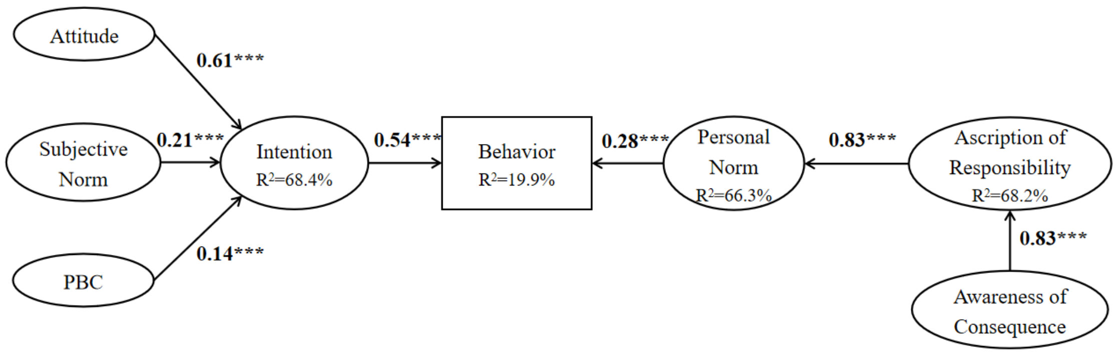

FIGURE 3 Structural equations modeling and standardized path coefficients (integrated model)

Note. p* < 0.1; p** < 0.05; p*** < 0.01.