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Combining the Theory of Planned Behavior, The Expected Utility Theory, and Diffusion of Innovation Theory to Analyze Factors Affecting Farmers' Intention to Use Pesticides: The Case Study of Quang Nam Province in Vietnam

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ABSTRACT

The main purpose of this study is to examine the farmers' intention of pesticide use by using a combination of the theory of planned behavior, the expected utility theory, and the diffusion of innovation theory. The data were collected from 362 farmers in Quang Nam from April to December 2020 and were analyzed by a structural equation model. The analysis results show that farmers' intention to use pesticides is affected by many variable groups from the above theories. The combination of these theories limits the disadvantages of applying only one theory into studying the farmers' intentions of pesticide use.

Keyword

Intention, pesticides, planned behavior theory, expected utility theory, diffusion of innovation theory, farmers, Quang Nam.

Introduction

Pesticides are the optimal method to eliminate pests and diseases in agricultural production in general and in rice production in particular. They help to improve production efficiency; ensure profits, and food supply; and save time. Therefore, they play an essential role in farmers' food production [1]. About two million tons of pesticides are used annually worldwide, of which China is the largest contributor, followed by the US and Vietnam was at 27th position [2].

However, the use of pesticides has also caused many serious consequences, especially in rural areas of developing countries. On average, three million farmers are poisoned with pesticides, and 25 million farmers suffer from mild poisoning, leading to about 180,000 deaths annually among agricultural workers, due to incorrect awareness [3], lack of knowledge, regulations, education [4]. Pollution of pesticide residues also causes other serious harms affecting the aquatic environment, prevents the growth and structure of aquatic ecosystems [5].

Therefore, understanding the motivations, values, attitudes and purposes of pesticide use is an important basis to propose implications for farmers and policy makers to reduce or at least follow the correct process of pesticide use in agriculture, aiming to a green agriculture.

However, currently theoretical and empirical models have tended to explain the decision-making behavior of farmers to adopt technology from the perspective of a particular industry Pannell et al. [6]. Ghadim et al. [7] used the expected utility theory proposed

by Daniel Bernoulli (1738) to examine farmers' decisions based on the benefits and risks of pesticide use [7]. Meanwhile, the theory of planned behavior (TPB) by Ajzen, [8] shows that attitudes, social norms and behavioral control awareness are the most important factors affecting the decision to adopt innovation. farmer technology [8]. However, the TPB theory does not consider the role of information coming from friends, the media or extension workers. In another approach, diffusion of innovation theory (DOI) focuses on the impact of information sharing through proactive communication on farmers' decision to adopt innovation [9-11]. The decision to apply technological innovation in agriculture is influenced not only by psychological factors but also by economic, social and cultural factors [12]. In this study, we rely on the model proposed by [13,14] which integrates expected utility theory, psychosocial theory and expanding the model by investigating accessibility to information, perceptions of benefits, risks, prices as well as the system of local pesticide shops to explain the intention of pesticide use in rice production of farmers in Quang Nam province.

Theoretical framework

Previous theoretical and experimental studies on farmers' decision to apply technological innovation in agriculture were developed in three main approaches which are as follows:

The first is based on the expected utility theory (EUT), which was initiated by Bernoulli (1738), and then developed by Batz et al [15]. Ghadim argue that the basis of EUT theory is that farmers decide to apply an improved technology if they expect its utility to be higher in comparison with a traditional technology. They also add that farmers' subjective perceptions of benefits and risks resulting from innovation affect their decision to apply technological innovation. Specifically, economic risks are an important factor of the decision-making process. Based on the concepts of value and motivation, the expected utility theory provides a framework for analyzing farmers' intentions to apply technological innovation in agriculture. However, the theory just takes the perception of maximizing expected benefits into account, but not to consider the effects of psychosocial factors and social pressures on farmers when deciding to apply innovation. Bergevoet et al (2004) argue that pure economic models are not capable enough of explaining the full complexity of farmers' decisions, which are often driven by both economic and non-economic factors.

The second is based on psychosocial theories, of which the theory of planned behavior (TPB) and the diffusion of innovation (DOI) theory are centerpieces. Specifically, the decision-making behavior of farmers to adopt technological innovation is explained by psychosocial factors. There are the most important contributors to the approach, such as [12,14,16-21]. Khan et al, analyzes the factors affecting the use of pesticides, employing survey data collected through interviewing 1000 farmers in 8 provinces of China in March 2013. As a result, the research shows that the perception of behavioral control, behavioral goals, behavioral attitudes, and subjective norms has a positive effect on farmers' intention to comply with standards. More particularly, the perceived behavioral control factor is the most influential one, while the subjective norm factor is the least influential one. The literature shows that the TPB is useful for explaining farmers' decisions through finding out main influential factors. It is notable that information obtained from friends, media, and agricultural extension officers is not considered as an influential factor explaining farmers' behavior in the TPB [21].

Based on the combination of the theory of planned behavior and the diffusion of innovation theory, Tutkun and Lehmann, (2006) explain the behavior of farmers in Switzerland. As seven out of eight factors of the model are statistically significant (their p-values all are under 0.001), the combined model is evaluated to be highly feasible. Importantly, the communication factor of the DOI theory explains 76% of the change in farmers' receptive behavior [10]. However, the above work only focuses on psychological, socio-economic factors, but does not consider farmers' perception of the benefits and risks of technological innovation, as explaining their decision to employ technological innovation.

The third is based on the combination of the expected utility theory and the psychosocial theories. By following this approach, farmers' decision to adopt technological innovation is analyzed remarkably by [13]. The study was carried out by synthesizing articles on the decision to adopt technological innovation in agriculture. The research classified variables, including the following groups: beliefs; awareness of the characteristics of the improvement; intention and attitude; subjective norms and perceived behavioral control; farmers' goals and objectives; background factors include farmer characteristics, household, farm, farming context, information reception and learning process. It is remarkable that this study does not mention the role of spreading information. While, according to Rogers [22], information transmission is the first stage of the process of applying innovation. To improve the approach, Tinh et al. employed the combination of the theory of planned behavior, the expected utility theory, and the diffusion of innovation theory for explaining farmers' intention of applying technological innovations in agricultural production, with the study on applying VietGAP standards to produce vegetable in the two Vietnamese provinces of Da Nang and Quang Nam [14].

Research method

Research model and the scale

The research model is based on the previous studies [13,14,16,17-20,23] proposes the model of factors affecting intention of farmer in Quang Nam to use pesticide on the next seasons. This model focuses on analysing factors: (1) Communication; (2) Perceived benefits; (3) Perceived risks of environment and health; (4) Subjective norms; (5) Perceived behavioral control; (6) Moral norms; (7) Intention. In addition, through interview and survey, this research supplements observation "Pesticides stores are located in the vicinity and I can easily buy them" which belongs to Perceived behavioural control.

Research hypotheses

Hypothesis H1: There is a positive relationship between the communication factor and farmers' intention to use pesticides in Quang Nam province.

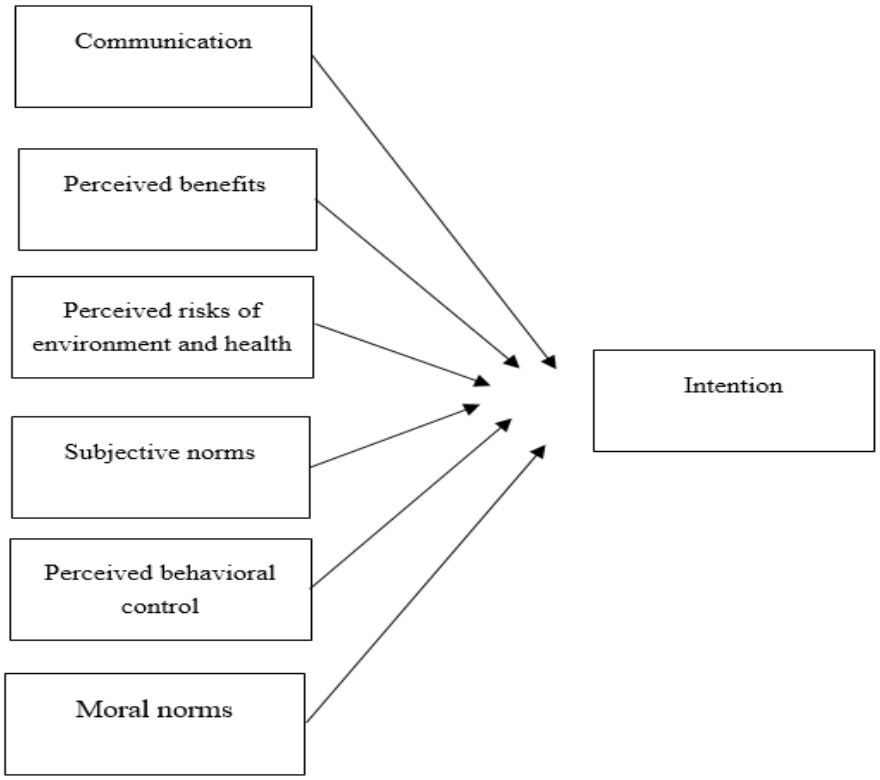

Figure 1: Research framework of farmers' intention to use pesticides.

Hypothesis H2: There is a positive relationship between the perception of benefits and farmers' intention to use pesticides in Quang Nam province.

Hypothesis H3: There is a negative relationship between the perception of health and environmental risks and farmers' intention to use pesticides in Quang Nam province.

Hypothesis H4: There is a positive relationship between the subjective norm factor and farmers' intention to use pesticides in Quang Nam province.

Hypothesis H5: There is a positive relationship between the behavioral control factor and farmers' intention to use pesticides in Quang Nam province.

Hypothesis H6: There is a negative relationship between the moral norm factor and farmers' intention to use pesticides in Quang Nam province.

Research approaches

In order to analyse this experiment, the study apply the combination of quanlitative and quantitative methods.

Regarding quanlitative research : Firstly, the research team reviews the related documents to identify factors affecting the intention of farmers to use pesticide in agriculture in Quang Nam province. In addition, we also interviewed deeply 8 agricultureal workers (Tuy La – Dien Ban: 3; Lang Chau Bac – Duy Xuyen: 3; Cam Kim - Hoi An: 2) in April 2020. Interviewees are farmers who are engaged in rice production. The number of interviewees stopped when the information was saturated, which meant no new information was available.

Next, the research uses the quantitative method (SEM) to to test and measure the factors affecting the intention to use pesticides of farmers in Quang Nam province. The data was conducted through a direct survey using questionnaires in November and December, 2020. The convenient sampling method aims to achieve a sample size that is large enough to ensure suitability for a quantitative study. The measurement model includes 32 observed variables, according to (Hair et al., 2010), the required sample size is n = 160 (32 x 5). To achieve the set sample size, 400 questionnaires were distributed. As a result, 385 responses were collected, of which 23 were invalid, and 362 were satisfactory. Data were entered and analysed by using SPSS 20 and AMOS 20 software. All observations used a 5-point Likert scale, ranging from (1) strongly disagree to (5) strongly agree.

Analysis approaches

Based on data, the reliability of each component in the scale is assessed by using a reliability coefficient tool, named Cronbach's Alpha. Subsequently, exploratory factor analysis (EFA) was applied to the reliability test-satisfied variables to discover the structure of the scale of factors affecting farmers' intention to use pesticides in Quang Nam province. As conducting EFA, the authors used the *Principal axis factoring* extraction method, along with Promax rotation and breakpoints associated with extracting eigenvalue-greater-than-one factors. The next step is employing confirmatory factor analysis (CFA) to test the reliability and validity of the measurement model. Finally, the linear structural model is analyzed to examine the general model. The model is evaluated to be suitable for the data when indexes such as: Chi-

squared adjusted for degrees of freedom (CMIN/df) ≤ 2; RMSEA < 0.08; TLI, CFI ≥ 0.9 [25].

The Results of Analysis

The features of research sample

Survey information and secondary data both show that rice-producing households only produce two crops/year (Winter-Spring and Summer-Autumn). The rest of the year the land is mostly vacant because of bad weather (the rains, floods, and storms). On average, farmers often have to use insecticides to kill insects for four times each crop. There are some popular kinds of insecticides, such as Stenchaetothrips biformis Bagnall, Nivaparvata lugens Stah, Scirpophaga incertulas Walker, Piryculariа oryzae Cav, and Rice ragged stunt virus. Most of the respondents in the study are in the age group of 40 - 50 (278 people, accounting for 76.79%); and the remaining people are over 50 years old (84 people, accounting for 23.21%). Thereby, it shows that farmers are mainly in the adult age.

In terms of gender, the majority of the main agricultural workers of the surveyed households are female, with 245 accounting for 67.67%. The results of this survey also show that women both grow rice and raise pigs and cows to increase their household income. Meanwhile, the men here are mostly construction workers, when in the harvest they will stay at home to share the field work with their wives.

The rice-growing area of a farm household is eight poles on average (in Vietnam's Central region, one pole equals 500 m2); the smallest area of rice production land employed by a farm household is three poles, and the largest is 14 poles. Households with a large area are mainly renting fields from other households.

With regard to rice production experience of the main agricultural worker in the household, the average is 27 years, the maximum is 50 years, the lowest is 10 years. With the experience gained, farmers can identify pests, water and fertilizer, so as to reduce costs and improve rice production efficiency.

With respect to the education level of the main agricultural worker in the household, 178 people (accounting for 49.2%) graduated from lower secondary school, 156 people (accounting for 43.1%) completed primary school, and the rest have a high school diploma. The significantly low level of education of farmers can greatly affect the risk perception and the application of technical advances in their rice production.

Testing factors

After collecting data, the reliability of latent variables is tested using Cronbach's alpha reliability coefficient. According to (Nunnally, 1978) the value of Cronbach's alpha coefficient exceeding the threshold of 0.70 proves the consistent and high reliability of the scales. The results of the CFA analysis showed that, Chisquare/df=1.539; GFI=0,899; TLI=0,964; CFI=0,968; RMSEA=0,039. This proves that the scale model fits the data of the market. However, the GFI index = 0.899 < 0.9. This problem requires tissue improvement through modification of indicators in MI (Schumacker et al., 2004). The second CFA results are as follows: Chisquare/df=1.515; GFI=0,900; TLI=0,965; CFI=0,970; RMSEA=0,038. The next thing is to perform tests in confirmatory factor analysis (CFA), as follows: composite reliability (result: CR > 0.7); convergent (result: AVE > 0.5) and discriminant (result: MSV < AVE). The results show that all factors meet the requirements of reliability.

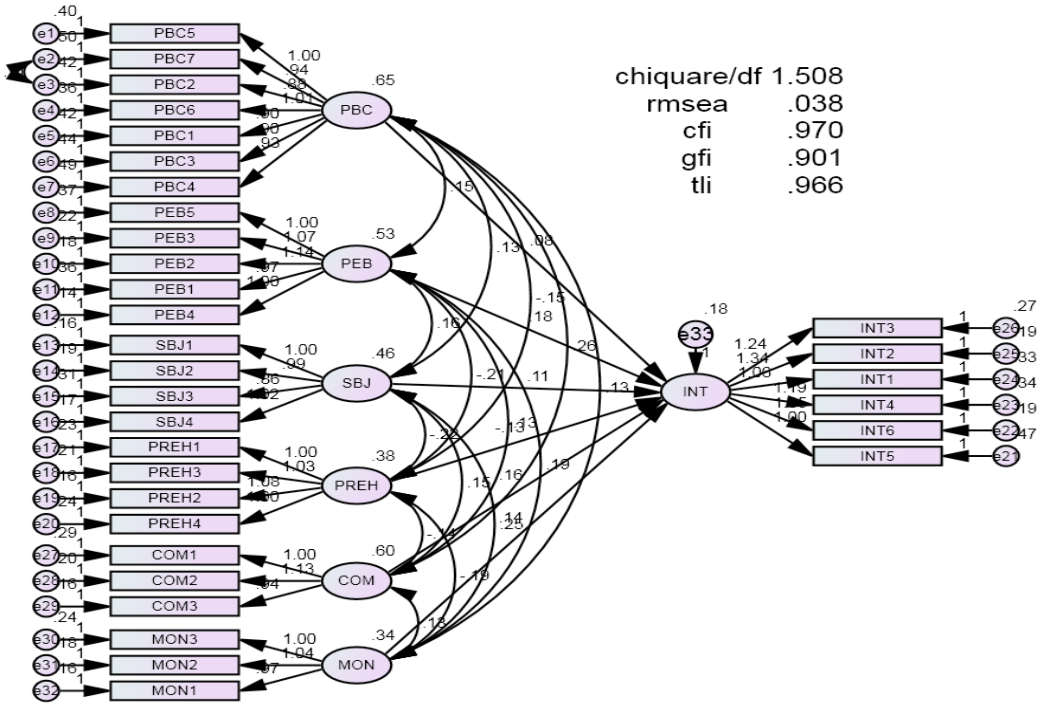

Figure 2: The results of SEM

Source: author's calculations

Table 1: The results of testing the reliability of the scale.

Factor	The number of observed variables	Reliability level				Value
		α	CR	AVE	MSV	
PBC	7	0.904	0.904	0.575	0.180	
PEB	5	0.917	0.920	0.697	0.228	
SBJ	4	0.890	0.892	0.676	0.389	
PREH	4	0.883	0.883	0.654	0.286	Satisfied
COM	3	0.893	0.897	0.743	0.183	
MON	3	0.842	0.844	0.644	0.389	
INT	6	0.901	0.904	0.612	0.241	

Source: author's calculations

The results of SEM (Chisquare/df=1.508; GFI=0,901; TLI=0,966; CFI=0,970; RMSEA=0,038) demonstrates that the scale model of factors affecting farmers' intention to use pesticides is consistent with market data.

Thus, the variables of communication, perceived benefits, subjective norms, and behavioral control all have positive impacts; the concepts of health and environmental risk perception, and ethical standards have negative impacts on the intention to use pesticides; and all are statistically significant ($p<0.05$). With the above test results, this study (based on the combination of both qualitative and quantitative methods) provides empirical evidence that contributes to a confirmation of and a supplement to the theoretical model of [13].

Table 2: The results of testing the causality among factors in the theoretical model.

			Estimate	S.E.	C.R.	P	Label
INT	<---	PBC	.110	.050	2.181	.029	
INT	<---	PEB	.211	.052	4.088	***	
INT	<---	SBJ	.146	.074	1.981	.048	
INT	<---	MON	-.182	.092	-1.993	.046	
INT	<---	COM	.185	.047	3.940	***	
INT	<---	PREH	-.158	.074	-2.138	.033	

Source: author's calculations
Note: *** $p< 0.001$

Discussing the result of regression

The analysis results show that the communication factor has a positive correlation with the intention to use pesticides in rice production of farmers ($\beta = 0.185$ và $p <0.001$). Thus, farmers, who have more communication relationship through channels such as exchanging information with stores, friends, surrounding households, or suffering websites about pesticides by personal mobile phone, have more intention to use pesticides in rice production. Especially, with the advancement of information technology, accessing to information about pesticides is very easy for farmers. In some cases, selling-pesticide agents are the only units that can provide information to farmers with low education levels [18].

In fact, it has been shown that pesticides are now used increasingly and commonly and play an important role in agricultural production because they help to increase productivity, save labour, and perform at the right time. The results indicate that the perceived benefit of using pesticides are positive and statistically significant ($\beta = 0.211$ and $p < 0.001$). This shows that the attractiveness of the economy causes the serious pollution of pesticides. Therefore, farmers often ignore risks and protective instructions when using pesticides, they only care about benefits, but do not care about health and the environment [28].

Perceived risks of health and environment have a negative correlation with intention to use the drug that is statistically significant ($\beta = -0.158$ and $p < 0.05$). Many studies have shown that the overuse of pesticides not only destroys the environment but also causes serious health consequences for both farmers and consumers, and the surrounding environment such as pollution of soil, water, grass and other vegetation [29], especially causes cancer [30].

Previous studies [20,21] all confirmed that Subjective norms have a positive correlation with intention of farmers to use pesticides in the future ($\beta = 0.146$ and $p < 0.05$). Other farmers confirm the use of pesticides for pest control [21] and using more pesticides to harvest larger quantities of produce [2].

When farmers feel confident, have full experience, and have enough protective clothing, they are more likely to use pesticides in rice production in the future. The analytical results show that there is $\beta = 0.11$ and $p < 0.05$. This result is also consistent with [19,20]. In addition, this research also found that pesticide shops located in the vicinity are an important basis for explaining intention of farmers to use pesticides in the future. Therefore, this may be one of the main reasons leading to the increasing use of pesticides by farmers in Quang Nam in general and in Vietnam in particular. This implies that it is necessary to control the pesticide market via strict regulations from central to local government levels.

Moral norm plays an important role in responsibilities and obligations of farmers to the community and the environment ($\beta = -0.182$ and $p < 0.05$). This result is consistent with [21].

Conclusion

The main objective of this study is to explain the factors affecting farmers' intention to use pesticides, using the combination of the theory of expected benefits, the theory of intended behavior and the theory of innovation diffusion. The analysis results show that the intention to use pesticides of farmers is influenced by groups of variables generated from the above theories such as perceived benefits, perceived risks, behavioral control, norms. subjectivity and ethical standards. In addition, actively communicating and sharing information with pesticide dealers and neighbourhood households, regularly watching and reading the contents of pesticides on the internet, and the availability of surrounding pesticide warehouses are new factors that contribute to the explanation for farmers' intention to use pesticides in rice production in the next crop.

According to this study, there are applicable suggestions for reducing or at least standardizing farmers' behaviors of employing pesticide in rice production. The first is raising farmers' awareness

of the harmful effects of pesticides. The second is promoting the role of agricultural extension officers in guiding the proper use of pesticide. Finally, in the long run the pesticide market needs to be controlled strictly, comprehensively implementing regulations from central to local government levels. Expanding the research scope of the area to the other provinces of Vietnam will be suitable for further research. This will be important for confirming, detecting, and adjusting variables affecting farmers' intention to use pesticides for crops in the future.

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