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RESEARCH ON THE INFLUENCING FACTORS OF WILLINGNESS OF FACILITY VEGETABLE GROWERS TO PARTICIPATE IN IOT E-COMMERCE

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Abstract. *IoT e-commerce, which combines IoT technology and e-commerce, provides a new way to solve the problems of intelligent production and quality traceability of fresh agricultural products. However, growers' willingness is affected by technology and the environment, so they often have a low initiative in the adoption of emerging technologies and business models. Therefore, it is significant to find the factors that affect growers' willingness to participate in IoT e-commerce. Based on the survey data of 228 rural households, this paper uses the technology acceptance model and theory of planned behavior to empirically analyze the factors affecting the willingness of facility vegetable growers to participate in IoT e-commerce. The results show that the behavioral attitude has a significant and positive impact on the willingness to participate in IoT e-commerce. Perceived usefulness, perceived behavior control, and subjective norms indirectly and positively affect the willingness. Among them, perceived usefulness has the greatest influence, followed by perceived behavior control and subjective norms. The behavioral attitude is also indirectly influenced by perceived ease of use, subjective norms, and perceived behavior control.*

Keywords: IoT e-commerce, Facility vegetable growers, Technology acceptance model, Theory of planned behavior

1. **Introduction.** With the development of the Internet and the logistics industry, more and more consumers buy fresh agricultural products through the e-commerce platform. Although traditional e-commerce makes it convenient for consumers to buy fresh agricultural products, there are also some problems [1,2]. For example, traditional e-commerce fails to solve the problems of intelligent production and quality traceability of fresh agricultural products [3]. IoT e-commerce, which combines IoT technology and e-commerce, provides a new way to solve the problems. IoT e-commerce integrates IoT technology into the production, processing, logistics, and transportation of fresh agricultural products. It can monitor, record and optimize each link in real time. Besides, it can realize the production intelligence while ensuring the quality and safety of agricultural products. However, affected by many factors such as individual characteristics, technology, and the social environment, facility vegetable growers have a low initiative to participate in IoT e-commerce. It is a key issue to improve growers' willingness to participate in the IoT e-commerce of agricultural products.

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The research on the participation intention of the IoT e-commerce is mainly from two aspects: the cognition of emerging e-commerce and the participation intention of emerging e-commerce. In terms of the cognition of emerging e-commerce, Cheung and To [4] introduced trust tendency into the theory of planned behavior (TPB) as a theoretical framework. And they analyzed the attitude and behavior of trust tendency characteristics on built-in advertising in the commercial app. Cho et al. [5] analyzed consumers' perception of different food distribution apps. Frik and Mittone [6] identified the main factors affecting e-commerce consumers' purchase intention and trust perception. Yang et al. [7] studied the e-commerce industry for agricultural products in China. In terms of the participation intention of emerging e-commerce, Gorla et al. [8] found that the existence of informal interest groups and the tolerance of decision-makers on negative information of B2B e-commerce had a significant impact on the adoption behavior. Nazir and Roomi [9] focused on obstacles to the adoption of e-commerce in emerging economies. Koe and Sakir [10] analyzed the motivation of Malaysian entrepreneurs to adopt e-commerce. Lin et al. [11] empirically analyzed the influencing factors of e-commerce participation from the perspective of poor families.

The existing research on related issues provides a theoretical reference, but there are still some research gaps. First, few studies analyze the adoption behavior of IoT e-commerce. Secondly, less attention has been paid to the willingness to participate in IoT e-commerce from the perspective of facility vegetable growers. Therefore, this paper takes facility vegetable growers as an example to study the influencing factors of facility vegetable growers' willingness to participate in IoT e-commerce.

The main contributions of this paper are as follows. First, we pay attention to the factors that influence the willingness to participate in IoT e-commerce, extending existing research on the willingness to adopt emerging e-commerce. Second, we focus on the factors that influence the willingness to participate in IoT e-commerce from the perspective of facility vegetable growers, expanding the research perspective of emerging e-commerce.

The organization of this paper is as follows. Section 2 proposes the theoretical hypothesis. Data and methods are described in Section 3. The results are presented in Section 4. The last part gives the conclusion.

2. Theoretical Model and Research Hypothesis.

TAM is a combination of rational behavior theory and behavior and expectation theory [12]. In TAM, behavioral attitude (BA), perceived usefulness (PU), and perceived ease of use (PEU) are the main variables affecting willingness to participate (BI). TPB was initially proposed to study the factors influencing the willingness of households to transfer their agricultural land [13]. In TPB, perceived behavior control (PBC) and subjective norms (SN) are the two main variables affecting the behavioral attitude (BA). At present, TAM and TPB are widely used to explore the influencing factors of willingness to participate [14]. TAM model and TPB model can analyze the factors affecting participation intention from different perspectives. In this paper, we propose a hypothetical model of facility vegetable growers' willingness to participate in IoT e-commerce based on TAM model and TPB model.

In TAM model, behavioral attitude can be interpreted as the preference of facility vegetable growers for participating in IoT e-commerce. Ha and Nguyen [15] studied consumers' online purchase intention, and found that behavioral attitude will affect behavioral intention. The more positive the attitude towards participation behavior, the higher the willingness to participate. In TAM model, perceived usefulness is interpreted as the degree to which users perceive the usefulness of a product. Wang et al. [16] studied the purchase intention of electric vehicles, and found that perceived usefulness affects behavior and attitude. In TAM model, perceived ease of use can be explained by the degree to which users perceive the product to be easy to use. According to TAM model,

perceived ease of use may directly affect perceived usefulness. Therefore, we propose the following hypotheses.

H1: Growers' behavioral attitudes towards participating in IoT e-commerce have a positive impact on their willingness to participate.

H2: Perception of the usefulness of participating in IoT e-commerce has a positive impact on the behavioral attitude.

H3: Perceived ease of participation in IoT e-commerce has a significant positive impact on the perceived usefulness.

In TPB model, subjective norms can be interpreted as the degree to which others and the social environment affect growers' willingness. In daily production and planting, growers often communicate with their neighbors, relatives, and friends, and their willingness is often affected by the opinions of their neighbors, relatives, and friends [17]. The social environment in which growers live often affects their attitudes towards new technologies. The more the grower's neighbors, relatives and friends support them in adopting the new technology, the higher the grower's willingness to adopt the new technology. On the other hand, perceived behavior control can be explained as the condition basis for growers to perceive themselves. The higher the economic level and growing skills of the grower, the more beneficial the grower perceives the benefits of participating in IoT e-commerce [18]. Perceived behavior control may have a significant positive impact on growers' behavioral attitude. Therefore, we propose the following hypotheses.

H4: Subjective norms positively influence growers' behavioral attitudes towards participating in IoT e-commerce.

H5: Perceived behavior control positively influences growers' behavioral attitudes toward participating in IoT e-commerce.

In the integration model of TAM and TPB, there may also be influencing relationships among different influencing factors. The stronger the economic ability, knowledge level and technical ability of facility vegetable growers, the easier it is to learn and master new technologies [19]. Therefore, perceived behavior control may indirectly affect behavioral attitude by affecting perceived ease of use. Perceived behavior control may have a significant positive impact on perceived ease of use. Social network around growers may affect growers' perceived usefulness [20]. In other words, subjective norms may have a significant positive impact on perceived usefulness. Therefore, subjective norms may indirectly affect behavioral attitude by affecting perceived usefulness. Therefore, we propose the following hypotheses.

H6: Perceived behavior control positively affects the ease of use of facility vegetable growers' perceived participation in IoT e-commerce.

H7: Subjective norms positively affect growers' perception of the usefulness of participating in IoT e-commerce.

3. Methodology and Data.

3.1. Sampling and questionnaire design.

We constructed variable indicators that affect growers' willingness to participate in IoT e-commerce based on existing studies. In the questionnaire, the Likert 5-level scale method is adopted for the measurement of the scale (i.e., '1 = strongly disagree' to '5 = strongly agree'). The specific questionnaire scale and literature sources are shown in Table 1.

3.2. Data collection.

We used a questionnaire survey to collect data. Jing Yang County, Shaanxi Province, China, was selected as the site for the questionnaire survey. A total of 228 valid questionnaires were collected. The basic information of the sample is shown in Table 2.

Table 1. Scale indicators and literature sources

Construct	Item	Measurement items	Literature sources
BA	BA1	It is a wise choice to sell vegetables through IoT e-commerce	[15]
	BA2	Participating in IoT e-commerce helps to sell more vegetables	
	BA3	The development of IoT e-commerce will greatly drive the economic development of the village	
	BA4	Generally speaking, I am very supportive of participating in IoT e-commerce	
SN	SN1	My close relatives and friends strongly support my involvement in IoT e-commerce	[17]
	SN2	Government policies will influence whether I participate in IoT e-commerce	
	SN3	The views and behaviors of village cadres will affect whether I participate in IoT e-commerce	
PBC	PBC1	I have a certain level of knowledge to support my participation in IoT e-commerce	[18]
	PBC2	I have a certain technical level to support my participation in IoT e-commerce	
	PBC3	I have certain economic conditions to support my participation in IoT e-commerce	
	PBC4	I can decide whether to use IoT e-commerce sales facilities	
PU	PU1	IoT e-commerce can significantly increase production	[14,15]
	PU2	IoT e-commerce can significantly increase the sales price	
	PU3	IoT e-commerce can ensure the quality of facility vegetables	
	PU4	IoT e-commerce can save the labor cost of planting	
PEU	PEU1	Learning to use IoT devices is simple	[15,16]
	PEU2	It is easy to use IoT devices	
	PEU3	It is easy to learn how to sell vegetables through IoT e-commerce	
BI	BI1	If I have the opportunity, I am willing to participate in IoT e-commerce	[15]
	BI2	I am willing to participate in the training of IoT e-commerce	
	BI3	I am willing to overcome difficulties in order to participate in IoT e-commerce	

4. **Empirical Results.**

4.1. **Reliability and validity analysis.** In order to test the validity of the questionnaire, we use SPSS 22.0 software to conduct KMO and Bartlett spherical tests on 21 measurement items of facility vegetables' willingness to participate in IoT e-commerce. The results show that the scale data has good validity, and the factor analysis is appropriate for the data.

In addition, Cronbach's α coefficient, average variance extracted (AVE), and composite reliability (CR) are tested as the measurement indicators of reliability test and validity test. The test results are shown in Table 3.

Table 2. Basic information of investigated facility vegetable growers

	Classification	Number	Percentage (%)
Gender	Male	128	56.1
	Female	100	43.9
Age	Under 30	5	2.2
	30-40	22	9.6
	41-50	71	31.1
	51-60	90	39.6
	Over 60	40	17.5
Education level	Primary school or below	54	23.7
	Junior middle school	140	61.4
	Senior high school	28	12.3
	College or advance degree	6	2.6

Table 3. Reliability and validity test

	Item	Loading	α	AVE	CR
BA	BA1	0.642	0.901	0.713	0.907
	BA2	0.668			
	BA3	0.747			
	BA4	0.712			
SN	SN1	0.66	0.832	0.646	0.844
	SN2	0.868			
	SN3	0.856			
PBC	PBC1	0.821	0.859	0.609	0.861
	PBC2	0.838			
	PBC3	0.711			
	PBC4	0.543			
PU	PU1	0.800	0.850	0.603	0.857
	PU2	0.830			
	PU3	0.778			
	PU4	0.538			
PEU	PEU1	0.862	0.868	0.714	0.880
	PEU2	0.874			
	PEU3	0.546			
BI	BI1	0.726	0.875	0.715	0.882
	BI2	0.836			
	BI3	0.850			

In Table 3, the Cronbach's coefficient value for each latent variable is greater than 0.7. This shows that the scale has high reliability. The AVE value of each latent variable is between 0.603 and 0.715. And the CR value of combination reliability is between 0.88 and 0.907. These results indicate good convergence validity for each latent variable. On the other hand, the discriminant validity of the model can be tested by the correlation table. In Table 4, the minimum value of the square root of the AVE value of each latent variable is 0.776. Besides, the maximum value of the correlation coefficient between each latent variable is 0.749. These results show that the discriminant validity of the model is good.

TABLE 4. Correlation between latent variables

	BA	SN	PBC	PU	PEU	BI
BA	0.844					
SN	0.513	0.804				
PBC	0.417	0.318	0.780			
PU	0.683	0.493	0.274	0.776		
PEU	0.413	0.386	0.749	0.343	0.845	
BI	0.640	0.310	0.410	0.478	0.430	0.846

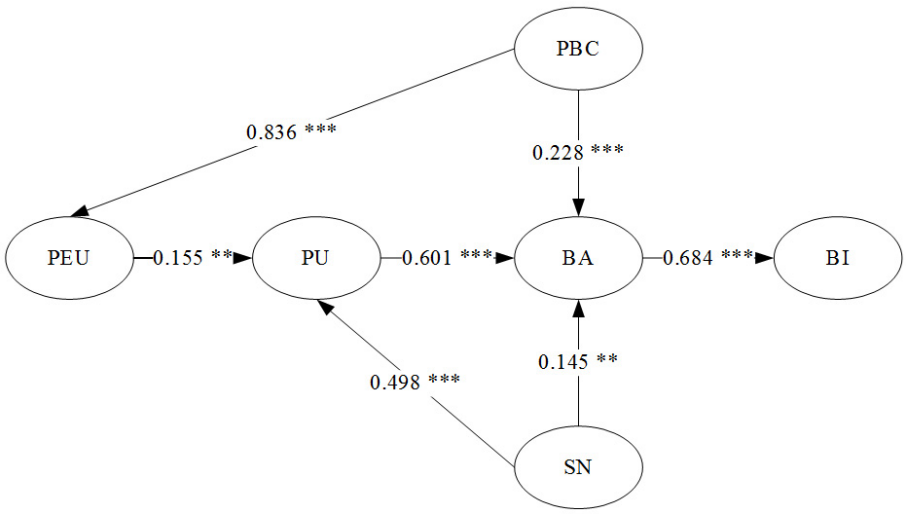
4.2. **Model fitting test.** By using SPSSAU software, the fitting test is carried out for the established structural equation model. After fitting correction, the fitting results are shown in Table 5.

TABLE 5. Calculation results of the fitting index of model

	χ^2/df	RMSEA	CFI	NNFI	IFI	SRMR
Judgment criteria	< 3	< 0.10	> 0.9	> 0.9	> 0.9	< 0.1
Our results	2.401	0.078	0.923	0.911	0.924	0.086

The following indicators are used to measure the fitting of the measurement model: Chi-square degree of freedom ratio (χ^2/df), root mean square error of approximation (RMSEA), comparative fit index (CFI), non-normed fit index (NNFI), incremental fit index (IFI) and standardized root mean square residual (SRMR). The results of the comparison between the judgment criteria and our results are shown in Table 5. It can be seen from Table 5 that the fitting degree of the model is good.

4.3. **Result.** SPSSAU software is used to calculate the established structural equation, and the standardized path coefficient is obtained, as shown in Figure 1.



Note: ** $p < 0.05$, *** $p < 0.01$.

FIGURE 1. Path coefficient

It can be seen from Figure 1 that the standardized path coefficient value of behavioral attitude for the willingness to participate is 0.684. This indicates that the behavioral attitude of facility vegetable growers participating in IoT e-commerce has a positive impact on their willingness to participate. The standardized path coefficient of perceived usefulness for the behavioral attitude is 0.601. This shows that perceived usefulness has

a significant positive impact on behavioral attitude. The standardized path coefficient of perceived ease of use for the perceived usefulness is 0.155. This shows that perceived ease of use has a significant positive impact on perceived usefulness. The standardized path coefficient of subjective norms for the behavioral attitude is 0.145. This shows that subjective norms have a significant positive impact on behavioral attitude. The standardized path coefficient of perceived behavior control for the behavioral attitude is 0.228. This shows that perceived behavior control has a significant positive impact on behavioral attitude. The standardized path coefficient of perceived behavior control for the perceived ease of use is 0.836. This shows that perceived behavior control has a significant positive impact on perceived ease of use. The standardized path coefficient of subjective norms for the perceived usefulness is 0.498. This shows that subjective norms have a significant positive impact on perceived usefulness.

5. **Conclusions.** The main results we found from the empirical analysis of field survey data from 228 facility vegetable growers are as follows. First, behavioral attitudes directly and positively affect growers' willingness to participate in IoT e-commerce. Second, perceived usefulness, perceived behavior control and subjective norms directly and positively affect growers' behavioral willingness to participate in IoT e-commerce. Third, the behavioral attitude of facility vegetable growers participating in IoT e-commerce is indirectly and positively affected by perceived ease of use, subjective norms and perceived behavior control.

Based on the above findings, we put forward some suggestions. First, the government should establish demonstration projects and hold more lectures to increase growers' perception of the usefulness and ease of use of IoT e-commerce. Second, the government should strengthen the normative beliefs of important groups such as growers' neighbors, relatives, and friends to enhance growers' willingness to participate in IoT e-commerce. Third, the government should cooperate with e-commerce enterprises to increase support and subsidies for growers to participate in IoT e-commerce to lower the threshold.

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