A Study on the Impact And Cultivation of Digital Literacy And Farmers' E-commerce Participation Behavior
—Analysis Based on Survey Data of Kiwifruit Farmers in Shaanxi Province

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Abstract. To comprehensively promote rural revitalization in the context of the digital economy, accelerate the modernization of agriculture and rural areas, and promote the common prosperity of rural farmers, it is crucial to identify the key factors affecting the e-commerce participation behavior of farmers, and to improve the digital literacy and cultivation of farmers. This paper analyzes the e-commerce participation behavior of rural households and its influencing factors based on the survey data of 1044 peasant households in the main producing areas of kiwi fruit in Shaanxi Province, from the perspective of rural households' digital literacy, and combined with the factors of rural households' human capital and government policies by using the double-hurdle model. The results show that media technology literacy, information awareness literacy, access literacy, information dissemination literacy, e-commerce technology literacy, education level, and government e-commerce guidance have a significant impact on farmers' e-commerce participation behavior; while the age of the head of the household, gender, courier delivery points, and e-commerce integrated service stations do not have a significant impact on farmers' willingness to participate in e-commerce. In view of this, it is necessary to improve the system supply, do a good job of top-level design, based on the multidimensional attributes of farmers' digital literacy cultivation, so as to achieve the cultivation of the main body of the rights and responsibilities of the clear, to create a digital literacy cultivation position, the supply of diversified content, and the construction of a multidimensional cultivation system, in order to meet the needs of the development of the rural digital economy.

Keywords: farmers, e-commerce participation behavior, information literacy, double-hurdle model (DHM)

1 Introduction

According to relevant statistical data in 2022, China has a rural population of 491 million, with a total agricultural output value of approximately 8.44 trillion yuan, contributing over 50% to the national economy. Under the promotion of rural revitalization and poverty alleviation strategies, China's rural economy has achieved good and stable development.In 2022, the national rural online retail sales reached 2.17 trillion yuan, a year-on-year increase of 3.6%.

However, there is still a significant gap between the target of exceeding 800 billion yuan by 2025 as clearly stated in the "14th Five Year Plan for the Development of Agricultural and Rural Informatization in China", and the development of e-commerce for agricultural products still has a long way to go.With the rapid development of information technology, relying on the digital economy to build a new rural development system has become an important content and goal of rural development. In April 2023, the Central Cyberspace Administration and five other departments issued the "Key Points for Digital Rural Development in 2023", which 1mentioned the need to take multiple measures to develop county-level digital economy, ensure high-quality development of digital rural areas, and enhance the digital literacy and skills of farmers.China is currently actively promoting the construction of digital rural areas, promoting the construction of an agricultural power, and promoting the common prosperity of rural farmers.

As the main production area of kiwifruit in Shaanxi Province, Meixian and Zhouzhi County have high yields, good quality, and high reputation of kiwifruit, which is popular both domestically and internationally. It has become the leading industry in Meixian County's economy and the main source of income for farmers.In rural e-commerce, it has a dual advantage of product and reputation. However, under the traditional agricultural product procurement system, the purchase price of kiwifruit is relatively low and the sales volume is limited, resulting in the income of farmers still being at a low level, making it difficult to leverage the industrial advantages and social effects of kiwifruit, seriously limiting the development of county-level characteristic economy. The promotion of rural e-commerce is a necessary way to develop characteristic rural economy and increase income.In view of this, this article takes kiwifruit growers in Meixian County, Shaanxi Province as an example to explore the impact of their digital literacy level on their e-commerce participation behavior. This has important practical significance for improving their e-commerce participation behavior, increasing their income, and promoting rural economic development.

The popularization of the Internet and technological progress in the information age have promoted the flourishing of agricultural product e-commerce.As an emerging business model and sales path, building a multi-channel agricultural product trading platform effectively integrates online and offline resources, achieving precise sales and full traceability, and providing channel selection and technological support for the transformation and upgrading of county-level rural economy and the expansion of farmers' income.Agricultural e-commerce has the characteristics of low standardization, transparent transaction process, virtual transaction, and multiple similar products.Under the wave of new rural infrastructure and digital technology development, agricultural e-commerce can solve the difficulty of selling agricultural products [1], promote farmers to change their previous role as passive price receivers [2], improve negotiation and bargaining power, significantly reduce transaction costs [3], and bring many conveniences to farmers, such as market information, allowing others to choose and place orders to purchase agricultural products without leaving home, and fresh and diverse products [4],It has become an engine and new driving force to promote the development of agriculture and rural economy.

As the main participants in agricultural e-commerce, farmers' participation directly affects the overall operation and development of agricultural e-commerce. The "Lupin Behavior Model"

points out that human behavior is a product of the interaction between individuals and the environment, and the way, direction, and intensity of behavior are influenced and constrained by both internal and external factors[5].Farmer behavior mainly refers to a series of reactions made by farmers based on their own conditions and strength, combined with external environmental stimuli and restrictions. The participation behavior of farmers in e-commerce is not only a social behavior, but also an economic behavior. This article defines participation behavior as the voluntary participation behavior of farmers in agricultural product e-commerce.The participation behavior of farmers in e-commerce is influenced by various factors, and their cognition will affect their acceptance of the matter.High frequency, comprehensive, and high-quality digital training that meets the needs of farmers can help farmers obtain more effective agricultural product market information, improve digital technology and internet management skills in e-commerce, enhance their behavioral control, and thus improve their participation in e-commerce[6].The perception of new technologies by farmers can affect their decision-making to adopt them. The higher the education level of farmers, the more sufficient their social capital will be, which in turn affects their enthusiasm and level of participation in e-commerce behavior. From other aspects, transaction characteristics, farmer's cognitive perception, logistics and distribution systems, government policies, infrastructure, and other macro environments can affect farmer's e-commerce participation behavior.

The development of agricultural e-commerce cannot be separated from the support of digital technology and information technology. Only when participating entities have a high level of digital literacy can they more easily share the digital dividend[7].The concept of digital literacy was first defined by foreign scholar Gilster as the comprehensive ability to acquire, understand, and organize digital information[8].The European Commission summarized digital literacy as information, media, network literacy and computer communication technology literacy, and based on this, outlined the Comprehensive Classification Evaluation standard of digital literacy (Dig-Comp2.1)[9].The United Nations Educational, Scientific and Cultural Organization believes that digital literacy is the ability to collect, organize, perceive, understand, integrate, evaluate, and create information safely and reasonably using digital technology for residents' employment and entrepreneurship. It has constructed the Global Framework for Digital Literacy, which includes seven types of literacy, including internet and communication technology literacy, information literacy, computer and media literacy, and 26 consideration indicators[10].Havrilova defined the connotation of digital literacy from the dimensions of digital information perception, understanding, and application [11].With the rapid development of information technology, the concept of digital literacy has become increasingly broad. In terms of digital literacy evaluation, most of the current research on digital literacy in China is based on foreign research, referring to the definition and evaluation framework of digital literacy in foreign countries, and has not established a localized theoretical system that combines China's national conditions. Domestic scholars mainly focus on the information literacy and media literacy of rural residents in their research on digital literacy.Rural residents are the endogenous driving force of digital rural construction, and the level of digital literacy of this group is related to the progress of China's digital rural construction and the timely achievement of rural revitalization strategy goals.

There have been some studies on the impact of digital literacy on e-commerce participation behavior, but most of them focus on the digital literacy of urban residents, and research on

rural digital literacy is still in its early stages.With the steady advancement of the digital rural strategy, the Internet and information communication infrastructure are gradually improving, social capital actively participating, and the trend of returning home for entrepreneurship. By examining the participation status of farmers in e-commerce, we can find the right assistance goals for the continuous promotion of rural revitalization construction and fill the digital information gap in rural economic development [12-15].In addition, relevant research is mostly based on inter provincial panels, and it is particularly urgent to conduct targeted surveys and research on micro level farmers. On the basis of retaining the education level of farmers, the age of the head of household, and government propaganda policies, this article takes kiwifruit growers in Meixian County, Shaanxi Province as a sample to study the impact of digital literacy on the participation behavior of farmers in e-commerce. It puts forward rational suggestions for the development of rural e-commerce in China and helps the digital process of rural revitalization strategy.

2 Data sources

The statistical data used in this paper were obtained from the main kiwifruit production areas in Zhouzhi County, Xi'an City, Shaanxi Province, and Meixian County, Baoji City, Shaanxi Province, and field surveys on the situation of individual kiwifruit growers were conducted using random sampling methods. Zhouzhi and Meixian counties have obvious natural location advantages, with temperate rainfall and deep fertile soil, making them one of the best eutrophic areas for kiwifruit in the world. The two counties account for one-third of the kiwifruit growing area and production in the whole of China. Since the reform and opening up, kiwifruit in Zhouzhi and Meixian counties has become a famous landmark industry in the country. Conducting the survey in kiwifruit growing villages in Zhouzhi and Meixian counties ensured the representativeness of the survey data. A total of 1,044 valid samples were retrieved, and the behavior of kiwifruit farmers in using e-commerce for selling agricultural products and its influencing factors were collected from two aspects: digital literacy and e-commerce participation behavior. The questionnaire involved basic information about farmers, kiwifruit cultivation, green agricultural technology, and farmers' digital literacy.

2.1 Basic data characteristics

In terms of age level, the age of household heads in the survey sample was dominated by those aged 42-56 and 56-70, accounting for 39.10% and 38.87% of the survey sample respectively, with fewer aged below 42 and above 70, at 7.68% and 14.35% respectively. As for the education level, respondents were mainly educated for 4-8 years, 8-12 years, and 12-16 years, accounting for 25.53%, 38.99%, and 25.19% of the survey samples respectively, followed by less than 4 years, accounting for 10.29% of the survey samples. The specific statistical results are shown in Table 1.

Table 1. Statistical characteristics of the survey sample

Sports event	Options	Frequency	Percentage (%)	Sports event	Options	Frequency	Percentage (%)
Age of head of	Under 42	80	7.68	Educational level	Less than 4	97	9.29

household					years		
	42-56 years	408	39.1		4-8 years	267	25.53
	56-70 years	406	38.87		8-12 years	407	38.99
	70 years and over	150	14.35		12-16 years	263	25.19
	excellent	646	61.86	Distinguishing between	women	248	23.78
Health status	general	365	34.96	the sexes	male	796	76.22
	Sick for years	33	3.18				

2.2 Definition and description of variables

2.2.1 Explained variables

The explanatory variable in this paper is farmers' e-commerce participation behavior, the questionnaire to "whether there is participation in agricultural e-commerce behavior" as the question of data collection, the farmers "yes" and "no" two choices were assigned as 1 and 0, respectively. The survey data show that the total number of interviewed farmers with e-commerce participation behavior is 343, accounting for 32.85% of the survey sample, and there are 701 households without e-commerce participation behavior, accounting for 67.15% of the survey sample, which shows that the proportion of e-commerce participation behavior of the local farmers is seriously insufficient, and is in urgent need of improvement, which coincides with the current e-commerce retail sales of agricultural products accounted for a low proportion of the real situation. reality.

2.2.2 Explanatory variables

The core explanatory variable of this paper is mainly digital literacy. The digital literacy level of new farmers is mainly measured from five dimensions, including media technology literacy, information awareness literacy, information access literacy, information dissemination literacy, and e-commerce technology literacy, and multiple questions are selected under each dimension for detailed measurement. In order to facilitate statistics, the measurement questions under each dimension were set with equal weight proportions, and the specific measurement values of each dimension were obtained after summation. The corresponding questions in the questionnaire and the descriptive statistics are shown in Table 2.

It can be seen that farmers' media technology literacy and information awareness literacy are generally high, with mean values of 6.526 and 4.196, but the level of information access literacy is average, with a mean value of only 2.883. Most of the surveyed farmers browse the Internet, search for information and obtain data through the use of cell phones, and they can accurately express and obtain their search needs, but the reliability and effectiveness of the information obtained are not high. However, the reliability and effectiveness of the information obtained is not high. A large number of farmers use cell phones to promote their products, but most of them only use one way to promote their products, and most of them use the WeChat circle of friends.

Table 2. Digital literacy of farmers

Variable name	Counterpart	Maximum values	Minimum value	Average value	Standard deviation
Media Technology Literacy	Do you own a digital device and have access to the Internet? Can you download the mobile app independently? Can you apply for an account, perform basic operations such as logging in? Can you bind the software with WeChat, Alipay, cell phone number, etc.? Do you shop online through a mobile app? Are you able to communicate with your family and friends using cell phone messaging software? Can you connect your device to a wireless network and switch to mobile data at any time? Can you use different menu settings on the device to make it easier to use?	8	0	6.426	3.228
Information Awareness Literacy	Do you check the market price of kiwifruit online? What is the time interval for you to check the market price of kiwifruit online? (take values 0-5) Do you browse and search for the data or information you want on your cell phone network? Do you record and collect the data or information you collect?	6	0	4.691	3.536
Information access literacy	Are you able to accurately express your search needs when searching for information? Are you able to collect the data you want quickly? Do you regularly browse for relevant information on specific websites?	6	0	3.012	3.008

| Information Dissemination Literacy | Is the information you get credible and current? Do you utilize your circle of friends and microblogging groups for promotional activities? Do you utilize short videos for promotional campaigns? | 2 | 0 | 1.353 | 1.667 |
| E-commerce technical literacy | Are you able to independently download there e-commerce software? Can you register an account independently and bind it with WeChat, Alipay, cell phone number, etc.? Are you able to set up an online store on your own? Are you able to do product shelving, pricing and store bonuses? Are you able to sell products at a discount during special times such as holidays? Are you able to advertise the sale of kiwifruit in your WeChat circle of friends? | 6 | 0 | 2.534 | 2.644 |

2.2.3 Other control variables

Referring to the existing related literature research[9-12] , the control variables mainly include the basic situation of farmers, resource endowment, etc. In order to show the control variables in a more detailed and intuitive way, this paper subdivided the resource endowment into two dimensions: the local government support situation and the infrastructure situation. At the same time, seven specific variables, such as the age of the head of household, gender, the degree of guidance of the local government to the rural e-commerce industry, and whether there is an express delivery point, are controlled.

Table 3. Meaning of control variables

Control dimension	Variable name	Options	Frequency	Percentage (%)
Basic information on farmers	Age of head of household	Under 42	64	6.103
		42-56 years	414	39.682
		56-70 years	400	38.344
		70 years and over	166	15.871
	Distinguishing between the sexes	Women	232	22.250
		Male	822	78.750

		Less than 4 years	305	29.186
	Educational level	4-8 years	392	37.527
		8-12 years	267	25.527
		12-16 years	251	23.997
Government support	The extent to which local governments are guiding the rural e-commerce industry	Strongly disagree.	201	19.205
		Disagree	277	26.565
		General	231	22.155
		Agree with	227	21.777
		Couldn't agree more	108	10.298
	Is rural e-commerce promoted in your village community?	There are	568	54.432
		Not have	476	45.568
Infrastructure situation	Courier distribution point	There are	933	89.345
		Not have	111	10.655
	E-commerce integrated service station	There are	664	63.578
		Not have	380	36.422

As can be seen from Table 3, the feedback from the sample farmers indicates that the local government's guidance of the rural e-commerce industry is low, and most of them chose the words "generally", "disagree" and "strongly disagree". Only 10.298% of the farmers strongly agree, 21.777% agree, and nearly 60% of the farmers give poor feedback. Nearly half of the sample farmers' villages and communities do not have effective rural e-commerce promotion, and more than half of the sample farmers' villages and communities have moderate rural e-commerce promotion. The prevalence of rural courier sites is high, and there are basically courier delivery points in the locations of the sample farmers, accounting for 89.345% of the total, which still has room to rise. Most of the sample farmers' locations have e-commerce integrated service stations, accounting for 63.578%, and the setup of service stations still needs to be strengthened.

2.3 Reasons and hindrances for not engaging in agri-commerce

In order to further understand the reasons for not participating in agricultural e-commerce and the obstacles, two multiple choice questions were set in the questionnaire, namely, "Reasons for not participating in agricultural e-commerce" and "Perceived obstacles to participating in agricultural e-commerce at present". As shown in Table 4, most of the farmers have a certain degree of understanding of agricultural e-commerce, and only 33.256% of the farmers said they did not understand agricultural e-commerce. Farmers who did not participate in

agricultural product e-commerce due to not knowing how to operate it were 43.335%, those who did not participate in agricultural product e-commerce due to lack of manpower were 22.364%, those who did not participate in agricultural product e-commerce due to financial constraints were 22.898%, those who did not participate in agricultural product e-commerce due to lack of energy were 21.425%, and those who did not participate in agricultural product e-commerce due to other reasons were 7.896%. It can be seen that farmers did not participate in agricultural product e-commerce for more reasons, the main reason is that they do not know how to operate it, and the lack of manpower, financial constraints, and the lack of time and energy are also some of the reasons. At the same time, the surveyed farmers believe that the current obstacles to participation in agricultural e-commerce, accounting for a larger proportion of the reasons in order to the lack of professional guidance and funding, government support is not strong, the network infrastructure is not sound, the lack of quality standards and logistics infrastructure is not sound and so on for consideration.

Table 4. Reasons and hindrances for sample farmers not participating in agricultural e-commerce

Reasons why farmers do not participate in agricultural e-commerce			Farmers perceive current barriers to participation in agricultural e-commerce		
Options	Frequency	Percentage (%)	Options	Frequency	Percentage (%)
Not realize	347	33.256	Lack of funds	483	46.253
Not know how to operate	452	43.335	Lack of quality standards	294	28.152
Lack of manpower	233	22.364	Lack of professional guidance	584	55.966
Funding restrictions	239	22.898	Inadequate logistics infrastructure	286	27.365
Lack of time and energy	224	21.425	Little government support	427	40.879
Else	82	7.896	Inadequate network infrastructure	326	31.202
			Farmers do not recognize the potential	306	29.335
			Else	92	8.769

3 Empirical analysis of the factors influencing farmers' willingness to participate in e-commerce

3.1 Model selection

The double-hurdle model was proposed by Cragg (1971), who argued that an individual's decision to participate in an activity consists of two components-the first hurdle, which determines whether the individual is zero or not, and the second hurdle, which determines the extent to which the individual participates in the activity if the first stage is non-zero. hurdle) is what determines the individual's level of participation in the activity, conditional on the first stage being non-zero. The key feature of this model is the two definitions of a "zero observation," one in which the individual's choice is zero regardless of changes in the surrounding environment, and the other in which the individual can have a non-zero choice but the current environment causes him to choose zero. At the methodological level of statistical inference research, the determination of zero observations can usually be dealt with using the idea of Tobit regression, and the further judgment of "subsuming zero values" and "choosing zero values" is in essence a methodological approach similar to that of heckman. In essence, it is to further refine Tobit's subsumption process in a similar way as heckman's methodology, so as to deal with the problems of distribution subsumption and self-selection at the same time. Therefore, the two-column model in fact consists of two parts: the "selection model" and the "regression of subsumption", while the selection model is similar to the heckman, which needs to select the selection variables.

First, a model of farmers' willingness to participate in e-commerce is constructed. The equation is as follows:

$$\text{Prob}(\,y_i\,=\,0\mid x_{1i}\,)\,=\,1-\emptyset(x_{1i}\alpha) \tag{1}$$

$$\text{Prob}(\,y_i\,>\,0\mid x_{1i}\,)\,=\,\emptyset(x_{1i}\alpha) \tag{2}$$

y_i is the explained variable,Equation (1) indicates that farmers' willingness to participate in e-commerce is 0, and Equation (2) indicates that farmers' willingness to participate in e-commerce is not 0;x_{1i} is the explanatory variable and control variable;$\emptyset(x_{1i}\alpha)$ represents the cumulative distribution function of the standard normal distribution,α is the parameter to be estimated,i denotes the ith farmer.

Secondly, considering the degree of farmers' participation in e-commerce, the following equation can be established:

$$E(\,y_i\mid y_i\,>\,0, x_{2i}\,)\,=\,x_{2i}\beta+\delta\lambda(x_{2i}\beta\mid\delta) \tag{3}$$

Where, $E(\,y_i\mid y_i\,>\,0, x_{2i}\,)$ represents conditional expectation, that is, farmers' participation in e-commerce; $\lambda(x_{2i}\beta\mid\delta)$ is the inverse Mills ratio, x_{2i} is the explanatory and control variables, β is the corresponding parameter to be estimated, and δ is the standard deviation of the truncated normal distribution.

On the basis of equations (1) - (3), the log-likelihood function can be established as follows:

$\ln L = \sum_{y_i=0}\{\ln[\,1-\emptyset(x_{1i}\alpha)\} + \sum_{y_i>0}\{\ln\emptyset(x_{1i}\alpha)-\ln\emptyset(\beta x_{2i}\mid\delta)-\ln(\delta)+\ln\{\emptyset[y_i\,-\,\beta x_{2i}\mid\delta]\}(4)$

In the analysis of this paper, considering the actual situation of villagers' participation in agricultural e-commerce, the villagers' failure to engage in e-commerce sales behavior itself may result from their own initiative and willingness to participate in e-commerce, as well as due to the state of the rural e-commerce environment and the promotion of the state of the village to participate in. "Therefore, for the sample self-selection problem caused by these two forms, this paper chooses the degree of guidance of the local government on rural e-commerce industry and the degree of e-commerce publicity in the village community as the selection variables, and conducts a regression in the subsequent modeling design, the specific model design is shown in Table 5.

Table 5. Model variable settings

Variant	Typology	Define
Sell	Explained variable	Log of e-commerce sales of farmers
Income		Logarithm of total harvest of farm households
Ratio		Farmers' e-commerce sales as a percentage of total harvests
Q2	Explanatory variable	Subjects' media technology literacy scores
Q3		Subjects' information awareness literacy scores
Q4		Subjects' information access literacy scores
Q5		Subjects' Information Communication Literacy Scores
Q6		Subjects' e-commerce technical quality scores
Q7	Control variable	Age of head of household
Q8		Sex of head of household
Q9		Years of education of the head of household
Q12		Is there an express delivery point in your village or community?
Q13		Whether the village or community has set up an integrated e-commerce service station.
Q10	Select Variable	The extent to which local governments are guiding the rural e-commerce industry
Q11		Has there been any rural e-commerce promotion in your village or community?

3.2 Variance inflation factor test

Considering that the variables in the model may have multicollinearity, in order to ensure the accuracy of the model, the variables are tested for multicollinearity before the benchmark regression. There are various methods to test multicollinearity, and the variance inflation factor (VIF) is used for testing. Table 6 shows that the variance inflation factors of all variables are obviously close to 1, indicating that the degree of multicollinearity among variables in the model is in a reasonable range, and there is no significant correlation between variables.

Table 6. Results of multicollinearity test

Variant	VIF
q2	1.12
q3	1.17
q4	1.15
q5	1.06
q6	1.12
q7	1.03
q8	1.01
q9	1.25
q12	1.16
q13	1.18

3.3 Analysis of factors affecting agricultural e-commerce

First, based on the impact of villagers' e-commerce-related qualities on agricultural e-commerce, this paper summarizes the lower-end 0 values based on the Tobit model, and yielded analytical results as shown in Table 7.

Table 7. Tobit model regression results

	(1)	(2)	(3)
	Sell	Income	Ratio
Main			
Q2	0.730***	0.769***	0.0640***
	(6.69)	(6.80)	(6.10)
Q3	1.629***	1.717***	0.145***
	(12.54)	(12.67)	(11.79)
Q4	0.505***	0.519***	0.0495***
	(3.69)	(3.65)	(3.86)
Q5	0.289**	0.311**	0.0234**
	(2.45)	(2.51)	(2.13)
Q6	0.509***	0.518***	0.0539***
	(4.16)	(4.08)	(4.63)
Q7	0.0393**	0.0359*	0.00481**
	(2.10)	(1.85)	(2.54)
Q8	-1.706***	-1.737***	-0.168***
	(-3.55)	(-3.47)	(-3.63)
Q9	1.297***	1.365***	0.114***
	(16.30)	(16.54)	(15.05)
Q12	0.511***	0.583***	0.0271
	(2.59)	(2.91)	(1.34)
Q13	0.574**	0.486*	0.0848***
	(2.05)	(1.67)	(3.29)
_cons	-31.00***	-32.19***	-2.910***
	(-19.16)	(-19.13)	(-18.82)

	/		
var(e.sell)	23.34***		
	(12.03)		
var(e.income)		25.10***	
		(12.03)	
var(e.ratio)			0.220***
			(13.58)
N	1044	1044	1044
pseudo R2	0.409	0.410	0.523
F	114.7	115.4	107.2
p	5.54e-160	1.32e-160	4.37e-152

From the above results, first of all, based on the statistical results of the pseudo R-square and F-test, the R-square is basically in the range of 0.4-0.5, while the F-tests are all significantly passed at the 1% level, so it can be basically determined that the variable selection of the model has sufficient validity.

Further, in terms of the effects of the five explanatory variables, the quality and willingness of residents at the level of e-commerce and information technology can significantly contribute to the residents' active participation in e-commerce business and earning a sufficient amount of income, and further expand their income for the whole year. Among the five variables, q4 (Information Access Literacy Score) has the strongest effect, q3, q5 and q6 (Information Awareness, Information Dissemination and E-commerce Technological Literacy) also have strong effects, while q2 (Media Technology), as a relatively basic digital literacy, has the weakest effect among the five quality categories.

Mechanistically, rural residents' participation in e-commerce has a full governmental coordinating and platform role, which makes their qualities at the active level, such as information dissemination, relatively weaker on e-commerce sales than information acquisition, and e-commerce technological literacy should be cultivated as a category of basic literacy for rural residents.

3.4 Endogeneity analysis based on a two-column model

Further, since there are subjective willingness and objective conditions that prevent rural residents from participating in e-commerce business, this paper carries out a two-column regression based on the degree of government's encouraging policies for e-commerce at the exogenous level as a selection variable, and firstly the results of the selection in the first column are shown in Table8.

Table 8. Results of the selection of the first column

	(1)	(2)	(3)
	Sell	Income	Ratio
Hurdle			
Q10	-0.928	-2.454	-0.0940
	(-0.00)	(-0.04)	(-0.00)
Q11	-0.0733	-0.129	-0.0521
	(-0.00)	(-0.10)	(-0.00)
_cons	10.09	15.20	6.047
	(0.00)	(0.05)	(0.00)

	sigma		
cons	4.831***	5.005***	0.469***
	(23.35)	(22.02)	(23.74)

It can be observed that the two-column selection effect is relatively weak, but effectively cleans up the model (simga is significant at the 1% level), so the model selection effect in the first column is largely consistent with the hypothesis.

Further, the Tobit model after the first column selection has been made is shown in Table 9.

Table 9. Tobit model after first column selection

	(1)	(2)	(3)
	Sell	Income	Ratio
Above			
Q2	0.730***	0.768***	0.0640***
	(6.89)	(6.96)	(6.17)
Q3	1.629***	1.716***	0.145***
	(10.01)	(10.14)	(9.15)
Q4	0.505***	0.520***	0.0496***
	(3.91)	(3.84)	(3.92)
Q5	0.289**	0.312**	0.0234*
	(2.30)	(2.35)	(1.90)
Q6	0.509***	0.516***	0.0539***
	(4.61)	(4.34)	(4.97)
Q7	0.0393**	0.0361*	0.00481**
	(2.03)	(1.79)	(2.54)
Q8	-1.706***	-1.742***	-0.168***
	(-3.58)	(-3.47)	(-3.62)
Q9	1.297***	1.364***	0.114***
	(16.43)	(16.39)	(14.89)
Q12	0.511***	0.582***	0.0271
	(2.75)	(3.01)	(1.47)
Q13	0.574**	0.487**	0.0848***
	(2.42)	(1.98)	(3.64)
_cons	-31.00***	-32.18***	-2.910***
	(-15.85)	(-15.77)	(-15.23)
N	1044	1044	1044
chi2	572.7	575.9	496.4
p	1.25e-116	2.50e-117	2.63e-100

It can be observed that the coefficient of q6 (e-commerce technological literacy score) shows a certain degree of increase and is basically close to the coefficient of q4 (information access literacy) after the endogeneity caused by the sample self-selection problem is eliminated, which implies that the basic qualities that relatively centrally affect the rural subjects can be found to be mainly the access to information and e-commerce, after eliminating the differences in the choices caused by the subjective willingness and the objective policy supports. Technology Literacy.

3.5 Robustness tests

Further, in order to verify the robustness of the model, a linear regression (Ols) model is

introduced in this paper for estimation, which yields the results shown in Table 10.

Table 10. Results of model robustness tests

	(1)	(2)	(3)
	Sell	Income	Ratio
Q2	0.249***	0.265***	0.0195***
	(7.77)	(7.96)	(6.65)
Q3	0.472***	0.501***	0.0376***
	(12.16)	(12.34)	(10.74)
Q4	0.249***	0.258***	0.0225***
	(5.70)	(5.64)	(5.81)
Q5	0.167***	0.179***	0.0131***
	(4.13)	(4.23)	(3.66)
Q6	0.197***	0.202***	0.0198***
	(4.81)	(4.71)	(5.21)
Q7	0.0101	0.00837	0.00140**
	(1.50)	(1.20)	(2.02)
Q8	-0.905***	-0.928***	-0.0820***
	(-4.53)	(-4.47)	(-4.15)
Q9	0.512***	0.543***	0.0407***
	(22.36)	(23.11)	(17.62)
Q12	0.222***	0.259***	0.00904
	(3.05)	(3.40)	(1.29)
Q13	0.280**	0.226*	0.0425***
	(2.34)	(1.81)	(4.04)
_cons	-7.249***	-7.554***	-0.620***
	(-15.40)	(-15.54)	(-12.85)
N	1044	1044	1044
adj. R2	0.587	0.594	0.509
F	249.0	264.6	121.6
p	4.60e-267	9.94e-277	8.67e-167

No significant changes in the significance and direction of the core coefficients can be observed, and in summary, the model is sufficiently robust.

4 Conclusions and recommendations

4.1 Conclusions of the study

Based on the survey data of 1044 farmers in the main producing areas of kiwi fruit in Shaanxi Province, to construct a new digital literacy system for farming households that contains media technology literacy, information awareness literacy, information access literacy, information dissemination literacy, and e-commerce technology literacy, and introduces control variables in two aspects of the government's support situation and the infrastructure situation, and utilizes the two-column modeling analysis to deeply discuss the effects of digital literacy on the participation of the farmers in e-commerce and the role of the mechanism, and utilizes the Ols model for robustness testing. behavior and the influence and mechanism of its role, and the robustness test was carried out using the Ols model, and the conclusions of the

empirical analysis mainly include the following aspects:

1.Media technology literacy, information awareness literacy, information acquisition literacy, information dissemination literacy, e-commerce technology literacy and other factors have a significant impact on the e-commerce participation behavior of farmers, and all of them can promote the behavior of farmers' participation in e-commerce. As the production and provider of agricultural products, the higher the level of digital literacy of farmers, the stronger their ability to actively collect, acquire and disseminate information using digital means, and the stronger their willingness and demand to actively participate in e-commerce, which directly affects the popularity and development level of rural e-commerce.

2.The level of education is also crucial for farmers to participate in e-commerce behavior. The level of education directly affects the degree of proficiency of farmers participating in e-commerce and the breadth and depth of data mining, in practice, the longer the number of years of education, the higher the educational endowment of farmers, the stronger the subjective initiative of accepting new things, new skills, the less time costs required in learning to participate in e-commerce activities, so the higher the level of education the higher the possibility of farmers participating in e-commerce, the more the practical benefits obtained The higher the level of education, the higher the possibility of farmers to participate in e-commerce and the more obvious the practical benefits.

3.The local government's guidance to the rural e-commerce industry plays a positive role in regulating the behavior of farmers' participation in e-commerce. Through positive publicity and guidance and moderate support, the government can, on the one hand, enhance farmers' knowledge and recognition of agricultural e-commerce, and enhance the initiative and enthusiasm of farmers to participate in e-commerce; on the other hand, through the basic guidance of information technology, it can directly reduce the initial cost of participation in the farmers to form the agglomeration of farmers to participate in the realization of the scale effect, and to facilitate the cooperation of mutual aid to further reduce the operating costs, and at the same time. At the same time, it can help farmers avoid the risks in the process of e-commerce transactions and improve the level of e-commerce utilization by farmers.

4.2 Policy recommendations

At present, international organizations such as UNESCO and the Food and Agriculture Organization of the United Nations (FAO), as well as China's government, believe that improving farmers' digital literacy is an important tool for promoting the transformation of the agricultural digital economy, and have issued relevant policies to implement them, but the system of cultivating farmers' digital literacy is still in its infancy. In view of this, combined with the empirical findings above, the following policy recommendations are put forward:

4.2.1 Improve the supply of systems and make a good top-level design.

Farmers' Digital Literacy Cultivation is a multidimensional and multilevel integrated system, and a hierarchical structure from shallow to deep. At present, China's macro-guidance policy for the improvement of farmers' digital literacy is mostly lacking in specific strategic planning, specialized systems and implementation rules. In reality, it is recommended to take farmers as the main body, centering on the improvement of farmers' digital literacy as the core, and constructing a service system of cultivating farmers' digital literacy with the main push of

government authorities and the participation of social subjects. First of all, we should emphasize the importance and legitimacy of cultivation according to the law, in order to improve the dimension of the legal system to highlight the necessity of farmers' digital literacy cultivation, specifically recommended that the Ministry of Agriculture and Rural Development first in the form of departmental regulations to enhance the farmers' digital literacy as the goal of the development of the digital transformation of agriculture and the development of policies and plans, which must include farmers' digital literacy to enhance the content of the relevant cultivation. At the same time, farmers, as one of the disadvantaged groups, deserve digital help in the information age, and it is recommended that the Ministry of Science and Technology introduce regulations to bridge the digital divide in the development of the digital economy by allowing farmers to gradually establish digital concepts, master and utilize digital technology and other digital literacy training. The two ministries should work together to introduce education and guidance programs for farmers' digital literacy, and embed digital literacy in agricultural training and financial services by groups of people and by phases, so as to ensure that the policies are targeted and effective in a synergistic manner. After the relevant rules and regulations have been tested and amended by social practice, when the conditions of social development and legal demand are fulfilled, they will be upgraded to regulations or legal provisions, which will further highlight the legitimacy and importance of farmers' digital literacy, and thus better help the development of rural digital economy.

4.2.2 Clarify the rights and responsibilities of the main body and create a position for the cultivation of digital literacy.

Based on the multidimensional attributes of the cultivation of farmers' digital literacy, as the main body of rural revitalization and common wealth farmers, to improve their digital literacy necessarily requires the diversity and collaboration of the main body. First of all, to promote the party and government departments, research institutes, various universities, enterprises and social organizations and other subjects to work together to build. Local party and government departments as the leading administrative force, in the specific implementation of the rural revitalization strategy and the transformation of the digital economy in the process of early and pilot practice to cultivate the basis, to do a good job of policy advocacy and service leadership at the same time, but also actively organize the participation of all the main parties to take the initiative to build a multi-body communication and collaboration platform, and do a good job in the role of the leader, the organizer and the role of the server positioning. On the basis of promoting the digitization of farm bookstores, we have actively carried out teacher training for farmers' digital literacy education, formulated unified standards to clarify the responsibilities and competence requirements of trainers, strengthened the training of trainers' professional capacity in agriculture, and enhanced their practical ability and competence. Research institutes and colleges at all levels have highlighted the advantages of combining policy advice and industry-academia-research, especially vocational colleges and universities with the right professional characteristics, to assume the responsibility of digital literacy training and talent cultivation, and to give full play to their strengths in assisting rural revitalization and social think-tanks, so as to better realize the integration and interoperability of industry-academia-research. While exporting their own products and services, Internet enterprises should take up the responsibility of practicing the transformation of the digital economy. They can not only develop, upgrade and maintain various application software and digital content to meet the needs of real-life diversified farmers, but also carry out

corresponding marketing training based on their own business operation practices, so as to realize the effective fusion of their own economic benefits and social benefits. Various social organizations and volunteers can provide farmers with more convenient and diversified digital literacy knowledge learning and skills training services, as well as social supervision of the above subjects, which constitutes a closed loop of the matrix of social subjects for the cultivation of farmers' digital literacy. At the same time, each subject should have clear responsibilities, promote in a coordinated manner, and realize the scale effect. This ensures that participating subjects give full play to their own advantages, provide accurate and high-quality educational content and training methods, and quickly and effectively improve the level of digital literacy among farmers.

4.2.3 Diversify content supply and build a multi-dimensional cultivation system.

The process of cultivating farmers' digital literacy is characterized by multiple subjects and diverse and variable contents, and in reality, only by building a multi-dimensional cultivation system can we meet the needs of the development of rural digital economy. In terms of content, the cultivation program should be formulated in a gradual and targeted manner. Farmers' digital literacy has rich connotations and is gradually deepened at different levels. On the one hand, it promotes training for farmers in the use of network terminal equipment and digital transaction tools such as Alipay, provides guidance for e-commerce professionals, and improves the ability of farmers, especially the middle-aged and elderly groups, to use electronic products. On the other hand, it has provided training on new forms such as live streaming with goods and short video creation, while focusing on network security education to raise farmers' awareness of the rule of law and security on the Internet and risk prevention, and to help them identify potential risks in their e-commerce activities and provide them with effective relief paths. On the basis of the above shallow cultivation, new digital application scenarios are constantly enriched to continuously empower the cultivation of farmers' digital literacy and enhance the service experience of farmers' digital production and life. In terms of training objects, we should focus on the principle of fairness and moderation under the guidance of different types of farmers to carry out differentiated training, create an inclusive cultivation atmosphere, relying on the resources and human endowment of different regions, combined with the actual needs of farmers' digital literacy, to provide differentiated training programs and technical support, and at the same time, focus on tapping into the local outstanding talent resources, with the case of teaching and the head-geese effect and other popular At the same time, we focus on tapping local outstanding talent resources, and use case teaching and the goose effect and other popular teaching modes to inspire farmers to actively participate in e-commerce with enthusiasm and creativity, and strive to set up an organized digital literacy enhancement team and help twinning groups. In the process of cultivation, hardware and software infrastructure investment is a prerequisite, which not only requires continuous investment of funds, but also needs to pay more attention to the effective integration of information technology and the local characteristics of the agricultural economy, establish and improve the long-term mechanism of farmers' digital literacy cultivation and the construction of practice bases, and rely on the advantages of the existing experts to set up a think-tank, create a new mode of farmers' digital literacy cultivation of regional characteristics, and achieve the complementarity of advantages and resource sharing between on-line and off-line. The online and offline advantages are complementary and resource sharing is realized. At the same time, we should pay attention to real-time interaction and practical feedback,

build and improve the evaluation system and timely upgrade, boldly correct mistakes and seriously improve, and constantly enrich and optimize the training program of farmers' digital literacy.

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