Factors Influencing Willingness and Ability of Farmers to Adopt New Technologies: A Case Study of Guanzhong Area

TIAN Jing-na, LI Lu-tang*

College of Economics and Management, Northwest A&F University, Yangling 712100, China

Abstract Based on data of 248 rural households in Pucheng County and Huxian County, we established the Two-Level Logit Model to analyze the willingness of farmers to adopt new technologies, its influence factors, and probability of successful adoption of new technologies. Results show that the willingness has positive correlation with whether the farmer is head of household, the educational level, occupation, agricultural loan, the number of family labor, and information dissemination channel, while it has negative correlation with non-agricultural employment proportion and whether the farmer is village cadre. In the model of the probability of farmers' successfully adopting new technologies, occupation, agricultural loan, planting area, gender and educational level are positively correlated, while age and non-agricultural employment proportion are negatively correlated. Large-scale flow of rural labor plays a negative role in popularization of technologies in rural areas through influencing factors, including number of family labor, non-agricultural employment proportion, educational level, gender, and whether the farmer is village cadre. Finally, on the basis of results of empirical study, we put forward countermeasures and suggestions for strengthening ability of farmers to adopt new technologies.

Key words New technologies, Willingness of adoption, Farmers' ability, Logit Model

Guanzhong Area is located in the center of Shaanxi Province. From west to east, it lies between Baoji City and Tongguan County. Flat and fertile, it is the granary and cash crop production area of Shaanxi Province. Its GNP (Gross National Product) accounts for 2/3 of that of the entire Shaanxi Province. In recent years, on one hand, Guanzhong Area shows a strong trend of high quality labor force of the right age flowing into non-agricultural industries, which is cross-province or cross-city. Government, in order to improve income of rural households, has drawn up various supporting measures to encourage outflow of labor force. On the other hand, local governments continuously adjust the agricultural industry structure. Various protected agriculture and fruit industries develop quickly and become a new economic growth point of agriculture. Thus, there is an emergent need of high quality rural labor force to develop modern agriculture through creative ways and means. Government strongly support local high quality talents (including those already flowed out) to strike root at their home town or return to start an undertaking. With the scale of rural labor outflow increasing year by year, such conflict between these two aspects are getting increasingly fierce. It influences rural production and life greatly. Especially, it has an essential impact on the promotion of innovation and technology in rural areas. Therefore, under the new situation, it is of great positive significance to study the factors influencing the promotion of agricultural technology.

1 Overview

With respect to factors that influence the willingness of farmers to adopt new technologies, many scholars have done beneficial study and come to lots of valuable conclusions. Lin Yifu points out that educational level, labor force and work arrangement, operation scale and agricultural production experience of the head of household are negatively correlated with whether farmers are willing to adopt new technologies to a great extent[1]. Zhu Mingfen *et al.* find out that large agricultural professional households have become the vanguard of adoption of new agricultural technologies after analyzing behavior differences of different types of households in regard to adoption of new technologies. Wen Kahua thinks that information dissemination channels are not clear and agricultural policies not stable, which influences transformation of scientific and technological achievements[3]. Han Junhui *et al.* think that main channels for farmers to obtain seed information include radio and television promotion, government or village committee promotion, introduction by acquaintances at seed stations, introduction by neighbors or acquaintances *etc.*, while other channels including data distributed by agricultural technology promotion departments, work away from hometown, exhibition of agricultural science and technology, internet *etc.* account for only a small part[4]. Zhu Xigang *et al.* think that production and operation scale, cropping system and crop rotation system, arable land resources endowment per capita *etc.* influence the technology adoption behavior of households[5]. The results of study carried out by Zhang Jian on the situation of farmers' adoption of greenhouse technology in Liaoning Province shows that age is an essential factor influencing adoption of greenhouses, *i. e.* the younger the head of a household is, the more possible he adopts the greenhouse technology[6]; however, the results of study carried out by Kong Xiangzhi *et al.* on the condition of farmers' adoption of new technology in western China shows that age of the head of a household has a positive impact on their adoption of new technology, that is, the older the head of a household is, the more possible he adopts new product breeds[7]. Zhou Jiehong has performed a survey on whether

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* Corresponding author. E-mail: tjn1208@163.com

planting area influences adoption of safe production technology, in which planting area is considered as a factor of house characteristics, but she hasn't drawn a clear conclusion[8]. Song Jun *et al.* study on factors influencing farmers' selection of technology through a combined approach of statistical description and empirical study and find out that farmers' selection of technology is influenced by farmer's income level, planting area, as well as educational level, age and gender *etc.* of farmers. Farmers' selection of technology varies with different income levels and resource conditions[9]. To sum up, willingness of farmers to adopt new technologies is influenced to a certain extent by their social experience, economic conditions, age, educational level, technology information dissemination channels, number of family laborers, planting scale, income level and stability of agricultural policies.

2 Data source and study method

2.1 Sample selection and questionnaire survey Pucheng County and Huxian County lie in the northeast and central part of Guanzhong plain near Xi'an City and have a large scale of rural labor flow. It is found that problems with promotion of technology of soilless-substrate seedling reflect the restraining factors of agricultural technology promotion in Guanzhong Area and this situation is a microcosm of agricultural technology promotion in Guanzhong Area. Therefore, we sample these two counties to investigate and study.

Technologies are not distributed to households at random, but selected by farmers at their own discretion under the precondition of Hypothesis of Economic Man. Whether farmers adopt a new technology depends on their resource endowment. We, through extensive literature research and considering characteristics of promotion of technology of soiless-substrate seedling, have sampled 4 villages, namely Zhongquan and Niancheng villages of Longchi Town in Pucheng County, Tongxin and Sanqi villages of Jiangcun Town in Huxian County. Finally, we got 248 valid questionnaires. Empirical study was performed from 4 aspects of characteristics of farmers, technology induction factors, information acquisition channels and other factors, with 12 factors in total. For specific definition and sample mean, see Table 1.

It is shown in Table 1 that basic characteristics of sampled farmers are: average age of the head of household, 50.2; average length of education, 7.6 years; average planting area per household, 0.38 hm^2; average agricultural laborers per household, 3.2 persons; average annual income per hectare of planted protected agriculture, up to 57 750 yuan.

Table 1 Content of questionnaire about adoption of new technologies by farmers and sample mean

Variable type	Variable name	Variable definition	Mean	Standard deviation
Explained variable	Willingness to adopt new technologies (Y)	Yes = 1; No = 0	0.48	0.500
Characteristics of farmers	Whether the farmer is head of household	Yes = 1; No = 0	0.55	0.490
	Gender	Male = 1; Female = 2	1.33	0.470
	Age	≤ 40 years old = 1; 41 to 50 years old = 2; 51 to 60 years old = 3; > 60 years old = 4	3.17	1.030
	Educational level	≤6 years = 1; 6 to 9 years = 2; >9 years = 3	1.61	0.640
	Whether the farmer is village cadre	Yes = 1; No = 0	0.14	0.350
	Occupation	Yes = 1; No = 0	0.11	0.310
Technology induction factors	Cultivated area	≤ 0.2 hm^2 = 1; 0.200 1 to 0.333 3 hm^2 = 2; > 0.333 3 hm^2 = 3	2.04	0.480
	Non-agricultural income proportion	Under 50% = 0; 50% or more = 1	0.09	0.290
Information acquisition channel	Information acquisition channel	Training by agricultural technology departments = 0; others = 1	0.72	1.070
Other factors	Number of family laborers	None or 1 person =1; 2 to 4 persons = 2; 5 persons or more = 3	2.02	0.459
	Agricultural loan	Yes = 1; No = 0	0.21	0.411
	Non-agricultural employment proportion	≤ 30% = 1; [30% to 50%] = 2; >50% = 3	1.91	0.761

Note: The data come from field investigation I performed on 248 households of 4 villages about their willingness to adopt the technology of soilless-substrate seedling.

2.2 Construction of Two-Level Nested Logit Model In order to construct a model, farmers' decision making process is divided into 2 levels: Level 1, whether they are willing to adopt new agricultural technologies; Level 2, for farmers willing to adopt, factors influencing success of new technology adoption is further analyzed.

For technology selection preference of Level 1, it is intended to investigate farmers' willingness to adopt new technologies, which means whether farmers are willing to abandon their original cultivation methods or technologies with low productivity and adopt those ones of high productivity. There are two answers: yes or no. In order to overcome the limitation that the coefficient standard deviation estimated through ordinary least square and weighted least square and T test don't apply the hypothesis of statistics, we introduce a binary Logit model to estimate willingness of farmers' to adopt new technologies and its influencing factors. The probability distribution is:

$$Y_{1i} = \begin{cases} P_{1i} & Y_{1i} = 1 \\ 1 - P_{1i} & Y_{1i} = 0 \end{cases} \quad (1)$$

where, P_{1i} is the probability that i farmers are willing to adopt

new technologies; $Y_{1i}=1$ means willingness; $Y_{1i}=0$ means unwillingness. General form of the model is:

$$P_{1i}=1/\{1+\exp[-\alpha+(\sum_{k=1}^{m}\alpha_i x_{ki})+\mu_i]\} \quad (2)$$

where, k is number of explained variables; β_i is regression coefficient of influencing factors; x_{ki} is an explained variable and means the level of No. k influencing factor of agricultural labor force of No. i sample; μ_i is stochastic error.

Level 2 of the Logit model is a model for probability of successful adoption of new technology, that is the probability whether new technologies would be successfully adopted under the conditions that farmers are willing to adopt new technologies and proactively participate in training or follow the development of new technologies. In this model, "farmers who are willing to adopt new technologies and have already been using new technologies" are defined as $Y_{2i}=1$; while "farmers who are willing to adopt, but are still wait-and-see and haven't adopted new technologies yet" are defined as $Y_{2i}=0$. The probability distribution is:

$$Y_{2i}=\begin{cases}P_{2i} & Y_{2i}=1\\ 1-P_{2i} & Y_{2i}=0\end{cases} \quad (3)$$

where, Y_{2i} is the probability of successful adoption of new technologies of Y_{2i} farmers. General form of the model is:

$$P_{2i}=1/\{1+\exp[-\beta+(\sum_{n=1}^{m}\beta_i x_{ni})+\varepsilon_i]\} \quad (4)$$

where, n is number of explained variables; β_i is regression coefficient of influencing factors; x_{ni} is an explained variable and means the level of No. n influencing factor of agricultural labor force of No. i sample; ε_i is stochastic error.

3 Results and analysis

3.1 Estimated regression results SPSS17.0 statistical software is used to process data. Firstly, all variables are introduced into regression equitation and tested to get Model 1; then all variables are set to backward introduction into equitation and regressed with Wald to get Model 2. In probability model of new technologies getting influenced, variables are introduced with the same method as Model 2 to get Model 3. From the running result of each model, their identification accuracy is respectively 68.1%, 67.3% and 87.1%. From the chi square values of models, it can be seen that these models fit well. For results estimated and verified based on parameters of each model, see Table 2.

Table 2 Model of factors influencing farmers' willingness to adopt new technologies and probability of successful adoption regression results

Variable	Model 1			Model 2			Model 3		
	B	Wals	Sig.	B	Wals	Sig.	B	Wals	Sig.
Head of household	0.976***	7.821	0.005	0.752***	6.557	0.010			
Gender	−0.437	1.463	0.226				0.375*	0.932	0.084
Age	−0.166	0.826	0.363				−0.488**	4.708	0.030
Educational level	0.758**	6.547	0.011	0.765***	8.177	0.004	0.548*	2.821	0.093
whether the farmer is village cadre	−0.918*	3.625	0.057	−0.858*	3.369	0.066			
Occupation	1.302**	6.412	0.011	1.493***	8.875	0.003	1.344***	7.057	0.008
Planting area of household	0.423	0.900	0.343				0.236**	0.347	0.046
Non-agricultural income proportion	−0.276	0.139	0.709						
Information acquisition channel	0.273*	3.702	0.054	0.252*	3.245	0.072			
Agricultural loan	1.117***	8.332	0.004	1.239***	11.119	0.001	1.167***	7.902	0.005
Family laborers	0.503	2.497	0.114	0.521*	2.752	0.097			
Non-agricultural employment proportion	−0.618***	9.140	0.003	−.637***	10.001	0.002	−0.611**	5.376	0.020
Constant	−2.143	1.946	0.163	−2.311***	7.824	0.005	−0.409	0.068	0.794
Chi-square	46.899***		0.000	42.389***		0.000	35.373***		0.003

Note: *** denotes significance at 1% level; ** at 5% level; * at 1% level.

3.2 Model results analysis

3.2.1 Model 1 and Model 2 are models for analysis of willingness probability of farmers to adopt new technologies.

(i) The overall fitting of Model 1 is better. These 3 variables, namely, head of household, agricultural loan and non-agricultural employment proportion are significant at 1% level. Significance of the variable-head of household, is greatly correlated with tradition in China. In rural areas, head of household is generally a male. This person is master of the family and makes important decisions of family production and life. Though the variable-gender, doesn't pass significance verification, but its coefficient is negative, which indirectly supports this interpretation. The significance of agricultural loan exceeds my expectation. It shows that governmental financial policy support greatly influences adoption of new technologies in rural areas. This can be explained as those farmers applying for agricultural loans generally have higher educational levels, stronger information absorption ability, and more attention to agricultural production. They want to vigorously develop agriculture with financial support of agricultural loans so as to improve their family income. Therefore, these farmers have motivation and basis for adoption of new technologies and can lead rural development. The results of Model 3 also prove this. The coefficient of non-agricultural employment is negative. From the fact that in Model 2 number of family laborers is significant at 10% level and its coefficient is positive, it can be seen that the larger the number of family laborers and the proportion of engagement in agriculture, the more possible a household is willing to adopt new technologies. Therefore, great importance must be attached to the phenomenon of large scale of rural labor force outflow to reduce its impact on promotion of new technologies in rural areas.

(ii) Educational level in Models 1 and 2 is more significant than in Model 3. Their significance is respectively below 5%

and 1% and coefficient positively correlated. This means that farmers with higher educational level are more willing to adopt new technologies for production, less discriminatory against new things and easier to accept absorb information. Occupation in Model 2 is significant at 1% level with its coefficient up to 1.302. Therefore, it is clear that promotion of new technology should take satisfying farmers' need as a breakthrough rather than let the tail wag the dog in the name of technology promotion enforcing farmers to perform certain production, which would cause unnecessary social conflicts. Whether the farmer is village cadre and information acquisition channels are significant at 10% level. The regression coefficient of whether the farmer is village cadre is negative, which doesn't match the statement in many literatures that village cadres take the lead among farmers and in the promotion of new technologies. In investigation and study, we found some village cadres are absent. They have taken the initiative flowing to non-agricultural industry for employment and don't care for village affairs. This is an warning sign for construction of grass-root organization in Shaanxi Province and a prominent negative impact of rural labor flow on villages. The regression coefficient of media channels is positive. This means that it is urgent to improve the function of grass-root agricultural technology promotion departments.

3.2.2 Model 3 is a model for analysis of probability of successful adoption of new technologies by farmers. Model 3 show different factors' influence on probability of farmers to successfully adopt new technologies. The results show that occupation and agricultural loan is significant at 1% level; non-agricultural employment proportion, planting area of household and age at 5%; gender and educational level at 10%.

(i) The influence of these factors-occupation and agricultural loan-on farmers' successful adoption of new technologies supports the analysis of Models 1 and 2. Further special attention must be paid to this aspect during the promotion of new technologies in future.

(ii) Through practical investigation it is found that among farmers who are more probable to adopt or already have adopted new technologies, most are large production or planting households, which is also supported by results of empirical study. This can be explained as: for households that have larger planting areas, their agricultural income accounts for a larger proportion of total income. These farmers pay more attention to seeds, pesticides and new technologies related to agricultural production, and would successfully adopt new technologies to improve labor productivity. Age is significant at 5% level, and its coefficient is negative. This shows that the older a farmer is, the more inflexible his thought is, and his probability to successfully adopt new technologies is smaller.

(iii) Gender is significant at level 10%. From the prospective of taking risks, generally, males have stronger risk awareness than females. Males are more able to absorb new technologies they got to know. Therefore, large scale of female laborers outflow has negatively influenced adoption of new technologies in rural areas. The coefficient of farmers' educational level (0.548) is positive and at significant level, which means that with the improvement of farmers' educational level, their enthusiasm for new technology adoption would increase. It is important to note that significance of educational level in Model 3 is lower than in Model 2, which means that the probability to successfully adopt new technologies is not influenced by educational level to that significant level as expected. This reflects from a side view that though school education is the basis for relearning, it is not a prerequisite. Practical learning ability is also important. New agricultural technologies can be mastered by farmers through training. Therefore, difficulty of new technology promotion should not be exaggerated with the excuse of low educational level of farmers.

4 Conclusions and suggestions

4.1 Conclusions Based on empirical study analysis of models of willingness of 248 households in Pucheng County and Huxian County to adopt soilless substrate seedling technology, its influencing factors and probability of successful adoption, we can draw the following conclusions:

(i) As long as innovative technologies promoted meet the needs of agricultural development and can really bring economic benefits to farmers, they can be promoted in a large scale on the precondition of medium level of investment and risk. There are many reasons for low rate of new technology adoption, among which the most important one is economic interests. When calculating costs, farmers would usually not count labor input and time cost. Besides, their planting areas are small. All these have greatly impaired the advantages of new technologies. In addition, another important aspect is insufficient governmental support.

(ii) Degree and direction of influence on farmers' willingness to adopt new technologies vary with different factors. Specifically, the willingness has positive correlation with whether the farmer is head of household, the educational level, occupation, agricultural loan, the number of family labor, and information dissemination channel, while it has negative correlation with non-agricultural employment proportion and whether the farmer is village cadre. In the model of the probability of farmers' successfully adopting new technologies, occupation, agricultural loan, planting area, gender and educational level are positively correlated, while age and non-agricultural employment proportion are negatively correlated. Large-scale flow of rural labor plays a negative role in popularization of technologies in rural areas through influencing factors, including number of family labor, non-agricultural employment proportion, educational level, gender, and whether the farmer is village cadre. Attention must be paid to this.

4.2 Policy suggestions

(i) Highlighting the service function of grass-root agricultural technology promotion stations to provide appropriate technological support for farmers; increase financial support by vigorously developing small credit business to financially support farmers, help them to enlarge planting areas and obtain economic benefits by increasing production scales.

(ii) Setting up correct concept of rural labor flow and make

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The soil type is mainly aquic cumulated irrigated soil, and fluvo-aquic soil and thick irrigation-silting soil. Grade III cultivated land has irrigation benefit of Yellow River, but is also influenced by topographical location, drainage condition and soil factors. The area of constraint soil layer (sand-leaking clay layer or entire body sand) influenced by salinification takes up 22% and 74% of the Grade III cultivated land respectively. Grade III cultivated land is the largest area of cultivated land in Yongning County. To improve its fertility, it is required to enhance and perfect drainage system and facility construction, reduce salinification, increase application of organic fertilizer, return straws to fields to increase organic matter content of soil, and improve physical and chemical properties of topsoil sandy or clay soil.

(iv) Grade IV cultivated land.

Major soil type is sandy soil. Entire body sand or calcic horizon becomes major obstacles to fertility of cultivated land. Therefore, it is required to increase organic matter content of soil to improve the fertility. Increase of organic matter in soil mainly relies on application of thoroughly decomposed organic fertilizer, because straws directly returned to field are not easy to decompose and will influence water moisture.

(v) Grade V cultivated land.

This grade of cultivated land belongs to low-yield farmland. Major obstacles are salinification and poor and barren soil. For Grade V cultivated land in different regions, it is required to take different improvement measures. In aeolian sandy soil area, it is proposed to increase application of organic fertilizer; in old irrigation area around lakes, it is preferred to improve drainage facilities and plant rice or other salt-resisting crops.

(vi) Grade VI cultivated land.

This grade of cultivated land also belongs to low-yield farmland. Major obstacle is soil salinification. For this grade cultivated land, it is required to select crops according to topographical location. In western areas, it is preferred to plant salt-tolerant industrial crops, such as sunflower; in old irrigation area where there is serious salinification, it is proposed to plant rice.

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appropriate flow policies. Mere labor outflow isn't the fundamental solution to develop local economy. Labor should flow both out and in, so that agriculture can obtain sustainable development. Therefore, vigorous support should be given in aspects such as policies, finance, technologies, training, *etc*. Encourage outflow of spare labor force and return back of high quality talents for starting an undertaking and driving the development of rural economy.

(iii) Stabilizing rural land management rights, make suitable circulation policies of land management rights so as to establish a good land system basis for development of modern agriculture.

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