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An Assessing Analysis of Factors Influencing the Adoption of Agricultural Technology for Farmers in China

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Abstract:
Agricultural technology application is one of the most important strategy to promote agricultural development. With the rapid development of global social and economic level, a series of novel technologies have been applied in agricultural production. However, up to now, the adoption of these agricultural technologies for farmers was not satisfactory due to the influences of various reasons. Therefore, In this work, rice farmers behavior were investigated on their new varieties adoption in the main rice producing areas in Heilongjiang province. The adoption information and key factors of farmers for agricultural were analyzed. More importantly, the analysis of influencing factors and its solutions for farmers' technology adoption was carried out to further strengthen the promotion performance and improve the adoption behavior of farmers.

Keywords: *Adoption behavior, Agricultural technology, Influencing factors, Farmer.*

I. INTRODUCTION

For most part in the worldwide, agriculture is the basis of survival and activities for animals and humans [1, 2]. In many countries, agricultural production risks play an important role in the selection and use of production inputs and adoption behavior of novel agricultural technology [3-5].

Agricultural technology is of great significance in improving agricultural production and agricultural growth [6, 7]. The application of novel agricultural technology is validated to effectively increase farmers' income and reduct the price of food and agricultural product [8]. Practical findings from farm surveys demonstrate that agricultural technology development is positively correlated with poverty issues in rural areas [9,10]. Therefore, the promotion of agricultural technology adoption is essencial for rapid development of rural economy and improvement of agricultural production efficiency, as well as the increase of farmers' income [11]. The aim of economic development is to solve the poverty problem and increase family income [12, 13]. As illustrated in Figure.1, the process of farmers' agricultural technology adoption is analyzed and summarized.

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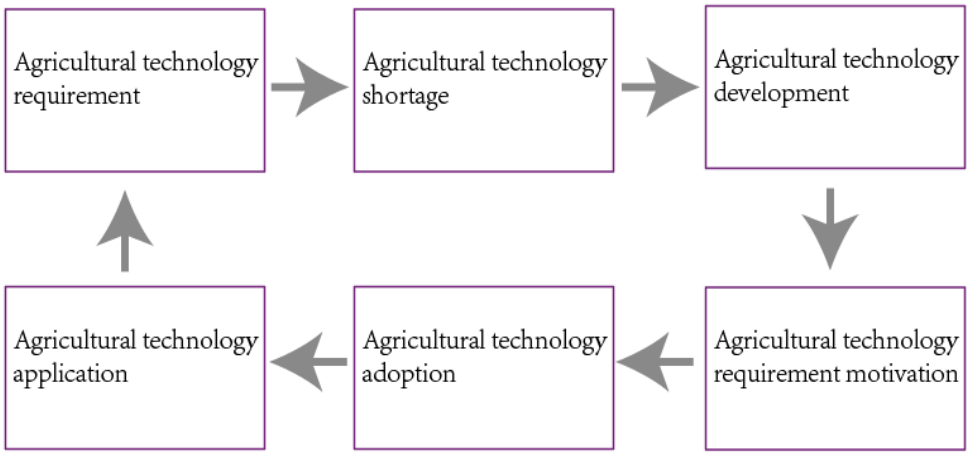

Fig 1: Analysis of farmers' agricultural technology adoption process.

In this paper, it investigated 306 farmers behavior on agricultural technology adoption in Heilongjiang province. Based on the logistic regression model, the analysis of factors influencing agricultural technology adoption was identified and assessed. Farmers' adoption behavior consists of farmers behavior to recognize and purchase agricultural equipment, accept and apply agricultural technology in the process of agricultural technology promotion. Nevertheless, the initiative adoption behavior for farmers was more effective than the promotion and popularity of agricultural technology. Thus, the analysis of farmer adoption behavior and improvement of the farmers adoption rate were vital for the change of behavior and the quality of agricultural production in the process of agricultural technology promotion.

II. THEORY AND METHODOLOGY

In this study, 306 rice farmers behavior were investigated on their technology adoption in the main rice producing areas in Heilongjiang province. In practical, the technology adoption of farmers is influenced by many factors. Therefore, the conduction of regression model for the analysis of these factors is highly in demand. Since both discrete and continuous variables are present in this research, the logistic regression model is selected for the validation analysis of the impact factors [14, 15]. In comparison with the farmers between adoption and non-adoption, we can evaluate the performance of technology adoption behavior. However, technology adoption is the programme of farmers self-selection. A series of variables make a difference in their technology adoption.

Via the analysis of the 306 samples, the dependent variable Y refers whether farmers adopted the new varieties or not. Furthermore, assume that the dependent variable Y is coded as 1 and 0, representing the adoption and non-adoption of the characteristics, respectively.

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TABLE I. Category for adoption and non-adoption[a,b].

		Predicted		
Predicted		Y		Percentage calibration
		adoption	Non-adoption	
Y	adoption	0	108	0
	non-adoption	1	198	100.0
	total percentage	/	/	64.7

a.Constant in model; b. Cut value = 0.500

These are only constant results that are performed from SPSS version 19 (IBM, New York, USA), which does not contain any independent variables. As shown in TABLE I, in the 306 sample datas, the frequency of adopting the new variety is the most, which has 198 sample points. P value, as the classification accuracy, was 0.647. Therefore, when the model does not contain any variables, all the observations in the samples predict to adopt new varieties, and the total accurate rate is 64.7%.

III. RESULTS

The differences focus on the nature of correlation between the adoption behavior and independent variables. In regression situations, the essencial quantity represents the mean value of the independent variable. In the logistic regression model, the coefficient denotes the change for the logit versus the change of the independent variable, which is determined by the difference between two logits in the model. As shown in TABLE II, the variables and characterization in the equations are achieved. In addition, the ratio of the adoption to non-adoption of the new varieties is obtained and analyzed.

TABLE II. Variables and characterization in equations.

Procedure	B	S.E.	Wald	df	Sig.	Exp (B)
Constant	0.606	0.120	25.675	1	0.000	1.833

B. Estimated value of the constant; S.E = Standard error; Wald = Wald χ^2

Where χ^2 is for the statistical test whether the total regression coefficient is 0 or not. The calculation formula is:

$$\chi^2 = (\frac{\beta_i - 0}{SE_{\beta_i}})^2 = (\frac{\beta_i}{SE_{\beta_i}})^2$$

In this study, χ^2=(0.606/0.120)*(0.606/0.120)=25.5025. Where df denotes the degree of freedom, and Sig. denotes the corresponding P value. Exp(B) is the β_0 power of e, indicating the ratio of the adoption to non-adoption of the new varieties.

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The performance of the fitted model plays a critical part for the evaluation of the survey. Generally, the assessment of the fitted logistic regression model is technical. We assumes the variables in the logistic regression model are significant in terms of statistical information and the model is fitted depending on the statistical sense

TABLE III. The assessment of the logistic regression model.

Procedure	-2Log Likelihood	Cox and Snell R^2	Nagelkerke R^2
1	0.000[a]	0.727	1.000

a. This result is not unique.

The -2log likelihood value, Cox and Snell R^2 and Nagelkerke R^2 were obtained from this model. Cox and Snell R^2 and Nagelkerke R^2 revealed the ratio of the variation of the response variable to the total variation of the reaction variable. The regression model has a good fitting performance due to the large fitting coefficient of Cox and Snell and Nagelkerke.

$$Cox\,\&\,Snell\ R^2 = 1-(\frac{L(0)}{L(\hat{\beta})})^{\frac{2}{n}}$$

$$Negel\ \ker ke\ R^2 = \frac{Cox\,\&\,Snell\ R^2}{1-L(0)^{\frac{2}{n}}}$$

Where L(0) is the likelihood value when this model only consists of the constant, L(β) is likelihood value of this current model.

$$Cox\,\&\,Snell\ R^2 = 1-(\frac{L(0)}{L(\hat{\beta})})^{\frac{2}{n}} = 0.7270$$

$$Negel\ \ker ke\ R^2 = \frac{Cox\,\&\,Snell\ R^2}{1-L(0)^{\frac{2}{n}}} = 1.0000$$

The parameters and significance of this model were achieved when all the independent variables were moved into the logistic regression model (TABLE III).

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TABLE IV. Variables and characterization in equations.

Variables	Score	df	P. value
Initiative and acceptance	10.595	1	0.001
Farm scale and scope	220.981	1	0.000
Numbers of growing varieties	5.069	1	0.024
Purchase seeds route	7.919	1	0.005
Soil characteristic	0.010	1	0.919
Order with the company	2.600	1	0.107
Gender	1.799	1	0.180
Age	1.162	1	0.281
Physical condition	0.832	1	0.362
Brand awareness	0.077	1	0.782
Obtain technology route	0.738	1	0.390
Satisfaction with subsidies	0.040	1	0.841
Guider for villages	0.077	1	0.781
Education level	0.842	1	0.359
Income level	0.005	1	0.946
Population	0.284	1	0.594
Growing areas	1.594	1	0.207
Agricultural machinery available	1.740	1	0.187
Training for grow technology	1.077	1	0.299

As seen in TABLE IV, it can be seen that there are four variables P. value < 0.05, indicating that the key influencing variables are farmers' initiative and acceptance, farm scale and scope, and numbers of growing varieties, as well as the purchase seeds route (Figure. 2).

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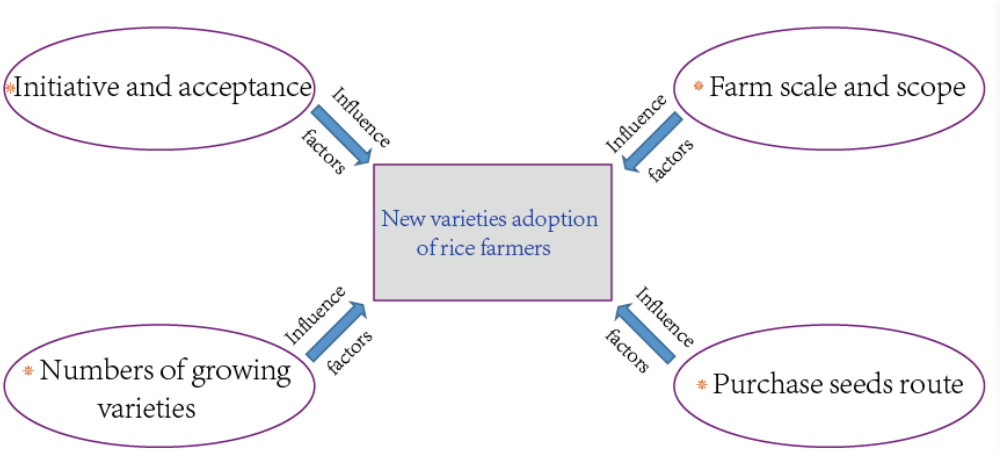

Fig 2: Analysis of rice farmers' new varieties adoption process.

IV. DISCUSSION AND ANALYSIS OF FACTORS INFLUENCING FARMERS' ADOPTION BEHAVIOR

4.1 Influence of Farmers' Initiative and Acceptance

In general, farmers are advanced in years with low education levels, which leads to the weak farmers' recognition and acceptance. In addition, these novel technologies and new methods are difficult for the application of farmers. Although some farmers have rich experience in practical production, they pay insufficient attention to agricultural technology and equipment, which also affects the adoption rate of farmers in agricultural technology promotion. In the process of practical application, it is no doubt that the convenience and high efficiency are obtained for the application of agricultural equipment, the disadvantage like the waste problem caused by large instruments is also serious. It can be illustrated that one of the main influence factors for farmer technology adoption is the low education level and the large age structure of farmers. Therefore, the change of farmers' awareness plays an important aspect for adoption behavior.

4.2 Impact of Education and Family Income

In the vast rural areas of China, it is essencial to improve the education level of farmers and rural productivity, as well as the adoption behavior of agricultural technology. Researches have been introduced to the adoption information of farmers for agricultural technology via a large number years of education [16]. These findings demonstrate that the education level is positively correlated with farmers' adoption behavior. A large numbers of studies pay attention to the family members for the decision-making, exploring the meaning and practical conditions for the adoption of agricultural technology [17-18]. The high educated farmers, as decision-maker in their family, are more likely for the technology adoption behavior owing to the analysis of input-output ratio and the attention of agricultural technology.

In addition, family income level is the key factor affecting the adoption rate of agricultural technology. In the rural areas, family income is extrordinary low owing to the enhancement

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effect of many factors, including low production ability, lack of skills, large family structure and insufficient land resources. Especially the disposable income for the average level is much lower than the urbanites. However, a large amount of production cost is required for the novel agricultural instruments and agricultural production tools, as well as novel seeds, fertilizers and pesticides. All these costs are expensive for farmers. Agricultural technology equipment is extrordinary expensive to purchase and maintain for farmers due to the low average income level, indicating that even though farmers are interested in the novel agricultural technology, they will not adopt these agricultural instruments. Meanwhile, the low education levels cause farmers pay attention to the current economic cost rather than the long-term perspectives and benefits. Therefore, they are reluctant to increase input costs in the short term, resulting in a generally low degree of agricultural mechanization.

4.3 Insufficient Agricultural Mechanization and Input-Output Ratio

Agricultural machinery, an important part of agricultural technology promotion, is a key factor for improving production efficiency. However, in the rural areas, the low popularity of agricultural machinery and equipment is the result of terrain constraints, natural environment limitations and economic conditions restrictions. More seriously, many farmers are unwilling to accept the novel agricultural machinery. Additionally, agricultural machinery and equipment are expensive with high professional level and high maintenance. Agricultural machinery was imployed only in the special seasons with low utilization efficiency. Agricultural equipments such as harvesters, transporters, and shredders were required to focus on improving the efficiency of mechanized production, which results in the high-cost for farmers and the high ratio of input to output. The increase in the ratio of input to output is important for farmers to pay attention to agricultural technology. So far, the most feasible way to increase the input-output ratio is to increase the sideline business. Once the agricultural production is completed by farmers with the application of technical equipment, there is enough time for sideline activities to improve the income level and the input-output ratio.

4.4 Effect of Promotion Performance of Agricultural Technology

In the process of agricultural technology promotion, many rural agricultural centers did not guide farmers according to the instructions, resulting in the insufficient recognize of novel agricultural technology and the understanding of advantages and advancement of agricultural technology. At the mean time, the promotion programme of agricultural technology was based on villages and countries in principle without high performance and scope. Two quantitative mehods have been introduced to access the recognition and application of numbers of extension activities. In these promoting programmes, technicians generally expound in the way of illustrating, talking to managers, demonstrations, and meetings rather than guide them how to apply the technology and method appropriately, which leads to the insipid conditions and insufficient recognition of new technology and novel ideas. The performance of initiative adoption by farmers did thus not come true.

4.5 Performance of Farm Scare and Novel Cooperatives

Empirical evidence from previous study indicate that farmers who have large-scale farms

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are more willing for the adoption behavior of agricultural technology. Farm size is a key factor for farmers' income, determining that farmers possess the ability to purchase and maintain the agricultural equipments and apply the novel methods. Greater financial conditions provide more opportunities to collection and analysis of the latest information of adopting technology and make the corresponding strategy for the future development[17]. In addition, farm size is positively correlation with farming technology adoption, large-size farm increases the possibility of adoption behavior of farmers[19].

Cooperative, a new business model, carried out in the rural areas to intensify land of farmers for conducting a novel agriculture system with intensive, large-scale and specialized characteristics. Meanwhile, farmers obtain additional income through land transfer, which greatly promoted the transfer of land to professional large families, family farms and agriculture Cooperatives. However, small cooperatives can not build factories on agricultural land owing to the national policy limitations on lands in rural areas, which cause that cooperatives can not be able to enhance the scale and scope. Meanwhile, the preservation and management of agricultural machinery and agricultural products are restricted. The low professional level of cooperatives and low industry performance of agricultural products processing are the result that agricultural products can not conduct long-distance transportation and the economic benefits are not satisfactory. In addition, there are multiple operational problems in the process of cooperative development for a high performance due to the short period of cooperative development.

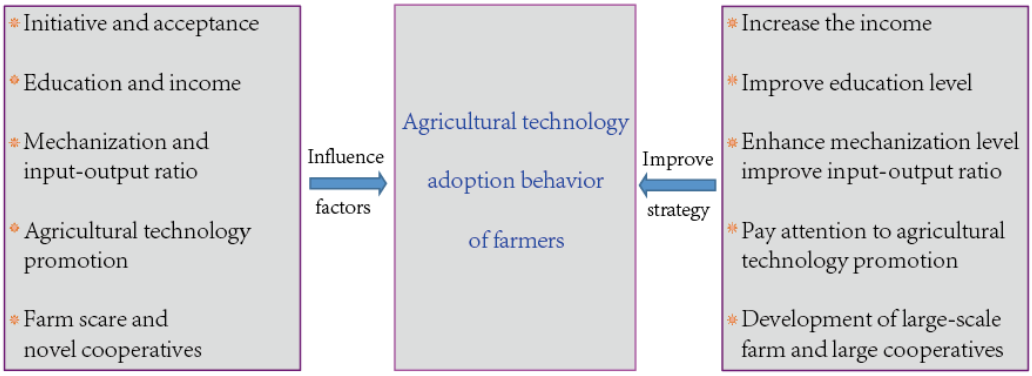

Fig 3: Influencing factors and improving strategy of farmers' agricultural technology adoption behavior.

V. IMPROVEMENT OF FARMERS' TECHNOLOGY ADOPTION BEHAVIOR

5.1 Increase the Income Level of Farmers

Increasing the income level of farmers is the basis on improving the promotion of agricultural technology and the adoption rate of farmers. The most meaningful solution to address the current agricultural income situation is to establish the agricultural industry chain.

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The commercialization mode is imployed to promote agricultural production. Modern communication technology, industry intensification, and procedure division make contribution to the application of this model. Policies and programmes proposed by government are the keys to enhance supports for the agricultural industry, raise farmers average income level and actively change their production conditions, as well as improve agricultural production and life quality of farmers. The promotion of various agricultural technology and organizational forms to increase the support for farmers to purchase agricultural machinery and equipment is effective for farmers to decrease the cost and increase the benefits. The economic conditions will be improved through the implementation of the policy of benefiting farmers. Combining the industry chain model with the support of government programmes will effectively improve the stability of farmers' income.

5.2 Improve Education Level of Farmers For Their Awareness

In the whole country, especially in the vast rural areas, it is vital to improve the education level of farmers and improve rural productivity. Then, The change of farmers views and the improvement of their intellectual and decision-making ability are also greatly correlated with the education level. Therefore, the improvement of farmers education levels make a significant contributions to the farmers technology adoption behavior.

5.3 Enhance Mechanization Level and Improve Input-Output Ratio

Agricultural machinery are closely correlated with the average land area, mechanical efficiency and mechanical price. Therefore, reducing farmers' economic burden and mechanical cost are the effective way to improve production level and production efficiency of farmers, and ultimately improve regional mechanization level and increase current economic level of farmers. In addition, effectively enhance farmers' purchasing ability and expand agricultural mechanization allow farmers to recognize the advantages of agricultural technology in the improvement of agricultural production efficiency. In addition, The increase in the ratio of input to output is important for farmers to pay attention to agricultural technology. So far, the most feasible way to increase the input-output ratio is to increase the sideline business. Once the agricultural production is completed by farmers with the application of technical equipment, there is enough time for sideline activities to improve the income level and the input-output ratio.

5.4 Pay Attention to Agricultural Technology Promotion

In the process of agricultural technology promotion, we should actively transform agricultural technology promotion patterns and focus on the popularity of machinery, technology, method, pesticides and fertilizers. The promotion and popularization of the vast rural areas and farmer's home are non-ignorable. Take the model household as an example to let other farmers actually recognize the benefits of agricultural technology. In these promoting programmes, technicians should teach them how to apply the technology and method appropriately in practical, resulting in the better recognition of new technology, novel ideas and methods.

5.5 Development Of Large-Scale Farm and Large Cooperatives

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Small-scale farm has limited financial opportunities and farm income to allow them for more technology activities and the use of agricultural machinery [20]. Therefore, the development of large-scale farm is much in demand. Up to now, the types of cooperatives include mechanical cooperatives, farming cooperatives, large-scale cooperation and small-scale cooperatives. The appropriate conduction of cooperatives plays an important role for regional application of agricultural technology. The development of target cooperatives depending on different levels of special regions can be able to effectively enhance the scale of cooperatives. For instance, rural areas carry out large machinery cooperative while suburban areas conduct large and small cooperatives rural areas carry out large machinery cooperative, which will facilitate the development of cooperative organization, and enlarge the scale of region industry, as well as increase their income and agricultural production efficiency. The development of large cooperatives will effectively enhance the ultilization of agricultural machinery and the application of agricultural technology.

VI. CONCLUSION

It can be concluded that the key influencing variables of farmers for adoption new varieties are initiative and acceptance, farm scale and scope, and numbers of growing varieties, as well as the purchase seeds route. Furthermore, the influencing factors of farmers' adoption behavior in the process of agricultural technology promotion mainly include farmers' initiative and acceptance, family income level, agricultural mechanization and input-output ratio, and promotion performance of agricultural technology, as well as development of large-scale farm and cooperatives (Figure.3). Agricultural technology promotion is positively correlated with agricultural technology adoption. More importantly, the enhancement the farmers' voluntary adoption behavior is the essencial factor for the improvement of agricultural technology promotion levels. Firstly, we need to analysis the factors influencing the farmers agricultural technology adoption. Then, special solutions are carried out to improve the agricultural technology promotion levels. Additionally, change the willingness of farmers actively is vital for the rapid development of rural areas economy.

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