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Analysis on Irrational Decision Making of Tobacco Family Farmers from the Perspective of Optimal Scale of Efficiency

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Abstract The larger the difference between the willingness scale of tobacco family farmers and the optimal scale of efficiency, the greater the degree of irrationality, and the higher the decision making risk. With the aid of DEA model, this study calculated the optimal scale of efficiency of Guiyang tobacco family farms. Using the ratio of willingness scale and efficiency optimal scale, it measured the degree of irrationality of family farmers. In addition, with the help of multiple linear regression model, it explained the irrational decision making mechanism of family farmers. Finally, it made a portrait of farmers who tend to make irrational decisions, to find specific farmers and guide them in their production and operation, reduce the risk of planting scale decision making and stabilize the sustainable development of the tobacco industry.

Key words Irrational decision making, Family farmers, Optimal scale of efficiency, Portrait

1 Introduction

Tobacco family farm is a form of tobacco production organization that bases family labors and implements autonomous operation, self-management and assumes its profits or losses[1]. Theoretically, developing tobacco family farms will help to realize the scale, intensification and specialization of planting operations, help to cultivate high-quality professional tobacco farmers, and stabilize the tobacco farmers[2]. However, in actual production, some traditional farmers lack a fully rational understanding of family farms. In the process of transition to family farmers, they are still not fully equipped with the qualities required by professional farmers and are prone to make irrational business decisions, for example, blindly pursuing the expansion of planting scale and ignoring the effective allocation of production factors, accordingly failure to increase the operation efficiency. The scale of agricultural production is not the bigger the better. The optimal operating benefit requires a more reasonable allocation of production input factors such as land, capital, and labor by adjusting the scale of the farm under a given internal and external environment. According to the theory of "rational peasant", farmers will make reasonable choices in their production behaviors in order to pursue the greatest production benefits. China's traditional tobacco farmers are restricted by comprehensive quality, internal and external conditions, and the rationality of their production behavior is difficult to achieve optimal state[3-6]. Zhang Zhongming[7] believed that the diversification of farmers' employment and income sources reduces their enthusiasm for land management, and the number of farmers who are willing to choose the optimal scale of efficiency is insufficient, while aging is also an important reason for farmers to choose the optimal scale of inefficiency. Zhang Hongyong[8] found that there is a significant difference between the intended planting scale area and the moderate scale area of tobacco farmers. At present, the tobacco planting area, the labor volume of the tertiary industry, the number of tobacco fields, the age of tobacco and the mechanical farming service have a significant impact on the willingness scale. Yang Chaofei[9] held that the construction of base units requires optimizing the tobacco planting entities, expanding the scale of planting, and improving the tobacco quality, but some operators in Henan tobacco area unilaterally pursued the expansion of business scale, and did not take into account the risks in tobacco production, and finally suffered serious losses. In the opinion of Wen Jintao *et al.*[10], farmers should carefully use agricultural loans and rationally choose a planting scale that matches the quantity and quality of their familes' labor force. If tobacco family farmers do not get the expected benefits after making new production and management decisions, it will greatly affect their enthusiasm for planting tobacco, which is not conducive to the stability of tobacco planting entities and the sustainable development of the tobacco industry.

The larger the difference between the willingness scale of tobacco family farmers and the optimal scale of efficiency, the greater the degree of irrationality, and the higher the decision making risk[11]. With the aid of DEA model, we calculated the optimal scale of efficiency of Guiyang tobacco family farms. Using the ratio of willingness scale and efficiency optimal scale, we measured the

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degree of irrationality of family farmers. In addition, with the help of multiple linear regression model, we explained the irrational decision making mechanism of family farmers. Finally, we made a portrait of farmers who tend to make irrational decisions, to find specific farmers and guide them to make optimal scale decisions, ensure the tobacco planting benefits, and stabilize the sustainable development of the tobacco industry.

2 Research methods

2.1 DEA model and variable selection The DEA model refers to data envelopment analysis. Its basic idea is based on marginal benefit theory and linear programming theory. It regards each evaluated object as a decision making unit (DMU), and uses linear programming and statistical data to determine relatively effective production frontiers. The degree to which each DMU deviates from the production frontier is used to judge its operational efficiency. The two basic models of DEA are the CCR model based on constant returns to scale and the BCC model based on variable returns to scale. For any DMU, through linear programming, it is able to establish a duality model and further introduce the slack variables s^+ and s^- of output and input, the expression of CCR model is as follows:

$$\min\theta$$

$$s.t.\begin{cases}\sum_{j=1}^{n}\lambda_j x_j + s^+ = \theta x_0\\ \sum_{j=1}^{n}\lambda_j x_j - s^- = y_0\\ \lambda_j \geqslant 0,\ j=1,2,\cdots,n\\ s^+ \geqslant 0,\ s^- \geqslant 0\end{cases}$$

where θ is the overall efficiency value of the DMU. In the case of variable returns to scale, the BCC model is expressed as follows:

$$\min\eta$$

$$s.t.\begin{cases}\sum_{j=1}^{n}\lambda_j x_j + s^+ = \eta x_0\\ \sum_{j=1}^{n}\lambda_j x_j - s^- = y_0\\ \sum_{j=1}^{n}\lambda_j = 1\\ \lambda_j \geqslant 0,\ s^+ \geqslant 0,\ s^- \geqslant 0\end{cases}$$

where η is the pure technical efficiency value of the DMU. Scale efficiency = Overall efficiency/Pure technical efficiency.

The DEA model can provide an efficiency optimization strategy for inefficient DMUs. The effective DMU obtained through the BCC model will form a production frontier, and the inefficient DMUs will be "projected" on the frontier. Through this projection, the gap between the non-effective DMU and the corresponding effective DMU can be measured, and the improvement direction and magnitude of converting it into an effective DMU can be provided, so as to determine the optimal scale of the efficiency of each DMU.

According to the characteristics of tobacco production and the actual local situation, we selected the purchase volume of high-quality tobacco and the profit of planting tobacco as output indicators, and selected land input, labor input and capital investment as input indicators. Specifically, the land input was represented by the tobacco planting area, and the labor input was represented by the amount of labor generated by the tobacco farmers themselves and their hired workers. In order to avoid repeated calculation, the capital investment was expressed as the amount of money spent in the entire tobacco planting process deducting labor and land rent, as indicated in Table 1.

Table 1 Input and output indicators of tobacco planting

Type	Indicator	Definition
Output indicator	Purchase volume of high-quality tobacco//kg	Gross weight of high-quality tobacco as determined by professional grading
	Profit//10^3 yuan	Total income from selling tobacco deducting various costs of planting tobacco
Input indicator	Area//ha	Gross area used for tobacco cultivation by farmers themselves and through circulation
	Amount of labor	Sum of the input of the farmer's own labor and hired labor
	Capital amount//10^3 yuan	Sm of costs excluding land rent and labor costs

2.2 Multiple linear regression model and variable selection We used the ratio of the willingness scale to the optimal scale of efficiency to measure the degree of irrationality of family farmers, and took this as a dependent variable to establish a multiple linear regression model. We selected the stepwise regression method for variable screening, the probability standard used is 0.10 for entry and 0.20 for deletion. At the same time, we tested the model fit, multicollinearity diagnosis and heteroscedasticity, and adjusted with 1/|unstandardized residual| as the weight, and finally used the weighted least squares (WLS) method to re-estimate the standardized regression coefficients to eliminate heteroscedasticity.

The degree of irrationality of family farmers is influenced by many factors. With reference to relevant research and local actual conditions, we divided the possible influencing factors into several types in Table 2.

2.3 Data sources The data were from the survey questionnaire of tobacco family farms in Guiyang tobacco area. We interviewed a total of 97 households, and collected 81 valid questionnaires with the response rate of 83.51%.

3 Results and analysis

3.1 Optimal scale of efficiency for tobacco family farms First, we used SPSS software to test the correlation between input and output indicators with the help of Pearson correlation coefficient. The results showed that all indicator variables passed the significance test. In other words, the input and output indicators satisfy the assumption of the same direction, indicating that the input indicators can effectively affect the output indicators (Table 3).

Table 2 Variable selection and definition

Variable type	Variable name	Variable definition
Degree of irrationality in decision making	Degree of irrationality in decision making (Y)	Willingness scale/Optimal scale of efficiency
Characteristics of personal and family	Farmer's age (X_1)	Specific age//years old
	Farmer's educational level (X_2)	1 = primary school and below; 2 = junior middle school; 3 = senior middle school or technical secondary school
	Family tobacco planting experience (X_3)	Specific value//years
	Number of family labors (X_4)	Specific value//persons
	Family loan capacity (X_5)	1 = [0, 30) $\times 10^3$ yuan; 2 = [30, 60) $\times 10^3$ yuan; 3 = 60 $\times 10^3$ yuan and above
Characteristics of land	Current land area (X_6)	Specific value//ha
	Years of land circulation (X_7)	1 = 1 year and below; 2 = 2 years; 3 = 3 years; 4 = 4 years; 5 = 5 years and above
	Number of plots (X_8)	Number of plots
	Convenience of tobacco fields (X_9)	1 = very inconvenient; 2 = not very convenient; 3 = general; 4 = convenient; 5 = very convenient
	Water conservancy facilities (X_{10})	1 = badly established; 2 = less established; 3 = general; 4 = established; 5 = well established
Characteristics of management system	Production management records (X_{11})	0 = No; 1 = Yes
	Financial management records (X_{12})	0 = No; 1 = Yes
Characteristics of green production mode	Soil protection technology (X_{13})	0 = No; 1 = Yes
	Green prevention and control technology (X_{14})	0 = No; 1 = Yes
	Cleaner production (X_{15})	0 = No; 1 = Yes
Characteristics of cost benefit	Unit yield (X_{16})	Specific value//kg/ha
	Average tobacco price (X_{17})	Specific value//yuan/kg
	Unit material cost (X_{18})	Specific value//10^3 yuan/ha
	Unit baking cost (X_{19})	Specific value//10^3 yuan/ha
	Unit employment cost (X_{20})	Specific value//10^3 yuan/ha
	Unit land cost (X_{21})	Specific value//10^3 yuan/ha
	Unit profit (X_{22})	Specific value//10^3 yuan/ha
	Per capita annual profit (X_{23})	Specific value//10^3 yuan/person
	Profit rate (X_{24})	Total profit/Total cost
Characteristics of family farm awareness	Awareness of family farms (X_{25})	1 = not know at all; 2 = not know much; 3 = general; 4 = know; 5 = well know
	Acceptance to developing family farms (X_{26})	1 = not necessary at all; 2 = not very necessary; 3 = generally; 4 = necessary; 5 = very necessary
	Possible impact of being a family farm on income (X_{27})	1 = much decrease; 2 = some decrease; 3 = no change; 4 = certain increase; 5 = much increase
Characteristics of social production services	Help to land circulation (X_{28})	1 = not helpful at all; 2 = limited help; 3 = general; 4 = helpful; 5 = very helpful
	Help to subsidy (X_{29})	1 = not helpful at all; 2 = limited help; 3 = general; 4 = helpful; 5 = very helpful
	Help to technology (X_{30})	1 = not helpful at all; 2 = limited help; 3 = general; 4 = helpful; 5 = very helpful
	Help to capital construction (X_{31})	1 = not helpful at all; 2 = limited help; 3 = general; 4 = helpful; 5 = very helpful
	Help to system (X_{32})	1 = not helpful at all; 2 = limited help; 3 = general; 4 = helpful; 5 = very helpful

Table 3 Correlation between input and output indicators of tobacco production

Item	Correlation	Area	Amount of labor	Capital amount
Purchase volume of high-quality tobacco	Pearson correlation	0.914***	0.937***	0.912***
	Significance (two-sided)	0.000	0.000	0.000
Profits	Pearson correlation	0.414***	0.503***	0.443***
	Significance (two-sided)	0.000	0.000	0.000

Note: *, **, *** indicate statistically significant at the 10%, 5%, and 1% levels, respectively; the same below.

Using DEAP 2.1 software, we calculated the optimal scale of efficiency of 81 tobacco family farms. The results in Table 4 show that the optimal scale of efficiency has a minimum value of 0.46 ha, a maximum value of 8.33 ha, and a mean value of 1.15 ha, 74.07% of the samples have the optimal scale interval of efficiency below 1 ha, and only 12.35% have the optimal scale interval of efficiency above 2 ha.

3.2 Influencing factors of the degree of irrationality of tobacco family farmers We used the ratio of willingness scale of tobacco family farmers to the optimal scale of efficiency to measure the degree of irrationality in decision making, as indicated in Table 5.

Table 4 Optimal scale of efficiency of tobacco family farms

Scale interval	Q'ty of samples	Percentage//%	Min	Max	Mean
[0,1)	60	74.07	0.46	0.97	0.69
[1,2)	11	13.58	1.00	1.48	1.13
[2,3)	3	3.70	2.44	2.75	2.56
[3,4)	3	3.70	3.04	3.33	3.23
[4,5)	3	3.70	4.06	4.65	4.32
[5,10)	1	1.23	8.33	8.33	8.33
Overall	81	100.00	0.46	8.33	1.15

Table 5 Degree of irrationality of tobacco family farmers

Degree of irrationality	Q'ty of samples	Percentage//%	Min	Max	Mean
[0,1)	4	4.94	0.85	0.98	0.90
[1,2)	41	50.62	1.02	1.96	1.62
[2,3)	35	43.21	2.00	2.88	2.33
[3,4)	1	1.23	3.00	3.00	3.00
Overall	81	100.00	0.85	3.00	1.91

When the ratio of willingness scale to the optimal scale of efficiency is 1, the decision is most rational; when the ratio is less than 1, the closer to 0, the higher the degree of irrationality; when the ratio is greater than 1, the greater the ratio, the higher the degree of irrationality. From Table 5, it can be seen that except for the ratios of 4 samples that are less than 1, the ratios of the remaining samples are all greater than 1, indicating that the vast majority of family farmers tend to exceed the optimal scale of efficiency for production and operation, and their operating risks will also increase with the increase of the degree of irrationality. Considering the consistency of the multiple linear regression analysis, we first conducted a multiple linear regression model analysis of 77 samples with a comparison value greater than 1 with the aid of the SPSS software to study possible influencing factors. The results are shown in Table 6.

From the regression results in Table 6, it can be seen that for the 77 samples with willingness scale greater than the optimal scale of efficiency, family loan capacity (X_5), current land area (X_6), average tobacco price (X_{17}), unit profit (X_{22}), and possible impact of being a family farm on income (X_{27}) are statistically significant at the 1% level; the unit employment cost (X_{20}) and help to capital construction (X_{31}) are statistically significant at the 5% level; the financial management records are (X_{12}) are statistically significant at the 10% level, showing that these 8 variables can better explain the irrational decision making mechanism of family farmers. For the 4 samples (group B) with the willingness scale less than the optimal scale of efficiency, we performed the one-way ANOVA between groups with another 77 samples (group A). From Table 7, it can be seen that two groups of samples had different degree of significance difference in number of family labors (X_4), loan capacity (X_5), current land area (X_6), convenience of tobacco fields (X_9), production management records (X_{11}), financial management records (X_{12}), acceptance to developing family farms (X_{26}) and help to land circulation (X_{28}).

Table 6 Regression results of factors influencing the degree of irrationality in decision making

Variable	Unstandardized regression coefficients	Std. Error	Standardized regression coefficients	*t*	*Sig.*	Tolerance	*VIF*
C	2.532***	0.543		4.668	0.000		
X_5	0.533***	0.087	0.500***	6.156	0.000	0.701	1.426
X_6	-0.136***	0.039	-0.292***	-3.484	0.001	0.661	1.514
X_{12}	-0.158*	0.081	-0.140*	-1.941	0.056	0.883	1.133
X_{17}	-0.059***	0.022	-0.199***	-2.728	0.008	0.868	1.152
X_{20}	-0.014**	0.006	-0.174**	-2.393	0.019	0.871	1.148
X_{22}	0.016***	0.003	0.502***	6.002	0.000	0.662	1.511
X_{27}	0.127***	0.041	0.226***	3.087	0.003	0.862	1.161
X_{31}	-0.059**	0.025	-0.181**	-2.377	0.020	0.802	1.248
	R^2 = 0.685, Adjusted R^2 = 0.648, Durbin - Watson = 1.941						

Table 7 One-way ANOVA results

Variable	Group A	Group B	*Sig.*
X_4**	2.14	2.75	0.028
X_5***	1.19	2.50	0.000
X_6***	1.35	5.62	0.000
X_9**	3.06	4.25	0.029
X_{11}**	0.38	1.00	0.013
X_{12}**	0.21	0.75	0.012
X_{26}**	4.19	5.00	0.043
X_{28}***	1.68	3.75	0.000

4 Conclusions and recommendations

4.1 Conclusions Through the DEA model, we calculated the optimal scale of efficiency of 81 tobacco family farms in Guiyang, the minimum value is 0.46 ha, the maximum value is 8.33 ha, and the mean value is 1.15 ha. We used the ratio of the willingness scale of tobacco family farmers to the optimal scale of efficiency to measure the degree of irrationality of family farmers. Except for 4 samples (group B) with the ratio less than 1, the ratios of the remaining 77 samples (group A) were all greater than 1. The results of multiple linear regression analysis show that for group A, 8 variables, namely, family loan capacity, current land area, unit tobacco price, unit profit, possible impact of being a family farm on income, unit employment cost, help to capital construction and financial management records are significant at different statistical levels, which can better explain the irrational decision making mechanism of family farmers. Through one-way ANOVA, we found

that group A and group B of samples had different degree of significance difference in number of family labors, loan capacity, current land area, convenience of tobacco fields, production management records, financial management records, acceptance to developing family farms and help to land circulation.

Based on the analysis results of the influencing factors of the 77 samples in Group A, we can make a portrait of the tobacco family farmers who make irrational decisions: they lack the help of the tobacco departments in capital construction, and the average tobacco price is also low; the current small land area does not require too many external employees, the labor cost is lower, so the unit profit is also higher; they do not have the habit of financial management records, but they are too optimistic that becoming tobacco family farms will greatly increase their income; in addition, the loan capacity is relatively strong, so they are likely to greatly increase the scale of planting, making it far beyond the optimal scale of efficiency.

The 4 samples in group B have more labors and stronger loan capacity, and have received greater help from the tobacco departments in terms of land circulation, which may be the reason why their tobacco fields are more convenient and the current land area is larger. They all think it is necessary to develop tobacco family farms, and they also have the habit of production management records and financial management records, which reflects their good management ability and business philosophy. However, it is worth noting that their production and operation decisions are more inclined to significantly reduce the scale, possibly because after a large-scale tobacco planting, they found that too large-scale will lead to a decrease in the efficiency of tobacco planting and they may also have a deeper understanding of the relationship between tobacco production efficiency and scale. Although their willingness scale is reduced to below the optimal scale of efficiency, the gap is not large, so we believe that the irrationality degree of their decision making is low

4.2 Recommendations The purpose of analyzing the irrationality of tobacco family farmers' decision making is to find out the key factors and then find family farmers who tend to adjust their production scale significantly. After finding them, it is not to completely prevent their decision to adjust the production scale, but to provide guidance for their production and operation in a targeted manner and reduce the risk of decision making.

4.2.1 Developing moderate scale of tobacco family farms in combination with the characteristics of local labor and land. On the one hand, the local farmland is relatively fragmented, which makes the farming conditions poor. On the other hand, the proximity to the provincial capital city makes the labor cost high. The tobacco family farms also have large differences in terms of labor cost and quality of tobacco fields. A small fraction of the large tobacco family farmers tend to reduce the scale, while most of the smaller tobacco family farmers want to expand the scale. It is recommended to find an appropriate scale range suitable for the local area, and help family farms to rationally allocate various input factors to increase the production efficiency. Small-scale family farmers should use agricultural loans cautiously and avoid the risks of blind investment.

4.2.2 Properly allocating infrastructure resources and providing assistance in facilitating the circulation of tobacco fields for small-scale family farms. If small family farms want to expand the scale, the tobacco departments can assist them in finding convenient, contiguous plots of land, extend the circulation period by standardizing contracts, supplemented by more infrastructure, especially baking facilities, to optimize their production factors and make them suitable for expanded-scale production.

4.2.3 Making effort to improve the positive driving effect of large-scale family farms and stabilize local tobacco production. The total yield of tobacco of large-scale family farms is also relatively high, and the excessive reduction of the planting area is not conducive to the stability of local tobacco production. At the same time, due to the large scale, the behavior of large-scale farmers may have a greater influence on the enthusiasm of other farmers to grow tobacco. If large family farmers reduce their tobacco production significantly, it may also affect the decisions of other farmers. Therefore, it is necessary to keep a good relationship with these larger family farmers, give them care and help in production technology, business management and other aspects through follow-up management, try to play a positive leading role of their opinion leaders while ensuring the income of their tobacco planting, and stabilize and promote the modern production of local tobacco.

4.2.4 Stressing the cultivation of the farmer's professional management concept and helping establish a professional management system. The development of tobacco family farms should not only stop at the change of name, but also have substantial changes in the quality of farmers and farm management. For one thing, it is necessary to pay attention to the professional cultivation of farmers, especially the concept of moderate scale operation, so as to avoid blind or large scale adjustment. For another thing, it is recommended to help farmers establish a modern management system in terms of production process and specifications, financial records and accounting, risk control and response, and improve their management level.

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