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A Study of Optimal Cultivation Scale based on Cobb-Douglas Function in Chinese Peasant Household

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Abstract **– In China, the basic units that agricultural products are the scattered farmers, of which the essential characteristic is the small scale production. Based on the field research data from 500 scattered farmers in Jiangsu and Zhejiang and through empirical analysis of Cobb-Douglas production function, the paper presented here aims finds that the production of agricultural products features increasing returns to scale, that the use efficiency of labor force and land element is comparatively low and that the allocative efficiency has not reached the Pareto Optimality which should be achieved by land circulation. Therefore, the government should establish the laws and regularities to motivate farmers' enthusiasm to be involved in land circulation abiding by the laws.**

Keywords **– Returns to Scale, Moderate Scale Management, Production Function JEL: A1.**

I. Introduction

Comparing the land utilization condition between scattered farmers and large-scale farms in Ethiopia, Stein (2009) concludes that the land cost is so low in this country that the labor productivity of farms is higher that of scattered farmers. Wang Xiuqing (2002) argues that land integration can achieve the scale operation of agricultural products and improve farmers' production gain. According to lv Meiye (2009), the improvement of production gain and increase of farmers' income can be both realized by large-scale cultivation of agricultural products through relocation of elements. In China, the small production scale and low efficiency of scattered farmers cannot meet the needs of markets for means of production and agricultural products. The reasons are as follows. First of all, their small-scale production is not well-organized. The market information asymmetry and unblocked market channels also lead to their disadvantage situation in the price game. They can hardly be the main part of modern agricultural market. In addition, the variety of production from scattered farmers is not enough and the quality of it is not guaranteed that cannot meet the need of mass wholesale market. So both the previous study and the current situation in China have proved that the production mode of scattered farmers is not helpful to the development of agricultural production. Most scholars argue that agricultural large-scale production is imperative in the transition of production mode.

II. Theoretical Foundation

Currently, in China the scale of agricultural operation is very small; technological innovation is hardly conducted; the contradiction of diseconomies of scale has stood out. When it comes to the scale of agricultural production in the academic circle, it means the size of scale is expressed by the operation acres of land. One country's current agricultural production scale is determined by two factors, i.e. the initial configuration condition of land resources and its adjustment procedures to the higher efficient configuration. The allocation of resources will constantly adjust from certain original state to form present agricultural production situation. Obviously different from general industries, the core of agricultural production scale is land and there is only the approach of merger or combination to enlarge the production scale. Farmers cannot gain the land needed to enlarge the scale from other industrial departments. The production status can be described as below.

For $Q_1 = A_1 f(K_1, L_1, T_1)$ (1)

$Q_2 = A_2 f(K_2, L_2, T_2)$ (2)

$Q^* = A^* f(K^*, L^*, T^*)$ (3)

Then:

$T^* = T_1 + T_2$ L_2 (4)

Then: $Q^* > Q_1 + Q_2$ (5)

Q stands for quantity; K stands for capital; L stands for labor; T stands for technology. Moderate scale management should be carried out and in the process of production great effort should be put into preponderant agricultural production regional distribution and base construction by government's positive guidance and farmers' willingness. The development of featured agriculture, advancement of agricultural mechanization and improvement of labor productivity will continuously reduce the production cost and gradually gain the benefit of economies of scale with the large-scale and professional production.

The agricultural industry has the obvious advantage of economies of scale. The larger and more concentrated the scale is, the lower the cost is and the higher the benefit is. The increase of marginal income is much more useful to the scientific and mechanical development which will bring about more benefits of economies of scale.

III. Questionnaire Survey

3.1. Main Content of Survey

The questionnaire is designed from two aspects, i.e. farmers' basic information and land circulation based on studying plenty of document and previous research. ① Farmers' basic information: gender, age, education degree, head of a household or not, the age and education degree of head of a household, family population, family total labor force, agricultural labor force, non-agricultural labor force,

household income, agricultural income, non-agricultural income, total acres of cultivation land, acres of private land, acres of leased land, total input of production, total revenue, rent of soil, to name just a few. ② Land circulation: source of cultivated land, reasons of horizontal expansion, patterns of leased land, preferential policy of leased land offered by government or not, convenience of leased land or not, guidance of leased land offered by government or not, knowing procedures of leased land or not, willing to combine scattered land or not, willing to increase cultivation acres or not.

3.2. Selection of Survey Places and Patterns

Jiangsu and Zhejiang province are chosen as the survey places. Firstly, they are both economically strong and big province. As the economically strong province, their conditions to develop agriculture are richly endowed by nature. As the economically big province, they are the representatives of most provinces. Moreover, they have developed economy and residents have high demand for quality of life. Jiangsu and Zhejiang province are among the most developed provinces in China, with favorable economic foundation and strong internal impetus of production transition of agricultural products.

Taking the differences of dialects into consideration, local college students who are heading to hometown are invited to help conduct this survey. To make sure the authenticity and validity of the questionnaires, direct interview is adopted. Investigators ask questions and farmers answer them and fill in the questionnaires on the spot. The number of questionnaires randomly distributed in Nantong, Fengxian and Wuxi in Jiangsu province is 320 while that of Anji in Zhejiang province is 180. Five hundred farmers related to tea, vegetables, rice and apples are selected. The number of final valid questionnaires is 473.

IV. Analysis of Farmers' Optimal Cultivation Scale based on Cobb-Douglas Function

4.1. Cobb-Douglas Production Function

The basic form of Cobb-Douglas production function is:

$$Y = f(L,K) = AL^{\alpha}K^{\beta} \qquad (6)$$

Capital fixed input includes seeds, chemical fertilizer, pesticide, rent of soil, fees of hire labor, irrigation and so on. This paper supposes that capital input is fixed and the capital input per unit of acre is about ¥ 665.1 from China Rural Statistical Yearbook data. If the land element is introduced into the production function above, the form above should be transferred into:

$$Y = AL^{\alpha}H^{\beta} \qquad (7)$$

The research data are analyzed as follows:

Labor force input (L): Generally speaking, labor force should include the number and quality of it. The study presented here will calculate the actual labor force according to the survey.

Land input (H): In this survey, acres of land from respondents only refer to the cultivated acres used for agricultural production.

Tab. 1 Data processing

Y	L	H	LnY	LnL	LnH
.50	1.00	3.30	-.69	.00	1.19
1.00	2.12	3.65	.00	.75	1.30
1.50	2.60	7.00	.41	.96	1.95
2.00	2.20	5.07	.69	.79	1.62
2.50	2.50	6.55	.92	.92	1.88
3.00	2.10	5.61	1.10	.74	1.73
3.50	3.00	5.25	1.25	1.10	1.66
4.00	1.88	5.49	1.39	.63	1.70
4.60	7.00	10.00	1.53	1.95	2.30
5.00	2.63	5.31	1.61	.97	1.67

Tab. 2 Residual analysis

LnY	LnL	LnH	$\hat{\ln Y}$	Residual e
-.69	.00	1.19	-.10834	-.58481
.00	.75	1.30	.39007	-.39007
.41	.96	1.95	1.07999	-.67452
.69	.79	1.62	.70124	-.00809
.92	.92	1.88	.99952	-.08323
1.10	.74	1.73	.76703	.33158
1.25	1.10	1.66	.90144	.35133
1.39	.63	1.70	.68931	.69699
1.53	1.95	2.30	1.93517	-.40911
1.61	.97	1.67	.83950	.76993

Taking the logarithm from two sides of (7) to get:

$$\ln Y = \ln A + \alpha \ln L + \beta \ln H$$

The result of regression analysis with SPSS Software is:

Production function:

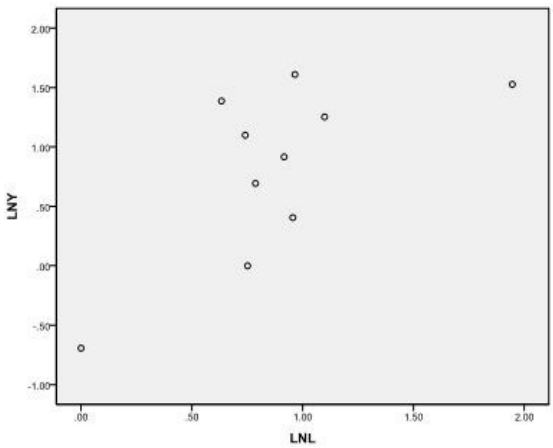
$$Y = 0.309747L^{0.543}H^{0.891} \qquad (8)$$

Tab. 3 Residual statistics

	Minimum	Maximum	Mean Value	Standard Deviation	N
Predicted Value	-.1083	1.9352	.8195	.51973	10
Residual	-.67452	.76993	.00000	.52020	10
Standard Predicted Value	-1.785	2.147	.000	1.000	10
Standard Residual	-1.144	1.305	.000	.882	10

a. Dependent Variable: LNY

Residual plots are as follows:



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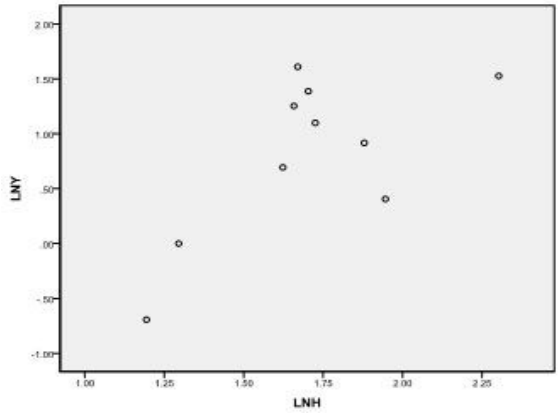

Fig. 8 Residual Plots

The residual plots show that the residual randomly fluctuate around e = 0, which basically satisfy the assumption of static model.

4.2. Marginal Rate of Substitution in Factors of Production

In economics, marginal rate of substitution in factors of production refers to one factor of production can be replaced by another one when this one reduces under the unchanging gross output circumstance. According to (8), the substitution rate of labor to land is:

$$MRS_{LH} = \frac{\alpha}{\beta} * \frac{H}{L} \qquad (9)$$

The result can be calculated $\frac{\alpha}{\beta} = \frac{0.543}{0.891} < 1$

This shows that land element in Jiangsu and Zhejiang province is hardly replaced by labor force element and land element contributes more to the quantity and benefit of agricultural production. Therefore, making sure the land cultivation scale is the main approach to ensure farmers' income and safe quality of agricultural products.

4.3. Production Returns to Scale

According to economics, the returns to scale of (8) production function is as follows:

$$f(\lambda L, \lambda H) = A(\lambda L)^{\alpha}(\lambda H)^{\beta} = \lambda^{\alpha+\beta} AL^{\alpha}H^{\beta} = \lambda^{\alpha+\beta} f(L, H) \qquad (10)$$

In economics, when $\alpha + \beta = 1$, constant returns to scale appears;

when $\alpha + \beta > 1$, increasing returns to scale appears;

when $\alpha + \beta < 1$, decreasing returns to scale appears.

Because $\alpha + \beta = 0.543 + 0.891 > 1$, the production of agricultural products in Jiangsu and Zhejiang province has the characteristics of increasing returns to scale, which illustrates that the use efficiency of labor force element and land element is comparatively low and has not reached the optimal scale. The government should put forth effort to improve the use efficiency of production factors.

4.4. Optimal Scale of Production

Suppose that the factor endowment which farmers can put into production is labor T and land R and the factor which can be put on production is agricultural labor L and land H. Then the factor put into non-agricultural production is $(T-L)$ and $(R-H)$.

The agricultural income can be expressed as:

$$P_A Q(L, H) - W_A L - t * H \qquad (11)$$

P_A stands for the market price of agricultural products. The agricultural products market is still considered as perfectly competitive one. P_A remains invariant. W_A stands for hire wages of peasant household. According to China Rural Statistical Yearbook, in Jiangsu and Zhejiang province, W_A = ¥32.78/ (acre·day); t stands for the contract fee of unit land and t = ¥17.27/ acre.

The non-agricultural income is:

$$p_1 W_1 (T-L) + p_2 P_R (R-H) \qquad (12)$$

P_1 is the ratio of transfer of rural labor, $P_1 = 45.51$; W_1 is farmers' net income who are working in non-agricultural industry, W_1 = ¥ 15417.14/household; p_2 is the transfer rate of right to use land, p_2 = 35.63%; P_R is the net income of transferring the right to use unit land, P_R = ¥86.5/acre. t- P is the transaction expenses that land transfer needs plus the expenses that land reclamation needs.

The gross profit of farmers is the combination of (11) and (12):

$$\pi = P_A Q(L, H) - W_A L - t*H + p_1 W_1 (T-L) + p_2 P_R (R-H) \qquad (13)$$

To make π optimal, $\frac{\partial \pi}{\partial L} = 0, \frac{\partial \pi}{\partial H} = 0$ should be the premise.

Then:

$$\begin{cases} \frac{\alpha P_A Q}{L} - W_A - p_1 W_1 = 0 \\ \frac{\beta P_A Q}{H} - t - p_2 P_R = 0 \end{cases} \qquad (14)$$

The extremum L = 1.15, H = 60.688

The average cultivation scale of agricultural products in survey places: $\overline{H} = 4.52$ acre

The optimal land circulation scale: $\Delta H = H^* - \overline{H}$ = 60.688 - 4.52 = 56.168 acre.

V. Conclusion and Policy Suggestions

5.1. Conclusion

Through the calculation of Cobb-Douglas production function in Jiangsu and Zhejiang province, their optimal land circulation scale is much larger than the current average cultivation scale. The production of agricultural products has the characteristics of increasing returns to scale. The use efficiency of labor force element and land element is comparatively low and the allocative efficiency has not reached the Pareto Optimality. The optimal allocation of resources needs to be achieved by land circulation. Therefore, land circulation should be encouraged and supported to make full use of land resources. Some places in Jiangsu and Zhejiang province are carrying out fertile farmland of a large area which enlarges the scale of land circulation. When the benefit caused by land circulation equals the circulation cost, the land will gradually achieve the optimal production scale.

5.2. Policy Suggestions

The government should establish laws and regularities. There must be laws to go by and the laws must be observed

and strictly enforced in the process of land circulation. The construction of farmland, road transport and water conservancy should be strengthened and the ability to provide auxiliary items for electrified and mechanized equipment should be improved. The publicity and guidance to farmers should be enhanced and their enthusiasm to be involved in land circulation should be motivated.

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