Analysis on Technical Efficiency and Influencing Factors of Rapeseed Production

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Abstract Based on micro survey data of 344 rapeseed farmers in 19 rapeseed counties of Hubei Province, with the aid of stochastic frontier production function model and efficiency loss model, this paper analyzed basic production situations, demographic characteristics of rapeseed farmers, technical efficiency loss, and main influencing factors. In Hubei Province, there are mainly following problems in rapeseed production: serious aging of rapeseed farmers; relatively scarce labors; the middle-aged and old farmers have higher technical efficiency level; with increase in farmer age, their technical efficiency firstly declines and then rises. In view of these situations, it came up with recommendations including raising educational level of rapeseed farmers to realize large scale economy and effectively reduce technical efficiency loss, and local government, specialized associations and agricultural machinery extension departments should provide proper technical guidance according to demands of farmers to reduce technical efficiency loss.

Key words Rapeseed, Technical efficiency, Stochastic frontier production function, Efficiency loss model

1 Introduction

China is a large rapeseed producer. Since the reform and opening-up, China's rapeseed production has been making constant progress. Both the planting area and total yield rank first in the world, and rapeseed is widely planted in most provinces of China. Besides, rapeseed oil is a common vegetable oil in China and rapeseed oil takes up a larger portion in rapeseed supply. These bring huge demand for rapeseeds. Although domestic rapeseed production basically can satisfy raw material supply, China still imports large volume of rapeseed. In 2007, the import volume reached 30 million tons, which influences healthy development of domestic rapeseed industry. Besides, in recent years, due to small comparative benefit of rapeseed production, numerous rural young and middle-aged labors give up family agricultural production activities and go to cities to look for jobs, leading to rural labor age structure constantly becoming aging. In addition, rapeseed planting has low profit, agricultural land generally declines, rapeseed import compels domestic rapeseed purchasing price to decline, accordingly dampening farmers' planting enthusiasm. Rapeseed farmers usually give up rapeseed and plant crops with higher income. These lead to constant shrinkage of rapeseed production and the prospect is not optimistic.

In China's rapeseed industry, Hubei Province plays an extremely important role in rapeseed production, consumption and trade. Its rapeseed planting area has been ranking in the first place from 1996 to 2014. Besides, in total yield and high quality rate, Hubei Province ranks first, so it is of great significance and reference value to study rapeseed production of farmers in Hubei Province. In foreign countries, there are extensive researches about agricultural productivity, technical efficiency and rapeseed production. In researches of agricultural productivity, existing literature mainly adopts DEA method and stochastic frontier production function model. In the application of DEA method, Meng Lingjie[10] analyzed technical efficiency of agricultural production in 15 years. Li Ran[8] studied changes in rapeseed productivity in different regions of China by similar method. Li Gucheng made an empirical analysis of total factor productivity using DEA-Malmquist productivity index[7]. A lot of scholars studied productivity by DEA method, such as Guo Junhua, Lu Wenguang and Tian Tao[20].

In the application of stochastic frontier production function model, Tian Wei *et al.*[17] mainly studied technical progress rate of main cotton production regions; Jin Fuliang *et al.*[6] made an empirical analysis on winter rapeseed production technical efficiency of 1707 different scale of farmers, and stated that it is able to effectively promote technical efficiency of farmers through large-scale land operation, optimizing resource allocation, and speeding up mechanized farming; Sun Hao[14] analyzed overall conditions and change characteristics of per unit area technical efficiency in main wheat production regions, and made comparison between regions.

In sum, most existing researches focus on overall agricultural productivity[11, 21] and regional productivity disparity[4, 6, 19]; at micro level, researches about family production efficiency focus on existing production scale[9, 12], cultivated land issue[15, 22], and resources and environment[13, 16]. However, there are few researches about production situations and technical efficiency from the perspective of demographic characteristics of rapeseed farmers. Therefore, with reference to the above researches, from the perspective of demographic characteristics, we analyzed rapeseed production, technology choice and technical efficiency of rapeseed farmers in Hubei Province.

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2 Data source and demographic characteristics of farmers

Data in this study were collected from 19 main rapeseed production counties in Yichang, Xiangyang, Huanggang, and Jingzhou of Hubei Province. By one-to-one field interview, we surveyed production area, production cost, sales conditions, planting psychology, and economic benefits of 344 rapeseed farmers. In these farmers, the average age is 53.6 years old with standard deviation of 8.14; 296 farmers are older than 45, accounting for 86.05% of total samples, showing the general problem of labor aging. 256 farmers have educational level at or below junior middle school, accounting for 74.42% of total samples, showing relatively low educational level. The farmland area per family is 9.42 mu, rapeseed planting area is 4.04 mu, accounting for 42.9% of total farmland area. In employment, numerous young and middle-aged rural labors go to cities, while old labors remain in rural areas. Agricultural income, migrant work, breeding, and agricultural subsidy income become major source of farmers' family income. Among all 344 farmers, 79 farmers are pure farmers with concurrent income proportion less than 10% and account for 22.97% of total samples; 113 farmers mainly undertake agricultural production with concurrent income proportion in the range of 10% – 50%, accounting for 32.85% of total samples; 151 farmers mainly undertake non-agricultural production with concurrent income proportion higher than 50%, accounting for 43.90% of total samples; only one farmer is pure non-farmer.

3 Statistical analysis of rapeseed planting

In the questionnaire, 213 farmer families have more than a half of "the number of family labors" being "migrant workers", accounting for 61.92% of total samples, indicating that more than a half farmer families have insufficient agricultural labor, most young and middle-aged labors prefer to do migrant work. In the surveyed area, agricultural labors for rapeseed production are in short. Considering the influencing of aging, labor demand in busy farming season is more intense. The multiple choice question "reasons for your increasing or reducing rapeseed planting area in the next year" can reflect planting intention and technical choice tendency of farmers. A total of 295 farmers answered this question. The results are listed in Table 1, from which it can be seen that high cost of means of production is the main reason for farmers changing their rapeseed planting area, the next reason is high labor input, and finally is labor scarcity. In addition, rise of rapeseed price, fine seed policy, seasonal conflict, and low planting benefits also influence farmers' planting area.

315 farmers answered the question "Is there specialized rapeseed association nearby?", about 224 farmers joined the specialized rapeseed association. In these 224 farmers, 191 farmers are equal to or older than 45, accounting for 70.22% of the age group; 33 farmers are younger than 33, accounting for 76.74% of the age group, showing that most farmers join specialized rapeseed associations to seek specialized assistance. The proportion of old farmers joining specialized rapeseed associations is lower than that of young and middle-aged groups.

Table 1 Reasons for farmers increasing or reducing rapeseed planting area

Reasons	Frequency	Percentage //%
Fine seed policy	102	14.17
Rise of rapeseed price	108	15.00
Cost of means of production	161	22.36
High labor input	154	21.39
Labor scarcity	126	17.50
Seasonal conflict	49	6.81
Low planting benefit	20	2.78

4 Model building and description

In this study, we mainly applied stochastic frontier production function to analyze the productivity. This method was firstly applied in cross-sectional data, and then widely applied in stochastic frontier production analysis of panel data in various fields. Besides, based on the stochastic frontier model proposed by Battese *et al.* [2], we adopted trans-log production function with flexible form. Both input and output adopt logarithmic form. Also, we introduced quadratic term, which effectively avoids the assumption of neutral technology and fixed output. Then, we studied interaction of input factors and their influence on explained variables, and the difference in technological progress of technical factors, and improved estimation accuracy of progress rate of technical efficiency growth[17]. Production function applied in this study is as follows:

$$\ln Y_i = b_0 + b_1 \ln Ld_1 + b_2 \ln Lr_i + b_3 \text{Ln } F + b_4 \ln P_i + b_3 \ln S_i + b_6 \ln M_i + b_7(\ln Ld_i)^2 + b_8(\ln Lr_i)^2 + b_9(\ln F_i)^2 + b_{10}(\ln P_i)^2 + b_{11}(\ln S_i)^2 + b_{12}(\ln M_i)^2 + b_{13}(\ln Ld_i)^2)(\ln Lr_i) + b_{14}(\ln F_i) + b_{15}(\ln Ld_i)(\ln P_i) + b_{16}(\ln Ld_i)(\ln S_i) + b_{17}(\ln Ld_i)(\ln M_i) + b_{18}(\ln Lr_i)(\ln \mathrm{F}_\mathrm{i}) + \mathrm{b}_{19}(ln\mathrm{Lr}_\mathrm{i})(ln\mathrm{P}_\mathrm{i}) + \mathrm{b}_{20}(ln\ \mathrm{Lr}_\mathrm{i})(ln\mathrm{S}_\mathrm{i}) + \mathrm{b}_{21}(ln\mathrm{Lr}_\mathrm{i})(ln\mathrm{M}_\mathrm{i}) + \mathrm{b}_{22}(ln\mathrm{F}_\mathrm{i})(ln\mathrm{P}_\mathrm{i}) + \mathrm{b}_{23}(ln\mathrm{F}_\mathrm{i})(ln\mathrm{S}_\mathrm{i}) + \mathrm{b}_{24}(lnF_i)(\ln M_i) + b_{25}(\ln P_i)(\ln S_i) + b_{26}(\ln P_i)(\ln M_i) + b_{27}(\ln S_i)(\ln M_i) + (V_i - U_i) \quad (1)$$

In this study, we adopted micro cross-sectional data of farmers in Hubei Province of the year 2013, and made $T = 1$ when setting stochastic frontier and in-efficiency model. Although existing literature mainly adopts time series data, since our study object is traditional rapeseed production area, agricultural technology is relatively stable, cross-sectional data can well reflect technical features[5].

Table 2 lists names of selected variables and description statistics: Y_i denotes total rapeseed yield of family i, expressed in jin/family; L_{di} denotes rapeseed planting area of family i, expressed in mu/family; L_{ri} denotes labor input of family i, expressed in people/family; F_i denotes chemical application of family i, expressed in yuan/family; P_i denotes pesticide input of family i, expressed in yuan/family; Si denotes seed input of family i, expressed in yuan/family; M_i denotes mechanical operation cost of family i, expressed in yuan/family; b_k denotes parameter to be estimated ($k = 0, 1, 2\cdots14$); $V_{it} - U_{it}$ denotes compound disturbance term and V_{it} is stochastic error term, representing stochastic factor and error influencing final output, submitting to normal distribution of zero mean value and variance of σ_v^2. Uit is non-negative stochastic variable submitting to half-normal distribution, represents technical efficiency loss, and mainly used to reflect inefficiency degree of production, the mean value is μ, and variance is σ_u^2. For data with input variable being zero, assign it to 1 when entering the trans-log production function model, after logarithmic operation, $ln1 = 0$, so it does not change significance of original data.

Table 2 Descriptive statistics of input and output variables of farmers' rapeseed production

Name of variable	Mean value	Standard deviation	Min.	Max.
Total rapeseed yield (Y_i) // jin/family	1362.62	1629.83	0	10000
Rapeseed planting area (Ld_i) // mu/family	4.04	4.71	0	30
Labor input (Lr_i) // people / family	1.51	0.76	0	4
Chemical fertilizer (F) // yuan/family	452.62	554.00	0	3800
Pesticide (P) // yuan/family	83.08	106.14	0	780
Seed (S) // yuan/family	77.51	116.79	0	800
Mechanical operation cost (M) // yuan/family	248.47	375.26	0	1980

Actual operation formula of technical efficiency follows the event in-efficiency[1] model:

$$TE = \frac{E[\hat{Y}it \mid U_{it}, X_{it}]}{E[\hat{Y}it \mid U_{it} = 0, X_{it}]} \quad (2)$$

where E(·) is mathematical expectation. If $U_{it} = 0$, *i.e.* $TE_{it} = 1$, denoting family i has technical efficiency complete free of loss; if $U_{it} > 0$, $0 < TE_{it} < 1$, the farmer has certain degree of efficiency loss in production.

The efficiency loss model is set to be:

$$m_i = \delta_0 + \sum_{h=1}^{13} \delta_h Z_{hi} \quad (3)$$

In model (3), Z_{hi} is influencing factor possibly leading to difference in technical efficiency between farmers. On the basis of researches of Battese[3] and Schultz (1987), combined with purpose of this study, we divided factors influencing farmers' technical efficiency into three types: demographic characteristics of farmers, agricultural operating characteristics of farmers, and farmers' acquisition of new knowledge and skills, including a total of 13 variables. Statistical analysis is listed in Table 3.

Table 3 Definition and descriptive statistics of the efficiency loss model

Name of variable	Definition of variable	Prospective direction	Mean value	Standard deviation	Max.	Min.
Demographic characteristics of farmers						
Age (Z_1)		Impossible to judge	53.60	8.14	81	34
Square of age (Z_2)	$Z_2 = Z_1^2$	Impossible to judge	2943.51	877.82	6561	1156
Educational level (Z_3)	0 = Illiterate; 1 = Primary school; 2 = Junior middle school; 3 = Senior middle school or secondary school; 4 = College and above	–	1.97	0.75	4	0
Agricultural operating characteristics of farmers						
Rapeseed planting area (Z_4)		–	4.04	4.71	30	0
Land circulation (Z_5)	Yes = 1, No = 1	–	0.24	0.42	1	0
Concurrent business of family (Z_6)	Yes = 1, No = 0	–	0.77	0.42	1	0
Farmers' acquisition of new knowledge and skills						
Relatives and friends (Z_7)	Yes = 1, No = 0	Impossible to judge	0.21	0.41	1	0
Grass-roots information service station (Z_8)	Yes = 1, No = 0	–	0.23	0.42	1	0
Specialized association (Z_9)	Yes = 1, No = 0	–	0.12	0.32	1	0
Means of agricultural production operating department (Z_{10})	Yes = 1, No = 0	–	0.54	0.50	1	0
Local government (Z_{11})	Yes = 1, No = 0	–	0.25	0.43	1	0
Village cadres (Z_{12})	Yes = 1, No = 0	Impossible to judge	0.33	0.47	1	0
Agricultural machinery extension department (Z_{13})	Yes = 1, No = 0	–	0.76	0.43	1	0

5 Results of empirical analysis and explanation

5.1 Results of parameter estimation We mainly adopted frontier4.1 software to estimate the above models. If $\gamma = 0$ is accepted, it can be deemed there is no efficiency loss. If γ statistic is significant, it means there is technical efficiency loss. Results of parameter estimation are listed in Table 4.

Table 4 Parameter estimation results of stochastic frontier production function model

Item	Coefficient	Estimated value	t statistic
Constant term	b_0	0.259***	4.415
ln*Ld*	b_1	0.479*	1.322
ln*Lr*	b_2	6.380***	13.76
ln*F*	b_3	0.623***	3.456
ln*P*	b_4	0.773***	2.992
ln*S*	b_5	-1.184***	-7.741
ln*M*	b_6	1.239***	19.500
(ln*Ld*)2	b_7	0.131*	1.555
(ln*Lr*)2	b_8	0.324*	1.604
(ln*F*)2	b_9	0.036*	1.795
(ln*P*)2	b_{10}	0.039	0.504
(ln*S*)2	b_{11}	0.054***	4.067
(ln*M*)2	b_{12}	0.046***	4.123
(ln*Ld*)(ln*Lr*)	b_{13}	1.493***	10.530
(ln*Ld*)(ln*F*)	b_{14}	-0.195**	-2.295
(ln*Ld*)(ln*P*)	b_{15}	0.023	0.200
(ln*Ld*)(ln*S*)	b_{16}	-0.324***	-6.573
(ln*Ld*)(ln*M*)	b_{17}	0.328***	12.800
(ln*Lr*)(ln*F*)	b_{18}	-0.787***	-8.098
(ln*Lr*)(ln*P*)	b_{19}	-0.905***	-7.541
(ln*Lr*)(ln*S*)	b_{20}	-0.082*	-1.860
(ln*Lr*)(ln*M*)	b_{21}	0.048*	1.506
(ln*F*)(ln*P*)	b_{22}	-0.050	-0.985
(ln*F*)(ln*S*)	b_{23}	0.170***	6.643
(ln*F*)(ln*M*)	b_{24}	-0.202***	-13.420
(ln*Pi*)(ln*Si*)	b_{25}	0.104***	2.961
(ln*Pi*)(ln*Mi*)	b_{26}	-0.158***	-6.804
(ln*Si*)(ln*Mi*)	b_{27}	-0.028***	-4.217
σ^2		1.062***	8.155
γ		0.961***	103.900
Sample size			344.000

Note: degree of freedom approximate value 120, ***, ** and * denote significance level at 1%, 5% and 10% level respectively.

Table 4 indicates that γ value is 0.961 and significant at 1%, showing technical in-efficiency is main source of variation in compound disturbance term, accounting for 96.1%; rapeseed production has technical in-efficiency, and 96.1% of total disturbance can be explained, and only 3.9% comes from external influence such as statistical error. According to results of parameter estimation, firstly, labor, chemical fertilizer, pesticide, seed, mechanical operating cost in rapeseed production are significantly correlated with total yield of family at 1% statistical level. Secondly, labor and mechanical operating cost have significant complementary relationship with land, indicating that expansion of planting area is inseparable from effective support of labor and mechanical input, while reduction of labor results in shortage of labor for maintaining original planting area. Chemical fertilizer and seeds have significant replaceable relationship with land, indicating that farmers can save land through applying new high-yield chemical fertilizer and new crops that have high reaction to chemical fertilizer. Thirdly, chemical fertilizer, pesticide, and seeds have significant replaceable relationship with labor, indicating that fine seed and scientific, high efficient and reasonable application of chemical fertilizer can effectively reduce labor input. Fourthly, there is complementary relation between chemical fertilizer and seed, but significant replaceable relation with mechanical operating cost, indicating that high yield and new crops can save land and reduce input of mechanical operating cost. Fifthly, there exists significant complementary relation between pesticide and seed, while there is significant replaceable relation between pesticide, seeds and mechanical operating cost, indicating that combination of high efficient pesticide and fine seed can increase rapeseed output, and effectively save mechanical input cost.

Facing labor shortage in busy farming season, major solutions for farmers include applying high yield fine seed, increasing chemical fertilizer and scientific utilization rate, and high efficient and reasonable application of chemical fertilizers. Besides, combination of mechanical operation can alleviate labor shortage and realize conserved use of resources to a certain extent.

Derive logarithm of input factors in two sides of model (1), we can obtain elastic calculation formula of input factors:

$$\varepsilon_{Ld} = b_1 + 2b_7 \ln Ld_i + b_{13}\ln Lr_i + b_{14}\ln F_i + b_{15}\ln P_i + b_{16}\ln S_i + b_{17}\ln M_i \quad (4)$$

$$\varepsilon_{Lr} = b_2 + 2b_8 \ln Lr_i + b_{13}\ln Ld_i + b_{18}\ln F_i + b_{19}\ln P_i + b_{20}\ln S_i + b_{21}\ln M_i \quad (5)$$

$$\varepsilon_F = b_3 + 2b_9 \ln Fi + b_{14}\ln Ld_i + b_{18}\ln Lr_i + b_{22}\ln P_i + b_{23}\ln S_i + b_{24}\ln M_i \quad (6)$$

$$\varepsilon_P = b_4 + 2b_{10} \ln P_i + b_{15}\ln Ld_i + b_{19}\ln Lr_i + b_{22}\ln F_i + b_{25}\ln S_i + b_{26}\ln M_i \quad (7)$$

$$\varepsilon_S = b_5 + 2b_{11} \ln S_i + b_{16}\ln Ld_i + b_{19}\ln Lr_i + b_{23}\ln F_i + b_{25}\ln P_i + b_{27}\ln \mathrm{M}_i \quad (8)$$

$$\varepsilon_M = b_6 + 2b_{12} \ln M_i + b_{17}\ln Ld_i + b_{21}\ln Lr_i + b_{24}\ln F_i + b_{26}\ln P_i + b_{27}\ln / S_i \quad (9)$$

Take average value of logarithms of input factors for rapeseed planting farmers, substitute estimated results of Table 4 and mean value into elastic calculation formula, we obtain average output elasticity of input factors, as shown in Table 5.

Table 5 Average output elasticity of input factors of rapeseed planting farmers

Input factors	Average output elasticity
Rapeseed planting area (*Ld*)	0.612
Labor input (*Lr*)	0.797
Chemical fertilizer (*F*)	0.105
Pesticide (*P*)	0.285
Seed (*S*)	-0.076
Mechanical operating cost (*M*)	0.204

In the average elasticity of input factors, only the elasticity of seeds is negative, indicating that seed use is relatively surplus in rapeseed planting. Increase in seed input will not bring effective increase of output. Thus, it is recommended to use fine seeds to increase yield. The average elasticity of rapeseed planting area, labor input, chemical fertilizer, pesticide and mechanical operating cost is positive, indicating input of these production factors is relatively low. Therefore, increasing input of such production factors can increase rapeseed yield. The average output elasticity of rapeseed planting area and labor input is high, indicating planting area and labor still play an important role in agricultural development, and increasing planting area and labor input can significantly increase rapeseed yield. In comparison, the average output elasticity of pesticide and mechanical operating cost is small, reflecting the input of these three factors have reached certain level, increasing their input can increase output, but the effect of yield increase is not significant, effective yield increase needs reasonable and scientific choice of all input factors.

5.2 Comparison analysis on technical efficiency of farmers in different age groups Average technical efficiency level of sample farmers is 0.7879 with standard deviation of 0.1368. 48 farmers have technical efficiency level higher than 0.9, accounting for 13.95% of total samples. 229 farmers have technical efficiency in the range of 0.7 – 0.9, accounting for 66.57% of total samples, and the rest farmers have technical efficiency lower than 0.7, indicating that most farmers have low technical efficiency of rapeseed production and the efficiency is to be improved.

The age of farmers is in 34 to 81 years old. To study technical efficiency characteristics of different age groups, we divided their age into four groups: [34,45), [45,55), [55,65), and [65,81], respectively representing young, middle age, old age, and venerable age labors. Technical efficiency distribution, average value and standard deviation of four groups are shown in Fig. 1 and Table 6. It can be seen that the distribution density of [45, 55) and [55,65) age groups is the highest, the fluctuation of technical efficiency of [65,81] age group is the lowest, while the fluctuation of technical efficiency of [55,65) age group is the highest and the average technical efficiency level is the lowest, while the average technical efficiency of age group [45,55) is the highest. These indicate that middle and old aged farmers have highest average technical efficiency level, technical efficiency level of farmers older than 65 is stable, while technical efficiency and fluctuation of young and middle aged farmers remain at the intermediate level.

Table 6 Technical efficiency average value and standard deviation of farmers in different age groups

Age group	Average value	Standard deviation
[34,45)	0.785	0.134
[45,55)	0.798	0.126
[55,65)	0.779	0.155
[65,81]	0.788	0.090

5.3 Analysis of estimation results of efficiency loss model

5.3.1 Influence of demographic characteristics of farmers on technical efficiency. Table 7 indicates that age coefficient of agricultural labor (Z_1) is –0.087, smaller than 0 and passes significance test at 1% level, the square coefficient (Z_2) is 0.001, higher than 0 and passes significance test at 5% level, sign of Z_1 and Z_2 is opposite, indicating that labor age has significant influence on technical in-efficiency, the curve takes on U shape. With the increase of farmers' age, their technical efficiency firstly declines then rises, possible because increase of age will bring rich experience to farmers, they will reduce efficiency loss, while they reach certain age, the aging problem will make their physical power and intelligence level decline and consequently increase the efficiency loss. Educational level of farmers exerts significant negative influence on technical efficiency loss, indicating that it is possible to reduce technical efficiency loss through raising educational level of farmers. Farmers with high educational level will be more sensitive to new technology, new equipment and agricultural input, and can better grasp the situation and conform to expected situations.

Table 7 Estimation results of efficiency loss model

Name of variable	Coefficient	t statistic
Demographic characteristics of farmers		
Age (Z_1)	–0.087***	–2.702
Square of age (Z_2)	0.001**	2.158
Educational level (Z_3)	–0.459***	–2.552
Agricultural operating characteristics of farmers		
Rapeseed planting area (Z_4)	–0.222***	–5.231
Land circulation (Z_5)	0.524	1.208
Concurrent business of family (Z_6)	–0.096	–0.210
Farmers' acquisition of new knowledge and skills		
Relatives and friends (Z_7)	0.119	0.309
Grass-roots information service station (Z_8)	0.170	0.349
Specialized association (Z_9)	–0.724*	–1.348
Means of agricultural production operating department (Z_{10})	1.686	0.349
Local government (Z_{11})	0.836***	2.563
Village cadres (Z_{12})	0.382	0.953
Agricultural machinery extension department (Z_{13})	–0.604**	–1.737

5.3.2 Influence of agricultural characteristics of farmers on technical efficiency. The rapeseed planting area of farmers has signifi-

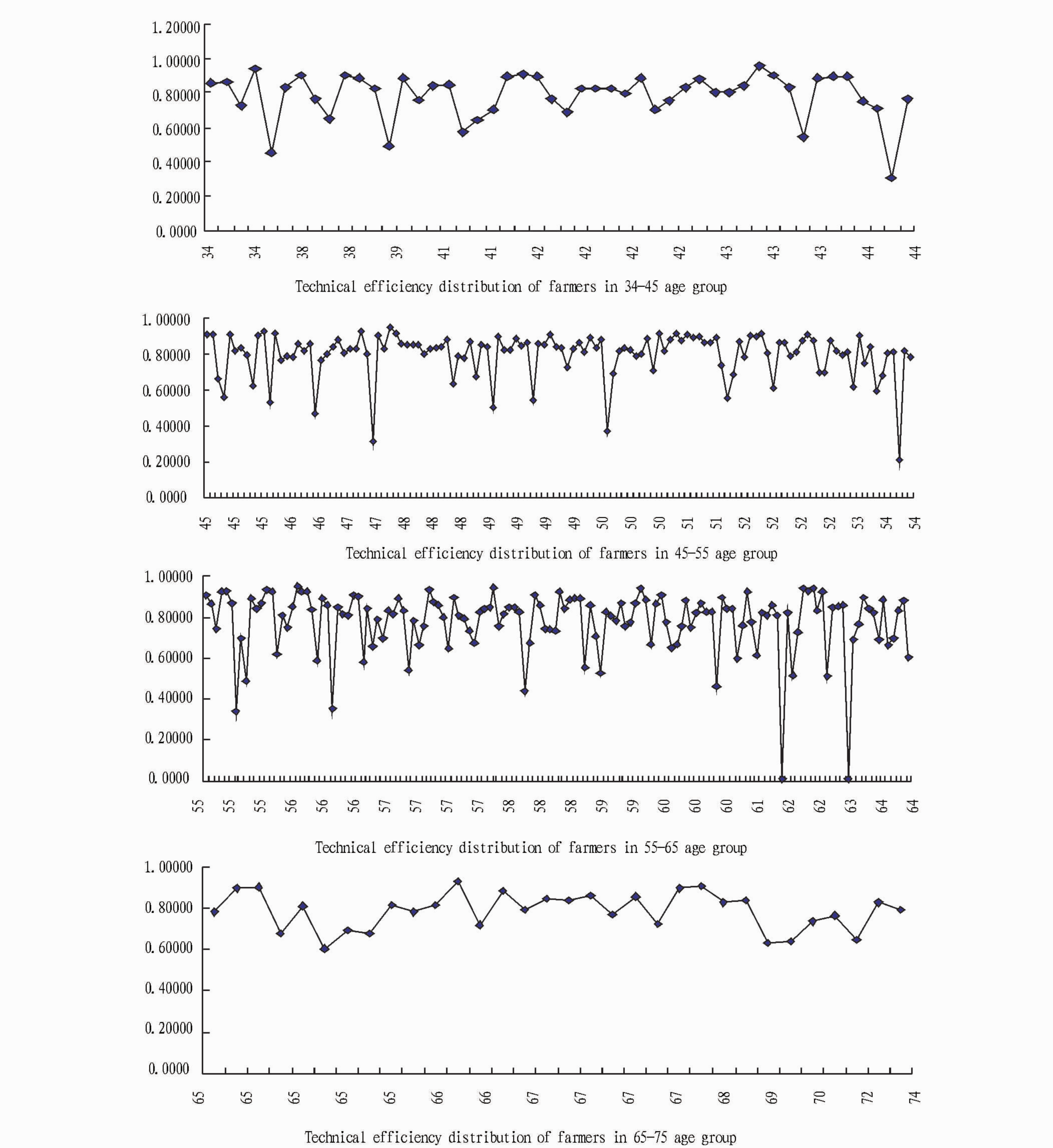

Fig. 1 Technical efficiency distribution of farmers in different age groups

cant negative influence on technical efficiency loss and is statistically significant at 1% level, consistent with the expectation. Expanding the planting area can effectively reduce the efficiency loss and manifest function of large scale economy.

5.3.3 Influence of acquisition of new knowledge and skills on technical efficiency. Local government has significantly positive influence on technical efficiency loss, the direction is opposite to expectation, possibly because technology provided by government may not suit local conditions well. Specialized association and agricultural machinery extension department have significant negative influence on technical efficiency loss, which is consistent with the expectation. Specialized association and agricultural machinery extension department are situated in grass-roots area, are grass-roots department closest to farmer production, so they can provide effective technical support and guidance, help farmers to reduce loss of technical efficiency.

6 Conclusions

(i) Sample rapeseed farmers in Hubei Province have serious aging problem. Labor is relatively insufficient in busy farming season. High cost of production means and labor input and shortage of labor are major reasons influencing farmers reducing rapeseed planting area. Therefore, effective production cost control and preferential policy to attract labor return can effectively realize increase in rapeseed yield. (ii) The average efficiency level of rapeseed planting of sample farmers in Hubei Province is 78.79% with standard deviation of 0.1368. This indicates that if other factors are not changed, maintaining existing production conditions and productivity and eliminating disturbance of efficiency loss, it is possible to raise the technical efficiency of farmers' rapeseed production by 21.21%. (iii) In the process of rapeseed planting, seed input is relatively saturated, increasing input will not bring increase of technical efficiency. Therefore, it is recommended to adopt high yield high quality fine seed, scientifically apply chemical fertilizers and pesticide, conduct mechanical farming to alleviate the problem of labor shortage, to realize conserved use of resources. (iv) Middle aged and old farmers have richer production efficiency than young farmers, while acceptance ability of new technology and formula of young farmers is high, so they have the highest average technical efficiency. Farmers older than 65 are stable in technical efficiency, while young and middle aged farmers lack efficiency and their stability degree is to be improved, so their technical efficiency and fluctuation remain in the intermediate level. (v) Labor age makes the technical efficiency take on U shape. In other words, efficiency loss firstly declines and then increases. Increase of educational level and realization of scale economy can effectively reduce the purpose of technical efficiency loss. Therefore, local government, specialized associations and agricultural machinery extension department should provide technical guidance consistent with demands of farmers, to reduce loss of technical efficiency.

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