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Analysis on Efficiency and Influencing Factors of New Soybean Producing Farms

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Abstract: The efficiency of new soybean producers is of great importance to the agricultural development of China. Based on the survey data of some counties (cities) in Heilongjiang, Jilin, Liaoning, and Inner Mongolia Autonomous Region, the efficiency of new soybean producers in these regions is calculated by means of the data envelopment analysis (DEA) model. Then, the Tobit model is used to select relevant explanatory variables to study the factors affecting the production efficiency, and relevant conclusions and suggestions are put forward. The results show that (1) in 2017, the new soybean producers' average technical efficiency of soybean production in the research samples was 0.618, of which the average pure technical efficiency was 0.680 and the average scale efficiency was 0.872; (2) factors such as the degree of education, the soybean planting area, the degree of mechanization, and the soybean sales channel have positive impacts on the efficiency of new soybean producers, while the ones such as the stability of the soybean price, the difficulty in obtaining soybean market information, and the implementation of the soybean subsidy policy have negative impacts.

Keywords: new agricultural producer; soybean production efficiency; data envelopment analysis (DEA); Tobit model

1. Introduction

Soybean is one of the main grain sources in China, and its production is very important to global economic development [1,2]. The improvement of soybean production efficiency is conducive to ensuring the efficient development of China's agriculture. However, in recent years, with the rapid development of agricultural production technology, the efficiency of international soybean production has been continuously improved, while the frequent occurrence of agricultural disasters in China, the instability of soybean price [3], and the imperfect insurance system of soybean production have led to the low production efficiency of soybean in China. At the same time, new agricultural producers, including family farms, big growers, farmers' cooperatives and so on, have grown rapidly in recent years, which occupy an important position in the soybean producers as the main carrier of China's agricultural modernization development. Therefore, it is of great significance to calculate the soybean production efficiency of the new agricultural producers and study the influencing factors of soybean production efficiency.

At present, the academic research on related fields mainly includes the following three aspects. The first one is the studies on new agricultural producers. Kostov et al. [4] explored the efficiency difference between family farms and agricultural enterprises, and believed that the intervention of family factors make the production efficiency of family farms higher than that of agricultural enterprises. Yang et al. [5] explored the efficiency of family farms in China. It is believed that there is a weak positive correlation between the production efficiency of family farms and environmental performance, and the scale expansion of family farms can improve the production efficiency and environmental performance of family farms. Yan et al. [6] explored the relationship between family farm production scale and farm production efficiency in China, and believed that producing moderate land scale, encouraging land leasing, and strengthening land consolidation can promote the production efficiency of family farms. Skevas and Grashuis [7] calculated the technical efficiency of grain marketing cooperatives in the Midwest of the United States, and hold that spatial spillover effects affect the technical efficiency of cooperatives. Tufa et al. [8] found that soybean yields and net crop incomes for adopters are significantly higher than those of non-adopters over the entire probability distribution of ISVAPs adoption in Malawi. Gong et al. [9] proposed that cooperative membership may encourage farmers to learn more advanced technology and take advantage of productivity-enhancing practices. Lu [10] proposed that the government should guide farmers to realize joint land operation and transfer of farmland management rights on a voluntary basis. Rodriguez and Gonzalez [11] found that Cuban agriculture needs to be transformed through the implementation of an agroecological base, the importance of family farming, as well as aspects that can come into play in the socio-ecological resilience of other family farms in the country.

The second one is the studies on the efficiency of soybean production. Rade et al. [12] have explored the influencing factors of Serbia organic soybean and common soybean to determine the technical efficiency, cost efficiency, and driving factors of soybean. Dong et al. [13] have studied the production efficiency and influencing factors of the soybean production system in the Midwest of the United States. It is considered that soybean producers should be vigorously recommended to accept the concept of sustainable agriculture. Jiang and Li [14] have explored the soybean production efficiency and its influencing factors of 15 modern agricultural machinery cooperatives in Heilongjiang Province. It is considered that strengthening the education of agricultural technology and moderating production scale can improve the pure technical efficiency and scale efficiency of soybean production. Mousavi-Avval [15] researched the energy consumption in soybean production in Iran. It is considered that the input of electricity, chemical fertilizer, and diesel oil can be reduced on the premise of unchanged soybean output.

The third one is the application of the related efficiency calculation models. Yang et al. [5] used the DEA model and improved the cross efficiency model to study the production efficiency and environmental performance evaluation of family farms in China. Zhang et al. [16] adopted a two-stage DEA model to analyze the technical efficiency of industrial pollution control in China. Ebo et al. [17] calculated the technical efficiency of sample fishing ground by means of the stochastic frontier analysis model (SFA) with flexible risk based on the production function of a transcendental logarithm. Ali et al. [18] used DEA–Tobit analysis method to measure the production efficiency of non-seasonal pepper and sweet pepper in the Punjab province of Pakistan and explored many factors affecting the production efficiency.

In summary, scholars in this field have conducted research on the new agricultural producers and soybean production efficiency, which can be used as references for this paper. The following two problems need to be paid attention to in the study. One is that the macro data are used more in the previous research, and the research scope of the studies using micro data is small, which makes it difficult to accurately obtain the technical efficiency of soybean production in a certain region. The other one is that northeast China, as the main production area of soybean in China, not only has advantages of excellent land resources and planting climate conditions but also has a large area of soybean production land. It is of great significance to study the soybean production efficiency and influencing factors of the new agricultural producers in northeast China. Therefore, based on the field investigation in 2017 of Heilongjiang Province, Jilin Province, Liaoning Province, and some counties (cities) in Inner Mongolia Autonomous Region, the DEA–Tobit model was used to measure the soybean production efficiency of new agricultural producers in northeast China, to explore the influencing factors of soybean production efficiency, and to draw the corresponding conclusions, so as to enrich the research results in related fields.

2. Data Sources and Research Method

2.1. Data Sources

The data are from the fieldwork in Heilongjiang Province, Jilin Province, Liaoning Province, and Inner Mongolia Autonomous Region from July 2018 to June 2019. The survey methods mainly included questionnaire surveys, face-to-face interviews, telephone interviews, and field observations. The reason for choosing these regions is that they are the main soybean producing regions in China. As shown in Table 1, from 2016 to 2018, the soybean planting area and yield in these four regions basically exceeded half of that of the country, with 60% in 2017. These survey regions were selected according to the soybean production level of each region, and the selection results are shown in Table 2.

Table 1. Soybean planting areas and yields in China.

	2016		2017		2018	
	Planting Areas (1000 ha.)	**Yields (10,000 t.)**	**Planting Areas (1000 ha.)**	**Yields (10,000 t.)**	**Planting Areas (1000 ha.)**	**Yields (10,000 t.)**
China	7599.0	1360.0	8245.0	1528.0	8413.0	1597.0
Heilongjiang Province	2883.9	503.6	3735.5	689.4	3567.7	657.8
Jilin Province	200.1	39.9	220.2	50.2	279.2	55.1
Liaoning Province	132.4	28.2	74.3	19.3	73.5	18.0
Inner Mongolia Autonomous Region	615.5	100.5	989.0	162.6	1094.2	179.4
Proportion of four regions in the whole country (%)	50.4	49.4	60.9	60.3	59.6	57.0

Note: The data come from China Rural Statistical Yearbook (2017–2019).

Table 2. Distribution of survey regions.

Province-Level Regions	Prefecture-Level Regions	County-Level Regions
Heilongjiang Province	Heihe City	Nenjiang City Beian City
	Qiqihar City	Keshan County Kedong County
	Suihua City	Qing'an County
Jilin Province	Jilin City	Yongji County Jiaohe City
	Yanbian Korean Autonomous Prefecture	Dunhua City
Liaoning Province	Dalian City	Zhuanghe City Pulandian District
	Shenyang City	Xinmin City
Inner Mongolia Autonomous Region	Hulunbuir City	Zhalantun City Arun Banner Morin Dawa Daur Autonomous Banner

The survey was mainly dealt with the relevant soybean production information of new agricultural producers in 2017. When the research samples are selected, the following aspects were mainly considered. (1) The regional distribution of the research samples should be as uniform as possible; (2) The selected samples are the new agricultural producers, not including the independent small growers which refer to those who planted more than 5 ha; (3) Data should be selected from complete and real research samples. According to the three basic aspects considered above, the survey data were collated and organized according to the corresponding research needs. In total, 800 questionnaires were given out, 652 of which are valid, with an effective rate of 81.50%. The sample characteristics and distribution are shown in Table 3.

Table 3. Characteristics and distribution of 652 samples.

		Quantities	Proportion (%)
	Total	**652**	**100.00**
Regional distribution	Heilongjiang Province	184	28.22
	Jilin Province	176	26.99
	Liaoning Province	154	23.62
	Inner Mongolia Autonomous Region	138	21.17
Planting area (S)	5 ha. $\leq S <$ 15 ha.	278	42.64
	15 ha. $\leq S <$ 60 ha.	272	41.72
	60 ha. $\leq S$	102	15.64
Proportion of agricultural income (A)	$S <$ 35%	73	11.20
	35% $\leq S <$ 70%	195	29.91
	70% $\leq S$	384	58.90
Land type	Level land	397	60.89
	Depression or hillock	64	9.82
	Mixed type	191	29.29

2.2. *Research Methods*

For the calculation of the efficiency of the new agricultural producers on soybean production, the data envelopment analysis (DEA) of the non-parametric method proposed by Charnes et al. [19] and the stochastic frontier analysis model (SFA) of the parametric method proposed by Batton and Coeli [20] are mainly used. The SFA model of the parametric method needs to be based on the specific production function model, which can represent the concrete relation between the input and the output; thus, the unknown parameters can be estimated by the measurement regression method, and the efficiency of new agricultural producers can be calculated. This stochastic model specification not only solves the noise problem associated with deterministic frontiers but also allows the estimation of standard errors and tests of hypotheses, while the DEA model of non-parametric method adopts a linear programming model, which needs no assumption for the specific production function model. Its advantage is to eliminate the necessity of making arbitrary assumptions about the functional form of the frontier and the distributional form of the error terms. Although the SFA model can separate the non-efficiency items from the error items, there is no priori reason for the selection of any particular distributional form for the error items [21]. Therefore, in order to avoid the deviation of the efficiency calculation caused by the setting errors of error items distribution, the DEA model is used to measure and evaluate the efficiency of new agricultural producers on soybean production. Furtherly, the Tobit model, which is based on the principle of maximum likelihood estimation, is used to analyze the factors that affect the efficiency of new agricultural producers on soybean production.

2.2.1. Data Envelopment Analysis (DEA)

The basic data envelopment analysis (DEA) model is used to calculate the production efficiency of new soybean producers (TE), which is the technical efficiency under constant scale returns. The technical efficiency (TE) can be represented by the product of pure technical efficiency (PTE) and scale efficiency (SE). PTE is the technical efficiency under variable scale returns to scale, as shown in Formula (1).

$$TE = PTE * SE \tag{1}$$

Therefore, when the variable returns are adopted to scale DEA model [22], it can be formed as shown in Formula (2):

$$\begin{aligned}
&\min_{\theta,\lambda} \theta - \varepsilon(e^{\mathrm{T}}s^{-} + e^{\mathrm{T}}s^{+}) \\
&s.t. \quad \sum_{i=1}^{n} \lambda_i y_{ir} - s^{+} = y_{0r} \\
&\sum_{i=1}^{n} \lambda_i x_{ij} + s^{-} = \theta x_{0j} \\
&\sum_{i=1}^{n} \lambda_i = 1, \lambda_i \geq 0, s^{+} \geq 0, s^{-} \geq 0
\end{aligned} \tag{2}$$

In it, i = 1,2, ... , n; j = 1,2, ... , m; r = 1,2, ... , s. n is the number of DMUs, m the number of input variables, s the number of output variables, x_{ij} the input variable j of DMUi, y_{ir} the output variable r of DMUi, λ_i the variables weight of DMUi, S^+ the relaxation variable of input, S^- the relaxation variable of output, εa small number, e (1, 1, ... , 1)$^{\mathrm{T}}$, and θ the pure technical efficiency (*PTE*) to be evaluated.

2.2.2. Tobit Model

In this paper, the above calculation data of the efficiency of new soybean producers are taken as the explained variables, and some explanatory variables are selected to explore the relevant influencing factors of new agricultural producers. In view of the fact that the value range of soybean production efficiency evaluation is [0, 1], which belongs to the regression of limited explanatory variable, the Tobit model is adopted in order to avoid the deviation caused by OLS analysis, and its basic form is shown in Formula (3).

$$Y_i = \begin{cases} \sum_{i=1}^{n} \beta_i X_i + \mu, \sum_{i=1}^{n} \beta_i X_i + \mu > 0 \\ 0, \sum_{i=1}^{n} \beta_i X_i + \mu \leq 0 \end{cases} \tag{3}$$

In it, Y_i is the evaluation value of technical efficiency TE_i, X_i the explanatory variable corresponding to each influencing factor, β_i the regression analysis coefficient of each explanatory variable, and μ represents error items having the normal distribution form with a mean value of 0.

2.2.3. Selection of Index and Variable

(1) Index selection of data envelopment analysis (DEA)

① **Input index.** In the aspect of the input index, the land scale (*N*), the productive capital investment (*K*), and the productive labor input (*L*) related to the soybean in 2017 as input indexes. The land scale (*N*) refers to the land area actually used for the soybean production, including the lands of which the producer has acquired the right to produce by means of contract, leasing, and cooperation. Therefore, such lands are selected as indexes for measuring land input, and the measurement unit is ha. The productive capital investment (*K*) refers to the capital investment in addition to the land and the labor that the agricultural producers must put in for the production of soybeans, including seeds, chemical fertilizers, and pesticides. Therefore, this part of the capital is selected as a measurement index with a unit of 10000 yuan/ha. The productive labor input (*L*) refers to the quantity of the labor that the agricultural producers must put in with a measurement unit of day/ha. It is calculated by the number of days, and every 10 h per person is taken as 1 day.

② **Output index.** In the aspect of the output index, the annual sales income of soybeans is taken as the output index, of which the unit is 10000 yuan/ha.

In this paper, the data obtained are used to study the soybean production efficiency of the new agricultural producers in the survey area, and the selection of input–output variables and the corresponding explanation are shown in Table 4.

Table 4. Data envelopment analysis (DEA) input–output variables and the corresponding explanation.

Variable		Index	Unit
Input index	Land scale (*N*)	Agricultural production land area	ha.
	Productive capital investment (*K*)	Annual agricultural capital investment	10,000 yuan/ha.
	Productive labor input (*L*)	Annual labor input days	day/ha.
Output index	Agricultural output (*y*)	Annual soybean sales income	10,000 yuan/ha.

(2) Index selection of Tobit Model

According to the characteristics of the new soybean producers and the research needs for study, the following factors are selected as the explanatory variables to study the influencing factors of soybean production efficiency, as shown in Table 5.

① **The attributes of the household owner.** Three variables are chosen to explain the attributes of the household owner, including age, gender, and level of education. In general, the higher the level of education is, the lower the age is, and the easier it is to accept new technologies and ideas, the higher the efficiency of the resource allocation is. Consequently, higher technical operating efficiency can be obtained in the soybean production process. As a result, the expected influence of age is negative and the expected influence of the level of education is positive.

② **The attributes of family.** Three explanatory variables are selected to describe the attributes of the family, including soybean planting area (ha.), labor ratio (%) of soybeans, and soybean operating cost (10000 yuan/ha). In general, the larger the area of the soybean planting area is, the higher the labor ratio of soybean is, and the lower the operating cost of the soybean is, the higher the utilization efficiency of the capital and other resources is. Consequently, new soybean producers can have higher technical efficiency. As a result, the expected influence of the soybean planting area and the labor ratio of soybean is positive, and the expected influence of the soybean operating cost is negative.

③ **Production conditions.** Four explanatory variables are selected to describe it, including soil fertility, degree of mechanization, traffic condition, and convenience of water and power access. Agriculture has a strong natural attribute, and the production conditions have a great influence on soybean production efficiency. In general, the better the soil fertility is, the higher the degree of mechanization is, the better the traffic condition is, and the more convenient the access to water and power is, the higher the ability of production and the conversion efficiency of the production factors related to the soybean production are. Consequently, the new agricultural producers can have higher technical operating efficiency in the soybean production process. Therefore, the expected influence directions of the four explanatory variables of soil fertility, degree of mechanization, traffic condition, and convenience of water and power access are all positive.

④ **Market environment.** Three explanatory variables are selected to describe it, including the sales channel of soybeans, the stability of the soybean price, and the difficulty in obtaining soybean market information. The improvement of the technical efficiency in the soybean production process depends on the smooth soybean sales channel, the stability of the soybean price, and the quick acquisition of market information. Therefore, the expected influence of the soybean sales channel of soybean and the stability of the soybean price on the technical efficiency for new agricultural producers are positive, while the difficulty in obtaining soybean market information is negative.

⑤ **External policies.** In this paper, two explanatory variables from external policies are selected to describe the influencing factors, including the implementation of soybean subsidy policy and the promotion and training of soybean planting technology. Soybean subsidy and promotion of soybean planting technology are the two key contents of external policies. Active implementation of soybean subsidies and promotion and training of soybean planting technology are beneficial to improve the overall soybean production efficiency for the new agricultural producers. Therefore, the expected influence of soybean subsidy policy and soybean planting technology promotion and training on the technical efficiency of soybean production are both positive.

Table 5. Selection, interpretation, and descriptive statistics of variables in the Tobit Model.

Type of Variable	Name of Variable	Symbol	Meaning and Value	Mean Value	Standard Deviation	Expected Direction
Explained variable	New soybean producers' technical efficiency	*TE*	Continuous variable (value range [0, 1])	0.67	0.18	
Attributes of household owner	Age	*Age*	Continuous variable	49.62	11.31	−
	Gender	*Gender*	0–1, female = 0, male = 1	0.73	0.64	Uncertain
	Level of education	*Edu*	1–5, under primary school = 1, primary school = 2, middle school = 3, high school or technical secondary school = 4, college or above = 5	3.12	0.82	+
Attributes of family	Soybean planting area (ha.)	*Area*	Continuous variable	13.24	23.35	+
	Labor ratio for soybean (%)	*Labor*	Continuous variable (value range [0, 1])	64.24	18.26	+
	Soybean producing cost (10000 yuan/ ha)	*Cost*	Continuous variable	3.14	0.96	−
Production conditions	Soil fertility	*Soil*	1–5, very poor = 1, poor = 2, normal = 3, good = 4, very good = 5	3.21	1.14	+
	Degree of mechanization	*Mech*	1–5, very poor = 1, poor = 2, normal = 3, good = 4, very good = 5	3.09	0.87	+
	Traffic condition	*Traf*	1–5, very poor = 1, poor = 2, normal = 3, good = 4, very good = 5	3.27	0.92	+
	Convenience of access to water and power	*Conv*	1–5, very poor = 1, poor = 2, normal = 3, good = 4, very good = 5	3.32	1.08	+
Market environment	Sales channel of soybean	*Sales*	1–5, very poor = 1, poor = 2, normal = 3, good = 4, very good = 5	3.25	0.96	+
	Stability of the soybean price	*Price*	1–5, very poor = 1, poor = 2, normal = 3, good = 4, very good = 5	3.11	0.95	+
	Difficulty in obtaining soybean market information	*Infor*	1–5, very poor = 1, poor = 2, normal = 3, good = 4, very good = 5	2.87	1.31	−
External policies	Implementation of soybean subsidy policy	*Subsi*	1–5, very poor = 1, poor = 2, normal = 3, good = 4, very good = 5	2.81	1.19	+
	Promotion and training of soybean planting technology	*Tech*	1–5, very poor = 1, poor = 2, normal = 3, good = 4, very good = 5	2.62	0.98	+

3. Results and Analysis

3.1. Analysis of New Soybean Producers' Technical Efficiency

After sorting out and summing up the data obtained from the survey, based on the DEA model and by means of DEAP2.1, the technical efficiency of new soybean producers was analyzed and calculated, and the corresponding pure technical efficiency and scale efficiency were obtained. The results are as shown in Table 6.

On the basis of given input, the technical efficiency of new soybean producers represents the soybean production income that can be obtained. In this paper, the evaluation results of soybean production efficiency are shown in Table 4. Through the calculation of DEA model, it can be seen that the average technical efficiency of soybean production in the sample is 0.618, of which the average pure technical efficiency is 0.680 and the average scale efficiency is 0.872. On the whole, the three kinds of efficiency are all higher than 50%, which indicates that the production efficiency of the sample soybean producers is high, and the new agricultural producers are greatly affected by the scale benefit, and which also emphasizes the significance of the moderate scale production of the land.

In the technical efficiency evaluation, there are only 64 new agricultural producers who have reached the level of efficiency, accounting for 9.82%. It can be seen that in the soybean production process, the technical efficiency still needs to be further improved, which means not only the improvement of the utilization rate of input resources but also the improvement of resource allocation rate. There are 47 new agricultural producers with extremely low efficiency, accounting for 7.21%, 336 with moderately low efficiency, accounting for 51.53%, and 205 with slightly low efficiency, accounting for 31.44%. Therefore, there are more new low-efficiency agricultural producers, so it is very important to find out the causes of low efficiency and improve the technical efficiency of soybean production. It can be considered from two aspects: pure technical efficiency and the scale efficiency. In the aspect of pure technical efficiency, there are 42 units with extremely low efficiency, accounting for 6.44%, 305 with moderately low efficiency, accounting for 46.78%, 221 with slightly low efficiency, accounting for 33.90%, and only 84 new agricultural producers who have reached the level of efficiency, accounting for 12.88%. In the aspect of scale efficiency, there are 22 units with extremely low efficiency, accounting for 3.38%, 59 with moderately low efficiency, accounting for 9.05%, and 374 with slightly low efficiency, accounting for 57.36%, and 197 units have reached the level of efficiency, accounting for 30.21%. In general, the pure technical efficiency of new agricultural producers is low, and the scale efficiency is more consistent with the optimal state. Therefore, on the grounds of selecting a suitable operation scale, the improvement of use efficiency of the technology and the managing level of pesticide, chemical fertilizer, and agricultural machinery are the keys to improve the new soybean producers' technical efficiency.

Table 6. DEA Analysis results of new soybean producers' technical efficiency.

Range of Efficiency Value *TE*	Technical Efficiency			Pure Technical Efficiency			Scale Efficiency		
	Average Efficiency	Quantities	Proportion (%)	Average Efficiency	Quantities	Proportion (%)	Average Efficiency	Quantities	Proportion (%)
Seriously low efficiency ($TE < 0.4$)	0.228	47	7.21	0.221	42	6.44	0.211	22	3.38
Moderately low efficiency ($0.4 \leq TE < 0.7$)	0.539	336	51.53	0.576	305	46.78	0.626	59	9.05
Slightly low efficiency ($0.7 \leq TE < 0.99$)	0.825	205	31.44	0.802	221	33.90	0.879	374	57.36
Efficiency ($0.99 \leq TE$)	1.000	64	9.82	1.000	84	12.88	1.000	197	30.21
Mean value	0.618			0.680			0.872		

3.2. Analysis of the Influencing Factors of the Production Efficiency of New Soybean Producers

Based on the above-mentioned technical efficiency of soybean production calculated by the DEA model, it was set as the explained variable, a Tobit model regression analysis was made for each explanatory variable by means of STATA15.0, the significant explanatory variables in the all-factor regression analysis were extracted, and then robust regression analysis was carried out. The results are shown in Table 7.

Table 7. The result of Tobit regression analysis.

Influencing Factor	All-Factor Regression		Robust Regression	
	Coefficient	*p*-Value	Coefficient	*p*-Value
Age	−0.013	0.484		
Gender	0.268	0.491		
Edu	0.009 *	0.066	0.014 **	0.043
Area	0.187 ***	0.000	0.201 ***	0.000
Labor	0.079	0.723		
Cost	−0.082	0.181		
Soil	0.021	0.612		
Mech	0.187 ***	0.000	0.192 ***	0.000
Traf	−0.005	0.687		
Conv	0.062	0.296		
Sales	0.148 **	0.037	0.159 **	0.028
Price	−0.116 *	0.059	−0.094 **	0.032
Infor	−0.015 ***	0.000	−0.027 ***	0.000
Subsi	−0.007 *	0.080	−0.011 **	0.025
Tech	0.220	0.188		
Constant	0.637		0.536	
R^2	0.432		0.407	
Adjusted R^2	0.364		0.341	

Note: *, **, *** refers to significant at the 10%, 5%, and 1% level of significance, respectively.

According to the results of the Tobit regression analysis, 7 of the 15 variables in the regression model are significant at the 10% level of significance at least. In addition, these 7 variables in the robust regression are significant at the 5% level of significance at least (as shown in Table 7), while the other explanatory variables are insignificant, indicating that they have no significant influence on the technical efficiency of soybean production. The level of education, the soybean planting area, the degree of mechanization, and the sales channel of soybean have positive influences on the technical efficiency of soybean production, while the stability of soybean price, the difficulty in obtaining soybean market information, and the implementation of soybean subsidy policy have negative influences on the technical efficiency of soybean production.

(1) In the aspect of attributes of household owner, the two variables of age and gender are insignificant. However, the level of education of household owner is significant at 10% level of significance, and the regression coefficient is positive, which is the same as the expected impact direction, indicating that the higher the education level of producers is, the more beneficial it is to improve the technical efficiency of soybean production. The mean value of the variable of education level in the sample is 3.12, which indicates that the education level of household owners in the sample is not high and is an important factor restricting the production of soybean.

(2) In the aspect of attributes of family, only soybean planting area is significant at a 1% level of significance, and its regression coefficient is positive, which is the same as the expected impact direction. This shows that the larger the planting area of soybean is, the higher the technical efficiency of soybean production is. According to the research results, the average value of the soybean planting area is about 13.24 ha, and the sample soybean planting area is at a medium level, indicating that the

technical efficiency of soybean production can be improved by encouraging land leasing and other similar measures.

(3) In the aspect of attributes of production conditions, the mechanization level variable is significant at 1% level of significance, and the regression coefficient of the explanatory variable is positive, which is the same as the expected impact direction. This shows that the higher the mechanization level is, the higher the technical efficiency of soybean production is. The mean value of the mechanization level in the sample is 3.09, which does not show the obvious advantage of a high mechanization level. Therefore, the mechanization scale and rational allocation of mechanical tools are important factors that restrict the new agricultural producers to improve the technical efficiency of soybean production.

(4) In the aspect of the market environment, the sales channel of soybean, the stability of soybean price, and the difficulty in obtaining soybean market information are significant at the 10% level of significance at least. The regression coefficient of soybean sales channel is positive, which is the same as the expected impact direction, indicating that the direction of the influence of the soybean sales channel affects the technical efficiency of soybean production is the same direction. The mean value of soybean sales channel variable in the sample is 3.25. Therefore, reasonable acquisition of effective soybean sales channels is beneficial to the improvement of the technical efficiency of soybean production. The regression coefficient of the stability degree of soybean price is negative, which is different from the expected impact direction. The possible reason for it is that the stability degree of soybean price is greatly influenced by subjective factors. In addition, the data collected from the survey areas are limited and the situations are different, so the stability degree of soybean price has no obvious influence on the technical efficiency of soybean production. The difficulty in obtaining soybean market information is negative, which is the same as the expected impact direction, indicating that the difficulty in obtaining soybean market information has a restrictive effect on the technical efficiency of soybean production. Additionally, the average difficulty in obtaining soybean market information in the sample is 2.87. Therefore, the establishment of a market information dissemination platform and the promotion of agricultural information exchange are important ways to improve the technical efficiency of soybean production [23].

(5) In the aspect of external policy, the implementation of the soybean subsidy policy is significant at 10% level of significance. In addition, the regression coefficient is negative, which is opposite to the expected impact direction. The possible reason for it is that the soybean subsidy policy is affected by the selling price of the soybean to a certain extent. So when the producers think that the implementation of the soybean subsidy policy is better, the selling price of the soybean in the same period may be lower. As a result, the soybean subsidy policy has a negative influence on the technical efficiency of soybean production.

4. Conclusions and Suggestions

Based on the survey data of some counties (cities) in Heilongjiang, Jilin, Liaoning, and Inner Mongolia Autonomous Region, the production efficiency of new soybean producers from these areas are calculated in this paper by means of the data envelopment analysis (DEA) after the selection of appropriate input and output indexes. With the calculation results as explained variables, relevant explanatory variables were selected, and the impact of related factors on the production efficiency of new soybean producers was analyzed by means of the Tobit model. The main conclusions are as follows.

4.1. Conclusions

(1) The average technical efficiency of soybean production in 2017 was 0.618, of which the average pure technical efficiency was 0.680 and the average scale efficiency was 0.872. In the aspect of technical efficiency, only 64 new agricultural producers were efficient, accounting for 9.82%. Therefore, it can be concluded that technical efficiency still needs to be further improved. In the aspect of pure technical

efficiency, 84 new agricultural producers were efficient, accounting for 12.88%, and 197 in the aspect of scale efficiency, accounting for 30.21%. Therefore, the scale efficiency is higher than that of pure technology in the production process of new soybean producers.

(2) The improvement of education level, the expansion of soybean planting area, the improvement of the mechanization level, and the broadening of soybean sales channels can improve the technical efficiency of soybean production. The enhancement of the instability of soybean price, the increase of difficulty in obtaining soybean market information, and the inappropriate soybean subsidy policy will reduce the technical efficiency of soybean production.

4.2. Suggestions

(1) **The multi-level policy of talent introduction should be established to improve the quality of labor of soybean production.** The quality of labor engaged in soybean production is the key to affect the efficiency of soybean production. The government should formulate relevant measures to prevent the outflow of the young labor force, improve the education level of the labor force, establish the dissemination platform of relevant technology and production knowledge, and gradually improve the soybean production mode.

(2) **Moderate scale production of soybean should be continually promoted.** The moderate scale production of soybean can effectively improve the production efficiency of soybean. The government should issue relevant policies, actively guide the moderate scale circulation of land, establish the relevant land leasing platform, introduce agricultural insurance to reduce the risk of scale production, and optimize the soybean planting structure so as to improve the production efficiency of soybean.

(3) **Agricultural technology should be used to improve the efficiency of resource allocation.** The introduction of the agricultural technology can better optimize the allocation of the production and operation resources, increase the strength of the construction of agricultural infrastructure, widely promote the new agricultural technology, improve the mechanization level of the soybean production and the efficiency of the resource utilization. By these means, the pure technical efficiency of soybean production can be improved, and the technical efficiency of the soybean production can be improved.

(4) **The soybean online sales platform should be built to expand sales channels.** The government should strive to maintain a good market order of soybean, establish a multi-channel soybean market, continuously stabilize the price of the soybean, and set up a variety of acquisition channels for soybean market information, so as to reduce the operational risk for the new agricultural producers and improve the production efficiency.

(5) **The supervision mechanism of soybean subsidy implementation should be strengthened.** The government's policies on soybean subsidies are important factors to guide the soybean production of new agricultural producers. Issuing effective soybean subsidy policy can guarantee the soybean producers' interests, promote the introduction of the relevant supporting policy, optimize the implementation of the soybean-related policies, and ensure the effective implementation of soybean subsidies. It is beneficial to the improvement of the efficiency of new soybean producers.

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References

1. Sabala, E.; Devadoss, S. Impacts of Chinese Tariff on World Soybean Markets. *J. Agric. Resour. Econ.* **2019**, *44*, 291–310.

2. He, R.; Zhu, D.; Chen, X.; Cao, Y.; Chen, Y.; Wang, X. How the Trade Barrier Changes Environmental Costs of Agricultural Production: An Implication Derived from China's Demand for Soybean Caused by The Us-China Trade War. *J. Clean. Prod.* **2019**, *227*, 578–588. [CrossRef]
3. Zhang, D.; Zang, G.; Li, J.; Ma, K.; Liu, H. Prediction of Soybean Price in China Using QR-RBF Neural Network Model. *Comput. Electron. Agric.* **2018**, *154*, 10–17. [CrossRef]
4. Kostov, P.; Davidova, S.; Bailey, A. Comparative Efficiency of Family and Corporate Farms: Does Family Labour Matter? *J. Agric. Econ.* **2019**, *70*, 101–115. [CrossRef]
5. Yang, Y.; Zhuang, Q.; Tian, G.; Wei, S. A Management and Environmental Performance Evaluation of China's Family Farms Using an Ultimate Comprehensive Cross-Efficiency Model (UCCE). *Sustainability* **2019**, *11*, 6. [CrossRef]
6. Yan, J.; Chen, C.L.; Hu, B.L. Farm Size and Production Efficiency in Chinese Agriculture: Output and Profit. *China Agric. Econ. Rev.* **2019**, *11*, 20–38. [CrossRef]
7. Skevas, T.; Grashuis, J. Technical Efficiency and Spatial Spillovers: Evidence from Grain Marketing Cooperatives in the US Midwest. *Agribusiness* **2020**, *36*, 111–126. [CrossRef]
8. Tufa, A.H.; Alene, A.D.; Manda, J.; Akinwale, M.G.; Chikoye, D.; Feleke, S.; Wossen, T.; Manyong, V. The Productivity and Income Effects of Adoption of Improved Soybean Varieties and Agronomic Practices in Malawi. *World Dev.* **2019**, *124*, 104631. [CrossRef]
9. Gong, T.C.; Battese, G.E.; Villano, R.A. Family Farms Plus Cooperatives in China: Technical Efficiency in Crop Production. *J. Asian Econ.* **2019**, *64*, 101129. [CrossRef]
10. Lu, H.; Xie, H.L.; Yao, G.R. Impact of Land Fragmentation on Marginal Productivity of Agricultural Labor and Non-agricultural Labor Supply: A Case Study of Jiangsu, China. *Habitat Int.* **2019**, *83*, 65–72. [CrossRef]
11. Rodriguez, L.C.; Gonzalez, J.A.C. How to make prosperous and sustainable family farming in Cuba a reality. *Elem.-Sci. Anthr.* **2018**, *6*, 77.
12. Rade, P.; Kleut, Z.; Dokic, D. Exploring the Drivers of Efficiency in Organic and Conventional Soybean Production. *Custos E Agronegocio Line* **2018**, *14*, 214–229.
13. Dong, F.; Mitchell, P.D.; Knuteson, D.; Wyman, J.; Bussan, A.J.; Conley, S. Assessing Sustainability and Improvements in US Midwestern Soybean Production Systems Using a PCA–DEA Approach. *Renew. Agric. Food Syst.* **2016**, *31*, 524–539.
14. Jiang, Y.B.; Li, S. Research on Soybean Production Efficiency of Agricultural Machinery Cooperative in Heilongjiang Province. *Soybean Sci.* **2016**, *35*, 1018–1024.
15. Mousavi-Avval, S.H.; Rafiee, S.; Jafari, A.; Mohammadi, A. Optimization of Energy Consumption for Soybean Production Using Data Envelopment Analysis (DEA) Approach. *Appl. Energy* **2011**, *88*, 3765–3772.
16. Zhang, J.J.; Wu, Q.; Zhou, Z.X. A Two-Stage DEA model for Resource Allocation in Industrial Pollution Treatment and Its Application in China. *J. Clean. Prod.* **2019**, *228*, 29–39.
17. Ebo, O.E.; Adwoa, O.J.; Edu, O.G. Production Risk and Technical Efficiency of Fish Farms in Ghana. *Aquaculture* **2018**, *495*, 55–61.
18. Ali, Q.; Khan, M.T.I.; Ashfaq, M. Efficiency Analysis of Off-Season Capsicum/Bell Pepper Production in Punjab-Pakistan: A DEA Approach. *J. Anim. Plant Sci.* **2018**, *28*, 1508–1515.
19. Charnes, A.; Cooper, W.W.; Rhodes, E. Measuring the Efficiency of Decision Making Units. *Eur. J. Oper. Res.* **1978**, *2*, 429–444.
20. Battese, G.E.; Coelli, T.J. Frontier Production Functions, Technical Efficiency and Panel Data: With Application to Paddy Farmers in India. *J. Product. Anal.* **1992**, *3*, 153–169.
21. Coelli, T.J. Recent Developments in Frontier Modelling and Efficiency Measurement. *Aust. J. Agric. Econ.* **1995**, *39*, 219–245. [CrossRef]
22. Banker, R.D.; Charnes, A.; Cooper, W.W. Some Models for Estimating Technical and Scale Inefficiencies in data envelopment analysis. *Manag. Sci.* **1984**, *30*, 1078–1092. [CrossRef]
23. Su, Y.; Han, L.; Wang, J.; Wang, H. Quantum-behaved RS-PSO-LSSVM method for quality prediction in parts production processes. *Concurr. Comput.-Pract. Exp.* **2019**, *9*, e5522.