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Can China's soybean production satisfy its demand in the future? The efficiency analysis of China's soybean production

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Abstract

The paper reviews soybean production and its demand change in China. It proposes that the improvement in technical efficiency of soybean production is indispensable for the increase of soybean output and, in turn, to satisfy the domestic demand for soybean. The paper investigates the technical efficiency, scale efficiency, profit efficiency, and Malmquist index of China's soybean productivity. According to the result of estimate, the paper proposes that the rapid improvement of China's soybean production is difficult and China will continue to import soybeans including GM soybeans to satisfy its domestic demand in the future.

Keywords: Technical Efficiency, Scale Efficiency, Profit, Production, Malmquist

Introduction

After China's entry of WTO, facing international competition, crop sector in China has raised questions about possible effects of such competition on China's agricultural production and agricultural market. Producers of major field crops such as corn and soybeans are directly confronted with foreign cheaper agricultural products. Although soybean is an important crop planted in China traditionally, the yield of it is much lower than that of US and other countries in America(Hunter et. al. 2000). Recently with the sharply increasing consumption of soybeans, China's soybean production can't satisfy the domestic demand of soybeans and it has become one of the largest soybean importers. Therefore, in China the improvement in soybean production should be made urgently.

Furthermore, China is the largest grain producer and consumer in the world, presently, and China's future food balance are specially significant for the world grain production(Huang J et. al. 1997). However, in recent decades, there have not had sufficient practical analyses in estimating China's crop production. Because of the difficulties associated with the availability of specific input and output information, the soybean production analysis of China was scarce. Generally, some classical approaches are applied in the estimation such as using the relationship between the input allocations and production

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parameters under some assumption in parametric estimation. However, such method is not always appropriate in empirical production analyses when we are applying micro-level data. In this paper, these problems mentioned above might be solved due to the availability of such micro-level specific input and output information. The sample data in this paper are averages which are from 45 counties in 15 important provinces of China. Thus, the biased estimates induced by different production technologies in different provinces can be eliminated. Having used a extended DEA model, the paper can supply not only different technical efficiencies in different provinces of China but also technical efficiency change indices and Malmquist indices over 7 years (from 1994 to 2000).

Moreover, the centrally planned economies has heavily regulated and distorted the agricultural production in China. Some regulations are only available in China such as the extra payment of agricultural production imposed by local government and household responsibility system(HRS). Given the intensive population and its regional unbalance characteristic in China, the HRS policy can lead to the fragment of agricultural land and regional difference of farm size. In this paper, scale efficiency estimates and SE change index are also included in the model to provide a detailed analysis.

Soybean Demand and Production in China

China is a huge market for soybeans. In marketing year 2000, the domestic soybean market of China claimed more than 15 percent of total soybean use in the world. In fact, China's soybean consumption has increased rapidly from 8.6% of the global soybean consumption in 1992 to 15.74% of it in 2000. From table 1, the consumption of soybeans in China increased slowly from 1978 to 1991, but in next 10 years, the consumption of soybeans in China had been tripled from 8756 thousand tons in 1991 to 26177 thousand tons in 2000. Most of the explosive growth in consumption has come in 1993 and 1997 with growth rates of 41% and 28% respectively. The growth in consumption has come as a result of increased demand in China for meat products, soybeans and soybean meal.

On the other hand, although China's farmers improved yields gradually in the past five years up to roughly 1.6-1.7 tons/hectare, from the typical yield of 1.3 tons/hectare in the 1980's, China's domestic soybean production has not been improved sharply in recent years. Moreover, the growth of harvested area in China has been substantially lower than the growth of soybean planted acres in the United States over the past several years. Because soybean planting is mostly practiced in small scale household farm in China, the productivity of soybeans in China is generally low. In most provinces of China, for the sake of the high intensive population, the household farms are very small and the area of each farm may be only one hectare. Furthermore, because of large population and relative scarce of planting land in these provinces, the large nation-owned farms are sparse and most of soybean is produced by small household farm. In addition, the small and disaggregated planting plots can restrict the application of agricultural machinery and other inputs. Therefore, the limited scale of soybean farms in China may induce the low pro-

duction capacity and efficiency in the farm operation. Although we can not draw the conclusion that the low yield in China was absolutely induced by small and disaggregated planted area, it may have potential impact on technical efficiency and production capacity.

Year	1978	1980	1988	1989	1990	1991	1992	1993
Quantity	755.2	830	1026.2	905.1	971.3	875.6	1015	1433.5
1994	1995	1996	1997	1998	1999	2000	2001	2002
1576.1	1407.3	1430.9	1547.2	1992.9	2304.5	2617.7	2760	3028

Table 1. The consumption of soybeans in China Unit: Ten thousand tons

The figure1 depicts the China's soybean output from 1961 to 2001. It can be discovered from this figure that the highest output year was 1994 in which the total yield of China was up to 16000 thousand tons. However, the yield was dropped to 13500 thousand tons in 1995 and grew slowly in next three years. In 1999 it dropped to 14251 thousand tons from 15152 thousand tons in 1998.



Figure 1. China's Soybean Output Unit: Thousand tons

A recent year in which China's soybean yield had been reduced was 2001, even though the planted area of 2001 had been expanded from 9.306 million hectares in 2000 to 9.4818 million hectares. Moreover, in 2001, China's per-hectare yield stood at 1,625 kilograms, far lower than the world's average of 2,340 kilograms. Therefore, it can be concluded that the per-unit soybean output is very low in China, and it should be improved dramatically to meet the need of country. The data in the figure2 were calculated by making soybean annual consumption minus soybean output from 1988 to 2001. From figure2, it is manifest that the gap between China's soybean demand and domestic output was enlarged. Therefore, China's domestic soybean production can not satisfy the

growing demand totally. In recent years, China becomes one of the world's largest importers of soybeans.

Presently, although the government has strengthened its extension efforts to promote more intensive production systems, soybean production in China had still declined in 1999 and 2001 as discussed above. Moreover, China's domestic market for soybeans is expected to be affected by rising imports and the associated declining price of soybean oil. In fact, patterns in the trade depend on a number of factors, including relative proximity, and degree of price sensitivity in a market. In China's domestic market, the government regulates the market price and wholesale price, which distorts the price of soybeans. Thus, the price-competitive nature of the market can not be displayed clearly in China's domestic markets. However, even with such government regulation, the price of domestic soybeans in China is still higher than the price on the global market. Because prices play a central role in all types of global market adjustments, in any year, a large number of soybean imports will make the nation obtain lower market price, and producers in that country face constant pressures to cut costs in order to remain competitive. Thus, besides the low yield and limited planted area, the decline of soybean production is also attributed to the importation of the foreign produced soybeans whose price is lower than domestic produced soybeans. In terms of price and cost, the important way which can reduce cost is to promote the technical efficiency of soybean production. Therefore, presently the most important target of China is to promote its soybean production efficiency. Moreover, plus government policy and financial support in line with World Trade Organization rules, efforts to expand production can also include the technical change of soybean production.



Unit: Ten thousand tons

As a result, the most important measure of China's producers is to improve the technical efficiency of soybeans on the available planted area of soybean.

In this paper, to analyze the efficiency of China's soybean production, a method should be used to measure the technical efficiency.

The DEA efficiency model

Presently, the most popular methods found in the frontier estimate involve the stochastic frontier using econometric methods and non-parametric data envelopment analysis(DEA) using mathematical programming techniques. Since DEA is deterministic and non-parametric, a frontier estimated by this technique is believed to be sensitive to stochastic noise in the data. However, the main advantage of DEA is that it eliminates the need for the parametric assumption of the underlying technology. In this study, a DEA model is applied to estimate technical efficiency of soybean production in China. Furthermore, the paper extends the application of estimate result by calculate the profit efficiency.

Generally, the DEA approach defines the technical efficiency in terms of a minimum set of inputs needed to produce a given output(input-orientated model) or maximum output obtainable from a given set of inputs(output-orientated model)(Charnes et al 1994). In this paper, we use output-orientated DEA model in which technical efficiency can be defined as the capacity of producing the maximum level of output for a given quantity of inputs and technology. The technical efficiency of a farm is expressed by the ratio of its total weighted output to its total weighted input. In DEA analysis, the weights are estimated by the linear programming method. According to its definition, technical efficiency and scale efficiency estimates can range from 0 to 1, representing no output and the fully technically efficient operation separately.

In this paper, we use an output-orientated CRS/VRS efficiency model to estimate the technical efficiency and scale efficiency of China's soybean production. According to Fare(1994), the CRS model can be expressed as:

$$\frac{1}{E_i} = \operatorname{Max} \phi_i$$
st
$$\sum_{j=1}^J \lambda_j \quad y_{qj} - \phi_i y_{qi} \ge 0, q = 1, ..., Q$$

$$x_{pi} - \sum_{j=1}^J \lambda_j \quad x_{pj} \ge 0, p = 1, ..., P$$

$$\lambda_i \ge 0, j = 1, ..., J$$
(1)

where x is the input, y is the output and i is the number of the DMU. $1/\Phi$ defines a TE score which varies between zero and one. Index Q represents type of output and index P represents input. λj (j=1,...,J) are non-negative constants. Under the assumption of constant returns to scale, the above CRS model can provide technical efficiency of each DMUi point by solving the above linear programme set up according to the definition.

Based on the CRS model, the VRS model can be easily made by imposing the convexity constraint.

$$\frac{1}{E_{i}} = \operatorname{Max} \phi_{i}$$
st
$$\sum_{j=1}^{J} \lambda_{j} \quad y_{qj} - \phi_{i} y_{qi} \ge 0, q = 1, ..., Q$$

$$x_{pi} - \sum_{j=1}^{J} \lambda_{j} \quad x_{pj} \ge 0, p = 1, ..., P$$

$$\sum_{j=1}^{J} \lambda_{j} = 1$$

$$\lambda_{j} \ge 0, j = 1, ..., J$$
(2)

One output(soybeans) and four inputs (seed quantity, labor, the cost of machine, and fertilizer quantity) were used in the DEA model. All output and input variables used for this study are expressed on a per $mu(667m^2)$ basis.

With the result of above estimate, we can calculate the impact of operation policy modification on profit when pursuing full technical efficiency. Besides output, another important source of uncertainty faced by farmers is profit, which will influence their future decision. Here, we define the profit as $W = V \cdot \Sigma X_m$, where ΣX_m is the total cost of inputs. W is profit, X_m is the cost of input, and V is output value. The above function can be rewritten as $\Delta W = \Delta V - \Delta \Sigma X_m$. Then, if we want to estimate profit variation we should calculate input cost variation and output value variation. The cost variation can be expressed as: $\Delta \Sigma X_m = \Sigma [\Delta P_m(\Delta x_m + x_m) + \Delta x_m P_m]$. In this function, x and P represent the applied quantity and the price of input, and ΔP , Δx represent the variations of them respectively. The profit function can be written as: $\Delta W = \Delta V \cdot \Sigma [\Delta P_m(\Delta x_m + x_m) + \Delta x_m P_m]$. Thus the profit variation arises where the variation of profit is necessarily related to input price, input quantity, output value and variations of them. This function can be applied to evaluate the economic impact of technical change of soybean plant systems on soybean profit uncertainty in China. We can use above function and the estimate result of DEA model to calculate the profit change.

In this paper, the profit function can be expressed as: $W = Py - \Sigma x_m P_m$. In this function, y is output and P is output price. Here, to make the model simple, we hypothesize that the price of input and output are given and would not change with adoption of new operation policies for pursuing full technical efficiency. Thus, we can calculate the profit change at the full technical efficiency by using differential function of above function as:

$$\Delta W = P \Delta y - \Sigma P_m \Delta x_m \tag{3}$$

Based on above information, we compare the real profit and the target profit of DEA

model and the target profit can be written as $W'=\Delta W+W$. Presently, the DEA model is commonly employed for technical efficiency analysis, although some additional studies employ such method in estimating profit efficiency directly. Most studies relating to profit efficiency analysis use cost function and profit maximization hypothesis in the DEA model. In this paper, to make the model simple we assume that the technical efficiency is a necessary condition for profit efficiency and our target profit will be calculated on the basis of estimated result of traditional technical efficiency DEA model. According to above discussion, the profit efficiency is defined as the proportion of real profit to target profit based on the assumption that farms are operated at the full technical efficiency.

Moreover, based on the above CRS/VRS DEA analysis, we conveniently make a Malmquist TFP(total factor productivity) index analysis. To make it simple, we only estimate the Malmquist TFP index by using CRS frontier. Based on panel data, Malmquist TFP index can be used to measure productivity change, and decomposed into technical change and technical efficiency change. According to Fare et al.(1994), an output-based Malmquist productivity change index can be written as :

$$m(y_{t+1}, x_{t+1}, y_t, x_t) = \left[\frac{d_t(x_{t+1}, y_{t+1})}{d_t(x_t, y_t)} \times \frac{d_{t+1}(x_{t+1}, y_{t+1})}{d_{t+1}(x_t, y_t)}\right]^{1/2}$$
(4)

The equation represents the productivity of the input-output $point(X_{t+1}, Y_{t+1})$ relative to the point(X_t, Y_t). Where $D_t(X_{t+1}, Y_{t+1})$ represents the distance from the period t+1 observation to the period t technology. A value of the index m greater than one indicates an improvement in TFP from period t to period t+1. In fact, the index m is the geometric mean of two output based Malmquist TFP indices.

We solve the linear programme of DEA model using the computer program, Deap version 2.1 developed by Coelli(1996), and we will use multi-stage method to calculate slacks instead of one-stage method.

Data

It should be noted that two data sets are applied in the paper. One data set used in the DEA model to estimate technical and scale efficiencies is site-specific data set which will be explained in detail in this paper. Another data set used in the Malmquist TFP analysis is panel data set, which will only be mentioned in brief in the paper.

In the cross-sectional data set for TE and SE estimates, one output(soybeans) and four inputs (seed quantity, labor, the cost of machine, and fertilizer quantity) are used. The data set is cited from the survey led by state planning and development commission of China. All data in this data set are based on the planted area of 1 mu which is about 667m². Data for the empirical analysis came primarily from the survey of soybean farms in 15 Provinces in China(The locations of these provinces are depicted in the figure 3). In each province, the soybean farms in three important counties(Xian) were surveyed. Specifi-

cally, more than 100 samples were surveyed in one county. For each county, averages of surveyed farms' output and input data were calculated. Therefore, in our model there were totally 45 calculated sample averages, representing 45 counties in 15 important provinces in China. In fact, the real number of .surveyed farms were more than 5000. Some provinces such as XiZhang were not included in the survey because they can not represent the overall soybean production ability in China. In fact, the yield of the 15 included provinces occupied the 82 percent of total soybean outputs in 2001 in China. Table 2 lists summary statistics of the sample data used in TE and SE estimates. The quantity of soybean output of individual farm ranged from 62.09kg to 196.07kg per mu with an average of 124kg per mu in these provinces. Labor input also varied widely from a minimum of 2.63 work days to a maximum of 18.57 work days per mu per season.

The panel data set for the Malmquist index analysis, are cited from "The Cost and Income Collection of China's Agricultural Products" from 1997 to 2001. In the Malmquist index analysis, because the data of Fujian province is absent, there are only data from 14 provinces. We make all Malmquist index averages be geometric means over 14 important soybean production provinces in China. Thus, any zero Malmquist index of any province in any year will be exhibited by a zero Malmquist index average.

Variable	Sample mean	Standard deviation	Minimum value	Maximum value
Output(kg)	124	29.9	62.09	196.07
Labor(days)	8.2	3.05	2.63	18.57
Machine(yuan)	10.84	9.58	0.79	40.44
Fertilizer(kg)	5.55	2.62	1.25	10.47
Seed(kg)	6.8	1.65	3.43	10.87

Table 2. Summary statistics for variables in the DEA model



Figure 3. The locations of 15 provinces in China

Results of CRS/VRS DEA analyses

In China, it is well noted that most soybean farmers carry out extensive culture system in small household farms, and even in nation-owned large soybean farms the production operation is generally conducted under the semi-intensive system. According to a survey completed by China's government, the average cost of soybean production in China is 7% -13% higher than soybeans produced in US. The yield of soybean produced in China is only about 1600kg per hectare, but the yield of soybean produced in US is higher than 2500 kg per hectare. From above discussion, it can be safely concluded that the proportion of intensive soybean farms is quite low in China. In other words, in China, there exists great potential for increasing soybean production through improvements in technical efficiency. Table 3 depicts the frequency distribution of the estimated technical efficiency and scale efficiency scores for the soybean samples in China. Apart from some fully technically efficient samples in the model, the estimated technical efficiencies range from 36.8% to 98.5%, with a mean technical efficiency level of 83.2%. There are only three samples whose estimated technical efficiency scores are 50% or below. Besides 18 fully technically efficient samples, another 18 estimated technical efficiency scores range from 60% to 80%. In fact, of 18 fully technically efficient samples 16 samples are samples averaging over about 1500 real surveyed farms collected in 6 provinces(HeiLongJiang, JiLin, LiaoNing, Hubei, Yunnan, and AnHui). Furthermore, three low TE score samples(below 49%) are all from ShanXi province, representing whose soybean productivity should be essentially promoted in the future. From table 3, the scale efficiency scores are mostly range from 80% to 99% and only one scale efficiency score is lower than 80%. The average scale efficiency of these samples is around 94.4%. In these samples, according to estimate result, 12 samples are operating in the areas of constant returns to scale, 22 samples are in the areas of decreasing returns to scale, and 11 are in the areas of increasing returns to scale. The 12 constant returns to scale(CRS) samples are mostly from HeiLongJiang, JiLin, LiaoNing, AnHui, ShanDong, HuBei, and YunNan provinces, and 11 increasing returns to scale(IRS) samples are mostly from HeiLongJiang, LiaoNing, AnHui, and HeNan provinces. In fact, presently, the fragmentation of cultivation induced by the Household Responsibility System and intensive population is the most important reason for low productivity and efficiency in agricultural production system in China.

In addition, according to DEA estimate result, the mean values of four input slacks are 0.627(days), 0.191(kg), 1.335(yuan), and 0.139(kg) separately.

Based on above analysis, we calculate the profit variation using function (3). From figure 4, it is manifest that, besides 18 fully technically efficient samples, the target profit variations range from 3.29 to 216.29 yuan. There are only three samples(two from HeNan, one from FuJian) whose profit variations are lower than 50 yuan and there are 16 samples(three from HeBei, three from HuNan, two from ShanXi, two from JiangSu, two from ShanDong, two from YunNan, one from NeiMeng, and one from FuJiang) whose profit variations range from 51 to 150 yuan. 8 samples whose target profit variations are higher than 150 yuan come from ShaanXi, NeiMeng, JiangSu, and FuJiang.

Efficiency Dange	Number of Observations			
Efficiency Kange	Technical Efficiency	Scale Efficiency		
0.30-0.39	1	_		
0.40-0.49	2	1		
0.50-0.59	3	_		
0.60-0.69	5	_		
0.70-0.79	8	_		
0.80-0.89	5	7		
0.90-0.99	3	25		
1.0	18	12		
Total	45	45		

Table 3. Technical and scale Efficiency of Soybean Production in China



Figure 4. The frequency distribution of profit variation Unit: Yuan(RMB)



Figure 5. The frequency distribution of profit efficiency

In addition, the profit efficiency is estimated by calculating the proportion of real profit to target profit under the assumption that farms are operated at the full technical efficiency. Figure 5 depicts the frequency distribution of profit efficiencies of 15 provinces in China. It can be found that there is a negative value in the figure5 representing the soybean farmers in ShanXi province may suffer loss in operation. Most profit efficiency values range from 0.3 to 0.7 representing low profit efficiencies in China's soybean production. Thus, it can be concluded that there still have a large space for profit improvement in China's soybean production.

Estimated result of Malmquist index analysis

Although above analyses can provide technical efficiencies and scale efficiencies of China's soybean production, they are all based on the spatial data. Therefore, in addition to above discussion, we also analyze panel data and estimate their Malmquist indices. The Malmquist index of productivity change makes it possible to assess the changes in TFP. A value larger than 1 for the Malmquist index, or any of its components indicates an improvement in productivity or efficiency. A value smaller than 1, indicates deterioration. The average growth rate is the difference between the measured index and 1.

Because the Malmquist Index of HuBei province from 1996 to 1997 is zero, the geometric means of Malmquist Indices over 14 provinces are zero. It is highlighted in the table 4 that the Malmquist Index and Technological Change averages from 1996 to 1997 are the geometric means of only 13 provinces. Furthermore, the zero Malmquist Index from 1996 to 1997 may come from the impact of the flood in 1997 in some provinces of China which can destroy the soybean and other crops. In fact, it was manifest from table4 that the Malmquist Index average of other 13 provinces from 1996 to 1997 was only 0.781, the lowest index in the table4. Thus, from this Malmquist Index, the soybean production of China in 1997 was seriously suffered from the flood of this year. However, even without the Malmquist Index average from 1996 to 1997, the geometric mean of other five Malmquist Index averages from 1994 to 2000 was only 0.991, representing a weakly decreasing soybean production capacity in these years. In addition, the average decreasing rate of Malmquist Index is about 0.9%. From table4, we could discover that this decreasing trend might come from technological change and from 1997 to 2000 the technological change indices had been continuously lower than 1, representing a consistent technology decline. The estimated results of TE change suggest that only in 1997-1998 and 1999-2000, technical efficiencies were increasing. The average growth rate of TE change from 1994 to 2000 is negative, indicating a decreasing technical efficiency in the long term. The SE change in table4 shows a weakly increasing scale efficiency, but the growth is too slow.

Discussion and policy implications

Although the present study includes only 15 provinces in CRS/VRS analysis and 14 provinces in Malmquist analysis, it is still able to suggest some policy measures based on

this study. The findings reveal some useful characteristics of soybean production in China. The mean technical efficiency for the soybean farms in 15 provinces is estimated to be about 83.2%(VRS), which suggests that there should exist some potential for increasing soybean production in China through improved technical efficiency.

Year	CRS TE Change	Technolo- gical Change	VRS TE Change	SE Change	Malmquist Index		
1994-1995	0.914	1.026	0.996	0.918	0.938		
1995-1996	0.981	1.141	0.945	1.039	1.120		
1996-1997	0.996	0.784*	0.973	1.024	0.781*		
1997-1998	1.015	0.996	1.011	1.004	1.011		
1998-1999	0.961	0.951	0.930	1.034	0.914		
1999-2000	1.081	0.912	1.101	0.982	0.986		
*These data are the geometric means of only 13 provinces.							

 Table 4. Malmquist Index

The estimate results show that the farms of 15 provinces, on average, can increase their soybean production per-unit(mu) from 123.95kg/mu to 152.98kg/mu or 123.4% if all farms were able to operate at full technical efficiency¹. Moreover, at full technical efficiency, the profit of soybean farms in these 15 provinces can be improved by 70.29 yuan per mu averagely. Generally, the increasing profit may instigate soybean farmers to expand the production scale. Thus, if the farm can be operated at full technical efficiency, the planted area and inputs will be raised with the increasing profit. To specify the relationship between scale efficiency and profit, we make a simple regression between scale efficiency and profit. The t statistic of profit is 1.87 and its coefficient is 0.0005. Thus, although the impact of profit on scale efficiency is not substantial, it surely has positive impact on scale efficiency in China's soybean production and if the profit can be improved by 100 yuan the scale efficiency will be increased by 0.05. According to previous estimate, the average of target profit variation is about 70.29 yuan per mu and the average scale efficiency is about 0.944. Thus, if the soybean farms can be operated at full technical efficiency the average scale efficiency may be increased to 0.979. Presently, as a result of limited domestic production level and increasing demand for soybean consumption, the China's government should recognize the need to use profit stimulation instead of government regulation. One way to increasing profit is to reduce the agricultural tax and obligatory payments imposed by central government and local government separately.

On the other side, even though the profit can be improved substantially in China's soybean production and the farmers would be stimulated to expand the planted scale of soybean, the planted area of soybean can not be enlarged sharply because of relative scarce of agricultural land and fragment of land blocks. There are some methods, such as

the agricultural industrialization, proposed recently to solve the problem induced by the fragment of land blocks. By adopting agricultural industrialization, farmland within affected villages was reassigned and combined according to the plan of the new farmer and processing plant organization. However, although, farmers and local officials welcomed the agricultural industrialization as a way of overcoming land fragmentation and raising incomes, such method required highly systematized farmer organization and the incorporation of processing companies both of which are unfeasible things in China presently. In fact, in poorer areas in China adopting the agricultural industrialization is only an unrealistic slogan for poverty and underdevelopment.

The problems mentioned above together with the raised contract payments imposed by the local officials make the sharply improvement of China's soybean production difficult unless some innovative approaches, such as the application of GM seed, are used in China's soybean production system.

In addition, China's government want to make China become a main exporter of GM free soybeans. In relation to China's soybean exports, it can be found that amid worldwide concern over the safety of GM foods, China's non-GM soybean has been on an edge. In fact, import traders in Japan and South Korea express to expand soybean importation from China due to prevalent wariness to GMO products(Zhang et. al. 2003). Therefore, for success in the soybean trade and some other factors, China is one of those countries that tend to avoid using GM soybean seed. The Ministry of Agriculture announced recently that China's government planned to turn its northeast region into the world's largest producer of non-GM soybeans in five years. Therefore, it is manifest that the China's soybean production may not be able to improved substantially in recent years because of China's non-GM soybean policy. But with the rapidly increasing domestic demand for soybeans. In this case, a discrepancy stands between government's policy and China's real production capacity.

Conclusion

The paper has explored the soybean production system in China. It investigates the technical efficiency, scale efficiency, profit efficiency, and Malmquist index of China's soybean production, and also provides an overview of some problems surrounding soybean production system in China. After the paper reviews soybean production and the demand change in China, it has been proposed that the improvement in technical efficiency of soybean production is indispensable for the increase of soybean output and, in turn, satisfy the domestic demand for soybean. The estimated result of DEA model shows that technical efficiency of China's soybean production is not high, and in some provinces it is extremely low. According to the profit efficiency analysis, the increasing of TE in China's soybean plant system can improve the profit of China's soybean production activity. Furthermore, the results of Malmquist index analysis indicate a weak technological regress.

From this paper, it can be discovered that the level of China's soybean production capacity is rather low now and the present yield can not satisfy the domestic demand. The essential approaches to improve China's overall soybean production depend on the improvement of farm size or the introduction of high-yield varieties of soybean such as GM soybean in the short term. However, such methods are difficult to be implemented for the policy of China's government. Therefore, it is clear that China will continue to import soybeans including GM soybeans to satisfy the domestic demand in the future.

Notes

However, even though the total output of soybean in China would have been increased by 23.4%, there would still exist an enormous gap between the demand and production.

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