International Journal of Smart Home
Vol. 10, No. 5 (2016), pp. 93-104
http://dx.doi.org/10.14257/ijsh.2016.10.5.10

Research on the Development Efficiency of Family Farm based on DEA Model: A Case Study

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Abstract

In this paper, through the actual investigation of the production and operation in the main grain producing areas, the authors collected data from 89 farms in Northeast China. This paper first describes the individual characteristics of the family farm operators, the size of the land and the circulation of the farm, the situation of the farm to obtain funds and information services. Then we estimate the development efficiency based on the DEA model, by using the survey data. The results show that family farm business process is lack of new agricultural technologies; family farmers' management ability is weak, the factors of production inputs such as unreasonable causes share of the family farm in Northeast DEA efficiency is low. In order to develop the efficiency of the family farm, government should put forward and optimize the land circulation system, pay attention to the quality of the family farmers, and improve the agricultural technology extension system, optimize the allocation of production factors.

Keywords*: Family farms; development efficiency; DEA model; empirical analysis*

1. Introduction

Family farms are usually refers to family members as the main labor force, engaged in agricultural scale, intensive, commercialized production of business entities, the agricultural income as household income is the main source [1-2]. Central document first time note that the family farm in new agricultural business entities, and government should encourage and support the family farm land transfer. 2014 central document emphasizes increase the intensity of education training of new agricultural business entities of the leader and encourages local government private investors to provide loan guarantees for new agricultural business entities. In 2015, central document put forward the "family farm support service system", 2016 central document again called actively cultivate new agricultural family farms and other business entities. The "family farm" appeared in the central document for 4 consecutive years, indicating that the country attaches great importance to the family farm the degree of development of new agricultural business entities. From the view of quantitative research of family farm efficiency problem, analysis of factors influencing the development of family farms to improve the efficiency, has a strong practical significance.

At present, the research on the efficiency of family farms, foreign scholars started earlier. Kislev (1982) through empirical research pointed out that the ratio of labor cost and machine cost is the main factor to determine the scale of the development of family farms, reveal the 1930-70 in American family farm scale long-term rapid growth of reason [3]. Cornia (1985) selected 15 developing countries in FAO family farm data, using the Cobb - Douglas production function analysis of the elements of different size of the family farm investment, in land productivity and labor productivity between the

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ISSN: 1975-4094 IJSH

relationship, pointed out that the small scale farms due to land intensive use has a higher return rate [4]. Singbo & Lansink (2010) use DEA nonparametric method, constant returns to scale in the background, to Benin area 56 small family farms research, results show that 78.1% of the total farm low efficiency, technical efficiency and scale efficiency low accounted for 9.3% and 11.7%[5]. Tomas (2014), selected 200 family farm in 2004-2009 years of data, the bias correction Malmquist method to analyze the influence of productivity index of total factor productivity, the study found that planting mixed farm land productivity and input-output rate highest [6]. Liu (2009) in agricultural use as the input indexes, the empirical analysis of the Liaoning Province 72 households family farm economies of scale, the results of the study are: Liaoning Province, most of the family farm does not exist significant scale effectiveness and technical effectiveness, and points out the operating area of 133.33hm2 family farm for the moderate scale management [7]. The family farm in China's economic efficiency, social efficiency measured by He Jin (2014), combining the theory and practice of research methods, and points out that our existing system arrangements do not meet the needs of the development of family farms, should accelerate the establishment of a diversified supporting service system [8]. Cai Jian (2014) will be family farms and farmers and hired farm the three were compared, respectively, from the formation mechanism, development status and empirical research angle to carry on the analysis, draw the conclusion: among the three, family farm operation efficiency is higher, but there are still input redundancy and output problems such as low efficiency phenomenon [9]. Yu (2015) to the stochastic frontier analysis method to study the operating efficiency of the family farms in Fujian and that small and large scale farms achieve optimal operation efficiency, the family farms in Fujian has to get rid of seeking development to expand the scale of the traditional way [10]. Scholars believe that the impact on the efficiency of the family farm factors include: the comprehensive quality of the farmers, the size of the family farm, agricultural investment quantity, land system, rural financial conditions, agricultural social service system and government support policies [7-14].

In research methods, foreign scholars earlier the empirical study is applied to the family farm efficiency analysis, and domestic scholars multi from the perspective of qualitative analysis, there are a few scholars use the method of quantitative analysis to research the development efficiency of the family farm, but the study area for Southern grain producing areas, land resources condition, productivity level and the family farm scale were and major grain producing area of northeast, have bigger difference, there is no scholars from quantitative angle, using covers land input, input productivity, investment index system of major grain producing area of northeast planting family farm development efficiency were studied. In this paper based on the spot investigation data as the foundation, using DEA model from the angle of quantitative analysis of the efficiency of the major grain producing area of northeast family farms, the factors restricting the influence of family farm development efficiency and to accelerate the rapid and healthy development of major grain producing area in Northeast China and even the whole country family farms has important significance.

2. Literature Review

2.1. Family Farm

Foreign family farm development early time, the Dutch family farm in the early 19th century has achieved professional development, the family farm has been 200 years of history, and our country also has the small peasant economy of Japan also in the early part of the 20th century development of the lot size is relatively large family farms. Dacian ciolos (2014) at the annual meeting of the international family farms that family farm diversity is a trend of the world agriculture development. The sustainable development of

family farms has contributed to the rural areas of social, economic and environmental sustainable development. In Japan and South Korea, is small relative to the representative of the traditional agricultural country family farm scale, intensive production is obvious; in France on behalf of the European part of the country size of the family farm belongs to the medium, the degree of specialization is relatively high; and in U.S.A., Japan, Britain, Germany, Australia, as the representative of the people much less, the family farm much to large-scale farms mainly showed engaged in agricultural production specialization, mechanization and scale. Comprehensive view, although the traditional national foreign person much ground is little, the national family farm development in a certain extent than less much, but the family farm development still exist many problems, the family farm in the allocation of resources, output efficiency, profitability as well as to protect the environment is still subject to a concern of many scholars. Peluffo (2014) put forward model-aided project through the study found that many farms are the deterioration of soil quality, labor productivity is low, leading to high workload and low income farmer family farm. In this paper, the key factors of sustainable development of family farms, including farmer's education level, farm size, capital investment and farm business objectives, such as and create the family farm succession planning.

At present, there are many problems in China's agriculture development, land fragmentation business; farmers decentralized management, low return of agricultural production, the contradiction between small farmer and big market intensified. Farmer cooperatives development is thunder, little rain, from 2007, the state promulgated law on farmer professional cooperatives since, in many areas established bits and pieces of professional farmers cooperatives, really play a role, but very few. The development of leading enterprises is in pursuit of profit maximization principle ignores the ecological benefit of agriculture, the agricultural development in the area of become unsustainable, the farmland soil damage is serious. In all sorts of problems behind new agricultural business entities, in contrast, family farm has the sprout and development of realistic conditions and theoretical basis. Many domestic scholars not only summarize the actual conditions of the family farm, but also explain the advantages of the family farm compared to other business entities from the theoretical level. In-depth analysis of the advantage of the family farm production and points out that the scale of family farm is relatively large, there is conducive to the use of agricultural production technology, operators of family farms to family members as the main labor force than the efficiency of large-scale farm workers more high, the family farm management is the annual production plan for the formulation and implementation of more convenient.

2.2. The Elements of the Family Farm

At present, our country agriculture management system is based on the household contract management, unified and decentralized management system. Land ownership, contract rights, the right to use in the hands of different subjects, the ownership of the land belongs to the state and collective all, farmers have land contract right and the right to the use of, and right of contracting of land and the right to use and belong to different business entities. At present, about the land contract rights and the right to use mostly in the hands of the farmers. Therefore, family farms mainly want to the expansion of farm size must be from the farmers to transfer land use rights, so as to enhance the labor productivity in the family farm, lay the foundation. On the other hand, the improvement of land production efficiency is reflected in the intensive management of family farm production, including labor intensive and capital intensive technology and so on. Therefore, in addition to improving the labor productivity of the family farm, it is also the key to increase the efficiency of the land production to strengthen the agricultural investment, technological transformation and management level of the farm. Its specific measures mainly include: the implementation of mechanization, the use of advanced science and technology, strengthen water conservancy and other agricultural

infrastructure construction. In fact, enhance agricultural output efficiency of these specific measures if all by family farms to achieve does not necessarily maximize the income of farmer family. Therefore, family farmers can through the existing agricultural socialization service system realize part of the production chain outsourcing service is provided, thereby reducing the cost of production of the family farm.

Agricultural capital plays an irreplaceable role in the process of agricultural production. The use and allocation of capital in agriculture has its own unique characteristics. As the agricultural production cycle is longer, the capital in agriculture also showed a longer running cycle and relatively slow turnover rate. The seasonal nature of agricultural production determines the seasonal agricultural capital movement, only to the harvest of the season in order to achieve the recovery of agricultural capital. Agricultural natural risk and economic risk determine the high risk of agriculture, so agricultural capital also showed great instability. Agricultural products with the two kinds of production materials and information of the use of the agricultural capital cannot be completely transformed into the form of agricultural capital in the form of currency. In summary, a sound social service system, strengthen agricultural infrastructure construction and so on is based on the capital production factors of family farm cultivation of effective path.

3. Research Design

3.1. Research Object

In 2013, the Ministry of agriculture Statistics survey of the number of family farms in China, a total of about two to one, the operating area of about two acres of arable land. Among them, the number of family farms in Heilongjiang Province reached 1.3 million, the number of family farm in Jilin Province reached 2.1 million, in Liaoning Province, the number of family farms and 0.14 million, the business of 36.6 million mu of arable land, average operating area of 283.5 acres, Inner Mongolia number of family farms and 1.4 million, operating land area 487.14 million mu, the average operating area 334.04 acres. At present, the four northeastern provinces (autonomous regions) have been issued for the relevant standards family farms identified. Among them, provisions of the scale of planting in Heilongjiang Province in more than 200 acres, planting scale in Jilin Province without specific provisions, Liaoning Province planting scale for more than 100 acres of, Inner Mongolia area requirements of planting of the size of the family farm is 10 to 15 times of ordinary farmers, comprehensive four provinces on the family farm scale defined standards, selected in the empirical analysis of sample land scale minimum 100 acres and uncapped.

3.2. Data Sources

The data obtained by the author to follow the group on the northeast region of the family farm field sampling survey, because of the northeast region, the number of family farms, a very wide range, greatly increased the difficulty of the research. The article to the cultivation of family farm as the research object, selected in the Northeast eight major grain producing counties, 13 Township family farm research, questionnaires were distributed 156, recycling 147, which is suitable for the development efficiency analysis of sample 89.

The individual characteristics of the sample family farm operators from the point of view of the structure of gender (see Table 1), the number of male farmers in the survey for 87, accounting for general survey of 97.76%; the number of female operators rare, and only two women farmers accounted for research object of 2.24%. From the point of view of age structure, age of family farmers surveyed showed young, average age is 45.88 years, 30 years old the following family farmers have six accounted for than 6.74%, and more than half of the farmers the age distribution in 31-45 age. From the point of view of

culture, 58.93% farmers only junior high school (secondary) culture, with farmers in the high school and college and above accounted for than 26.97% and 6.74%, cultural degree of northeast family farmers still need to improve. On 89 farms, 30 family farmers also served as the village of the village cadres, the proportion reached 33.71%.

Table 1. The Individual Characteristics of Family Farmers

Index feature		Quantity (unit)	proportion (%)
Gender	male	87	97.76
	female	2	2.24
Age	16-30 years old	6	6.74
	31-45 years old	47	52.81
	46-60 years old	34	38.2
	61-70 years old	2	2.25
education	Primary school	11	12.36
	Junior high school	48	53.93
	high school	24	26.97
	College and above	6	6.74
Village cadres	yes	30	33.71
	no	59	66.29

Family farm land management and circulation sample 89 family farms operates a total land area of 21222 acres, average operating area of 238.45 mu, transfer of land area 18373 acres, household land transfer 206.44 acres, the circulation area accounted for 86.5% of the total operating area, higher degree of land circulation, the number of average farm plots for 8.06, land dispersion degree is higher (see chart 2). More than half of the farm business area distribution in the range of 100 to 200 mu, 37.08% of farm size distribution in the 200-500 mu, land the size of more than 500 acres of farm only 8 (8.99%), so, to summarise, smaller family farms in sample areas and need to optimize the land transfer system, help farms expand business scale.

Table 2. Family Farm Size and Land Transfer

area	Quantity	total cultivated area	Transferred area	Averaged flow area	Averaging block number
More than 1000	2	2100	2000	1000	10.4
500-1000	6	3660	3612	602	10.3
200-500	33	9100	7788	236	8.15
100-200	48	6362	4973	103.6	7.5
total	89	21222	18373	206.44	8.06

The family farm acquiring funds and information service in the source of funds for production (see Table 3), was investigated in 89 family farm with its own funds (66.11%) as the main production source of funds, followed by bank or credit union loan (26.45%), otherwise 4.96% production funding sources in government projects support funds, only a small part of the farm (2.48%) in the process of raising funds need to borrow money from relatives and friends. Family farm there are five ways of agricultural technology information acquisition: own experience or self-study, agricultural technology extension station training and guidance, to agricultural dealers consulting, government propaganda department, other ways (with relatives and friends exchange, radio, television, newspapers) and 23.91% of farmers on their own experience of cultivation and

management, 39.13% farmers received Township Agricultural Technology Extension Station training or guidance, 13.04% of the farm through to the agricultural dealers ask for information technology, otherwise 6.52% and 17.39% of farms by government propaganda and other ways to get agricultural information technology.

Table 3. Sources of Funds and Information Services of Family Farm

characteristics		Proportion (%)
Sources of funds	Self financing	66.11
	Loans from banks	26.45
	friends borrowing	2.48
	Financial support fund	4.96
Access to information services	Own experience	23.91
	Technology Extension Station	39.13
	Agricultural dealers	13.04
	Government propaganda	6.52
	Other ways	17.39

4. Empirical Analysis

4.1. Model Selection

Data envelopment analysis (DEA) is a kind of analysis method based on is the evaluation object is relatively non parametric technology efficiency, is firstly proposed by American Charnes, Cooper and Rhodes in 1978. The DEA model can be used to evaluate and calculate the efficiency and the input and output of the family farm in different types and different regions. Calculation is a basic principle: each was evaluated in terms of the sample family farm as a decision making unit (DMU), for all decision making units do development effectiveness evaluation. The evaluation results reaction is the relative efficiency of decision-making units. With n DMU, each DMUj has M type and S type input output, Xj means input, Yj means output.

$$X_j = (x_{1j},\ x_{2j},\ \ldots,\ x_{mj})^T$$

$$Y_j = (y_{1j},\ y_{2j},\ \ldots,\ x_{sj})^T,\ j = 1,\ 2,\ \ldots,\ n$$

$x_{ij} > 0$represents the first I input of the j decision making unit yij>0; DMUj represents the first R output of the DMUj; among them, i=1,2,... R=1,2; m,... , S.

DEA evaluation model for:

$$\begin{cases} \min\theta = V_D \\ \sum_{j=1}^{n} \lambda_j X_j + S^- = \theta X_0, \\ \sum_{j=1}^{n} \lambda_j Y_j - S^+ = Y_0, \\ \lambda_j \geq 0,\ j = 1,\ \ldots,\ n \\ S^- \geq 0,\ S^+ \geq 0. \end{cases}$$

Yj, Xj respectively means input and output indicators, said the weight coefficient of the first j indicators, θ said the development of the efficiency value of the calculation, S^+ and S^- is the representative of the slack variable. When θ =1 and S^+=0; S^-=0, the evaluation of

the DEA is DMU effective; when $\theta < 1$ and S^+, S^- at least one is not 0, the DMU is evaluated DEA is invalid.

4.2. Index Selection

In the concrete application of the DEA model, there are two forms, which are input oriented and output oriented. The input oriented means that the input is minimized under the current level of output, and the output is the direction of the output to maximize the output. There is no essential difference between these two forms. In this paper, we choose the input as the guide when we measure the efficiency value of the family farm. In the analysis of DEA model, the number of DMU is not less than 2 times of the input and output indicators. The number of the 89 decision making units is much more than that of the standard. Table 4 is the index to evaluate the efficiency of the family farm.

1) ***input indicators*** : family farm land management scale, production cost and labor input. Family farm scale management of land is refers to the production and operation of the land area of the family farm, planting family farms including family farmers own land including through other means (contracting, swaps) to obtain the land, unit of measurement of the indices for mu. Production cost refers to the family farm production management cost, mainly including seeds, pesticides, fertilizers, management fees and other expenses. Labor input includes both family labor input also include employee involvement, including crop harvest and field management in the amount of labor, labor input indicators measured in hours, namely a labor a day to remember for an hour.

2) ***Output indicators:*** family farmers are more concerned about the actual income of the family farm, and income mainly through crop yield and value to reflect. Because the family farm planting varieties, output gap between different varieties of a single species is not only larger, from the overall efficiency of the reaction of family farm. Therefore, the choice will be the diversification of family farm business gross income and crop production as output indicators to measure the efficiency of its development; the total income does not include labor migrant workers' income and other rental, interest and property income.

Table 4. Input and Output Indicators

index	variable	unit	Observed value	minimum value	Maximum value	average value	standard deviation
Input	Land input	Mu	89	100	1100	238.45	155.406
	Labor input	hours	89	30	540	178.55	105.991
	Productive cost	element	89	8300	1124200	145783.56	165331.285
Output	Annual output	kg.	89	39000	1600000	274637.98	273419.982
	annual income	Yuan	89	50160	1346000	235056.78	230126.097

The survey data analysis shows that the sample scale family farms selected from 100 acres to 1100 acres ranging, accord with the standard definition of the family farm, the average size of each farm is 312.91 acres. Because of the individual farm land scale is large, resulting in the production cost, labor cost and other aspects of the investment there is a huge difference, at the same time, the family farm output and income has significant difference.

4.3. Family Farm Efficiency Analysis

By Using DEA software, oriented model based on input, respectively from three aspects: technical efficiency, pure technical efficiency and scale efficiency of major grain producing area of northeast family farm development efficiency were analyzed, the results are shown in Table 5 shows.

Table 5. The Distribution of Family Farm Development Efficiency

Range	Total technical efficiency		pure technical efficiency		Scale efficiency	
	number	proportion	proportion	proportion	proportion	proportion
≤0.4	0	0.00%	0	0.00%	0	0.00%
0.4~0.5	2	2.25%	0	0.00%	0	0.00%
0.5~0.6	5	5.62%	1	1.12%	0	0.00%
0.6~0.7	11	12.36%	7	7.87%	3	3.37%
0.7~0.8	14	15.73%	12	13.48%	10	11.24%
0.8~0.9	27	30.34%	17	19.10%	6	6.74%
≥0.9	21	23.60%	26	29.21%	57	64.04%
=1	9	10.11%	26	29.21%	13	14.61%
total	89	100.00%	89	100.00%	89	100.00%
average value	0.822		0.890		0.923	

Note: total technical efficiency = pure technical efficiency * scale efficiency

1) ***Total technical efficiency:*** family farm total technical efficiency is refers to the family farm in the operation of the land, capital and labor force to achieve the maximization of income. Sample, only nine DEA effective family farm (technical efficiency, pure technical efficiency and scale efficiency values are 1), accounting for 10.11% of the total number of samples, DEA efficient representation the farm input and output reach the best effect, namely in the existing input output reached a maximum. The lower proportion of the effective farm shows that the current development of the family farm has a larger space to upgrade, which requires a reasonable configuration of the elements.

2) ***Pure technical efficiency:*** the total technical efficiency of the family farm to remove scale efficiency after the income for the pure technical efficiency, can be used to determine whether the input and output elements of the existence of redundancy. The size of pure technical efficiency reflects the level of labor, land and capital investment of the family farm, and the existing management and technical level. According to the estimation results of the DEA, the pure technical efficiency effective (pure technical efficiency value equal to 1) farm number reached 26, accounted for than 29.21%, indicating that the family farm production factor inputs play a good role in the existing scale and 63 other family farms in pure technical efficiency is invalid. Description of the sample area family farmers rarely accept related skills training, lack of understanding of new agricultural technology, new equipment, new varieties. Lack of effective use of new technology in agriculture during the operation of the family farm, also operators management capacity is weak, resulting in the low pure technical efficiency of the part of the family farm.

3) ***Scale efficiency:*** scale efficiency is the ratio of the overall scale efficiency and pure technical efficiency, which is used to determine whether the scale is optimal or not. When the family farm scale efficiency, the operating situation is the best, at

this time to maintain the existing scale; when the family farm scale efficiency is invalid, according to the situation to adjust the operating scale. From Table 2, we can see that the number of family farms in the scale efficiency is 13, the proportion is only 14.61%, and the remaining 85.39% of the family farm is in an invalid state of scale efficiency. But overall, the average scale efficiency is 0.923, and only 3 of the farm scale efficiency is less than 0.7, which shows that the size of the majority of the family farm is close to the optimal scale.

4) ***Returns to scale:*** in a sample of 89. 9 A DEA efficient family farms returns to scale in the invariant state, the remaining 80 DEA invalid family farm in, 37 in the stage of increasing returns to scale, indicating that the shortage of inputs; another 43 family farms in the stage of decreasing returns to scale, factor input too much. 37 in the scale of increasing returns to scale stage of family farm land scale are in the range of 100-200 acres, operating area of more than 500 acres of all samples of family farms are in the stage of diminishing returns.

Table 6. Distribution of Scale Return Period of Family Farm

Scale (MU)	Sample number	Increasing		Constant		Decreasing	
		number	Prop.	number	Prop.	number	Prop.
100~149	39	29	74.36%	7	17.95%	3	7.69%
150~199	18	8	44.44%	1	5.56%	9	50%
200~500	21	0	0%	1	4.76%	20	95.24%
More than 500	11	0	0%	0	0%	11	100%
total	89	37	41.57%	9	10.11%	43	48.31%

5. Conclusion

In this paper, we analyze 89 family farm development efficiency based on DEA model , on this basis, we put forward several policy suggestions, in order to help to improve the development efficiency of the major grain producing area of northeast family farms, fast realization of agricultural modernization.

First, improve the land transfer system. The formation of family farms cannot be separated from the land transfer; therefore, the land transfer is the first step in the development of family farms, but also the most important step. In Qiqihar Baiquan County research, family farmers said the land contract period is short, relational contracting instability, flow into the plots are too scattered are hindering the development of farm, and the local government has not yet been introduced effective transfer of land policy. Government in the development of land transfer related policies, both to take into account the fairness of farmers and to take into account the output efficiency of land. By innovating the land transfer mode, constructing the land circulation consultation platform, can effectively increase the information transparency in the process of circulation, reduce the cost of the land circulation of the family farm.

Second, government should pay attention to the cultivation of high quality family farmers. In any organization, the "people" are at the core of the family, the overall quality of the farmers to determine the prospects for the development of the farm. First, improve the production skills and management capabilities of existing home farmers. Research found that years of farming experience is the commonness of all farmers, but easily lead to narrow when faced with the problem of "empiricism", business ideas. Through conferences, seminars and other training methods, the farmers to promote new agricultural technology, new management concept can not only improve the farmer's cultural quality, professional skills, but also lay the foundation for the construction of modern agriculture. Second, increase the number of young family farmers. Encourage

agricultural college graduates who have returned to the countryside to form a family farm, young farmers on the market, the brand has higher sensitivity, will become the future agricultural development reserve strength.

Third, improve the level of family farm technology. Research found that the demand for new agricultural technology, new varieties of crops in every city of family farms are great, but existing agricultural extension way is single, to agricultural workers from time to time to home to family farmers technical explanation, this one to one mode although effect is good, but the number of agricultural workers lack the efficiency is very low. So the local government in addition to the establishment of the agricultural technology extension station should also strengthen scientific research institutes, the Province Agricultural University experts and family farmers docking, conduct regular technical training seminars. At the same time, it also promoted the transformation of agricultural scientific and technological achievements. Also enhance frontline extension staff working conditions to mobilize their enthusiasm for work, and attract excellent graduates of agricultural colleges and universities are engaged in the agricultural technology extension work, expand the agricultural extension staff.

Fourth, optimize the allocation of production factors, to carry out intensive management. The empirical results show that the input redundancy of production factors is the main reason that leads to the invalidation of the family farm. Excessive input usually occurs in the early stage of the development of the family farm, the family farmers blindly expand the scale of land or employment of labor. In the actual cultivation of family farms, it should be to the family farm development required, appropriate to reduce the land, capital, labor input, reasonable of configuration elements, reduce the daily operating costs of family farms, to avoid the production of waste of resources.

Acknowledgments

This paper is supported by the National Natural Science Foundation of China: “Economic impact of the commercial cultivation of Transgenic Herbicide Resistant soybeans in China”(71303038); The humanities and social science fund project of the Ministry of Education: “The evaluation of the development efficiency of the family farm in the main grain producing area of Northeast China and the research on its path and policy”(14YJC790157);Philosophy and Social Science Foundation of Heilongjiang Province: “Study on the cultivation and development of new agricultural production and management main body in Heilongjiang province”(14C032).

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