

Evaluation on Input-output Efficiency of Land Consolidation Project Based on DEA --- A Case Study of Land Consolidation Project in Chongyang County, Hubei Province

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Abstract

This article studies four land consolidation projects in four towns of Chongyang County, Hubei Province, establishes system indexes for evaluation on input and output of land consolidation projects in all the four towns and employs DEA method to make an analysis of the relative efficiency of the projects in order to make an analysis of the actual efficiency of land consolidation, decide whether land consolidation is highly effective and point out a direction of improvement for higher land consolidation efficiency in the future. The result shows that the land consolidation in Qingshan Town and Lukou Town is ineffective and the land consolidation in Shaping Town and Baini Town is effective, with an average efficiency of 0.77. It proves that the overall efficiency of land consolidation in the four towns is at an upper-and-middle stream. Inefficiency is mainly manifested in cost of construction of a project, original equipment cost, other costs and redundancy of unpredictable costs, while increment of land use ratio, quantity of employment added per unit investment, rate of coverage of newly added green vegetation, newly added annual pure economic interests and yield rate of static investment have too low output. In order to enhance the efficiency of land consolidation, it is necessary to arrange all sorts of input in a reasonable way and pay enough attention to the output.

Keywords: Chongyang County, Land consolidation, Efficiency, DEA

1. Introduction

1.1 Research background

With continuous development of the economic society and acceleration of the pace of urbanization, quite of a large area of farming land has been converted to urban construction land and rural farming land is in great shortage. At present, rural land resources in China are in great shortage, land utilization rate is low, the output of land is low and land is used in an irrational way, which all bring about negative influences upon the ecological environment and seriously restrains supply of land. How to improve rural land utilization rate and resolve the problem of non-intensive use of land currently is extremely urgent.

1.2 Research purpose

Land consolidation is an effective measure to increase effective cultivated land area, realize dynamic balance of the total quantity of cultivated land area and guarantee sustainable utilization of farming land and is a means to improve land quality, increase land utilization rate and promote intensification of land. Positive land consolidation is of great importance to alleviate contradictions between man and land, improve agricultural production conditions and ecological environment and promote rural modernization construction and economic development.

This article studies and analyzes land consolidation in the four towns in Chongyang County, Hubei Province and breaks through the limitation of traditional land consolidation to just belong to construction work. Combining input of such expenses as land leveling capital, capital for construction of water conservancy works, capital for field path construction and other project capital in the report of land consolidation project with output of social benefits, ecological benefits and economic benefits after completion of land consolidation project which are regarded as input-output for DEA systematic analysis, this article discusses studies on efficiency of land

consolidation project, conducts a quantitative study on efficiency of implementing the project of land consolidation, assesses the project performance, determines whether the project is effective or not, explores reasons for ineffectiveness and provides guidance for the investment direction of land consolidation project.

As an effective measure to improve land utilization means, land consolidation is of great importance to improve land utilization rate as it can increase land output benefits to a large extent and promote all-round development of agricultural and rural economy, which is helpful for sustainable utilization and development of land resources.

1.3 Review of literature both at home and abroad

Foreign study about land consolidation started the earliest in Germany which, at the very beginning, emphasized the quantity of output of land, while it now concentrates on protection and improvement of agricultural and ecological environment (Ma Kewei, 1991). The Netherlands took into account the efficiency of land consolidation output from the three aspects of economy, society and ecological benefits in calculating benefits of land consolidation (Fan Jinmei, 2005). Land consolidation in Russia started in the 17th Century and special schools were opened for that. However, post project evaluation started earliest in US in the 1930s and post projection evaluation on land consolidation has the following several aspects in its developmental direction:

- (1) Diversified development of project evaluation content. Evaluation is transferred from the initial economic evaluation to diversified economic, ecological and social evaluation, etc.
- (2) Standardization development of project evaluation. Evaluation is transferred from the initial disperse and unstandardized evaluation to systematic and standardized institution evaluation relying on law and system.
- (3) Evaluation on all the processes related with investment. Evaluation is made on each stage and aspect in the process of the project, and each process of implementation of the project is supervised and managed and each index is analyzed.

Evaluation on efficiency of land consolidation project at home is just at an initial stage and has not received attention of relevant authority, let alone methods about post benefit evaluation of land consolidation project, which needs to refer to and extend other academic achievements that are studied from multiple aspects. Su Shaoqing used analytic hierarchy process to make an evaluation on the overall benefits of land consolidation; Wang Xu et al used the dynamic investment method to make a preliminary evaluation on the economic benefits of land consolidation; Chen Chao et al conducted further research about the evaluation concept and content of land consolidation project.

On the basis of the aforementioned studies, this article studies all methods used recently, selects objective, accurate and comparative research method, draws up relevant index system and studies post project efficiency of land consolidation in four towns in Chongyang County, Hubei Province.

2. Research Methodology

2.1 Proposal of DEA

In 1978, A. Charnes, W. W. Cooper and E. Rhodes proposed Data Envelopment Analysis (DEA) about relative effectiveness of Decision Making Units. Currently, DEA is the most effective method to evaluate a system of multiple index input and multiple index output.

2.2 Analysis of DEA

Assuming that the number of sections or units is n (termed as decision making units) and all of the n units have comparability. Each unit has m input variables and s output variables.

X_j and Y_j ($j=1,2,\dots,n$) respectively stand for input variable and output variable of the decision making unit j and v and u respectively stand for input weight and output weight. With the data given, we get V_{C^2R} , ω , μ through running of LINDO Software.

Definition 1: If $V_{C^2R} = 1$, $\omega = 0$, $\mu = 0$, in the model, then it is decided that this decision making unit j_0 is DEA effective.

Definition 2: If there exists the optimal solution $\omega > 0$, $\mu > 0$, in the model, and, $V_{C^2R} = 1$, then it is decided that this decision making unit j_0 is weak EDA effective.

Definition 3: If $V_{C^2R} < 1$, in this model, then it is decided that this decision making unit j_0 is DEA ineffective.

As for land consolidation project, DEA effective means that this project has relatively rational allocation of input elements and highly effective standard of output benefits compared with other projects.

2.3 Advantages of DEA

This article employs Data Envelopment Analysis (abbreviated as DEA) to make an evaluation on efficiency of land consolidation project. So far, there have been few studies about evaluation on land consolidation efficiency. This article is going to employ DEA that has been widely applied in intensive land use to make an evaluation on land consolidation project which has the following advantages: (1) DEA is of great objectivity. (2) Data processing in DEA is of great scientificity. (3) DEA has great advantages as a method studying multiple inputs and outputs.

3. Establishment of Index System for Evaluation on Land Consolidation Efficiency

Index system for evaluation on efficiency of land consolidation has to start out from the essence of land efficiency, take into full consideration of relevant factors influencing input and output of land efficiency, bring and apply the influencing critical factors into the evaluation method and finally get reliable and effective evaluation results.

3.1 Selection of system indexes

There are relatively a lot of index systems for evaluation on efficiency of land consolidation project. Thus, this article begins with reality of land consolidation, the report about land consolidation project, the fact of output of the project, the “input-output” theory and ecological economics theory and the evaluation system in research methods of academic papers and selects the following indexes as the index system for evaluation on efficiency of land consolidation project.

<Insert Table 1 here>

3.2 Explanation of selection of evaluation indexes

The evaluation indexes used in this article are an index system that is selected for study on efficiency of land consolidation project report under the theoretical model of the basic research method of “input-output” in DEA. In selection of indexes, repetition and leakage is avoided. The above indexes are obtained through appropriate screening with a combination of all literatures and relevant factors of input and output in the actual project and each index is given a relevant definition.

The above index system includes the two major index categories of input and output. Input index system consists of input of funds required for the entire land consolidation project, including cost of construction of a project, original equipment cost, other costs and unpredictable costs as well as labor costs in the process of input, taking into full consideration of input and use direction of capital in all the aspects. The output index system consists of the output benefits after input of capital in the entire land consolidation project, which summarizes the benefits of output from the major three aspects, namely, social benefits, ecological benefits and economic benefits. Social benefits contain increment of land use ratio, newly added cultivated area, number of persons supported by newly added cultivated area and quantity of employment added per unit investment, which, altogether, sufficiently reflect the output benefits of social benefits. Ecological benefits contain rate of coverage of newly added green vegetation, which applies the coverage rate of green vegetation to reflect the ecological benefits after a land consolidation project is completed. Economic benefits contain newly added annual pure economic interests and yield rate of static investment, which respectively reflect the economic benefits after a land consolidation project is completed. In the implication of indexes, we respectively manifest the representative implication and calculation process of each index.

4. Case Study of Chongyang County

This article selects Baini Town, Qingshan Town, Shaping Town and Lukou Town as the text, borrows the report data about land consolidation projects in the four towns and the survey data after the projects are completed as the foundation, employs land consolidation index system and analyzes efficiency of land consolidation project with the method of DEA.

4.1 General situation of the project area in Chongyang County

4.1.1 Natural environment condition in the project area in Chongyang County

Chongyang County is subordinate to a county of Xianning City, Hubei Province. It is in the southeast of Hubei province and at the junction area of Hunan, Hubei and Jiangxi. It's to the west of Tongshan County in Hubei Province, to the north of Xiushui County in Jiangxi Province, to the east of Tongcheng County in Hubei

Province and Linhu in Hunan Province and south to Xian'an and Chibi in Hubei Province. Now, Chongyang County has jurisdiction over the eight towns of Tiancheng Town, Shicheng Town, Guihuaquan Town, Baini Town, Qingshan Town, Jintang Town, Lukou Town and Shaping Town and over the four townships of Tongzhong, Gaoshi, Gangkou and Xiaoling. The project area is surrounded by mountains in the four directions, flat in the middle and has the particular geographic landscape of "three surroundings". Namely, it is surrounded externally by medium and low mountains, surrounded in the middle by hills and surrounded internally by flat farmland. This project area is at the junction area of internal and external surroundings of the basin of Chongyang.

4.1.2 Social and economic condition in the project area in Chongyang County

In the project area, the social condition is stable, the superior cadres and the public have close relations, citizens within the area eagerly hope that farmland capital construction can be fulfilled as soon as possible. However, it is beyond their capacity as a result of the weak economic condition. According to collection of "Statistical Data about the National Economy in Chongyang County in 2008", we get the following economic condition in the project area of Chongyang County.

<Insert Table 2 here>

4.2 Evaluation on anticipated efficiency of land consolidation project area in Chongyang County

This article collects the report data and survey data at a later stage on the land consolidation project implementation in the four towns of Qingshan Town, Shaping Town, Lukou Town and Baini Town in Chongyang County. Qingshan Town is the renovation project of low hilly land of Caidun, Shaping Town is the reclamation project of damaged arable land, Lukou Town is the basic farmland renovation project and Baini Town is the reclamation project of the damaged arable land in three villages, including Langkou. We get the following table by synthesizing the evaluation system.

<Insert Table 3 here>

We get the following results by running the above data through LINDO Software:

<Insert Table 4 here>

4.3 Analysis of anticipated efficiency of land consolidation project area in Chongyang County

We get the following table about specific DEA analysis of land consolidation in Chongyang County by synthesizing the above statement:

<Insert Table 5 here>

According to the running result of LINDO Software, it is known that the value of anticipated effectiveness of land consolidation projects in the four towns of Qingshan, Shaping, Lukou and Baini in Chongyang County is respectively 0.76, 1, 0.32 and 1, and the average value of the four towns is 0.77, an average efficiency value of the four projects better than average. $X1^-—X5^-$ and $Y1+—Y7+$ in Shaping Town and Baini Town are all 0, so the land consolidation of Shaping Town and Baini Town is feasible and effective. Efficiency of land consolidation in Qingshan town is 0.76. And through an analysis of the input-output data, it can be known that cost of construction of a project, original equipment cost and unpredictable costs are redundant, among which cost of construction of a project is much redundant, which indicates that input cost of Qingshan Town construction of ditch, path and channel of land consolidation is much, but has not generated the effect expected. The following several output indexes of land consolidation in Qingshan Town haven't had sufficient output under the influences of input indexes: increment of land use ratio, quantity of employment added per unit investment, rate of coverage of newly added green vegetation, newly added annual pure economic interests and yield rate of static investment. Thus, it is necessary to make great efforts in these output indexes to increase the annual economic interests and get the ideal high-efficiency effect. Efficiency of land consolidation in Lukou Town is 0.32, at an extremely low efficiency level. And except for the number of labor force for a project is not redundant, all other input indexes have redundancy, so it is necessary to allocate the capital rationally in the projects. Among the output index system, increment of land use ratio, newly added cultivated area, number of persons supported by newly added cultivated area, newly added annual pure economic interests and yield rate of static investment have not attained the specific requirements of output, and especially number of persons supported by newly added cultivated area is insufficient. Therefore, it is necessary for this project to increase the number of persons supported by the increment of cultivated land area. And the second is the newly added annual pure economic interests, which is closely correlated with the number of newly added cultivated land area. In general, there is still the need to increase the number of newly added cultivated land area in this land

consolidation project and its output benefits also need to be increased in terms of economy.

5. Conclusion

This article has set up an index system for the end investment and output at a later stage of land consolidation project, employed DEA to make an evaluation on efficiency of the indexes, established a new evaluation system and more appropriate methods to assess whether land consolidation project actually is of efficiency and the problems existing as a result of the inefficiency and offered a direction for development and improvement of land consolidation project, which is helpful for intensive utilization of land. Given the above case studies, we can come to the following suggestions:

Firstly, it is necessary to strengthen the utilization ratio of input capital. In an actual land consolidation project, we have to intensify requirements on the prophase planning and design and assess whether allocation of prophase capital input is proportionate so as to economize capital in all aspects and increase the utilization ratio of capital.

Secondly, through an actual DEA analysis, we get the value of K and analyze the economies of scale of the land consolidation project. Then, according to the economies of scale of land, we decide the direction for increase or decrease of land input and output and lay foundation for data required in the whole process of land consolidation.

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Table 1. Index system for evaluation on efficiency of land consolidation project

Type	Category	Index names	Index unit	Index implication
Input index	Input of funds	cost of construction of a project	ten thousand RMB Yuan	input of ditch, path, channel and so on
		original equipment cost	ten thousand RMB Yuan	input of all sorts of equipment
		other costs	ten thousand RMB Yuan	preliminary work, supervision and acceptance inspection, etc.
		unpredictable costs	ten thousand RMB Yuan	investment of funds in other emergencies
	Input of labor force	number of labor force for a project	ten thousand persons	the number of labor force involved in the land consolidation project
		increment of land use ratio	percentage	(area of the project area that has been used/scale of construction of the project) ×100%
Output index	Social benefits	newly added cultivated area	hectare	cultivated area after implementation of the project-the original cultivated area of the project
		newly added cultivated land ratio	percentage	(newly added cultivated area/scale of construction of the project) ×100%
		number of persons supported by newly added cultivated area	person	newly added cultivated area ×(the total population of the town where the project is conducted/the total cultivated area of the town where the project is conducted)
	Ecological benefit	quantity of employment added per unit investment	person/ ten thousand RMB Yuan	newly added quantity of employment of the project/total investment in the project
		rate of coverage of newly added green vegetation	percentage	coverage rate of green vegetation after land reclamation-coverage rate of green vegetation prior to land reclamation
		Economic benefit	newly added annual pure economic interests	ten thousand RMB Yuan
yield rate of static investment	percentage		(newly added annual net output of the project/the total investment of the project) ×100%	

Table 2. Relevant statistical table about social and economic data in the land consolidation project area in Chongyang County

Towns/project	Population (person)	Cultivated area (Mu)	Per capita arable land area (Mu/person)	Annual per capita income (RMB Yuan/year)
Qingshan Town	51960	42489	0.82	3733
Shaping Town	7668	6733	0.88	4893
Lukou Town	21059	24743.3	1.175	2921.4
Beini Town	13924	11098.5	0.803	4458.7

Table 3. Index value of land consolidation project in the four towns in Chongyang County

Indexes/project	Qingshan Town project	Shaping Town project	Lukou Town project	Beini Town project
cost of construction of a project (ten thousand RMB Yuan)	2633.8608	2472.1	1869.92	430.57
original equipment cost (ten thousand RMB Yuan)	9.9549	12.54	40.54	0
other costs (ten thousand RMB Yuan)	297.4536	260.49	298.03	51.21
unpredictable costs (ten thousand RMB Yuan)	58.6263	54.9	44.17	9.64
number of labor force for a project (ten thousand persons)	41.2	38.2	30.1	7.3
increment of land use ratio (%)	3.12%	4.79%	2.85%	3.08%
newly added cultivated area (hectare)	352.453	430.16	29.74	81.6
number of persons supported by newly added cultivated area (persons)	6465	7348	380	1535
quantity of employment added per unit investment (person/ten thousand RMB Yuan)	0.304	0.302	0.401	0.306
rate of coverage of newly added green vegetation (%)	3.12%	2.95%	5.32%	4.15%
newly added annual pure economic interests ((ten thousand RMB Yuan)	318.08	308.14	188.2	231.04
yield rate of static investment (%)	10.60%	8.02%	8.35%	47.02%

Data source: land consolidation report and survey

Table 4. DEA evaluation value of land consolidation project in the four towns in Chongyang County

Evaluation unit	Qingshan Town project	Shaping Town project	Lukou Town project	Beini Town project
θ	0.76	1	0.32	1
X1 ⁻	107.06	0	30.05	0
X2 ⁻	4.82	0	12.87	0
X3 ⁻	8.1	0	27.61	0
X4 ⁻	2.23	0	1.4	0
X5 ⁻	0	0	0	0
Y1 ⁺	0.08	0	0.01	0
Y2 ⁺	0	0	77.19	0
Y3 ⁺	0	0	1631.55	0
Y4 ⁺	0.73	0	0	0
Y5 ⁺	0.11	0	0	0
Y6 ⁺	477.93	0	114.57	0
Y7 ⁺	1.39	0	0.53	0
K	4.4	1	4.09	1
economy of scale	descending	unchanging	descending	unchanging

(θ stands for DEA effective, X1⁻——X5⁻ stand for cost of construction of a project, original equipment cost, other costs and unpredictable costs and number of labor force for a project in the input indexes, Y1⁺——Y7⁺ stand for increment of land use ratio, newly added cultivated area, number of persons supported by newly added cultivated area, quantity of employment added per unit investment, rate of coverage of newly added green vegetation, newly added annual pure economic interests and yield rate of static investment in the output indexes, and K stands for the sum of the weights of input indexes and output indexes divided by θ . Economy of scale is judged according to the value of K. If the value K is larger than 1, then the economy of scale decreases progressively; if the value of K is 1, then the economy of scale is unchanged. And if the value of K is smaller than 1, then the economy of scale increases progressively).

Table 5. Analysis of efficiency of land consolidation project in Chongyang County

Projects	Input indexes	Output indexes
Qingshan Town project	cost of construction of a project, original equipment cost, other costs and unpredictable costs (redundancy)	increment of land use ratio, quantity of employment added per unit investment, rate of coverage of newly added green vegetation, newly added annual pure economic interests and yield rate of static investment (insufficiency)
Shaping Town project	Effective	Effective
Lukou Town project	cost of construction of a project, original equipment cost, other costs and unpredictable costs (redundancy)	increment of land use ratio, newly added cultivated area, number of persons supported by newly added cultivated area, newly added annual pure economic interests and yield rate of static investment (insufficiency)
Beini Town project	Effective	Effective