Evaluating the development performance of agricultural biotechnology parks with Data Envelopment Analysis

Recebimento dos originais: 22/02/2019
Aceitação para publicação: 04/02/2020

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Abstract

Agricultural biotechnology parks present the critical role to link traditional agriculture and biotechnology industry. Agricultural biotechnology parks also actively tutor and approve stationed enterprises establishing agricultural biotechnology parks to become the feature different from other science-based industrial parks. Based on the National Agricultural Biotechnology Park data announced by Ministry of Science and Technology China Rural Technology Development Center, 13 national agricultural biotechnology parks are sampled as the research subjects. The research findings are summarized as below. Wuhan Agricultural Biotechnology Park presents the best overall efficiency (1.00), and the pure technical efficiency change of all technology parks is improved. Furthermore, it is discovered that the production technology in technological change between two phases of technology parks is improved. Finally, suggestions are proposed according to the conclusion, expecting to assist parks in developing agricultural biotechnology parks and constructing agricultural biotechnology parks business systems for the use of agricultural biotechnology industry and agriculture development to enhance corporate business interests and promote agricultural competitiveness

Keywords: Agriculture. Agricultural biotechnology parks. Strategic alliance. Agricultural biotechnology. Performance evaluation.

1. Introduction

With the economic development and trade liberalization, agricultural business can hardly precede market competition with the agricultural production; the input and support of other resources are necessary.However, the rapid development of agricultural biotechnology provides the important driving force for agricultural transformation. The development of agricultural biotechnology presents profound influence on the increase of agricultural production, the protection of natural environment, the treasure of earth resources, the enhancement of farmer welfare, and the improvement of the quality of human life. Nevertheless, agricultural biotechnology could not independent exist, but has to closely combine with traditional agricultural systems. Regarding the combination to develop agricultural biotechnology, it is necessary to promote and establish agricultural technology parks and tutor the production of farmers outside of the park in order to form the agribusiness agricultural biotechnology parks system for assisting traditional agriculture in transformation to enhance the overall agricultural competitiveness.

Cooperative alliance is increasing in business circles and has become a trend. The allied members specialize in the fields to make up the shortage and create mutual benefits so as to form the new appearance of the industrial competition. In industrial production chain, there are central factories and various subcontractors constructing the complete center-satellite operation system with the business model of mutualism. The government stresses on the development of agriculture, establishes agricultural biotechnology parks to promptly develop industry cluster effect, and drive the overall development of upstream/downstream industries. The establishment of agricultural biotechnology parks by farmers' groups could ensure the sources of materials, reduce investment costs, and focus on the research and development of technology, product innovation, and marketing, to further enhance industrial competitiveness, performance, and profits.

As a result, in consideration of the trend of strategic alliance and cooperation benefits, farmers accumulate individual peasants to form a production and marketing organization, which is built the alliance with agricultural biotechnology enterprises to development the agricultural biotechnology parks alliance for both parties benefiting in the industrial value chain. In this case, increasing investment and stationing of enterprises in parks, under the demands for agricultural raw materials, would assist the stationed enterprises and farmer groups in industrial alliance and construct the agricultural biotechnology parks business systems for the use of agricultural biotechnology and agriculture development to enhance

corporate business interests and promote agricultural competitiveness for the overall development of the industry. The establishment of agricultural biotechnology parks shows the specific characteristics of supporting the development of agriculture and driving agricultural transformation. Agricultural biotechnology parks therefore play the important role in connecting traditional agriculture and biotechnology industry and become the characteristic of agricultural biotechnology parks different from other science parks. Nevertheless, it is wondered whether the alliance and cooperation between farmers' groups and enterprises in parks would result in goal displacement caused by both parties cooperating for the subsidies. It is therefore essential to discuss the real demands for the development of agricultural biotechnology parks in agriculture and the factors as well as establish the performance evaluation.

2. Literature Review

2.1 Agricultural biotechnology parks of strategic alliance

Gatrell et al. (2011) considered that, in the enhancement of technical specialization and rapid changes of market demands, operators were facing uncertain environment with various opportunities and risks to cope with such changes; enterprises would not be able to independently survive in the future that the strategic interaction and interdependence among enterprises became more important; strategic alliance therefore became the mainstream of corporate strategic thinking in order to reduce costs, spread risks, acquire key resources, and promote the competitive position. Vidgen& Gallegos (2014) indicated that the promotion of strategic alliance among enterprises resulted in the emergence of agricultural strategic alliance to cope with the trend.

The so-called agricultural strategic alliance referred to the alliance of two or more agricultural organizations or agribusinesses with resource sharing and functional complementation for the common goal (Smith et al., 2012). Abu-Saifan (2012) pointed out agricultural strategic alliance as the cooperation among agricultural organizations with the same trade or between cross-industry like logistics and process to exchange complementary resources, achieve the staged growth or win-win, and eventually maintain the long-term competitive advantages in the market.

Williams & Williams (2012) stated that agricultural strategic alliance, for reinforcing agriculture cartel and enhancing the horizontal alliance between agriculture and other industries, emphasized the strategic competition with agricultural sectors integrating all

resources to overcome the dilemma of peasants and achieve the function of reorganization (Malebana, 2014). Tyszka et al. (2011) pointed out the success factors in agricultural strategic alliance as risk competitive advantages, technical capability learning, financial support acquisition, and positive correlations with allied members which presented cumulative experiences and innovation ability, business scale and efficiency, stable and timely raw material supply ability, variety improvement and development capability, special production technology ability, stable financial conditions, and strategic alliance experiences.

Borzaga et al. (2012) regarded the upstream/downstream supply chain relationship between agricultural biotechnology enterprises and agricultural biotechnology parks. The so-called supply chain cooperation referred to the supply chain members stressing on mutual trust and cooperation and maintaining the supply chain cooperation; when the agricultural biotechnology parks system was the supply of upstream materials, the provided materials would affect the production performance of agricultural biotechnology enterprises.

Rotemberg-Shir&Wennberg (2011) pointed out agricultural biotechnology parks as applying the main points of strategic alliance to the integration with agricultural business of enterprises, and strategic alliance was a broadly utilized business tactic which strategically integrated different resources to develop larger benefits and effectively promote the overall competitiveness of allied partners.

2.2 Agricultural biotechnology

Urban(2013) regarded biotechnology as the research and development of technology platforms with the life science of gene recombination, cell fusion, tissue culture, fermentation engineering, and enzyme conversion to acquire intellectual property rights or produce products in order to create business opportunities (Chand &Katou, 2012).

Yokohari (2012) referred agricultural biotechnology to applying cellular and molecular biology to agricultural products and the production process so as to increase agricultural output, reduce usage costs and energy, improve quality, and develop relevant products (Smith et al., 2013). Metcalf & Widener (2011) further indicated that the definitions of agricultural biotechnology industry were different in the world, but it was based on the USA which first developed agricultural biotechnology.

The USA restrained agricultural biotechnology in genetically modified organisms (GMOs), biocides, and emerging bio-pharming. Aramand (2013) mentioned that the rapid development of biotechnology was an optimistic star industry globally, and the application of

biotechnology gradually integrated agriculture with medicine, food, and environmental protection industries to open up new application for agricultural activity and create new agricultural biotechnology industry.

Sams&Sams (2011) stated that latest agricultural biotechnology research and development results were broadly applied to change the produce properties and application, largely enhance the produce value, change the idea of traditional agriculture, and deeply affect agricultural output and utilization.

2.3. Performance evaluation

Ling et al. (2016) defined organizational performance as "the achievement of a specific desired end". In other words, performance referred to the consistency between actual output and expected output of an organization. Nonetheless, the setting of "desired end" became an argument among organizational theory scholars (Boyton et al., 2016).

Alikaj et al. (2016) regarded performance evaluation as a formal and structural system for measuring, evaluating, and affecting employees' work related attributes, behaviors, and results so as to understand employees' productivity – whether employees could be more efficient in the future so that the employees, the organizations, and the society could make profits (Lee, 2016).

Ersin (2016) further pointed out performance as the outcome of business activity, which contained the creation of operating revenue, the control of costs and expenses, and the presentation of profits. Kang et al. (2016) indicated that financial performance and marketing performance were generally used for presenting the business performance of a company. Financial performance included return on investment, return on sales, pre-tax income, sales volume, and sales growth rate; marketing, on the other hand, was measured by market share.

Delkhosh et al. (2017) proposed to judge organizational performance with finance, enterprise, and organization. (1) Financial performance was the commonest indicator for research as well as a definite method, e.g. sales growth rate and rate of return. (2) Corporate performance was mainly added operational performance, in addition to financial performance indicators, and was analyzed with other non-financial indicators, such as market share and product quality. (3) Organizational effectiveness applied a broader definition. In addition to above two, the goal satisfaction of various related persons was added to the achievement of goal set by the organization.

2.4 Establishment of research indicator

Summing up above performance evaluation indicators of service operation,Delphi Method is utilized in this study for making the performance evaluation indicators of the agricultural biotechnology parks in china agriculture. Delphi Method, also named expert judgment method, is a group decision-making method with qualitative and quantitativecharacteristics, focuses on interdisciplinary and future oriented, could have anonymous experts repeat votes and feedback for several runs through questionnaire survey, when the data are short or the situation is unknown, till the lowest opinion difference for a commonly acceptable answer (Rodrigue,2013).

The so-called “experts”, according to literatures, should present the following conditions (Jayawarna et al., 2013). (1) Presenting interests in participating in Delphi Method. (2) Presenting rich information for sharing. (3) The knowledge and skills in special fields are approved. (4) Presenting specialty on the surveyed topic, including practical experiences and theoretical research. (5) Agreeing that the research results cover the special information owned. Schwarzer& Warner (2013) also indicated that experts had to present level of knowledge, reliability, and accuracy and showed deeper knowledge of the industry than amateurs so that the judgment of experts was closer to the fact. The value of Delphi Method is established based on such answers.

3. Research Methodology

3.1 Research subject

Based on the National Agricultural Biotechnology Park data announced by Ministry of Science and Technology China Rural Technology Development Center, 13 national agricultural biotechnology parks are sampled as the research subjects.

Modified Delphi Method is applied in this study to enhance the benefit of questionnaire survey and have the experts directly focus on the research topicto objectively sieveinputs/outputs. Total 4 input/outputvariables are selected for this study. With strict sieving, 13 DMUs are available. The variable data are the income statements, prospectuses, and annual reports of agricultural biotechnology parks published by Ministry of Science and Technology.

3.2 Data Envelopment Analysis

Data Envelopment Analysis, an efficiency evaluation mathematical model developed

by Charnes et al. in 1978, estimates theefficiency by replacing common default functions with non-default production functions, calculates the efficiency frontier curve with the mathematical programming model, and compares the actual outputs with the original production functions as theefficiency.

Envelopment is the theoretical basis of DEA, and the basic principle is based on Pareto Optimality proposed by Pareto in 1972. It is defined that no one could enhance personal benefits without damaging others' profits.DEA, a multi-output to multi-input efficiency model which does not need to consider the weight setting in advance, compares the quantitative results of all DMUs to select DMUs with better performance one by one and then draws a curve of all efficient DMUs to be the efficiency frontier.

The relative efficiency of individual DMU is calculated with the distance between observation and efficiency envelope. In sum, DEA is a relative indicator, the efficiency boundary constructed through linear programming according to actual observation, and measures the efficiency of organizations based on the relative inefficiency, the difference between individual observation and efficiency boundary.

3.3 Definition of input/output

3.3.1 Input variable:

- Development expense: Various expenses occurred in the agricultural biotechnology
- parks development process.
- Development scale: Equipment, number of manufacturers, area of land, and
- number of employees of agricultural biotechnology parks.

3.3.2 Output variable:

- Net operating revenue: Gross operating revenue-sales return and allowance.
- Patented technology: The patented technology acquiring by the research and development of technology platforms.

4. Empirical analysis

4.1 Relative efficiency analysis

Table 1 shows the relative efficiency of organic farms. Wuhan Agricultural Biotechnology Park presents the best overall efficiency (1.00), followed by Xining Technology Park (0.99), andYangling Technology Park the worse (0.72).

Wuhan Agricultural Biotechnology Park shows the best pure technical efficiency(1.00), followed by Xining Technology Park (0.98), and Yangling Technology Park the worst (0.70).

Wuhan Agricultural Biotechnology Park appears the best scale efficiency (1.00),

followed by Jining Technology Park (0.99) and Xining Technology Park (0.99), and Danzhou Technology Park the worst (0.71).

Table 1: Relative efficiency of agricultural biotechnology parks

Agricultural Biotechnology Park	Overall efficiency	Pure technical efficiency	Scale efficiency
Wuhan	1.00	1.00	1.00
Jining	0.98	0.96	0.99
Huaian	0.94	0.93	0.95
Quanzhou	0.97	0.96	0.97
Gongzhuling	0.96	0.95	0.96
Xining	0.99	0.98	0.99
Tai'an	0.88	0.84	0.92
Baima	0.86	0.84	0.88
Pudong	0.87	0.89	0.85
Danzhou	0.74	0.76	0.71
Yangling	0.72	0.70	0.75
Jimo	0.78	0.77	0.79
Meitan	0.81	0.80	0.81

4.2. Sensitivity analysis

The input/output variables are gradually removed for DEA, in order to understand the sensitivity to efficiency. From Table 2,

(1) all DMUs reduce the efficiency after removing "development expense"; that is, development expense presents higher importance on all DMUs,

(2) all DMUs reduce the efficiency after removing "development scale"; that is, development scale shows higher importance on all DMUs,

(3) all DMUs reduce the efficiency after removing "net operating revenue"; that is, net operating revenue reveals higher importance on all DMUs, and

(4) all DMUs reduce the efficiency after removing "patented technology"; that is, patented technology appears higher importance on all DMUs.

Table 2: Sensitivity analysis of single input and output being gradually removed

agricultural biotechnology park	original relative efficiency	removing development expense	removing development scale	removing net operating revenue	removing patented technology
Wuhan	1.00	0.98	0.97	0.95	0.93
Jining	0.98	0.93	0.92	0.91	0.90
Huaian	0.94	0.88	0.83	0.87	0.80
Quanzhou	0.97	0.91	0.92	0.90	0.88
Gongzhuling	0.96	0.93	0.91	0.88	0.85

Xining	0.99	0.94	0.92	0.90	0.86
Tai'an	0.88	0.83	0.80	0.81	0.78
Baima	0.86	0.80	0.78	0.77	0.73
Pudong	0.87	0.82	0.83	0.79	0.74
Danzhou	0.74	0.70	0.68	0.66	0.61
Yangling	0.72	0.66	0.65	0.63	0.60
Jimo	0.78	0.72	0.70	0.69	0.61
Meitan	0.81	0.75	0.72	0.70	0.68
Number of efficient DMUs	1	0	0	0	0

Data source: Self-organized in this study。

5. Conclusion

With investigation, total 13 technology parks are valid samples in this study. Data Envelopment Analysis is applied to evaluate the performance of agricultural agricultural biotechnology parks in technology parks.

The research results reveal the pure efficiency mean of most agricultural agricultural biotechnology parks in technology parks less than 1 that they have to improve the pure technical efficiency before enhancing the technical efficiency. In this study, Wuhan Agricultural Biotechnology Park presents better performance, possibly because it introduces and incubates technology-based enterprises in seed industry, process industry, and biotechnology industry, through the entrepreneurship center, to form the agricultural strategic alliance and develop agricultural biotechnology parks.

Under the guidance of such enterprises, local leading industries of rice, vegetable planting, and livestock feeding are rapidly developed. It powerfully promotes the transformation of agricultural technology, incubates agricultural high-tech enterprises, demonstrates and promotes technology, enhances agricultural structure adjustment, and increases agricultural efficiency andfarmers' income.Wuhan Agricultural Biotechnology Park therefore preliminarily confirms the provincial leading position in seed industry, bio-fertilizers, biocides, and biological veterinary drugs.

Moreover, the development of agricultural biotechnology parks for the agricultural strategic alliance has the allied members present cumulative experiences and innovation ability, variety improvementanddevelopment capability, and special production technology ability that Wuhan Agricultural Biotechnology Park shows the outstanding innovative

performance. Constant reinforcement of innovation is the key factor in the development of a park. The innovation ability index of Wuhan Parktherefore is on the top for year.

6. Recommendations

Aiming at agricultural biotechnology parks developing agricultural biotechnology parks, the following suggestions are proposed in this study.

Parks are suggested to continuously compile budget subsidies for promoting agricultural biotechnology parks; especially, the number of stationed enterprises inparks is growing, and there are new stationedenterprises approved inparks every year. Enterprises which intend to develop agricultural biotechnology parks should be tutored preferentially so as to enlarge the effectiveness of agricultural biotechnology parks.

The development of agricultural biotechnology parks stresses on the business benefits of enterprises, especially the possibility to enter thenew product market. Enterprisesin parks, which produce agricultural biotechnology materials with biotechnology, would directly apply the products to the agricultural production processes in order to improve the quality of the produce and enhance the agricultural output and competitiveness. Parks should actively assist such enterprises, through projects, in establishing agricultural biotechnology parks for the product trial promotion. It would help stationed enterprises in parksopen up the product market as well as promote the productivity of traditional agriculture.

Although business benefits are the major consideration of agricultural biotechnology enterprises developing agricultural biotechnology parks, which are achieved by the teamwork with farmers, enterprises should combine the goals and tactics in the process and treat agricultural biotechnology parks as the extension of the business system so that the agricultural biotechnology parks system becomes the bridge of agricultural biotechnology enterprises supporting the transformation of traditional agriculture, which could further becomes the firm backing of biotechnology industry.Farmer groups, on the other hand, should understand that the standpoint of participating in agricultural biotechnology parks of agricultural biotechnology enterprises relies on the capability to stably and timely supply materials. Such technical capability should be highlighted to combine with the demands of agricultural biotechnology enterprises so as to win the cooperation opportunities.

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