A study of performance evaluation on the introduction of enterprise resource planning into agriculture

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Abstract

In order to accelerate and upgrade the industry in the 21st century to face the wave of globalization, both individuals and corporate organizations encounter severe challenges in the era with diverse social environment and changing technology. Strategic planning and management are necessary for enhancing the competitiveness of an enterprise so as to complete the resource integration and planning as well as develop and maintain the existing competition ability of the organization. Aiming to integrate the mutual link of agricultural business management functions, domestic agricultural resource planning intends to enhance the utilization through resource sharing and service sharing. DEA is applied to measure the effectiveness of the introduction of enterprise resource planning into agriculture in this study. Total 3 input/output variables are used in this study, and, with cities in Fujiang Province as the samples, total 9 DMUs are selected. The research results show 1.the technical efficiency, scale efficiency, and returns to scale of cities measured with DEA, 2.sensitivity analysis with inputs and outputs being removed one by one and then DEA to understand the sensitivity to efficiency, and 3.the application of slack variable analysis to realize the improvement directions for inputs and outputs in areas introducing enterprise resource planning into agriculture. Suggestions are further proposed according to the results, expecting domestic agriculture to achieve resource sharing and service sharing and internal operation management to catch up agribusinesses.

Keywords: Agriculture. Enterprise resource planning. Performance evaluation.

1. Introduction

There is not the so-called sunsetting industry or traditional industry in the 21st century, but merely disappointing enterprises. In order to succeed in the global market nowadays, keen insight and the proper utilization are required for developing competitive advantages domestically or internationally, with any opportunities, in order to upgrade the industry to face the wave of globalization. In such an era with diverse social environment and changing technology, both individuals and corporate organizations encounter severe challenges. In order to enhance the competitiveness in the dynamic and changeable environment in the 21st century, strategic planning and management are required for facing various external environment changes. In this case, merely constant increase in internal strength and response ability could have an organization develop and maintain the existing competition ability by completing resource integration and planning through improvement. Enterprise resource planning (ERP) aims to assist enterprises in enhancing business effectiveness. The introduction of ERP is to integrate various resources in an enterprise to further promote the competitiveness. Enterprise resource planning is the command center for wars and could support existing business strategies under integration as the key success factor.

When an organization generates the competitive advantages with various resources and resource management methods, the use of resource development patterns would present higher growth than the use of other patterns. Some domestic agricultural businesses have realized the provision of customer-related products and order information, while the internal operation and management still could not catch up with the marketing. Agricultural ERP mainly integrates domestic agriculture businesses to link six management functions of production operation, inventory, personnel salary, financial accounting, refrigerated warehouse lease, and farmers' organization, which could be integrated or independently operated. For this reason, the introduction of agricultural ERP should be planned to guide agriculture managers changing towards business management. Agriculture businesses lack of service manpower or finance could enhance the utilization through resource sharing and service sharing. The performance on the introduction of enterprise resource planning to agriculture is therefore evaluated in this study, expecting that domestic agriculture could achieve resource sharing and service sharing and the internal operation management catch up with the path.

2. Literature Review

2.1 Enterprise resource planning

Feng & Xu (2015) defined enterprise resource planning as a method, in manufacturing, logistics, and service industries, effectively planning and controlling all resources required for acceptance, manufacturing, delivery, and settlement of customer orders. Laari et al. (2016) stated that the application of ERP should not be restricted to manufacturing, but expanded to logistics and service industries. Dubey et al. (2015) regarded ERP as an integrated information management in which production, marketing, stock, finance, and personnel in an enterprise were integrated. Marchewka (2015) pointed out ERP as the structural software to optimize internal value chain of a company. When it was installed in the entire enterprise, the departments could be contacted through logic transmission and share all data under integration. Chin et al. (2015) considered immediacy and integration as the difference of ERP from traditional data management that an enterprise could integrate the information work process in various departments and unite internal information process procedures so that the dispersed database could be immediately used; all operation information in the enterprise therefore merely needed to be produce once, i.e. "unification". Luthra et al. (2016) mentioned that the introduction of ERP could result in effectiveness for a company; however, not all companies with the introduction could acquire the expected effectiveness; it might result in disasters. The introduction of ERP was expensive and time & strength consuming; besides, the introduction would be hard to withdraw once it was started. After the introduction, the recovery of any mistakes would cost more time and money.

2.2. Performance evaluation

Social resources are limited. The optimal utilization of limited resources has been the concern of managers. Efficiency and effectiveness are often used for measuring the resource application ability and the goal achievement of an organization, which are also the key points in performance evaluation. In term of the definition of effectiveness, Dugelova & Strenitzerova (2015) regarded it as doing the right thing, revealing that an organization, under the premise of customers' maximal value, utilized the ability of acquiring income with external operation. It stressed on the measurement of ends, mainly discussing whether an organization effectively achieved the set goal within a period of time (Wijesiri & Meoli,

2015). Zhou et al. (2017) pointed out efficiency as doing the thing right. It emphasized the use of correct means, mainly to measure the effective application of internal resources in an organization. With the relationship between inputs and outputs, the least inputs were used for the most outputs or the method to reduce production costs were found out in order to enhance the cost effectiveness of resource use and take the result as the reference for improving organizational productivity (Nguyen et al., 2015).

Efficiency could be regarded as the performance on the process of transforming a set of inputs into outputs; it stressed on effective utilization of existing production resources. In economics, the idea of Pareto Optimality (Zhou et al., 2016) could be used for the explanation. From the aspect of input orientation, it indicated that, under the same output amount, an organization could not increase the output yield unless increasing input resources or reducing other output yield. In this case, the organization was efficient. From the aspect of output orientation, an organization, under the premise of maintaining the same inputs, could not reduce inputs unless reducing yield or increasing other input resources. The organization in this case was efficiency (Galagedera et al., 2017).

2.3. Data Envelopment Analysis

Cabrera et al. (2018) indicated that the evaluation of efficiency was an important issue in management; efficiency evaluation was the core of cost control; and, an effective efficiency evaluation method could assist departments in enhancing the resource input and product output efficiency, i.e. applying the least resources to product the most products. In other words, a good evaluation model was able to estimate the overall efficiency to present the resource use. Moreover, it should be able to precede evaluation with qualitative and quantitative data and various calculation units, deal with multiple inputs and outputs and external environmental factors, and avoid subjective factors in the setting of weights so as to assist decision makers in making decisions.

Chen & Jia (2017) explained Data Envelopment Analysis that Charnes et al. expanded Ferrel's method and established a general linear planning model to measure the production efficiency of various inputs and outputs under constant returns to scale. The first proposed DEA model was later called CCR model. The basic model of the Data Envelopment Analysis was under the premise of three production assumptions.

a) Constant returns to scale. In other words, returns would not increase or diminish

even the operation scale was increased.

b) Constant marginal productivity. Regardless the yield, the increased outputs for each increased input was the same.

c) Constant wasting of resource. An institution with bad efficiency would show constant proportion of the wasted input resources.

The efficiency measurement with DEA is based on "Pareto optimality", which indicates that no-one could increase another person's benefits without losing others' benefits. According to the point of view, the actual production could be compared with the production boundary (as the idea of envelope or efficiency frontier in economics) to further measure the efficiency. With the idea of envelope, all inputs and outputs of a decision making unit (DMU) are taken into account in DEA, and the relative efficiency of an individual manufacture to other manufacturers is calculated by dividing the weighted inputs with the weighted outputs.

2.4. Delphi Method and Modified Delphi Method

Delphi Method mainly combines the advantage of group expert opinions to avoid situational pressure caused by face-to-face discussion. Hsu & Hsu (2018) proposed 8 situations suitable for Delphi Method. (1) The research question presented little available information and high uncertainties. (2) The research question could not provide accurate analyses, but could collect subject judgment data as the answer. (3) A participant was able to provide useful opinions for broad and complicated issues, but lack of interaction and discussion with other participants; or, there were distinct specialties and experiences requiring for exchange. (4) It required many people for providing opinions aiming at the issues; however, the number of participants would be restricted when face-to-face conversation was applied to achieve effective interaction. (5) Time and location for face-to-face meeting would be hard to arrange, and large amount of expenses would be a problem. (6) The opinion exchange between individuals and the group required efficient interaction, without being affected by secondary group communication. (7) Different opinions and positions could easily result in displeasure in the face-to-face meeting process that an arbitration mechanism was required in the group communication process and the anonymity of participants should be ensured. (8) The heterogeneity of participants should be remained to avoid the advantage of majority opinions and individual personality traits affecting the variance of research conclusions. Hsu & Tsai (2017) explained Modified Delphi Method that, based on special

considerations of research, brainstorming open-ended questionnaire was omitted and a structured questionnaire was directly developed for the first-run survey. Directly using the structured questionnaire for the first-run survey could save a lot of time; besides, the structured questionnaire could have the experts focus on the research subject, without making guess on the open-ended questionnaire.

3. Research Design

3.1. Research method and object

Proper inputs/outputs should be selected for applying DEA to measure the effectiveness of introducing enterprise resource planning into agriculture. To combine the selection of inputs/outputs with expert opinions, reduce input costs, and avoid fuzziness in the survey process, Fuzzy Delphi Method is used for selecting inputs/outputs. Total 30 copies of questionnaire are distributed in this study, and 20 valid copies are retrieved, with the retrieval rate 67%. Researchers indicate that the public opinion with more than 5 participants could be the analysis reference. The interviewed experts in this study cover industry, official, and academia and show frequent interaction with agricultural technology that it should present certain representativeness.

After the calculation with Fuzzy Delphi Method, the geometric mean is regarded as the consensus of experts' evaluation of inputs/outputs, and the median or the evaluation scores of inputs/outputs is taken as the standard to select the inputs/outputs which are able to measure the introduction enterprise resource planning into agriculture. Total 3 input/output variables are selected, and, with strict selection among cities in Fujiang Province, total 9 DMUs are available. The variable data are acquired from publically issued prospectuses and annual reports.

3.2. Establishment of evaluation indicator

To establish the evaluation indicators with Delphi Method, the variables are defined as below.

(1) Input variable:

1. Financial: including costs for the introduction of enterprise resource planning

(2) Output variable:

I. Data quality: data correctness and data immediacy.

II. Use feedback: period for using the data.

4. Empirical Analysis

4.1. Relative efficiency analysis

For measuring the technical efficiency, scale efficiency, and returns to scale of cities with DEA, CCR input orientation model is first used for calculating the total efficiency to evaluate and compare the performance of the introduction of enterprise resource planning into agriculture. BCC model is further utilized for calculating the pure technical efficiency which is divided by total efficiency to acquire the scale efficiency. It tends to confirm the source of inefficiency being technical inefficiency or scale inefficiency. When scale inefficiency is the factor, returns to scale could be analyzed to judge the expansion, maintenance, or reduction of the business scale so as to enhance the business efficiency. The efficiency of the introduction of enterprise resource planning into agriculture of cities acquired with DEA is listed in Table 1.

Table 1: Relative efficiency

city	total efficiency	pure technical efficiency	scale efficiency	return type
Xiamen	1	1	1	CRS
Fuzhou	0.97	0.98	0.97	IRS
Putian	0.84	0.83	0.84	IRS
Sanming	0.90	0.90	0.91	IRS
Quanzhou	0.95	0.94	0.96	IRS
Zhangzhou	0.88	0.88	0.88	IRS
Nanping	0.82	0.81	0.83	IRS
Longyan	0.78	0.77	0.79	IRS
Ningde	0.72	0.70	0.74	IRS

4.2. Sensitivity analysis

The inputs and outputs are removed one by one for DEA to understand the sensitivity to efficiency. From Table 2, the removal of financial, data quality, and use feedback would reduce the number of relatively efficient DMUs, revealing the importance of such variables to affect the relative efficiency evaluated with DEA.

Table 2: Sensitivity analysis of removing single input and output one by one

DMU	original relative	removing	removing data	removing use

	efficiency	financial	quality	feedback
Xiamen	1	0.92	0.90	0.91
Fuzhou	0.97	0.90	0.88	0.93
Putian	0.84	0.80	0.76	0.77
Sanming	0.90	0.83	0.85	0.81
Quanzhou	0.95	0.89	0.87	0.83
Zhangzhou	0.88	0.84	0.83	0.80
Nanping	0.82	0.80	0.76	0.73
Longyan	0.78	0.72	0.70	0.7
Ningde	0.72	0.66	0.63	0.60
Number of efficient DMU	2	0	0	0

Data source: Self-organized in this study.

4.3. Slack variable analysis

In terms of slack variable analysis, the improvement of cities with excessive inputs and outputs in the introduction of enterprise resource planning into agriculture is shown in Table 3. Aiming at the items with excessive inputs to reduce input units could have the cities achieve business efficiency. Xiamen, with business efficiency, shows the input resources reaching the optimal use.

Table 3: Improvement in agriculture

decision making units （DMU）	input improvement	output improvement	
	financial	data quality	use feedback
Xiamen	0	0	0
Fuzhou	1	0	0
Putian	2	1	1
Sanming	1	0	1
Quanzhou	0	1	0
Zhangzhou	1	1	1
Nanping	2	0	2
Longyan	3	1	2
Ningde	3	3	4

Data source: Self-organized in this study.

5. Conclusion

The research results reveal that 1 DMU, about 11% of all DMUs, presents strong efficiency on the introduction of enterprise resource planning into agriculture, with the efficiency=1, showing the better relative efficiency; 3 DMUs, about 33% of all DMUs, appear the efficiency in 0.9-1, as marginal inefficiency, revealing that the relative business efficiency could be more easily promoted; and, 5 DMUs, about 56% of all DMUs, show the efficiency lower than 0.9, as obvious inefficiency, where Ningde appears the lowest efficiency 0.72. The scale of domestic agriculture is not large and the operation is short of manpower to reflect the application of strategy management is urgently required. Agricultural transaction is directly related to the profit and management of agriculture that an inventory management, as the prior for the introduction into agriculture, is mostly used. A production operation management, related to the supply and quality of agriculture products, is followed. Agriculture ERP are applied by agribusinesses of vegetables, fruit, flowers, mushroom, rice, and grains. Agribusinesses expect that the ERP could help them more accurately and effectively grasp the production and sales. It reveals the high flexibility of agriculture ERP. According to actual demands to adjust the parameters, the operation of agriculture ERP could be integrated into actual business processes. To enhance the applicability and stability of agriculture ERP, and it should be continuously adjusted with opinions and feedback from agribusinesses.

6. Recommendations

According to the research results, suggestions aiming at the introduction of enterprise resource planning into agriculture are proposed in this study, as followings.

a)   An ERP could be strengthened by the emphasis and support of agribusinesses that it could establish vision and achieve strategic objectives as other types of change plans. The emphasis and support of agribusinesses contain the significant meanings of the acquisition of more resources and encouragement function. An agribusiness should deepen the subordinate and organizational group activity, present equal conversation, shape concerning leadership styles, and create the big family full of family relationship.

b)   To guide agribusinesses which intend to use enterprise resource planning currently and in the future to rapidly understand the ERP function and be familiar with the ERP operation, explanations and learning materials of ERP functions as well as various

guiding channels, e.g. training for use, online real-time instruction, individual instruction and guidance, and establishment of basic data, should be provided. It is expected to shorten the introduction period, reduce the introduction failure, and accelerate the ERP application effectiveness.

c)   It was difficult to promote the application of enterprise resource planning in the beginning. Nevertheless, increasing young farmers returning hometowns for farming in past years reduces the average age of agribusiness owners. It develops the management of agriculture with the idea of business management and shows high acceptance of the application of ERP communication technology. The strong learning ability could positively assist agricultural business management.

7. Reference

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