An Exploratory Study on Project Management Maturity Assessment for Agricultural Enterprises

Jiren Shen

Beijing Capital Agribusiness & Food Group, China
shenjiren@bjcag.com

Abstract. In order to improve the project management level of agricultural enterprises and ensure the market competitiveness of agricultural enterprises, this paper researched the project management maturity of agricultural enterprises based on project management theory, established the agricultural enterprise project management maturity model through expert brainstorming and index importance analysis, and evaluated the agricultural enterprise project management maturity model by using fuzzy comprehensive judgment method. Finally, the maturity of project management of the sample agricultural enterprises in Hebei Province was evaluated through empirical analysis. The experimental results show that current agricultural enterprises generally attach importance to quality management and have strong quality awareness, but have single product characteristics and lack innovation. Through the above study, this paper puts forward constructive opinions and suggestions for agribusiness project management.

Keywords: Agribusiness, project management, maturity, fuzzy comprehensive evaluation method.

1. Introduction

With the deepening of China's economic system reform, the domestic economy maintains continuous and rapid growth, and domestic agricultural enterprises are sparing no effort to improve their comprehensive strength (Institute of Hazardous Chemicals, Chinese Academy of Sciences, 2011). Each process of the birth, growth and expansion of agricultural enterprises is inseparable from the products, and product quality represents the innovation of agricultural enterprises. The effectiveness and efficiency of project management is an important basis for the improvement of the overall strength of agribusiness and is crucial for the success of strategic planning in agribusiness. More and more agribusinesses have adopted project management as a key strategy to maintain competitive advantage and are using various means to improve project management capabilities.

Project Management Maturity (PMM) is used to define the extent to which project management processes are defined, managed, measured, and controlled (Reniers and Amyotte, 2012). Project management maturity is measured using project management process capability, which refers to the degree to which the desired outcome can be achieved by following a project management process.

This paper adopts a project management perspective to evaluate agricultural enterprises, first modeling the maturity of project management in agricultural enterprises, then proposing a corresponding assessment method for the model, and finally evaluating the maturity of project management in sample agricultural enterprises through empirical analysis. Through the above research, this paper puts forward constructive suggestions and recommendations for agribusiness project management.

2. Model Development for Agribusiness Project Management Maturity

The research work on the Chinese project management body of knowledge started in 1993, initiated and organized by the Project Management Research Committee (PMRC) of the Chinese Society for Preferential Methodology and Economic Mathematics Research (C-PMBOK) (Wang, 1992). This organization launched a Chinese project management knowledge system document, the Chinese Project Management Body of Knowledge (C-PMBOK), in July 2001 and the second edition in October 2006 (Wang , and Dong, 2011).

To establish the maturity model of agricultural enterprise project management, firstly, a realistic evaluation index system of agricultural enterprise project management maturity is established according to the Chinese Project Management Body of Knowledge, and then the key process domains of each maturity level of agricultural enterprise project management are identified based on the gray correlation analysis. Finally, the two are organically combined to form a complete maturity model of agribusiness project management.

2.1. Agribusiness project management maturity model construction principles

The maturity evaluation index system is an organic whole composed of a series of interrelated indicators, which reflect the degree of completion of the project's methods and approaches for the expected project goals. Industry specificity refers to the characteristics of enterprise project management that change with the different industries to which they belong. The specificity of agricultural enterprises requires a high level of coordination between the level of project management and the content of project management, and prohibits problems in project quality and safety.

In this paper, from the perspective of project management, combined with the industry specificity of agribusiness project management, we seek to establish the principles for the construction of a generic agribusiness project management maturity evaluation index system. In constructing the index system, the following principles should be followed:

(1) Mandatory. Project management in agricultural enterprises has the mandatory feature of project results, requiring project management to focus not only on the process, but also on the management of results, which determines that in the process of management should not only focus on the level of implementation of the process, but also regularly divide responsibilities and rights, and strengthen the management of the project stage deliverables of each participating unit.

(2) Complexity. Project management in agricultural enterprises, with the complexity characteristic of project management systems, requires the project management process to pay more attention to the overall efficiency of the system and the achievement of overall goals. In the process of project device construction involves water and gas, electrical, steam, oil, instrumentation and other pipeline systems of various pipeline systems for the start-up of the new system, with the original system supporting the operation, the project single commissioning and the overall commissioning of the various stages, any error in the program will restrict the overall operation of the entire project, which also means the failure of the overall project of the enterprise.

(3) Traceability. The project management of agricultural enterprises is characterized by the tracking nature of the whole process inspection by government departments, which requires the management of the process and results in sections during the project, and the strengthening of the cooperation and communication between various systems to achieve the overall value of the final commissioning and commissioning. The overall capability of agribusiness project management is highly correlated with the supervision of the government fire supervision department. The whole process of project management is always under the supervision and management of relevant government departments (safety, quality supervision, environmental protection). In the project audit stage, construction inspection stage, testing and acceptance stage, government supervision departments are required to

keep strict quality control without any negligent links.

2.2. Establishment of basic evaluation index system

Based on the Chinese Project Management Knowledge System, the basic evaluation index system of project management maturity of agricultural enterprises was constructed based on the principles of constructing the project management maturity evaluation index system of agricultural enterprises, taking the five process capabilities of project management and comprehensive project management capabilities as the first-level indexes, and subdividing the first-level indexes through expert brainstorming to obtain the corresponding second-level indexes (Golinska et al., 2015).

2.3. Evaluation index screening

The secondary indicators obtained through expert brainstorming contain more subjective components (Shao et al., 2016). Therefore, in order to build an evaluation index system for project management maturity of agricultural enterprises, secondary indicators need to be screened.

In this paper, a five-level evaluation method is used to classify the importance evaluation indicators into "unimportant, less important, generally important, more important, and important" and the maturity evaluation indicators into "chaotic, simple, standardized, lean, and strategic". If the set V of evaluation objectives is expressed as the degree of strength and weakness, each level can be mapped to a score $V = \{1,2,3,4,5\}$.

The experts of the organization are divided into importance matrices R_s and ripeness matrices R_r according to the scoring criteria. Based on the importance matrix and maturity matrix, this paper selects the representative evaluation indexes from the basic evaluation indexes through importance analysis to build the evaluation index system of project management maturity of agricultural enterprises. The parameters involved in the scoring and analysis process are shown in Table 1.

Table 1: Parameter table

Parameter Name	Parameter symbol	Total
Ripeness index	i_i	M
Ripeness degree	rd_j	N
Significance degree	sd_t	S
Enterprise	u_k	R
Expert	e_q	L

Let r_{qij} be the importance score of the q expert on the i maturity indicator at the j maturity level and r_{qki} be the maturity score of the q expert on the k sample on the i maturity indicator, then R_s can be expressed as Eq. (1) and R_r can be expressed as Eq. (2). Let r_{ij} be the average importance rating of the k maturity indicator on the

i maturity level and be the average maturity rating of the first sample on the first maturity indicator, as shown in Eq. Then, R_r can be simplified as Eq (3).

The importance of the maturity index is measured using the affiliation function in fuzzy mathematics. If for any element X in the domain, there is a number $A(x) \in [0,1]$ corresponding to it, A is said to be a fuzzy set on U, and $A(x)$ is the affiliation degree of x to A. The basic evaluation index system of project management maturity of agricultural enterprises is used as a fuzzy set, and the secondary indicators are used as elements, and the secondary indicators are analyzed for their affiliation degree.

$$
R_s = \begin{bmatrix} \begin{bmatrix} r_{111} \\ \vdots \\ r_{L11} \end{bmatrix} & \begin{bmatrix} r_{112} \\ \vdots \\ r_{L12} \end{bmatrix} & \cdots & \begin{bmatrix} r_{11N} \\ \vdots \\ r_{L1N} \end{bmatrix} \\ \vdots & \vdots & r_{qij} & \vdots \\ \begin{bmatrix} r_{1M1} \\ \vdots \\ r_{LM1} \end{bmatrix} & \begin{bmatrix} r_{1M2} \\ \vdots \\ r_{LM2} \end{bmatrix} & \cdots & \begin{bmatrix} r_{1MN} \\ \vdots \\ r_{LMN} \end{bmatrix} \end{bmatrix} \cdots a, \quad R_r = \begin{bmatrix} \begin{bmatrix} r_{111} \\ \vdots \\ r_{L11} \end{bmatrix} & \begin{bmatrix} r_{112} \\ \vdots \\ r_{L12} \end{bmatrix} & \cdots & \begin{bmatrix} r_{11M} \\ \vdots \\ r_{L1M} \end{bmatrix} \\ \vdots & \vdots & r_{qki} & \vdots \\ \begin{bmatrix} r_{1R1} \\ \vdots \\ r_{LR1} \end{bmatrix} & \begin{bmatrix} r_{1R2} \\ \vdots \\ r_{LR2} \end{bmatrix} & \cdots & \begin{bmatrix} r_{1RM} \\ \vdots \\ r_{LRM} \end{bmatrix} \end{bmatrix} \cdots b \tag{1}
$$

$$
r_{ij} = \frac{\sum_{q=1}^{L} r_{qij}}{L} \cdots a, \quad r_{ki} = \frac{\sum_{q=1}^{L} r_{qki}}{L} \cdots b \tag{2}
$$

$$
R_s = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1N} \\ \vdots & \vdots & r_{ij} & \vdots \\ r_{M1} & r_{M2} & \cdots & r_{MN} \end{bmatrix} \cdots a, \quad R_r = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1M} \\ \vdots & \vdots & r_{ki} & \vdots \\ r_{R1} & r_{R2} & \cdots & r_{RM} \end{bmatrix} \cdots b \tag{3}
$$

Let $A_j(i_i)$ be the affiliation of the importance of maturity index i_i on maturity level rd_j. $count(r_{qij} = sd_t)$ is the number of times an expert selects importance level rd_j for maturity level sd_t, as shown in equation (4). Let r_{ij} be the importance of maturity index i_i on maturity level rd_j, as shown in equation (5). If the importance of a maturity indicator to all maturity levels is not more than "less important", the indicator will be removed from the maturity evaluation index system of agribusiness project management.

$$
A_j(i_i) = \left\{ \frac{count(r_{qij} = sd_t)}{L} \right\}, (t = 1, 2, \cdots, S) \tag{4}
$$

$$
r_{ij} = \max \left\{ A_j(i_i) \right\} \tag{5}
$$

$$
if \ \max_{j=1}^{N} \left\{ r_{ij} \right\} \leq 2 \ then \ delete \tag{6}
$$

In summary, the importance of the secondary evaluation indicators is calculated, and the secondary evaluation indicators that do not meet the requirements are eliminated according to the corresponding thresholds to obtain the agribusiness project management maturity model.

3. Assessment Methodology of Agribusiness Project Management Maturity Model

After constructing the maturity model of agribusiness project management, the corresponding evaluation method is proposed for it. The fuzzy comprehensive evaluation method is based on fuzzy mathematics and applies the principle of fuzzy relationship synthesis to quantify the factors that are not easy to quantify, and makes a comprehensive evaluation of the affiliation level of the evaluated thing from several factors. The fuzzy comprehensive evaluation method has a better judging effect on multi-factor and multi-level complex problems (Spalek, 2013). Therefore, in this paper, the fuzzy comprehensive evaluation method is used to evaluate the maturity model of agribusiness project management (Williams et al., 2014).

According to the fuzzy comprehensive judgment method, the object set $U = \{u_1, u_2, \cdots, u_R\}$, the secondary index $I = \{i_1, i_2, \cdots, i_M\}$ in the project management maturity evaluation index system is selected as the index set, and the five levels of maturity $D = \{d_1, d_2, \cdots, d_N\}$ is the rubric set.

Let $A_j(i_i)$ be the affiliation degree of experts making maturity level R rd_j comments on maturity index, and $G\,count(r_{qki} = rd_j)$ be the number of times experts select maturity level rd_j on maturity index i_i. From this, the evaluation matrix RR_{ij} is obtained, as shown in equations (7) and (8).

$$A_j\left(i_i\right) = \left\{ \frac{count\left(r_{qki} = rd_j\right)}{L} \right\}, \left(j = 1, 2, \cdots, N\right) \tag{7}$$

$$\mathrm{R}_{ij} = \begin{bmatrix} A_1\left(i_1\right) & \cdots & A_N\left(i_1\right) \\ \vdots & A_j\left(i_i\right) & \vdots \\ A_1\left(i_M\right) & \cdots & A_N\left(i_M\right) \end{bmatrix} \tag{8}$$

From the evaluation matrix R_{ij} and the maturity index weight vector W, the comprehensive evaluation result vector A of the appraisee is obtained, and the comprehensive evaluation result $A = W * R_{ij}$ of the appraisee is univariate and synthesized with the set of comments to obtain the comprehensive evaluation value Z of the appraisee.

4. Empirical analysis

4.1. Selection of secondary indicators of project management maturity in agricultural enterprises

In this paper, 20 assessors with B-level or above IPMP certification were selected as experts to obtain the secondary indicators of project management maturity of agricultural enterprises through expert brainstorming, so as to construct the basic evaluation index system of project management maturity of agricultural enterprises, as shown in Table 2.

Table 2: Basic agribusiness project management maturity evaluation index system

	Tier 1 Indicators	Secondary indicators
Project Management Maturity	Environmental discernment	Environmental discernment
		Information Adequacy
		Project requirements analysis capability
		Project opportunity analysis capabilities
		Project feasibility analysis capability
		Project economic capacity
		Solution Planning Capability
		Project Plan Scientific
		Project Evaluation Pass Rate
	Project Planning Process Capability	Project goal definition capabilities
		Project Scoping Capability
		Reasonableness of work breakdown
		Accuracy of working time estimation
		Schedule planning capability
		Resource Planning Capability
		Capital Planning Capability
		Security Planning Capability
		Risk Planning Capability
	Project Implementation Process Capability	Project Team Efficiency
		Team members' ability to cooperate
		Learning ability of team members
		Reasonableness of performance evaluation
		Project Information Management Level
		The extent to which project information is shared
		Conflict management skills
		Project Tracking Capability
		Plan execution capability
		Project coordination capabilities
		Frequency of project progress reports
		Project process control capability

		Project node control capability
	Project Control Process Capability	Project schedule control capability
		Project Resource Control Capability
		Project fund control ability
		Project Security Control Capability
		Project Change Control Capability
		Risk Identification Capability
		Risk Assessment Capability
		Risk Control Capability
	Project closeout process capability	On-time project completion rate
		Project acceptance rate
		Project fund final approval rate
		Project Management Success Rate
		Related personnel satisfaction
		Post-project evaluation capacity
		Degree of accumulated project management experience
		Reuse of project management experience capabilities
	Integrated project management capabilities	Project management knowledge awareness level
		Project Management Emphasis
		The ability to interface with the various processes of project management
		Integrity of documentation in project management
		Efficiency in the use of project management tools
		Frequency of use of project management tools and methods
		Emphasis on project management tools
		Project Management Strategic Planning Capability
		Multi-project management level

Experts were invited to rate the importance of maturity indicators. By analyzing the importance of the secondary evaluation indexes and eliminating the secondary evaluation indexes that do not meet the requirements according to the corresponding thresholds, we obtained the evaluation index system of project management maturity of agricultural enterprises, as shown in Table 3.

Table 3: Agribusiness project management maturity evaluation index system

	Tier 1 Indicators	Secondary indicators
Project Management Maturity	Project start-up process capability	Adequacy of examination information data
		Project requirements analysis capability
		Project opportunity research capabilities
		Project feasibility study capability
		Project economic capacity

		Solution Planning Capability
	Project Planning Process Capability	Project Scoping Capability
		Schedule planning capability
		Resource Planning Capability
		Risk Planning Capability
	Project Implementation Process Capability	Project Team Efficiency
		Learning ability of team members
		Reasonableness of performance evaluation
		Project Information Management Level
		Conflict management skills
		Project Tracking Capability
		Plan execution capability
	Project Control Process Capability	Project node control capability
		Project schedule control capability
		Project Resource Control Capability
		Project Change Control Capability
		Risk Identification Capability
		Risk Assessment Capability
		Risk Control Capability
	Project closeout process capability	On-time project completion rate
		Satisfaction of related personnel
		Post-project evaluation capacity
		Degree of accumulated project management experience
		Reuse of project management experience capabilities
	Integrated project management capabilities	Project Management Emphasis
		The ability to interface with the various processes of project management
		Integrity of documentation in project management
		Efficiency in the use of project management tools
		Project Management Strategic Planning Capability
		Multi-project management level

4.2. Comprehensive evaluation of project management maturity of sample agribusinesses

This paper adopts the above project management maturity model, comprehensively studies the current situation and problems of project management in agricultural enterprises, identifies the improvement directions, puts forward targeted opinions and suggestions on the project management level of agricultural enterprises, and enhances the market competitiveness of agricultural enterprises. In this paper, three samples

were selected for large, medium and small agricultural enterprises, and 270 questionnaires were distributed, 236 questionnaires were actually collected, 194 valid questionnaires. Based on the 194 valid questionnaires, the evaluation matrix R_{ij} is formed, and the maturity index weight vector W is uniformly distributed, resulting in the comprehensive evaluation result vector $A = W * R_{ij}$ for the appraisee, and the comprehensive evaluation result A of the appraisee is normalized and synthesized with the comment set V to obtain the comprehensive evaluation value of the three types of agricultural enterprises $\overline{Z_1} = 3.8722, Z_2 = 2.6493, Z_3 = 3.4344$, and the detailed evaluation results are shown in Table 4.

In summary, the average maturity level of project management in the agricultural industry is 3.186, which is at the normative level. From the five aspects of maturity evaluation, the maturity level of "project implementation process capability" of agricultural enterprises has the highest score among the six evaluated items, while "project closure process capability" is the worst. Agricultural enterprises attach importance to project management and generally recognize that project management is the life of the enterprise and actively participate in project management, but they still need to work on their advanced methods, project management tools, feedback and improvement in the implementation of project management. Agricultural enterprises have more prominent problems in development capabilities, participation in standard setting, non-conforming costs, and employee participation, and should take effective measures in technological innovation, standardization, and full staff training to continuously improve their competitiveness. Among them, the biggest gap between small agricultural enterprises and large and medium-sized agricultural enterprises is the knowledge management and project control process capability, with small agricultural enterprises lower than large agricultural enterprises by more than one point. Therefore, to shorten the gap between small agricultural enterprises and large and medium-sized agricultural enterprises, they should pay attention to knowledge learning and training and strengthen the role of project control on product quality.

5. Conclusion

In order to improve the project management level of agricultural enterprises and ensure the market competitiveness of agricultural enterprises, this paper researched the project management maturity of agricultural enterprises based on project management theory, established the project management maturity model of agricultural enterprises through expert brainstorming and index importance analysis, and evaluated the project management maturity model of agricultural enterprises by using fuzzy comprehensive judgment method. After empirical analysis, the actual situation matches with the calculated results, reflecting that agricultural enterprises generally attach importance to quality management, have strong quality awareness, and have generally established quality management systems, but are significantly

worse in terms of quality cost, product competitiveness, and quality role. The main reasons for this are the current vicious competition in the agricultural market with low prices as the main means, and the unstable product quality of small enterprises. The shortcomings of this paper are: 1. only the empirical method was used to select the threshold of the algorithm, failing to make full use of the actual information; 2. the research sample was limited to agricultural enterprises in Hebei Province, failing to extend to the whole country. The above will be used as the direction of future research.

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