Research on maturity of engineering project informatization management——As an example of Anhui Sanjian Engineering Co.,LTD.

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Abstract. With Anhui Sanjian Engineering Co.,LTD. as the research object, using the AHP, Delphi and CMM grading model, the index weight is calculated by Yaahp software, engineering project of Anhui Sanjian Engineering Co.,LTD. Engineering project information management maturity has carried on the preliminary judgment and set up evaluation index system of engineering project information management maturity in Anhui province.Through the comparison between the comprehensive evaluation score and the evaluation interval, it is concluded that the engineering project informatization management of Anhui Sanjian Engineering Co.,LTD. Engineering project information management maturity is at the management mode level.This paper studies and analyzes the current situation and deficiencies of engineering project informatization management construction of Anhui Sanjian Engineering Co.,LTD. engineering project information management maturity and points out the next development direction for its informatization management construction.

1.Introduction

1.1Research background

Information technology makes enterprises change from traditional management mode to information management mode**.**In the development course of our country from the introduction of electronic information technology to the use of information technology to promote modernization,information is developing at an unprecedented speed.However,the construction industry started late in informatization, and there are many characteristics such as large volume, large number of personnel, labor intensive, diverse production modes, high degree of marketization in the construction industry, and various contents, procedures and links of engineering projects. Facing the current information management environment,the application degree or maturity degree of information technology in construction enterprise engineering project management becomes the research trend.

1.2Literature review

Although the research on project information management in China is not long, the research on the index system has developed rapidly in recent years. According to the order of time, the author expounds the status quo of research on informatization management index system in China.

Lu Sun (2006) established a set of evaluation index system on information basis, information management, information organization and information environment based on IMM model. Although

the framework of the evaluation system was established, they did not carry out detailed research.Based on the standardization and optimization of enterprise management, Hong-Yun Lv (2010) proposed to establish a maturity evaluation system of engineering project information management with 4 first-level indicators and 19 second-level indicators.

When measuring the informatization level of large construction enterprises,Jian Zhang (2011) selected the evaluation object mainly for informatization talents, informatization utility, hardware facilities,informatization organization,and informatization software system as five informatization evaluation indexes, he constructed the evaluation index system.Pengfei Li (2013) took China's engineering projects as the research object and mainly constructed the indicator system from macro and micro perspective, which was formed with the level of hardware and software guarantee, information technology application and profitability, organization level and capability level. According to the analysis of informatization maturity model (CMM) now at home and abroad,Mingdong Huang and Zhigang Li (2014) combined with the current model and put forward a preliminary framework of the project information management maturity evaluation from the widthof hard software applications , the depth of the hard software application and the management of resources optimization degree.Changqing Sun etc.(2016) first proposed the concept of two-dimensional maturity of project management informatization from the two dimensions of project management and informatization, and designed the two-dimensional maturity evaluation index of project management informatization based on the project management process.

Through the analysis of relevant literature on project informatization management, the author finds that most scholars take informatization management technology as the research object, and focus on infrastructure, application level and practical effect as the research content.Few scholars analyze the informatization of engineering projects from the perspective of management, and they cannot fully evaluate the informatization management of engineering projects.This paper mainly analyzes the informatization of engineering projects from the perspective of management, and builds a complete evaluation system of informatization management maturity of engineering projects based on the CMM model.

2. Material and Methods

2.1 Connotation and characteristics of information management of engineering projects

Engineering project is a project with engineering construction as the carrier and a one-off engineering construction task as the object of management. It takes buildings or structures as the target output, needs to pay a certain fee, follows a certain procedure, completes within a certain time, and should meet the quality requirements, such as building a building, building a bridge, etc. This paper believes that the project information management refers to the use and development of information resources by making full use of information technology in the process of each link and level of project management, so that information resources can be shared, facilities can be effectively and reasonably allocated, the level and efficiency of project management can be improved, and management costs can be reduced.The project informationization management studied in this paper refers to the construction stage of the project life cycle.

2.2 Index system

According to the connotation and characteristics of project information, combined with the content of the project information management maturity evaluation method, the reference to related literature review, based on the principle of index system construction, this paper focuses on the evaluation indicators of economic and social benefits arising from information management of engineering projects,preliminary builds the maturity evaluation index system of project information management of Anhui Sanjian Engineering Co., LTD.

2.2.1Technical indicators(A_1). Based on the study of the project life cycle construction stage,

technology mainly refers to infrastructure construction and application level. In terms of infrastructure construction, it mainly includes input ratio of informatization construction and expenditure of informatization operation and maintenance. The application level mainly includes the number and position of information leaders, the type of informatization talents, the popularization rate of informatization technology and the level of informatization of business process.

2.2.2 Management indicators(A₂). Management indicators have two key process areas,namely information exchange and management norms with multiple key practices per key area. Information exchange can be reflected from the exchange and sharing of information and data, the integration level of information and data, and the integration level of information and data. The management standard is mainly reflected by the information security management level, management standardization level and information management organization.

2.2.3Performance indicators(A₃). The performance indicators have two key process areas: the overall application benefit and the degree of management innovation. The overall application benefit index mainly includes the enterprise economic benefit generated by informatization, enterprise social benefit generated by informatization and enterprise core competitiveness generated by informatization. The degree of management innovation is reflected from the degree of business model optimization and management mode optimization.

2.3 Research methods

The analytic hierarchy process (AHP) is a systematic method that classifies a complex decision-making problem with multiple objectives into one class, and then decomposes the problem into multiple objectives[10].Through the fuzziness of such qualitative indicators, the single hierarchical ordering (weight) and total ordering can be calculated, so as to be used as the objective multi-scheme optimization decision making method. This paper uses the analytic hierarchy process (ahp) to determine the weight value of each index element and to analyze the maturity of informatization management of engineering projects in anhui province.

In order to quantify the qualitative indexes, the weight of each index is assigned in this paper according to the 1-9 scale method. Due to the limitations of research conditions such as time and funds, the Delphi method was applied in this paper to only conduct a questionnaire survey on four experts, and the assignment of four experts was sorted out. According to the calculation thinking of AHP method, the weight of each indicator in this paper was obtained, and the judgment matrix was processed by Yaahp hierarchical analysis software. The weight calculation method of the first-level index is detailed below, and the weight of all indexes is calculated according to the same steps.

Table 1.The original data of the weight assignment of the first-level index of expert 1

Maturity	A_1	A_2	A_3	Normalization
A_1	1	1/5	3	0.1884
A_2	5	1	7	0.7306
A_3	1/3	1/7	1	0.0810

The feature vector is w_1= （0.1884,0.7306,0.0810),the maximum feature root $\lambda \max = \frac{1}{n}\sum_{i=1}^{n}\frac{(Aw)i}{wi}$

=3.0649,the consistency index: $CI = \frac{\lambda\max-n}{n-1} = 0.0324$,the average random consistency index

$CR = \frac{CI}{RI} = 0.0251$ <0.1, CR<0.1, indicating that this judgment matrix is a satisfactory consistency matrix.

Table 2. Original data for weight assignment of the first-level index of expert 2

Maturity	A_1	A_2	A_3	Normalization
A_1	1	5	3	0.6586

A_2	1/5	1	1	0.1562
A_3	1/3	1	1	0.1852

The feature vector is w1=（0.6586,0.1562,0.1852）, the maximum feature root $\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n}\frac{(Aw)i}{wi}$ =3.0291,the consistency index: $CI = \frac{\lambda_{\max}-n}{n-1} = 0.0145$,the average random consistency index $CR = \frac{CI}{RI} = 0.0251$ <0.1, CR<0.1, indicating that this judgment matrix is a satisfactory consistency matrix.

Table 3.Original data of weight assignment of the first-level index of expert 3

Maturity	A_1	A_2	A_3	Normalization
A_1	1	1	5	0.4806
A_2	1	1	3	0.4054
A_3	1/5	1/3	1	0.1140

The feature vector is w1= （0.4806,0.4054,0.1140）, the maximum feature root $\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n}\frac{(Aw)i}{wi}$ =3.0291, the consistency index: $CI = \frac{\lambda_{\max}-n}{n-1} = 0.0145$, the average random consistency index $CR = \frac{CI}{RI} = 0.0251$ <0.1, CR<0.1, indicating that this judgment matrix is a satisfactory consistency matrix.

Table 4.The original data of the weight assignment of the first-level index of expert 4

Maturity	A_1	A_2	A_3	Normalization
A_1	1	1/3	3	0.2583
A_2	3	1	5	0.6370
A_3	1/3	1/5	1	0.1047

The feature vector is w1= (0.2583,0.6370,0.1047), the maximum feature root $\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n}\frac{(Aw)i}{wi}$ =3.0385, the consistency index: $CI = \frac{\lambda_{\max}-n}{n-1} = 0.0193$, the average random consistency index $CR = \frac{CI}{RI} = 0.0332$ <0.1, CR<0.1, indicating that this judgment matrix is a satisfactory consistency matrix.

Table 5.Calculation results and comprehensive weight values of the four experts on the weight of first-level indexes

First-level index weight	Expert 1	Experts 2	Experts 3	Experts 4	Comprehensive weights
A_1	0.1884	0.6586	0.4806	0.2583	0.3965
A_2	0.7306	0.1562	0.4054	0.6370	0.4823
A_3	0.0810	0.1852	0.1140	0.1047	0.1212

According to the calculation method in the above process, the evaluation data given by the four experts are calculated, and the average value (the comprehensive weight of the last column) is calculated at last. We can also see that the management index is the biggest factor affecting the informatization maturity of engineering projects, followed by the technical index and finally the effectiveness index. Similarly, the weight of the four experts on the second and third indicators is calculated. The weight calculation results of the evaluation indicators are shown in the table below.

Table 6.Comprehensive weight value of the evaluation index system of informatization management maturity of engineering projects in Anhui Sanjian Engineering Co.,LTD.

The level of business process informatization	Criterion layer				
	First grade indexes	The secondary indexes	Three grade indexes	Weight	Serial num.
Evaluation system of informatization maturity of engineering project	A_1 （0.3965）	Infrastructure B_1 （0.5）	Input ratio of information construction C_1	0.6540	1
			Expenses of informationization operation and maintenance C_2	0.3460	2
		Application level B_2 （0.5）	An information-based leadership position C_3	0.0848	3
			The number of informationalized leadership C_4	0.1312	4
			Types of information talents C_5	0.2945	5
			Information technology penetration rate C_6	0.1619	6
			Level of informatization of core business process C_7	0.3276	7
	A_2 （0.4823）	Information communication B_3 （0.6667）	Exchange and sharing of information and data C_8	0.2948	8
			Information and data integration level C_9	0.3267	9
			The level of integration of information and data C_{10}	0.3785	10
			Information security management level C_{11}	0.3006	11
		Management specification B_4 （0.3333）	Management standardization level C_{12}	0.4495	12
			Perfect the system of information management organization C_{13}	0.2499	13
	A_3 （0.1212）	Degree of management innovation B_5 （0.6667）	Management mode optimization degree C_{14}	0.5841	14
			Degree of business model optimization C_{15}	0.4159	15
		Overall application benefit B_6 （0.3333）	Enterprise economic benefits generated by informatization C_{16}	0.2143	16
			The social benefits of enterprise generated by informatization C_{17}	0.2979	17
			The core competitiveness of enterprises produced by	0.4878	18

informatization C_{18}

2.4CMM model

The CMM model provides a stepped evolutionary framework, which is a relatively static level standard. On the one hand, it can evaluate its current process maturity, so as to formulate strict project quality standards and process improvement methods and strategies, and achieve higher maturity through continuous efforts. On the other hand, this standard can be used as the evaluation standard for the achievements of enterprise informatization, so that it is no longer blind and uncertain in the process of informatization. The CMM model gives 5 maturity levels, and its internal structure is composed of several key process areas (KPA). Each key process area further contains key practices to guide the enterprise to meet the objectives under each KPA, so that the whole process improvement work is formed from top to bottom into a regular step. From low to high, the CMM model is at the initial level, technical support level, management mode level, comprehensive integration level and optimization level. According to the actual situation of information management maturity level of engineering projects of Anhui Sanjian Engineering Co.,LTD. and referring to the representative hundred-mark system scoring method, the total score interval of each grade of information management maturity level of engineering projects of Anhui Sanjian Engineering Co.,LTD. is summarized by integrating various factors.

Table 7. Corresponding relationship between the informatization maturity level and the score interval of the project of Anhui Sanjian Engineering Co.,LTD.

Information maturity level of engineering projects	The value interval of engineering project informatization maturity
The initial stage	0~20
Technical support level	20~40
Management mode level	40~60
Integrated integration level	60~85
The optimizing level	85~100

3. Results

3.1Information management status of Anhui Sanjian Engineering Co.,LTD.

Based on national information technology, Anhui Sanjian Engineering Co.,LTD. has gradually realized digitization, intellectualization and networking. In terms of technology, the company has developed its own operation and management information system to deal with internal affairs and business processes. The decision-makers of the company drew on the experience of the group headquarters in implementing informatization, actively introduced advanced technologies, and successfully applied Cuhk i6p software to achieve collaborative office and comprehensive project management. From the perspective of management, the company has set up an independent information development department, and has the ability to analyze and evaluate the current situation of informatization. From the perspective of effectiveness, the company has gradually established an information economy environment closely connected with enterprise organization structure, technology research and development, production and manufacturing, marketing and after-sales service.The company changes the original business ideas, methods and modes of operation to achieve business model innovation and product technology innovation, and provides powerful methods and means to achieve it by means of information technology, but only limited the scope of the manufacturer's own products, ignoring the diverse needs of customers.

3.2 Evaluation results of informatization management maturity

This section takes Anhui Sanjian Engineering Co.,LTD. as the research object and conducts a questionnaire survey on the management, non-management and ordinary employees of the company.

Through the analysis of the survey data, combined with the detailed scoring rules given in the previous text and the weight calculated by the expert scoring, the score of the evaluation index of informationization management maturity of Anhui Sanjian Engineering Co.,LTD. was obtained through comprehensive calculation.

Table 8. Information management maturity evaluation of Anhui Sanjian Engineering Co.,LTD.

First grade indexes	WeightW_n	Secondary index score	Second index	Weight W_{ni}	Comprehensive scores of three levels	Three grade indicators	The survey value	Weight W_{nij}	The survey value *weight	The serial num.
A_1	0.3965	64.7	B_1	0.3333	73.46	C_1	70	0.6540	45.78	1
						C_2	80	0.3460	27.68	2
			B_2	0.6667	60.3315	C_3	70	0.0848	5.936	3
						C_4	60	0.1312	7.872	4
						C_5	50	0.2945	14.725	5
						C_6	75	0.1619	12.1425	6
						C_7	60	0.3276	19.656	7
A_2	0.4823	65.6	B_3	0.6667	65.896	C_8	80	0.2948	23.584	8
						C_9	60	0.3267	19.602	9
						C_{10}	60	0.3785	22.71	10
			B_4	0.3333	64.998	C_{11}	60	0.3006	18.036	11
						C_{12}	60	0.4495	26.97	12
						C_{13}	80	0.2499	19.992	13
A_3	0.1212	17.62	B_5	0.5	19.159	C_{14}	15	0.5841	8.7615	14
						C_{15}	25	0.4159	10.3975	15
			B_6	0.5	16.072	C_{16}	20	0.2143	4.286	16
						C_{17}	15	0.2979	4.4685	17
						C_{18}	15	0.4878	7.317	18

- Score of technical dimensions:

$I_1=I_{11}\times W_{11}+I_{12}\times W_{12}=73.46\times0.3333+60.3315\times0.6667=64.7$

$I_{11}=I_{111}\times W_{111}+I_{112}\times W_{112}=70\times0.6540+80\times0.3460=73.46$

$I_{12}=I_{121}\times W_{121}+I_{122}\times W_{122}+I_{123}\times W_{123}+I_{124}\times W_{124}+I_{125}\times W_{125}$
$=70\times0.0848+60\times0.1312+50\times0.2945+75\times0.1619+60\times0.3276=60.3315$

- Management dimension index score

$I_2=I_{21}\times W_{21}+I_{22}\times W_{22}=65.896\times0.6667+64.998\times0.3333=65.6$

$I_{21}=I_{211}\times W_{211}+I_{212}\times W_{212}+I_{213}\times W_{213}=80\times0.2948+60\times0.3267+60\times0.3785=65.896$

$I_{22}=I_{221}\times W_{221}+I_{222}\times W_{222}+I_{223}\times W_{223}=60\times0.3006+60\times0.4495+80\times0.2499=64.998$

- Score of effectiveness dimensions:

$I_3=I_{31}\times W_{31}+I_{32}\times W_{32}=19.159\times0.5+16.072\times0.5=17.62$

$I_{31}=I_{311}\times W_{311}+I_{312}\times W_{312}=15\times0.5841+25\times0.4159=19.159$

$I_{32}=I_{321}\times W_{321}+I_{322}\times W_{322}+I_{323}\times W_{323}=20\times0.2143+15\times0.2979+15\times0.4878=16.072$

- Anhui Sanjian Engineering Co.,LTD. Informatization management maturity total score：

$I=I_1\times W_1+I_2\times W_2+I_3\times W_3=64.7\times0.3965+65.6\times0.4823+17.62\times0.1212=59.43$

4. Discussion

The total score of informatization management of Anhui Sanjian Engineering Co.,LTD. under this evaluation system is 59.43 and the corresponding score interval can be seen as between 40 and 60, belonging to the management mode level. This is consistent with our initial judgment.An effective information system has been established throughout the company. *The informatization gradually involves the core business process of the company.*The information technology and management model are effectively combined. However, the company is facing a new challenge. The company is now in the transition stage of comprehensive integration. The company must review its business strategy, and take into account the problems of communication between departments, sharing of data resources and internal and external environment. Strict implementation of the informatization process, informatization process capability, informatization process performance and informatization process

maturity method and evaluation is the basic guarantee of success. Referring to the characteristics of management mode level in maturity level and compare with the current status of the company,it can be seen from the table that the positions of informationized leaders, the number of informationized leaders, the degree of optimization of management mode, the economic benefits of enterprises generated by informationization, the social benefits of enterprises generated by informationization and the score of core competitiveness of enterprises generated by informationization are relatively low.Although the company separated the information management department, it still should increase the number of informatization leadership, make information consciousness penetrated into the company's senior management,introduce different kinds of information talents, improve the level of company information and data integration level and improve the system of information security management to promote the construction of the company information.

5. Conclusions

At present, enterprise informatization management has become a major development trend of enterprise development in China. Meanwhile, informatization is an important way to enhance the core competitiveness of enterprises. In this paper,a preliminary study has been carried on Anhui Sanjian Engineering Co.,LTD. through referring to relevant literature and data, combined with the background of Anhui Sanjian Engineering Co.,LTD.,the grading range and evaluation index system of the project information management maturity of Anhui Sanjian Engineering Co., Ltd. are summarized and refined. There are some suggestions on the problems existing in the construction of informatization management of engineering projects in Anhui Sanjian Engineering Co.,LTD.

●From the perspective of technology, enterprises should strengthen the investment in infrastructure construction and the cultivation of information-based composite talents.

With the popularization of informatization,Anhui Sanjian Engineering Co.,LTD. should transform and upgrade from the management mode level to the comprehensive integration level from the perspective of infrastructure and talent training.The infrastructure is the various general technology platform, network and hardware infrastructure which supports and ensures the safe, reliable and efficient operation of various business application systems[11].In the information environment, increasing the investment in high precision and high quality computers, with the help of the high-speed processing capacity of computers, can greatly speed up the speed of information processing and improve the work efficiency.

In fact, the talent urgently needed by the enterprise of engineering project informatization is interdisciplinary talent. It includes the combination of single knowledge and multidimensional knowledge;the combination of network knowledge and practical ability;the combination of professional knowledge, market development ability and capital operation ability;and the combination of enterprise management ability and experience in international business operation. They should have a strong penetration and judgment of online information, and be able to excavate "obvious" commercial value from a common online information. Therefore, the leadership should strengthen the cultivation of compound talents and backbone training.

●From the perspective of management, enterprises should establish scientific and standardized engineering project information management system and engineering project information management sharing platform to enhance informatization application ability.

At present, Anhui Sanjian Engineering Co.,LTD. is at the level of management mode,accounting for a large proportion.Project informatization management has prepared the basic informatization management process,software and hardware platform and fixed informatization organization. Meanwhile,each department has established an independent computer data interactive system.but the project information management system is not formulate standard specification.The effective operation of the engineering project information system not only relies on the sophisticated computer, application software and network system, but also relies on its basic work. The goal of modernization of project management cannot be achieved without spending time and money on the project management system [12]. The management of project informatization can introduce different kinds of

informatization talents. Meanwhile,in the construction process of project management informatization, talents are needed to solve the problem of information exchange, integration and standardization between enterprises and projects (such as standardization of WBS, CBS and OBS codes).

●From the perspective of effectiveness, information-based enterprises should plan uniformly, implement step by step, optimize the management mode, grasp the overall thinking, find the entry point for the implementation of informatization, and steadily promote management informatization.

The purpose of information management is to integrate the management thoughts of enterprises into the system, so as to realize the smooth flow of things, the best use of money and the best use of people. Therefore, information management is a system engineering and an investment project highly concerned by the senior management of enterprises, which cannot be accomplished overnight.It needs to optimize the management mode, overall planning, step by step implementation, formulate practical and feasible information implementation program, and identify the information implementation of the breakthrough step by step to move forward.After grasping the overall idea of enterprise informatization, enterprises can follow the principle of benefit and practice mutual benefit, first part and then the whole, and take the road of informatization according to the actual situation of enterprises.

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