ERP system performance evaluation and empirical analysis

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ABSTRACT

This paper discusses the gray fuzzy evaluation method about the performance of ERP system. The index system is classified based on the balanced scorecard method, and which largely shows the main factors influencing of ERP system performance. According to the mathematical model, the quantitative process of gray evaluation is given and examples are calculated. Basically has the following conclusion, gray fuzzy comprehensive evaluation method can not only make full use of each evaluation index about financial, customer, internal processes and learning information, but also can be used to describe the level of performance, transverse comparison. This method has a wide range of practicality and good maneuverability, and the performance evaluation of ERP system has reference value.

KEYWORDS

ERP system; Performance evaluation; Gray fuzzy comprehensive evaluation method.

INTRODUCTION

In recent years, many enterprises have taken more attention to the information technology (IT) under the impact of the global informationization. The core of enterprise management informationization is the ERP (enterprise resource planning). ERP integrated the enterprise's internal resources all-round, not only improve internal operating efficiency, significantly enhance the market competitiveness of enterprises, so as to better and faster way of dealing with the change of the market, but also heighten the enterprise staff management consciousness and level. Every year, however, enterprises have to pay more attention to the strategy of the ERP investment returns, risk management, and other deep-seated problems, with huge sum and risk to the ERP. The focus of ERP has changed gradually from the initial construction of infrastructure to the deepening of ERP application and penetration stage. With ERP system application and implementation caused the change of enterprise management mode and business process reengineering, it will be a profound influence on the operation of the enterprise in each link. ERP system performance evaluation of enterprise, on the one hand, can fully understand and master the operating performance of ERP, help to make an information development match enterprise strategic goals, improve enterprises management, combined enterprise short-term interests and long-term goal effectively. On the other hand, it is to summarize the experiences of implementing project and to take the foundation for the subsequent IT project.

LITERATURE ABOUT PERFORMENCE EVALUTION OF ERP

Overseas relevant research dynamic

Some American experts and scholars had puts forward evaluation indicators and methods of MRPII (Manufacturing Resource Planning) application performance, among them the most famous are Oliver Wight's "ABCD performance evaluation" and Partner ERP project evaluation system, which have been widely learning and using for reference [1].

ABCD evaluation method included strategic planning, human factors and the cooperation spirit, total quality management (TQM), new product research and development, planning and control process five parts. Each part has a brief qualitative description to explaining the main consideration question and the different qualitative characteristics of ABCD four levels. Partner, the standardization of the famous American institutions, focuses on the long-term benefits and implementation of the evaluation system of ERP project which included project driving factors, transaction processing index and critical success factors [1].

Delone and Mclean put forward the six key index of IT project implementation on the research results. There ware system quality, information quality, system usage, customer satisfaction, employees effect and organization effect. On this basis, they had raised D&M model which introduced the connection between the key indexes. D&M model is a milestone in the IT project evaluation. From then on, many studies of IT evaluation are based on D&M model [2].

Domestic relevant research dynamic

In the late 70s China was introduced the internationally accepted ERP project performance evaluation method. At present, the representative is the evaluation index system of Tsinghua University with comprehensive benefit analysis, based on key success factors of the enterprise such as time, quality, cost, service and environment. In October 2002, in order to evaluate the Chinese enterprise informatization level correctly and objectively, and guide the enterprise information based on efficiency, the National Informatization Evaluation Center of China issued "The Chinese Structural Scheme of Enterprise Informatization Index System" and "The Information Benchmarking Selection Plan of Chinese enterprises ". Draw lessons from international general evaluation system of ERP project, the ERP system implementation effect evaluation is divided into two most: ERP basic evaluation index system and ERP performance evaluation index system [3].

Practice shows that the ERP project performance evaluation is a systematic concept, involving multiple levels and multiple factors, uncertainty and complexity. In practice, some indicators are quantified easily; however, other individual indicators can't be quantitative description or cannot be directly compared between indicators at the same time. Because of various reasons, evaluation can only make judgments on the basis of experience and knowledge. It is difficult to achieve the goal of overall optimal and to make effective performance evaluation separately with quantitative or qualitative method. This paper adopts the combination of qualitative and quantitative methods to analyze the performance of the enterprise implement ERP project.

ERP SYSTEM EVALUTION INDEX BASED ON THE BALANCED SCORECARD

Fuzzy comprehensive evaluation method is a systematic analysis method based on the fuzzy set theory (L.A.Z soon, 1965) [4]. Its advantages is to solve the quantify problem of the qualitative evaluation index reasonable. In the application of gray comprehensive evaluation method to evaluate the ERP project performance, should first establish the ERP project performance evaluation index system. Correcting analysis of the factors affecting ERP project performance, establishing a reasonable evaluation index system and the classification standard are warrants for the evaluation success. Balanced scorecard (BSC) from a strategic height, based on management, by adopting the idea of comprehensive balance, through the relationship between each other and mutual penetration, builds a three-dimensional and network structure [5]. Fuzzy comprehensive evaluation method builds up the strict, scientific and complete evaluation system structure, fully embodies the full cycle from

the strategy into action, it can effectively connected relationship between strategy, performance management and performance evaluation, and put the strategy into measurable indicators [6].

From these four perspectives "financial, customer, internal processes, and growth and learning", the balanced scorecard provides a method of examination of value creation strategy [7]. This is a list of long-term value and competition performance driving factors, overcome the limitation of simple performance management by financial means. ERP is a huge system, the main function modules including manufacturing module (master production plan, capacity requirements planning, bill of material, workshop management and quality management), supply chain management module (purchasing management, inventory management, sales management and inventory accounting), financial management module (accounting and financial management) , customer relationship management module, human resources management module, decision support system module and business intelligent module. Being established a mapping relationship between function modules of the ERP, the four aspects of BSC is shown in figure 1.
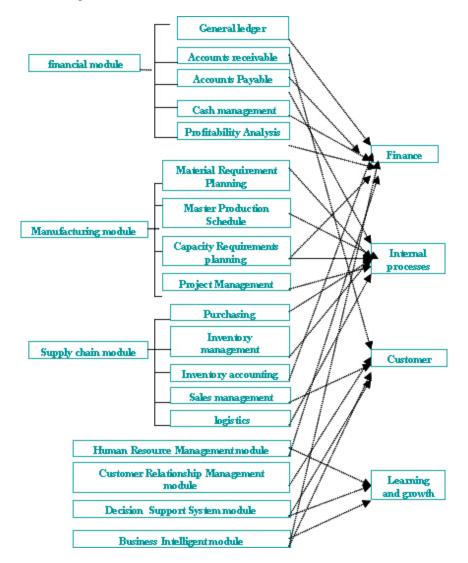

Figure 1: The mapping relationships between ERP system module and BSC scorecard

It can be seen from the figure 1, the financial management module including the general ledger, accounts receivable, accounts payable, cashier cash management and profitability analysis is corresponding BSC. Manufacturing module and supply chain management module belong to the internal production and operation process of each link in an enterprise, therefore, which are the corresponding internal processes of BSC. Sales management is not only corresponding internal processes, but also corresponding to the clients. Inventory accounting is corresponding financial too. Decision support system module and the business intelligence module are correspond to grow and learn, and corresponds to the customer, the financial aspect. In this way, the implementation effect of each module of ERP system and enterprise performance of each department can get a comprehensive evaluation through the four aspects of the balanced scorecard. Similarly, in the implementation of the balanced scorecard, the performance evaluation indicators tend to involve the enterprise's financial data, the cost, quality and production plan data in the process of manufacturing, sales, profit and employee information, etc.

Each evaluation index is mostly on the basis of large amounts of data statistics. Therefore, the balanced scorecard demands integration with management information system, and realize data sharing. Using the balanced scorecard performance evaluation in ERP environment, relevant data can be read from the module of ERP, so that the ERP system can realize the organic integration of the balanced scorecard system [7]. Based on this, we combine with the target system of the ERP system, the elements of performance evaluation and the problem characteristics of the research focus on current related evaluation, and propose the performance evaluation index system of ERP method balanced scorecard as the core in this paper. (table1).

Table 1: ERP system performance evaluation indicators based on the balanced

Indicators of the first layer	Indicators of the second layer	
Finance M_1	Return on assets	M_{11}
	Return on equity	M_{12}
	Capital turnover rate	M_{13}
	Profit growth rate	M_{14}
	Accounts receivable turnover	M_{15}
Customer M_2	Market share	M_{21}
	Customer satisfaction	M_{22}
	Customer loyalty	M_{23}
	New customer growth rate	M_{24}
	Customer response time	M_{25}
Internal Processes M_3	Average purchasing cycle	M_{31}
	Implementation plan	M_{32}
	Inventory turnover	M_{33}
	Product production cycle	M_{34}
	Basic data accuracy	M_{35}
Learn & Grow M_4	innovation	M_{41}
	Knowledge management	M_{42}
	Staff skills	M_{43}
	Employee satisfaction	M_{44}
	Decision efficiency	M_{45}

ESTABLISHMENT GREY ASSESSMENT MODEL OF THE ERP SYSTEM PERFORMANCE

For the performance evaluation of ERP system implementation, we adopt the multi-level fuzzy evaluation because there are many related influence factors that is easily weakened evaluation weight using the single factor to evaluate. According to the index system in table 1, ERP system performance evaluation can be divided into three levels, the overall target layer M, it indicates the ERP system performance evaluation which is primary evaluation index of a collection of the first layer evaluation index M={ M1, M2, M3, M4}. Mij is secondary evaluation index of a collection of notes for Mij = {M1j, M2j, M3j, M4j}. The specific steps of gray evaluation are as follows:

Determine factors set

According to the relationship of each factor in the system, evaluation indexes are divided into different levels, then, the hierarchy structure model is established. The index set of factor indexes, with M, according to the M= {M1, M2, M3, M4}, M1 ={ M11, M12, M13, M14, M15}, similarly to the M2 - M4, symbolic meanings are shown in table 1.

Determine index weights of the performance evaluation

Weight is also called the weight or the weighted coefficient, and is showed quantitative distribution based the important degree. It can reflect the relative importance of the indicators. In multi-level evaluation, the importance of evaluation indexes is usually different. Whether reasonable and scientific to the weight determination directly affects the accuracy of the evaluation. The meaning of the weight of each index as the index in this level is important degree relative to other indicators. The weight of each index is N={N1,N2,N3,N4} respectively, which are determined by expert investigation method or used Analytic Hierarchy Process (AHP) to get the weight of Ni= {Ni1, Ni2,…,Nin}.

The using AHP, there are five steps [8]:

Step1. Establish the system-level model;

Step2.Tectonic binary comparison judgment matrix; (positive reciprocal matrix)

Step3. Calculate the maximum eigenvalueλmax of judgment matrix and corresponding eigenvectors;

Step4. Calculate consistency index CI, RI, CR and do consistency test. As a general rule, the relative consistency index is smaller, the consistency of judgment matrix is better. When the relative consistency index less than 0.1, we can say that the judgment matrix is satisfied. Otherwise, return to the step2, to adjust or fixed the valuation of comparative judgment matrix;

Step5. Determine the weight of each single index in the lowest layer of the hierarchical structure model.

Determine grade value of evaluation

Grade value of evaluation is various kinds of evaluation results made by evaluators for evaluation objects, and convert the qualitative indicators to quantitative indicators, should be assigned to each index accordingly. In accordance with the principle of ten-point scale, the four rating scores were excellent, good, qualified and unqualified. Index levels in between the corresponding score for each value represented as R= {R1, R 2… Rn}.

Building the grey one-way evaluation model

According to the hierarchical structure model, the judgment matrix is established. In the judgment matrix, the fuzzy evaluation matrix Di of two factors is assigned according to the data analysis, questionnaire, expert opinion and analysts' cognition after the comprehensive. The grey single-tier mathematical evaluation model is Mi = Ni · R, where R means evaluation results of the i-th factor, and N is weights allocation matrix for the i-th evaluation index. The fuzzy comprehensive evaluation of the operator is chosen $S(\bullet, \oplus)$.

$$s_k = \min\left(1, \sum_{j=1}^{m} \mu_j r_{jk}\right), \quad k = 1, 2, \cdots, n$$

Setting up Gray Multi-level Comprehensive Evaluation Model

Multi-level evaluation model based on the sheer level evaluation model, the basic idea is: first of all, comprehensive evaluation is done on the base layer of the hierarchy system, then put the evaluation results Mi (Mi = Ni · R) of this level as a hierarchy of original indexes, repeated again on a single evaluation, and so on to the top.

$$M = W \circ R = (\mu_1, \mu_2, \cdots; \mu_m) \circ \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nn} \end{pmatrix} = (M_1, M_2, \cdots; M_n)$$

" ○ "is the fuzzy synthesis operator.

According to the most power principle of evaluation target M, evaluation of grey class level is determined. If Ri= max {R1, R2, …Ri }, then the value of the evaluation is the I class . Sometimes, the evaluation will lose effect because of dropping out too much information in accordance with the most power principle especially R cannot be directly used to rank and select for the evaluation object. Thus, we should do further processing with the grey comprehensive evaluation vector, so that make R with uniformitarian and calculate V value of the comprehensive evaluation. IF all grey class level were assigned according to the gray level, then, we can get each grey evaluation class hierarchical vector U=(U1, U2, …,Ui), calculate the comprehensive evaluation value V=R×UT, and sort evaluation object by the value V.

From the above description of the multilevel gray comprehensive evaluation method as you can see, its' main characteristic is to describe different evaluation vector of gray classes using the scatter multiple evaluators information. Then uniform zing this vector, when there are many participators in the evaluation, the result can also been used for sorting selection according to the grey comprehensive evaluation value, except for evaluation of the evaluation level.

THE EMPIRICAL ANALYSIS

There is an electrical incorporated company A which is a large state-owned B shares listed company in China. In September 2004, the company had built EFLY ERP system successfully and the implement ERP systems including financial, supply chain management, manufacturing and other 20 modules and a set of Easy Flow of workflow software. The overall objectives of the enterprise information construction are to reach the information integration among the company internal departments, suppliers and customers, to reach the research and development, production, management and service sharing resources, information and knowledge, and to improve enterprise's market reaction ability, innovation ability and customer satisfaction comprehensively. Through interviews and field survey with relevant personnel to understand the status of the whole system running, we adopted the questionnaire to answer questions, to obtain basic information of the evaluation. The results are shown in table 2(E= Excellent, W=Well, Q= Qualified, D= Disqualified).

Table 2: Performance evaluation data of the ERP system

First layer		Second layer		Evaluation value			
Index	Weight	Index	Weight	E	W	Q	D
M1	0.40	M11	0.30	0.5	0.3	0.2	0
		M12	0.30	0.5	0.3	0.1	0.1
		M13	0.13	0.4	0.3	0.3	0
		M14	0.13	0.7	0.2	0.1	0
		M15	0.14	0.6	0.2	0.2	0
M2	0.30	M21	0.09	0.5	0.3	0.2	0
		M22	0.27	0.4	0.3	0.3	0
		M23	0.27	0.6	0.2	0.1	0.1
		M24	0.28	0.5	0.2	0.2	0.1
		M25	0.09	0.3	0.4	0.3	0
M3	0.20	M31	0.23	0.3	0.5	0.2	0
		M32	0.23	0.4	0.3	0.3	0
		M33	0.23	0.7	0.2	0.1	0
		M34	0.11	0.6	0.3	0.1	0
		M35	0.20	0.5	0.3	0.2	0
M4	0.10	M41	0.30	0.7	0.2	0.1	0
		M42	0.30	0.4	0.3	0.2	0.1
		M43	0.13	0.5	0.3	0.2	0
		M44	0.13	0.3	0.4	0.3	0
		M45	0.14	0.6	0.3	0.1	0

Determine the Weights of ERP Performance Evaluation

The index weights of ERP performance evaluation is calculated by using the Analytic Hierarchy Process method (AHP). The first layer index Mi (i = 1, 2, 3, 4), whose weight vector is M={0.25,0.25,0.25,0.25}. The second index M1j(j=1,2,3,4,5), whose weight vector is M1={0.30,0.30,0.13,0.13,0.14}.

Dividing the evaluation level

Rating standards as shown in table 3:

Table 3: The grade standard of index evaluation of ERP system performance

Grade	0.9<Ri≤0.6	0.6<Ri≤0.4	0.4<Ri≤0.2	0.2<Ri≤0
Ri	Excellent	Well	Qualified	Disqualified

Building Evaluation Factor Matrix

According to the evaluation factors, to determine the membership of each factor and establish the evaluation matrix. The sample matrix can be divided into financial index R1, customer index R2, internal process index R3, learning and growth index R4. Evaluation grade level is got by the evaluation standard, which have filled in the corresponding mark sheets. According to the expert assessment, the sample matrix Ri is made after processing.

The maximum characteristic root of the judgment matrix R was calculated by the Mathematical software [9]. The mean random consistency index RI=1.12, The Random consistency ratio:

$$CR = \frac{CI}{RI} = \frac{0.004725}{1.12} = 0.00422 < 0.10$$

It is proposed that the hierarchical analysis sorting result was satisfactory consistency, namely the weights allocation is reasonable.

One-way Evaluation Respectively

First, calculate the comprehensive evaluation of M1, the evaluation result is V1 based on V1= M1·R1.

$$\begin{pmatrix} 0.5\ 0.3\ 0.2\ 0 \\ 0.5\ 0.3\ 0.1\ 0.1 \\ 0.4\ 0.3\ 0.3\ 0 \\ 0.7\ 0.2\ 0.1\ 0 \\ 0.6\ 0.2\ 0.2\ 0 \end{pmatrix}$$

V1= $(0.30,0.30,0.13,0.13,0.14)$.

= $(0.45,0.273,0.17,0.03)$

The same procedure may be easily adapted to obtain V2, V3, and V4.

The Comprehensive Evaluation

M= $\sum_i w_i s_i$ =0.4845×40%+0.283×30%+0.184×20%+0.029×10%=0.318

From the above, the performance grade of a company ERP system implementation is showed by the evaluation classification standard in the table 3. The evaluation result of "Financial indicators" is the "Well" and "customer indicators" is "Qualified". According to the indicators score, the rating can be sorted. The evaluation of "internal process indicators" and "learning and growth indicators" is a little lower than other indicators.

It means that the enterprise information management is still in the early stages of the integration application. DM (database mining) and providing information for business decisions is the highlight in the future work, including knowledge management, technological innovation. The purpose of ERP performance is to make the enterprise information management to achieve the stage of data integration management [10].

THE SUMMARY

Different companies have different background, the strategic target and the business operation strategy. Each ERP system also has its characteristics, and each ERP system performance indexes will be different. So, ERP system performance evaluation index system in the actual assessment should be appropriately increase or decrease according to actual situation [11]. ERP performance evaluation is broad, requires many basic data. Therefore, it is suggested that the company establish a special performance evaluation system with a special indicators database for data collection, sorting and processing. The enterprise may consider using other advanced information technology to evaluate when their technical force is abundant. For example, using business intelligence (BI) technology can process data with making the performance evaluation indicators database connected with ERP system, saving a large amount of data collection time, so as to improve the efficiency of performance evaluation. Using the "dashboard" visualization technology can display real-time performance evaluation of data [12].

The purpose of the performance evaluation of enterprise ERP system is to pass a comprehensive understanding of the effect of ERP system operation, grasp the implementation of enterprise strategy, to guide the enterprise's information construction and the management control, provide the basis for the system maintenance upgrade, while studying the effort level of the person in charge of the ERP system to fully arouse the enthusiasm of employees, and improve the work efficiency.

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