A Fuzzy Decision Model for ERP Software Assessment

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ABSTRACT

The assessment process of Enterprise resource planning (ERP) software is critical in the early phase of an ERP project due to the selection criteria of ERP software are numerous and fuzziness. ERP software is one of costly and crucial projects for business investment. This paper proposes a practical assessment model which applies both the fuzzy analytic hierarchy process (FAHP) approach and the fuzzy Delphi method to evaluate the ERP software.

In this assessment model, there are total 32 criteria sifted out which include 21 software criteria from ISO 9126 software quality standard. A real case of chain store retailer service industry is used to illustrate the application of the model. We find out the ‘business process reengineering (BPR) and system tuning time’ is significantly important of entire criteria in this ERP project. We also find ‘recoverability’ is the most important criteria among the software criteria of ERP software.

Keywords: ERP, FAHP, Fuzzy Delphi, Decision Making, ISO 9126 Standard

INTRODUCTION

Enterprise Resource Planning (ERP) system is a method for effective planning, and control for all resources needed to take, make, ship and account for customer orders in a manufacturing, distribution and service company (APICS Dictionary, 1998). Because of the improvement of computer hardware and software capability, ERP system had grown into an integrated software solution which is capable to run every function of an organization since the early 1990s, (Kapp, 2001). As a result of the complexity of the business environment, the limitations in available resources and the diversity of ERP alternatives, ERP software selection is tedious and time consuming (Wei and Wang, 2004). Therefore, ERP software selection is crucial in the early phase of an ERP project.

This paper presents a practical procedure to optimize the alternatives of ERP software. This procedure applies the fuzzy analytic hierarchy process (FAHP) approach and fuzzy Delphi method to be the analysis tools and also combines the ISO 9126 standard to interpret software characteristics, thus it is excellent to solve the decision making problems and facilitates group fuzzy decision making process. A practical case of chain store retailer service industry (company B) in Taiwan is demonstrated the practicality of the procedure.

LITERATURE REVIEW

FAHP Approach and Fuzzy Delphi Method

Frequently, human judgments are often ambiguous and cannot estimate his/her preference with a crisp numerical value (Herrera and Herrera-Viedma, 2000). Fuzzy set theory is developed for solving problems in which description of activities and observations are imprecise, vague and uncertain. Since Buckley (1985) incorporated the fuzzy set theory into the traditional AHP, FAHP were becoming a suitable tool to solve the real-world MCDM problems (Buyukozkan et al., 2004, Huang and Wu, 2005). FAHP had used to select e-marketplace software and evaluated the public transport system (Buyukozkan, 2004, Hsu, 1999). Other fuzzy set theories are also popularly adopted. Cheng and Lin (2002) adopted fuzzy Delphi method to evaluate the best main battle tank. A fuzzy multi criteria group decision making approach was proposed to select configuration items for software development (Wang and Lin, 2003).

ERP Software Assessment Method

Qualitative methods are very widely used in the past to score, rank, optimize and analysis the ERP software or other information technology (IT) system selection problem. Scott and Kaindl (2000) proposed a conceptual model for ERP package enhancement. Verville and Halingten (2003) also suggested a six-stage model to evaluate ERP software.
However, the quantitative methods were more often been used. Buss (1983) presented a ranking method in the early periods of IT projects. Rao (2000) evaluated ERP software package by using decision tree. Kumar et al. (2002) applied basic statistics in a real ERP selection case. Mathematical optimization methods such as goal programming, 0-1 binary programming and non-linear programming are also widespread been presented (Santhanam and Kyparisis, 1995, 1996, Lee and Kim, 2000, Talluri, 2000). Owing to the essence of IT system selection problem is a multi criteria decision making (MCDM) process, several papers adopted analytic hierarchy process (AHP) to be the analytical tool (Schniderjans and Wilson, 1991, Wei et al., 2005).

When implementing an ERP project, price and time are both the most important factors, besides, the vendor’s support is also a crucial issue (Langenwalter, 2000). Except the investment cost of ERP project, the annual maintenance cost and human resource cost are also the potential expense for organizations (Butlar, 1999, Bingi et al., 1999). Wei and Wang (2004) sift three categories of attributes to select an ERP system including project factors, software system factors and vendor factors. Everdingen et al. (2000) explored that software system and supplier are the major criteria which contents 10 sub criteria for selecting an ERP system. Bernroider and Koch (2001) even found that the priorities of criteria are different between small-medium sized company and large sized company. The system integration between existing information systems and ERP system is a further technical problem which might complicate the entire ERP project (Holland and Light, 1999).

### Software Quality Model

McCall et al. (1977) earliest proposed a prototype of software quality model which contents 11 criteria. Boehm et al. (1978) enlarged the characteristics of software and incorporates 19 criteria. Grady and Caswell (1987) defined five major factors containing 24 attributes for software quality and named FURPS model. These quality models are very similar to one another in many respects but differ mainly in terminology. Therefore, ISO 9126 standard (1991) standardized these quality models and drawn on the various quality models to produce a small set of six consistent characteristics, which give coverage of the main concepts of interest. The ISO 9126 software quality model is also been chosen to describe the software characteristics in our proposed assessment model.

### ASSESSMENT MODEL FOR ERP SOFTWARE

This section presents our proposed procedure which is containing five phases. A stepwise progress is readily described as follows:

**Phase 1:** Project Forming and Requirements Identification.

**Phase 2:** Feasible Software Searching and Assessment Criteria Extraction.

**Phase 3:** Hierarchy Construction for ERP Software.

**Phase 4:** Computing Fuzzy Weights and Fuzzy Scores of Criteria.

**Phase 5:** Synthetic Computation of Assessment Result and Select the Dominant ERP Software.

### FAHP Stepwise Procedure

FAHP has an existent sequential process, a stepwise procedure summarizing by Huang and Wu (2005) is presented below.

**Step 1:** Create the hierarchies

According to the problem characteristics, to decompose each attribute and build up the hierarchy structure, the 0th layer represents the ultimate goal; the 1st layer represents the primary aspects that affect the ultimate goal; the 2nd layer represents the major decision criteria of the 1st layer, and so on. The last layer represents the alternate choices of the feasible solutions.

**Step 2:** Create fuzzy pairwise comparison matrix

According to the layer structure built up in Step 1, the decision importance criteria converted into the semantic format were used to design polling questionnaires. The next phase was to convert the results of the questionnaire into fuzzy pairwise comparison matrix by using Saaty’s 9 scales.

**Step 3:** Group combination (unification, integration)

After creating the fuzzy pairwise comparison matrix, the geometric mean of each criteria in the matrix was calculated as Buckley suggested.
Step 4: Build up the fuzzy positive reciprocal matrix

After Step 3, obtaining the final calculated fuzzy numbers for each layer could form the fuzzy positive reciprocal matrix.

Step 5: Calculate the key factors’ fuzzy weights

The formulas are suggested by Buckley’s fuzzy AHP model.

Step 6: Hierarchy layer sequencing

In the final step, the sequential layers are linked together to calculate the final fuzzy weight values for each alternative.

**Fuzzy Delphi Method**

Let fuzzy number $A = (L, M, U)_{L-R}$. It can improve the weakness of the traditional Delphi method, in which the outermost data is deleted by the iterative procedure.

$$L = \min(a_1, a_2, \ldots, a_n)$$

$$M = \left( b_1 \times b_2 \times \cdots \times b_n \right)^{1/n}$$

$$U = \max(c_1, c_2, \ldots, c_n)$$

Where $M$ is defined as the geometric mean and its membership value is 1. Form $L$ to $M$ and from $M$ to $U$ denote any aggregation operations (or any types of experts’ consensus), different membership values are given as shown in Figure 1. We define the fuzzy numbers of linguistic variables to start the fuzzy Delphi method (see Table 1).

Figure 1: Fuzzy Delphi concept

<table>
<thead>
<tr>
<th>Linguistic variables</th>
<th>Fuzzy numbers (a,b,c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely Poor (EP)</td>
<td>(0,1,2)</td>
</tr>
<tr>
<td>Very Poor (VP)</td>
<td>(1,2,3)</td>
</tr>
<tr>
<td>Poor (P)</td>
<td>(2,3,4)</td>
</tr>
<tr>
<td>Medium Poor (MP)</td>
<td>(3,4,5)</td>
</tr>
<tr>
<td>Fair (F)</td>
<td>(4,5,6)</td>
</tr>
<tr>
<td>Medium Good (MG)</td>
<td>(5,6,7)</td>
</tr>
<tr>
<td>Good (G)</td>
<td>(6,7,8)</td>
</tr>
<tr>
<td>Very Good (VG)</td>
<td>(7,8,9)</td>
</tr>
<tr>
<td>Extremely Good (EG)</td>
<td>(8,9,10)</td>
</tr>
</tbody>
</table>

**Synthetic Computation and Defuzzification Policy**

Through the two fuzzy decision methods, FAHP and fuzzy Delphi, we calculate the fuzzy weights of entire criteria and the fuzzy scores of each criteria, respectively. And next we do the multiplication of fuzzy weights and fuzzy scores to synthesize the assessment result.

Finally, we adopt the center of gravity method to be the defuzzification policy. The defuzzified number is calculated by formula (2).
\[ U^* (C) = \frac{\int_{-c}^{c} C(z) zdz}{\int_{-c}^{c} C(z) dz} \]  

\[ U^* (C) \]: is defined as the value within the range of variable \( v \).

Where the area under the graph of membership function \( C \) is divided into two sub areas.

**CASE STUDY OF CHAIN STORE RETAILER SERVICE INDUSTRY**

We apply a firm of service industry to illustrate our assessment model in this research. Company B is the biggest chain store retailer of home improvement in Taiwan. This company owns over 20 direct stores in Taiwan and the business revenue is over 300 million US dollars per year. The company hires a staff of 1,500 people and there are over 30,000 merchandises for sale. Due to the sales and size of company is growing up and the number of upstream supplier is more than 500 firms, there are over 30,000 orders per week.

Thus, the company B decides to spin-off the MIS department and establishes a subsidiary company to manage the data transaction of parent company B. Through this project, company B determines to replace the information system of entire company.

**Phase 1: Project Forming and Requirements Identification**

Firstly, the general manager of company B organizes the project team including seven senior managers of different departments: administration, finance, warehouse management, supplier management, store management, purchase and a senior manager of the subsidiary company. The general manager also identifies several distinctive requirements and the qualified ERP software should provides the following functions:

1. The original POS (point of sales system) and EOS (electronic order system) must be integrated in the new ERP system.
2. The ERP system should include the CRM (customer relationship management) functions.
3. The inventory return rate should be improved.
4. The lead time and inventory level should be reduced.
5. The delivery rate should above 98%.
6. The stock-out rate should be below 10%.

**Phase 2: Feasible Software Searching and Assessment Criteria Extraction**

Once the requirements and the particular functions of ERP software are well defined, the project team could search qualified ERP software. After the preliminary screening by the limitation with budget, time and software functions, four feasible ERP software alternatives are came out. Among the four candidate alternatives, software S is an European product, software O is an American product, software D and F are the local products in Taiwan.

There are two kinds of ERP software attributes that had been classified, software attributes and project attributes, respectively. For the software attributes, we introduced ISO 9126 standard including six major characteristics and 21 sub characteristics to be the assessing attributes.

**Software attributes**

The 21 criteria of ISO 9126 standard is chosen to describe the ERP software characteristics. This software quality model identifies six key quality attributes. The detailed characterization is presented as follows (Bache and Bazzana, 1994) (see Table 2).

<table>
<thead>
<tr>
<th>Major characteristics</th>
<th>Sub characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functionality</td>
<td>Suitability, Accuracy, Interoperability, Compliance, Security</td>
</tr>
<tr>
<td>Reliability</td>
<td>Maturity, Fault tolerance, Recoverability</td>
</tr>
<tr>
<td>Usability</td>
<td>Understandability, Learnability, Operability</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Time behavior, Resource behavior</td>
</tr>
<tr>
<td>Maintainability</td>
<td>Analyzability, Changeability, Stability, Testability</td>
</tr>
<tr>
<td>Portability</td>
<td>Adaptability, Installability, Conformance, Replaceability</td>
</tr>
</tbody>
</table>
(1) **Functionality**
   This attribute is defined as the degree to which the software functions satisfies stated or implied needs and can be broken down into five sub-characteristics as follows: suitability, accuracy, interoperability, compliance and security.

(2) **Reliability**
   This attribute is defined as the capability of software that could maintain its level of performance under stated conditions for a stated period of time. It can be decomposed into three sub-characteristics as follows: maturity, fault tolerance and recoverability.

(3) **Usability**
   This attribute is defined as the degree to which the software is available for use and can be broken down into three sub-characteristics as follows: understandability, learnability and operability.

(4) **Efficiency**
   This attribute is defined as the degree to which the software makes optimal use of system resources. It can be decomposed into two sub-characteristics as follows: efficiency of time behavior and efficiency of resource behavior.

(5) **Maintainability**
   This attribute is defined as the ease with which repair may be made to the software and can be broken down into four sub-characteristics as follows: analyzability, changeability, stability and testability.

(6) **Portability**
   This attribute is defined as the ability of software that can be transferred from one environment to another. It can be decomposed into four sub-characteristics as follows: adaptability, installability, conformance and replaceability.

**Project attributes**

As mentioned above, the generally selection criteria of ERP system contents three major criteria: vender factors, cost factors and time factors. By the way of literature review and deep interview with the project teams of company B, we sift out four sub criteria of vender factors and four sub criteria of cost factors. And then we sort three time fences of the ERP project road map to be the sub criteria of time factors (see Table 3).

<table>
<thead>
<tr>
<th>Time fences of road map</th>
<th>Project activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning &amp; preparation</td>
<td>Project preparation</td>
</tr>
<tr>
<td>Software developing</td>
<td>Business process reengineering (BPR)</td>
</tr>
<tr>
<td>Testing &amp; go-live</td>
<td>Software developing &amp; tuning</td>
</tr>
<tr>
<td></td>
<td>Final testing</td>
</tr>
<tr>
<td></td>
<td>Software system go-live</td>
</tr>
</tbody>
</table>

Consequently, total 11 sub criteria have decomposed from three major criteria. The 11 criteria are displayed as follows, and we categorize them to the management criteria.

(1) Sub criteria of vender factors: market share and reputation, industrial credential, service and support, training solution.

(2) Sub criteria of cost factors: software cost, hardware cost, annual maintenance cost, staff training cost.

(3) Sub criteria of time factors: time for planning and preparation, time for BPR and system tuning, time for testing and go-live.

**Phase 3: Hierarchy Construction for ERP Software**

From the phase 2, the total 32 criteria including 21 criteria of ISO 9126 standard and 11 criteria of project attributes are extracted to describe the ERP software characteristics and project characteristics, respectively.

The hierarchy structure with layer $0^{th}$, $1^{st}$, $2^{nd}$ and $3^{rd}$ for company B and the alternative layer is located four software solutions (i.e., S, O, D and F) as shown in Figure 2.

The ultimate goal and two kinds of ERP software attributes are set in $0^{th}$ layer and $1^{st}$ layer, respectively. The $2^{nd}$ and $3^{rd}$ layers belong to major characteristics and sub characteristics, and the feasible ERP software are put in the alternative layer.
Figure 2: Hierarchy structure of ERP software assessment
Phase 4: Computing Fuzzy Weights and Fuzzy Scores of Criteria

We apply two fuzzy based methods, FAHP and fuzzy Delphi to calculate the fuzzy weights and fuzzy scores of criteria.

Computing the fuzzy weights of criteria by FAHP method

Firstly, we constructed a table of a set of question to identify ISO 9126 standard (see Table 4).

<table>
<thead>
<tr>
<th>ISO 9126 standard</th>
<th>Questions of linguistic expression to identify the ISO 9126 standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suitability</td>
<td>* The modules could fit the project propose, business processes and the current missions of the company.</td>
</tr>
<tr>
<td>Accuracy</td>
<td>* The output data report of ERP software is absolutely identical with the conventionally manual way.</td>
</tr>
<tr>
<td>Interoperability</td>
<td>* The output data of ERP software could be applied to other application systems such as POS (point of sales system), EOS (electronic order system), MES (manufacturing execution system), APS (advanced planning and scheduling system), CRM (customer relationship management system) and BI (business intelligence system), etc.</td>
</tr>
<tr>
<td>Compliance</td>
<td>* The software is developed by the popular CASE (computer-aided software engineering) tools.</td>
</tr>
<tr>
<td></td>
<td>* The software developing process conforms to software-related standards such as CMM (capability maturity model), etc.</td>
</tr>
<tr>
<td>Security</td>
<td>* The software provides various functions of security such as data encryption techniques, firewalls and authority access settings, etc.</td>
</tr>
<tr>
<td>Maturity</td>
<td>* The software has been implemented in other companies of the same industries, and holds high customers’ satisfaction.</td>
</tr>
<tr>
<td>Fault tolerance</td>
<td>* The software has the ability to maintain a specified level of performance when the software faults or the users infringe the SOP (standard operation procedure).</td>
</tr>
<tr>
<td>Recoverability</td>
<td>* The recovering and resuming process is automatic performing, and the recovered data is completely correct.</td>
</tr>
<tr>
<td></td>
<td>* There are at least 2 redundancies of backup modes such as hard-disk, CD-ROM and tape, etc.</td>
</tr>
<tr>
<td>Understandability</td>
<td>* The logic concepts of software modules are similar to the actual business processes.</td>
</tr>
<tr>
<td>Learnability</td>
<td>* The software provides help functions, and the software company provides multilingual manuals such as English and Chinese, etc.</td>
</tr>
<tr>
<td></td>
<td>* The consultant provides the BPR (business process reengineering) training to make the logic concepts of software more understandable.</td>
</tr>
<tr>
<td>Operability</td>
<td>* The GUI (graphical user interface) and window interface are available.</td>
</tr>
<tr>
<td></td>
<td>* The software supports multilingualism such as English and Chinese, etc.</td>
</tr>
<tr>
<td>Time behavior</td>
<td>* The response time of report is reduced under the equivalent data processing loading.</td>
</tr>
<tr>
<td>Resource behavior</td>
<td>* The resource duration that is suggested by the supplier.</td>
</tr>
<tr>
<td>Analyzability</td>
<td>* The software could record the log files of all transactions.</td>
</tr>
<tr>
<td>Changeability</td>
<td>* The software is well-modularized</td>
</tr>
<tr>
<td></td>
<td>* There are high-level cohesion and low-level coupling between the software modules to avoid ripple effect.</td>
</tr>
<tr>
<td>Stability</td>
<td>* The software would not failure after the customizing modification.</td>
</tr>
<tr>
<td>Testability</td>
<td>* The software has particular test programs for each function of every module.</td>
</tr>
<tr>
<td>Adaptability</td>
<td>* The software could be installed on various operation systems such as UNIX and Windows, etc.</td>
</tr>
<tr>
<td>Installability</td>
<td>* The software could automatically process the dependence between modules.</td>
</tr>
<tr>
<td></td>
<td>* One step installation when initiation.</td>
</tr>
</tbody>
</table>

Then using the hierarchy structure of total 32 criteria and the stepwise FAHP approach as mentioned above, the fuzzy weights of layer 1st, 2nd and 3rd are calculated by eight decision makes. After the fuzzy weights of each layer has been computed and linked together, the final fuzzy weights of entire 32 criteria is calculated as shown in Table 5.
### Table 5: Fuzzy weights of entire 32 criteria for company B

<table>
<thead>
<tr>
<th>Attribute Major criteria</th>
<th>Sub criteria</th>
<th>Fuzzy weights</th>
<th>Center of gravity for fuzzy weights</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software</td>
<td>Functionality</td>
<td>Suitability</td>
<td>(0.01537, 0.02866, 0.06443)</td>
<td>0.03615</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Accuracy</td>
<td>(0.01481, 0.03140, 0.07380)</td>
<td>0.04000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interoperability</td>
<td>(0.00744, 0.01444, 0.03396)</td>
<td>0.01861</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Compliance</td>
<td>(0.00416, 0.00963, 0.02056)</td>
<td>0.01145</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Security</td>
<td>(0.01553, 0.02527, 0.05232)</td>
<td>0.03104</td>
</tr>
<tr>
<td>Reliability</td>
<td>Maturity</td>
<td></td>
<td>(0.00946, 0.01636, 0.03468)</td>
<td>0.02017</td>
</tr>
<tr>
<td></td>
<td>Fault tolerance</td>
<td></td>
<td>(0.01696, 0.02749, 0.05614)</td>
<td>0.03535</td>
</tr>
<tr>
<td></td>
<td>Recoverability</td>
<td></td>
<td>(0.02403, 0.04180, 0.08024)</td>
<td>0.04869</td>
</tr>
<tr>
<td>Usability</td>
<td>Understandability</td>
<td></td>
<td>(0.00635, 0.01384, 0.02957)</td>
<td>0.01659</td>
</tr>
<tr>
<td></td>
<td>Learnability</td>
<td></td>
<td>(0.01244, 0.02527, 0.04767)</td>
<td>0.02846</td>
</tr>
<tr>
<td></td>
<td>Operability</td>
<td></td>
<td>(0.01409, 0.02618, 0.05043)</td>
<td>0.03024</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Time behavior</td>
<td></td>
<td>(0.02277, 0.04096, 0.06793)</td>
<td>0.04389</td>
</tr>
<tr>
<td></td>
<td>Resource behavior</td>
<td></td>
<td>(0.01565, 0.02942, 0.05145)</td>
<td>0.03217</td>
</tr>
<tr>
<td>Maintainability</td>
<td>Analyzability</td>
<td></td>
<td>(0.00702, 0.01265, 0.02645)</td>
<td>0.01537</td>
</tr>
<tr>
<td></td>
<td>Changeability</td>
<td></td>
<td>(0.00861, 0.01568, 0.03085)</td>
<td>0.01838</td>
</tr>
<tr>
<td></td>
<td>Stability</td>
<td></td>
<td>(0.00710, 0.01362, 0.02888)</td>
<td>0.01653</td>
</tr>
<tr>
<td></td>
<td>Testability</td>
<td></td>
<td>(0.00615, 0.01232, 0.02591)</td>
<td>0.01479</td>
</tr>
<tr>
<td>Portability</td>
<td>Adaptability</td>
<td></td>
<td>(0.00614, 0.01315, 0.02775)</td>
<td>0.01568</td>
</tr>
<tr>
<td></td>
<td>Installability</td>
<td></td>
<td>(0.00282, 0.00710, 0.01671)</td>
<td>0.00888</td>
</tr>
<tr>
<td></td>
<td>Conformance</td>
<td></td>
<td>(0.00327, 0.00753, 0.01691)</td>
<td>0.00924</td>
</tr>
<tr>
<td></td>
<td>Replaceability</td>
<td></td>
<td>(0.00525, 0.01123, 0.02354)</td>
<td>0.01334</td>
</tr>
<tr>
<td>Project Vender</td>
<td>Market share &amp; reputation</td>
<td></td>
<td>(0.01661, 0.03599, 0.07172)</td>
<td>0.04144</td>
</tr>
<tr>
<td></td>
<td>Industrial credential</td>
<td></td>
<td>(0.03687, 0.07177, 0.13139)</td>
<td>0.08001</td>
</tr>
<tr>
<td></td>
<td>Service &amp; support</td>
<td></td>
<td>(0.02818, 0.05499, 0.10542)</td>
<td>0.06287</td>
</tr>
<tr>
<td></td>
<td>Training solution</td>
<td></td>
<td>(0.01862, 0.03942, 0.07574)</td>
<td>0.04460</td>
</tr>
<tr>
<td>Cost</td>
<td>Software cost</td>
<td></td>
<td>(0.02137, 0.04413, 0.08037)</td>
<td>0.04862</td>
</tr>
<tr>
<td></td>
<td>Hardware cost</td>
<td></td>
<td>(0.01976, 0.04167, 0.07664)</td>
<td>0.04603</td>
</tr>
<tr>
<td></td>
<td>Annual maintenance</td>
<td></td>
<td>(0.02835, 0.05691, 0.10352)</td>
<td>0.06293</td>
</tr>
<tr>
<td></td>
<td>Staff training</td>
<td></td>
<td>(0.01385, 0.03239, 0.06414)</td>
<td>0.03679</td>
</tr>
<tr>
<td>Implementing time</td>
<td>Planning &amp; preparation</td>
<td></td>
<td>(0.02687, 0.05524, 0.10768)</td>
<td>0.06326</td>
</tr>
<tr>
<td></td>
<td>BPR &amp; system tuning</td>
<td></td>
<td>(0.04195, 0.07651, 0.14250)</td>
<td>0.08699</td>
</tr>
<tr>
<td></td>
<td>Testing &amp; go-live</td>
<td></td>
<td>(0.03663, 0.06697, 0.12670)</td>
<td>0.07677</td>
</tr>
</tbody>
</table>

*Computing the fuzzy scores of each criteria by fuzzy Delphi method*

By using the fuzzy Delphi method, table 6 lists the fuzzy scores for four alternatives relative to the first criteria “Suitability”, and other fuzzy scores for four alternatives relative to remaining 31 criteria are computed as the same way.
Table 6: Fuzzy scores of the ERP software relative to the first criteria “Suitability” for company B

<table>
<thead>
<tr>
<th>ERP software</th>
<th>Fuzzy scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>(7, 7.96, 10)</td>
</tr>
<tr>
<td>O</td>
<td>(5, 7.65, 9)</td>
</tr>
<tr>
<td>D</td>
<td>(5, 7.32, 9)</td>
</tr>
<tr>
<td>F</td>
<td>(4, 5.94, 8)</td>
</tr>
</tbody>
</table>

Phase 5: Synthetic Computation of Assessment Result and Select the Dominant ERP Software

Base on the synthetic computation result in Table 7, the local ERP software D in Taiwan is the dominant solution in the final rank. And the project team agrees that software D is the optimal decision for their company.

Table 7: Synthetic assessment result of the ERP software for company B

<table>
<thead>
<tr>
<th>ERP software</th>
<th>Assessment result</th>
<th>Center of gravity</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>(2.34649, 6.17385, 14.78995)</td>
<td>7.77010</td>
<td>3</td>
</tr>
<tr>
<td>O</td>
<td>(2.14993, 5.93325, 14.29131)</td>
<td>7.45816</td>
<td>4</td>
</tr>
<tr>
<td>D</td>
<td>(2.67117, 6.86643, 15.92624)</td>
<td>8.48795</td>
<td>1</td>
</tr>
<tr>
<td>F</td>
<td>(2.60858, 6.64363, 15.52024)</td>
<td>8.25748</td>
<td>2</td>
</tr>
</tbody>
</table>

CONCLUSION

Our research proposes a five phase assessment model for group decision makers to evaluate the ERP software. This model applies both the fuzzy analytic hierarchy process (FAHP) approach and the fuzzy Delphi method to analyze the weights and the scores of criteria and which also proffers decision makers an effectiveness and efficiency procedure.

The proposed model contributes two major advantages:

(a) Introducing the ISO 9126 standard to interpret the software characteristics of ERP project, a more complete and flexible overall model is conducted for ERP assessment problem.

(b) Adopting FAHP method is more practical to solve the real-world MCDM problems.

A successful case is applied to prove our proposed model is practical for use. Among the case, there are 32 criteria sifted out. We found that time issue is the most important attribute for company B. Within the software attributes, recoverability is the most important criteria. Among the project attributes, BPR & system tuning time, industrial credential and testing & go-live time are the top three important criteria.

REFERENCES


