Applied Soft Computing 28 (2015) 196–207

Contents lists available at ScienceDirect

Applied Soft Computing

journal homepage: www.elsevier.com/locate/asoc

Using Fuzzy Analytic Network Process to assess the risks in enterprise resource planning system implementation

Betty Chang[a], Chin Kuo[a], Chih-Hung Wu[b,*], Gwo-Hshiung Tzeng[c]

[a] Graduate Institute of Management, National Ilan University, Ilan, Taiwan
[b] Department of Digital Content and Technology, National Taichung University of Education, Taichung, Taiwan
[c] Graduate Institute of Urban Planning, National Taipei University, Taipei, Taiwan

ARTICLE INFO

Article history:
Received 25 November 2012
Received in revised form
11 November 2014
Accepted 21 November 2014
Available online 11 December 2014

Keywords:
Enterprise Resource Planning (ERP)
Risk Assessment
Fuzzy Analytic Network Process (FANP)

ABSTRACT

The aim of this paper was to evaluate the risk level for both intra-organizational cultures and for different industries in implementing an enterprise resource planning (ERP) system. This study adopts the Fuzzy Analytic Network Process (FANP) method to assess ERP implementation risks, which were categorized into four dimensions: management and execution, software system, users, and technology planning. An empirical survey was conducted that utilized the collected survey data of 20 ERP experts in Taiwan to assess, rank, and improve the critical risks of ERP implementation via the FANP method. Based on the results of the FANP method, a follow-up survey of ERP end-users in different departments of three industries was conducted to assess how intra-organizational cultures and cross-industries affect users' perceived risks a real world scenario. Our research results demonstrated that "lack of management support and assistance" is vital risk for a successful ERP implementation. Top management support and involvement are crucial and essential factors to the success of a firm's ERP implementation. "Ineffective communication with users" was found to be the second highest risk factor. The benefits of using the FANP method for evaluating the risk factors come from the clear priority weights between alternatives. Finally, this study provides suggestions to help enterprises decrease ERP risks, and enhance the chances of success of ERP implementations among intra-organizational cultures and across-industries.

1. Introduction

Today, the Enterprise Resource Planning (ERP) system is capable of combining all of the financial activities and information of firms, including sales, billing, purchasing, wage payment, utilities, taxes, and communication costs, especially in the exchange of information within and across organization boundaries [1,2]. Therefore, firms are implementing ERP systems to improve their enterprise performance and reinforce their competitiveness in the rapidly increasing global competition among industries. Current ERP systems are playing a critical role in underlying choices in technology development or tradeoffs implicit in new product development [2]. Presently, an ERP system is more than just an accounting information system widely accepted by enterprises [3].

While decision makers decide on how to integrate or implement ERP, the best e-business strategy may be determined by choosing from different e-business models. An ERP system is an integrated set of programs that provides support for core organizational activities, such as manufacturing and logistics, finance and accounting, sales and marketing, as well as human resources [4]. An ERP system helps different departments of an organization to share data and knowledge, reduce costs, and improve the management of business processes. The implementation of ERP systems in organizations is an enormously complex undertaking. ERP systems can affect nearly every aspect of organizational performance; hence, measures of their success must reflect this fact in the real world [5]. When an organization plans to introduce an ERP system, the goal, the implementation method, and the Business Process Reengineering (BPR) should be considered first [6]. The influences of work flow, work style, and the organizational culture must also be considered by decision makers. In general, there are three methods of ERP system implementation strategy, namely the step-by-step, the big bang, and the roll-out approaches [7]. Each of these methods has its own set of opportunities and threats.

Business intelligence models are useful in measuring and controlling financial or market risks. Business intelligence models such

* Corresponding author at: 10F-1024, Department of Digital Content and Technology, National Taichung University of Education, 140, Min-Shen Road, Tai Chung 40306, Taiwan, ROC. Tel.: +886 4 22183024; fax: +886 4 22183270.

E-mail addresses: ptchang@mail.niu.edu.tw (B. Chang), ckuo@mail.niu.edu.tw (C. Kuo), chwu@mail.ntcu.edu.tw (C.-H. Wu), ghtzeng@mail.ntpu.edu.tw (G.-H. Tzeng).

http://dx.doi.org/10.1016/j.asoc.2014.11.025
1568-4946/

as Data Envelopment Analysis (DEA) were adopted for developing the risk scoring model to assess the performance of Internet stocks [8]. Fuzzy multiple criteria decision-making (FMCDM) methodology has been used in determining, defining, testing, and comparing complex multi-level criteria for selecting strategic alliance partners for linear shipping [9]. In developing the methodology for supplier selection and evaluation in a supply chain, structured methodology – Data Envelopment Analysis (DEA), technique for order preference by similarity to ideal solution (TOPSIS), and multi-attribute decision-making (MADA) methods are adopted to rank, select, and improve potential supply chain suppliers [10,11] based on influential relationship map [12]. In risk management, a prototype expert system was applied to support the entire design process of risk management vehicles [13]. To measure the success factors of ERP implementation, an analytic hierarchical prediction method based on the Multi-Criteria Decision Making with Incomplete Linguistic Preference Relations (InLinPreRa) by natural language is adopted to help organizations become aware of the critical factors affecting ERP [14].

Decision-making problems in the real world rarely can be represented by crisp numbers; they typically take place in a fuzzy environment where the information is imprecise or uncertain [15]. Decision-making information is hard to come by, and it is often unclear, particularly in private companies [9]. The thinking and perceptions of people are often vague; although the scales in the questionnaires are equal, the interpretations of the respondents would still be different [16]. The real problem can be represented in a better way using fuzzy numbers instead of crisp numbers to evaluate the related factors. In Dağdeviren's study, a fuzzy AHP approach was proposed to determine the level of faulty behavior risk (FBR) in work systems in a real manufacturing company [17]. Using a fuzzy AHP approach, these factors were evaluated based on the work system with different weights and fuzzy linguistic variables. The FBR levels of work systems can determine and plan for work systems [17]. Some studies have proposed new fuzzy set theories to evaluate the rate of aggregative risk in software development [18,19] and ERP implementation risk [14].

In reality, human thought is vague and cannot be expressed precisely. Perceptions and feelings which are often expressed by natural language in experts are vague. For example, some words (e.g., "beautiful", "old" and so on) do not have precise measurement; likewise, human perspectives for assessing the risks in ERP implementation are also different. Thus, Fuzzy Set Theory is adopted in this paper. Analytic Network Process (ANP) used in fuzzy environment because in real-world problems, the relationships between the dimensions (or so-called factors) are usually interdependent and sometimes even exert feedback effects in a fuzzy environment; thus, in this study, fuzzy ANP (FANP) is used for assessing the risks in ERP system implementation.

In addition, the decision-maker (DM) has to express their subject option of preference information in various formats of preference presentation in the real-world. Five main preference formats include the ordering of alternatives, utility values, fuzzy estimates, multiplicative preference relations, and fuzzy preference relations cover a majority of real-world situations as decision makers' presentation of preference information [20]. To overcome the problem, Pedrycz et al. [20] proposed several types of transformation functions for converting different preference formats into fuzzy preference relation. Transformation functions for additive reciprocal fuzzy preference relation (ARFPR) include ordered array, utility value, multiplicative preference relations, and nonreciprocal fuzzy preference relation (NRFPR). Other types of transformation function for NRFPR included ARFPR, ordered array, utility, and multiplicative preference relation.

To rank and improve decision alternatives, fuzzy multi-criteria analysis often requires comparing fuzzy utilities (fuzzy numbers). Although the existing fuzzy ranking/improving methods have their advantages, these methods have some potential drawbacks including the capability to compare similar or a large set of fuzzy utilities [15]. Adequate transformation functions are helpful in converting heterogeneous preferences of information (e.g., qualitative or quantitative, ordinal, and even based on various types of scales (e.g., ordinal, interval, and ratio scales)) [20]. Moreover, one of the possible adequate methods for multi-criteria analysis is to consider an index of comparability to measure the possibility of distinguishing a doubtful judgment [21].

Some other tools such as Dependence and Feedback mechanisms can be used to improve the discussion procedure for communicating to the experts who have different options between his/her own opinions and the consensus opinions [20,22,23]. In addition, in order to increase individual consistency of each expert in the experts' group consensus, the web based consensus support system can also be utilized [23]. However, it is important to understand the advantages, weaknesses, and restrictions of these methods to adequately use those tools for avoiding the negative effect in the discussion process, namely inducing an expert to construct a complete fuzzy preference model with satisfying consistency conditions, but does not reflect the experts' real preferences [21].

ERP solutions go through three lifecycle phases: selection, implementation and operation [24]. In the real-world problem (i.e., ERP implementation risk evaluation), experts have to face the problem that using such traditional additive models may not provide an appropriate evaluation method due to the dependence and the feedback relationships that exist among the criteria [25,26]. Therefore, ANP is proposed to overcome the problem of dependence and feedback among criteria or alternatives [27]. Compared with other decision-making methods, the ANP results of evaluating and comparing alternatives are based on decision-makers' preferences [25] and address multi-attribute decision-making where attributes exhibit dependencies [26]. Therefore, if the criteria of importance can be captured properly, the quality of decision-making involved in evaluating ERP implementation risks will be enhanced correspondingly.

The ANP method has the function of establishing an evaluation framework for the criteria, which are dependent and feedback. In addition, it has the ability to rank and improve the importance of the criteria identified by systems (i.e., ANP method can be used in systematic approach to problem-solving, instead of addressing the systems of the problem, and can be to identify the sources of the problem, i.e., can avoid "stop-gap piecemeal"). In other words, the ERP risk factors identified in this study can be ranked and improved according to the weights calculated with the ANP method. Therefore, this study proposes a novel approach which combines Fuzzy Set Theory (FST), Triangular Fuzzy Number (TFN), and Analytic Network Process (ANP) to address the imprecise nature of the vague problems, used in selecting the best ERP design for the company that will implement the ERP system. In addition, a survey of ERP end-users in different departments of three industries was conducted to understand which types of ERP system designs were conceived as the least risky, and how the intra-organizational cultures affect the risks in real world scenarios by systematic consideration. The benefits of using the FANP method for evaluating the risk factors come from the clear priority weights between alternatives that it provides. From the information collecting process and the integral data, end-users from different departments of companies in across various industries could evaluate the degree of risk of each of the criteria and fully understand their own requirements.

The Fuzzy ANP (FANP) method, which was used in this study for assessing risks while firms implement ERP systems, addresses with the imprecise and uncertain nature of human comparison