Information Sciences 179 (2009) 2333–2341

Contents lists available at ScienceDirect

Information Sciences

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

A fuzzy model to evaluate the suitability of installing an enterprise resource planning system

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ARTICLE INFO

Article history:
Received 15 December 2008
Accepted 20 December 2008

Keywords:
Multi-expert decision-making
Evaluation
Heterogeneous information
ERP

ABSTRACT

The use of enterprise resource planning (ERP) as a foundation for the integration of the complete range of business processes and functions, is clearly useful and economically profitable in most very large organizations which manage a great deal of data in their information systems. However, the decision of installing an ERP system in all the companies is not always so clear, it will depend on the size, future profits and other features of the company. Therefore, different parameters (features, aspects) will be evaluated to make a decision about the suitability of the ERP system. These parameters might have different nature or the knowledge about them could be vague or imprecise. Thus, this implies that it would be suitable that the evaluation process can manage heterogeneous information. In this paper we shall present a fuzzy evaluation model to evaluate the suitability of an ERP system based on a multi-expert decision-making (ME-DM) process that is able to deal with heterogeneous information.

1. Introduction

The information technologies (IT) have an enormous impact on the productivity of the organizations. Companies have implemented systems such as enterprise resource planning (ERP) [13,17,19,23], material resource planning [4], electronic data interchange [20], etc., for improving their productivity. However, ERP systems have received much more attention recently for their potential in more effective decision-making. The installation of the ERP systems in big companies has produced an optimization of the companies internal value chain and hence important advantages and profits. This success has induced to other companies to install these costly systems expecting similar successful results. However, the installation of an ERP system is always very complex, expensive and has a massive impact on the entire organization. Due to these reasons the installation of the ERP should be evaluated carefully in order to avoid unsuccessful results in its implementation [17,19]. The use of decision analysis techniques in evaluation processes has provided successful results [3,15].

Our aim is to present a fuzzy evaluation model that studies and manages different parameters of a company to support the decision of installing an ERP system. To do so, we propose:

(1) **An evaluation scheme to study the suitability of an ERP system based on a multi-expert decision-making process**: We present a scheme that models our evaluation problem in a similar way to a decision-making process, where different experts provide their opinions and preferences about several parameters related to the implementation of an

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doi:10.1016/j.ins.2008.12.020

ERP in a company. Usually these parameters have different nature (qualitative or quantitative) and the knowledge about them are vague or imprecise. The use of the fuzzy logic provides tools to deal with this type of uncertain information [27–29].

(2) **A fuzzy model for evaluating the suitability of an ERP system**: The experts provide their knowledge about different parameters that are involved in the study of the suitability of an ERP system by means of heterogeneous information and we shall then present an evaluation model able to deal with such a decision situation [9], in which quantitative parameters are assessed by numerical, interval-valued values and, qualitative ones are assessed by using the fuzzy linguistic approach [26] that has got successful results managing qualitative information [5,6,10,12,22,25].

We propose a resolution process for this evaluation model based on a classical decision-making resolution process [18], but slightly modified:

(a) *Aggregation phase*: it obtains a collective value for each parameter, but as this model deals with heterogeneous information. This phase is a three-step process:
  (i) Make uniform the information: The heterogeneous input information is unified into fuzzy sets in a basic linguistic term set (BLTS) using different transformation functions [9].
  (ii) Aggregation process: Once all the input information is expressed by fuzzy sets, this process obtains a collective value for each parameter by using an aggregation operator.
  (iii) To facilitate the computation processes in the next phase and improve the comprehensibility of the results these fuzzy sets will be expressed by means of linguistic 2-tuples [7].

(b) *Exploitation phase*: in an evaluation problem this phase computes a global measurement of the evaluated item. In our case, this phase will compute a suitability degree from the collective values obtained in the aggregation phase. This suitability degree will be used to make a decision regarding the installation of the ERP system.

This paper is structured as follows: in the Section 2 we shall make a brief introduction to enterprise resource planning systems and present the evaluation scheme to study the suitability of an ERP system dealing with heterogeneous information; in Section 3 we shall show a brief review of the fuzzy linguistic 2-tuple representation model that will be used during the evaluation process to deal with heterogeneous information; in the Section 4 we present the fuzzy evaluation model for studying the suitability of an ERP system; in the Section 5 we shall present an application of the fuzzy model. Eventually, some concluding remarks are pointed out.

2. Studying the suitability of an ERP system

In this section, we review the ERP systems and define the evaluation scheme based on an ME-DM problem to evaluate the suitability of an ERP system in a company.

2.1. Enterprise resource planning

An ERP system is a structured approach to optimize a company's internal value chain. The software, is fully installed across an entire enterprise, connects the components of the enterprise through logical transmissions and sharing common data with an integrated ERP. When data such as a sale becomes available at one point in the business, it courses its way through the software, which automatically calculates the effects of the transaction on other areas, such as manufacturing, inventory, procurement, invoicing, and booking the actual sale to the financial ledger [13,17,19,23].

What ERP really does organize, codify, and standardize an enterprise's business process and data. The software transforms transactional data into useful information and collates the data so that it can be analyzed. In this way, all the collected transactional data become information that companies can use to support their business decisions. When an ERP system is fully developed in a business organization, it can yield many benefits: reduce cycle time, enable faster information transactions, facilitate better financial management, lay groundwork for e-commerce, and make tacit knowledge explicit.

ERP software is not intrinsically strategic; rather, it is an enabling technology, a set of integrated software modules that make up the core engine of internal transaction processing. The installation of an ERP, implies a great investment, because of, requires major changes in the organizational, cultural and business processes. The most important changes are those referred to individual roles inside the organization. A lot of ERP products have forced the companies, to redesign their business processes for removing useless tasks and focusing the released employees in value added activities, increasing dramatically the company's productivity and hence its profits.

These improvements have produced that all world wide organizations and increasingly small- and medium-sized companies are interested in the installation of this type of product. However, the suitability of the ERP is not always profitable. Because ERP systems are very complex and have a massive impact on the entire organization. Implementing an ERP system is always very expensive and time consuming, furthermore the productivity and profits of the company can not increase dramatically in some cases, such as it could be expected. Therefore, before installing an ERP must be evaluated its suitability in each company, analyzing a set of parameters of the organization to decide the viability of the ERP implementation [13,14]. In this paper we propose a fuzzy evaluation model based on a decision process dealing with heterogeneous information that studies the suitability of an ERP according to different parameters of each company.

2.2. Studying the suitability of an ERP system: evaluation scheme

The evaluation process of the suitability of an ERP system in a company consists of evaluating the opinions provided by several experts about some parameters [13,14]. So, this problem could be modelled as an ME-DM problem. An ME-DM problem has a finite set of experts $E = \{e_1, \dots, e_n\}$, who assess a set of m alternatives $X = \{x_1, \dots, x_m\}$, by means of utility vectors:

$$e_i \rightarrow \{p_{i1}, \dots, p_{im}\}.$$

Let p_{ij} $(i \in \{1, \dots, n\}, j \in \{1, \dots, m\})$ being the preference assigned to the alternative x_j by expert e_i. Each expert provides a utility vector with his/her preferences. However, in our evaluation problem X is a set of parameters instead of alternatives and due to their nature the experts could provide heterogeneous information assessed in different domains, such that, the utility vectors can be assessed by means of numerical, interval-valued and linguistic values. Being the utility vectors noted as:

$$\{p^k_{i1}, \dots, p^k_{im}\},$$

where p^k_{ij} is the preference assigned to the parameter x_j by expert e_i and assessed in the *domain* $D^k, k \in \{N, L, I\}$ numerical, linguistic or interval-valued respectively. For a further detail description of the different types of information domains see [9,21,26].

3. The 2-tuple linguistic representation model

This model was presented in [7] and recently, different approaches have been proposed to extend the 2-tuple linguistic representation model [6,24]. The former has shown itself as a good model to deal with heterogeneous information [8,9,16]. Due to the fact, that our fuzzy evaluation model deals with heterogeneous information, we shall use it.

The 2-tuple fuzzy linguistic representation model takes as the base of its representation the concept of symbolic translation.

Definition 1. The symbolic translation of a linguistic term is a numerical value assessed in [−0.5, 0.5) that supports the "difference of information" between an amount of information [0, g] and the closest value in {0,...,g} that indicates the index of the closest linguistic term in S (s_i), being [0, g] the interval of granularity of S (see Fig. 1).

From this concept a new linguistic representation model is developed, which represents the linguistic information by means of 2-tuples $(s_i, \alpha_i), s_i \in S$ and $\alpha \in [-0.5, 0.5)$.

This model defines a set of functions between linguistic 2-tuples and numerical values.

Definition 2. Let $S = \{s_0, \dots, s_g\}$ be a linguistic term set and $\beta \in [0, g]$ a value supporting the result of a symbolic aggregation operation, then the 2-tuple that expresses the equivalent information to β is obtained with the following function:

$$\Delta : [0, g] \rightarrow S \times (-0.5, 0.5),$$
$$\Delta(\beta) = (s_i, \alpha), \quad \text{with} \begin{cases} s_i, & i = \text{round}(\beta), \\ \alpha = \beta - i, & \alpha \in [-0.5, 0.5), \end{cases} \tag{1}$$

where round( ) is the usual round operation, s_i has the closest index label to "β" and "α" is the value of the symbolic translation.

Proposition 1. *Let $S = \{s_0, \dots, s_g\}$ be a linguistic term set and (s_i, α_i) be a linguistic 2-tuple. There is always a Δ^{-1} function such that, from a 2-tuple it returns its equivalent numerical value $\beta \in [0, g]$ in the interval of granularity of S.*

Proof 1. It is trivial, we consider the following function:

$$\Delta^{-1} : S \times [-0.5, 0.5) \rightarrow [0, g],$$
$$\Delta^{-1}(s_i, \alpha) = i + \alpha = \beta. \tag{2}$$

This representation model has a computational technique presented in [7]:

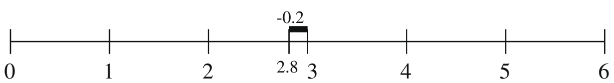

Fig. 1. Example of a symbolic translation.

(1) **Aggregation of 2-tuples**: The aggregation of linguistic 2-tuples consists of obtaining a value that summarizes a set of values, therefore, the result of the aggregation of a set of 2-tuples must be a linguistic 2-tuple. In [7] we can find several 2-tuple aggregation operators based on classical aggregation operators.
(2) **Comparison of 2-tuples**: The comparison information represented by 2-tuples is carried out according to an ordinary lexicographic order. Let (s_k, α_1) and (s_l, α_2) be two 2-tuples representing two assessments:
- If $k < l$ then (s_k, α_1) is smaller than (s_l, α_2).
- If $k = l$ then
  (a) If $\alpha_1 = \alpha_2$ then (s_k, α_1) and (s_l, α_2) represent the same value.
  (b) If $\alpha_1 < \alpha_2$ then (s_k, α_1) is smaller than (s_l, α_2).
  (c) If $\alpha_1 > \alpha_2$ then (s_k, α_1) is bigger than (s_l, α_2).

Once it has been presented the necessary basic concepts about the fuzzy linguistic 2-tuple representation model, we shall present in the next section the fuzzy model to evaluate the suitability of an ERP system. □

4. Evaluating the suitability of an ERP system

Our model for evaluating the suitability of an ERP system is based on scheme presented in Section 2.2 where each expert provides a vector with her/his evaluations. The domains used in this problem to assess the evaluations may be **N**umerical, **I**nterval-valued and **L**inguistic. To evaluate the suitability of the ERP system, we propose a two-phase fuzzy evaluation model based on a ME-DM process dealing with heterogeneous information [9,16]:

(1) Aggregation phase
  (a) Making the information uniform.
  (b) Aggregation process.
  (c) Transforming into linguistic 2-tuples.
(2) Exploitation phase

In the next subsections, we present in detail the working of both phases.

4.1. Aggregation phase

In this phase the individual evaluation utility vectors provided by the experts are combined to obtain a collective utility vector. As the evaluations of the experts are assessed in different domains, numerical (D^N), interval-valued (D^I) and linguistic (D^L) this phase is accomplished in three steps:

(1) *Making the information uniform*. The heterogeneous information is unified into a specific linguistic domain, called basic linguistic term set (BLTS) and symbolized as S_T. The BLTS is chosen according to the conditions shown in [9]:

$S_T = \{s_0, \ldots, s_g\}$.

Once the BLTS has been chosen each numerical, linguistic and interval-valued evaluation, p^k_{ij}, is transformed into a fuzzy set in S_T, $F(S_T)$ by using the respective transformation functions [9]:
  (a) **Transforming numerical values**, $p^N_{ij} \in [0, 1]$, **into** $F(S_T)$:

$$\tau : [0,1] \to F(S_T),$$
$$\tau(p^N_{ij}) = \{(s_0,\gamma_0),\ldots,(s_g,\gamma_g)\}, \quad s_i \in S_T, \gamma_i \in [0,1], \tag{3}$$
$$\gamma_i = \mu_{s_i}(p^N_{ij}) = \begin{cases} 0 & \text{if } p^N_{ij} \notin Support(\mu_{s_i}(p^N_{ij})), \\ \frac{s^N_{ij}-a_i}{b_i-c_i} & \text{if } a_i < p^N_{ij} < b_i, \\ 1 & \text{if } c_i < p^N_{ij} < d_i, \\ \frac{c_i-p^N_{ij}}{c_i-d_i} & \text{if } d_i < p^N_{ij} < c_i. \end{cases}$$

Remark 1: We consider the membership functions $\mu_{s_i}(\cdot)$, of $s_i \in S_T$, are represented by a parametric function (a_i, b_i, c_i, d_i) [2].
  (b) **Transforming linguistic values**, $p^L_{ij} \in S$, **into** $F(S_T)$:

$$\tau_{SS_T} : S \to F(S_T),$$
$$\tau_{SS_T}(p^L_{ij}) = \{(s_k,\gamma_k)/k \in \{0,\ldots,g\}\}, \ \forall p^L_{ij} \in S, \tag{4}$$
$$\gamma^i_k = \max_y \min\{\mu_{p^L_{ij}}(y), \mu_{s_k}(y)\},$$

where $\mu_{p^L_{ij}}(y)$ and $\mu_{s_k}(y)$ are the membership functions of the fuzzy sets associated with the terms $p^L_{ij} \in S$ and $s_k \in S_T$, respectively.

(c) **Transforming interval values**, $p^l_{ij} \in [0,1]$, **into** $F(S_T)$: Let $I = [\underline{i}, \bar{i}]$ be an interval value in [0,1]. We assume that the interval value has a representation, inspired in the membership function of the fuzzy sets [11]:

$$\mu_I(\vartheta) = \begin{cases} 0 & \textit{if } \vartheta < \underline{i}, \\ 1 & \textit{if } \underline{i} \leqslant \vartheta \leqslant \bar{i}, \\ 0 & \textit{if } \bar{i} < \vartheta. \end{cases} \tag{5}$$

The transformation function is

$$\begin{aligned} &\tau_{IS_T} : I \rightarrow F(S_T), \\ &\tau_{IS_T}(p^l_{ij}) = \{(s_k, \gamma_k)/k \in \{0, \ldots, g\}\}, \\ &\gamma^i_k = \max_y \min\{\mu_{p^l_{ij}}(y), \mu_{s_k}(y)\} \end{aligned} \tag{6}$$

being $\mu_{p^l_{ij}}(y)$ the associated membership function to the interval value, p^l_{ij}.

So far, the input information has been unified into fuzzy sets in the BLTS, now the evaluation model aggregates the input information to obtain a collective utility vector.

(2) *Aggregating individual utility vectors*. For each parameter, a collective value is obtained aggregating the above fuzzy sets on the BLTS. Each collective utility vector is expressed by means of fuzzy sets on the BLTS as follows:

$$\{\vartheta_1 = \{(s_0, \gamma^{c1}_0), \ldots, (s_g, \gamma^{c1}_g)\}, \ldots, \{\vartheta_m = (s_0, \gamma^{cn}_0), \ldots, (s_g, \gamma^{cn}_g)\}\}$$

being $s_i \in S_T$, and ϑ_j the collective value for the parameter x_j, with

$$\gamma^{cj}_0 = \mu(\gamma^{ij}_0), \quad i \in \{1, \ldots, n\},$$

where μ is an *aggregation operator* and i the number of experts.

(3) *Transforming into 2-tuples*: The collective utility vector expressed by means of fuzzy sets in the BLTS is far from the initial expression domains, are difficult to manage for several mathematical calculations and hard to understand by the experts. So they will be transformed into linguistic 2-tuples in the BLTS to facilitate its managing and the comprehensibility of the results. The transformation process is carried out by using the transformation function χ:

$$\begin{aligned} &\chi : F(S_T) \rightarrow [0, g], \\ &\chi(\tau(\vartheta)) = \chi(\{(s_j, \gamma), j = 0, \ldots, g\} = \frac{\sum_{j=0}^{g} j \cdot \gamma_j}{\sum_{j=0}^{g} \gamma_j} = \beta. \end{aligned} \tag{7}$$

Therefore, applying the Δ function (Definition 2) to the value β obtained in (7) we shall obtain a collective preference vector whose values are expressed by means of linguistic 2-tuples:

$$\Delta(\chi(\tau(\vartheta))) = \Delta(\beta) = (s, \alpha), \quad s \in S_T. \tag{8}$$

In Fig. 2 can be seen a graphical scheme of the aggregation phase:

4.2. Exploitation phase

Using the collective preference vector the exploitation phase, usually, obtains the best alternative(s) applying different choice functions that have been proposed in the choice theory literature [1]. However, in this problem it computes an overall value expressed by means of a linguistic 2-tuple. This overall value expresses a measurement of the degree of suitability for the installation of the ERP software in the company.

In our proposal we compute this overall measurement by aggregating the collective value for each parameter (different aggregation operators can be used depending on the importance of the parameters). This collective value will be interpreted as a degree of suitability for the installation of the ERP system according to Table 1.

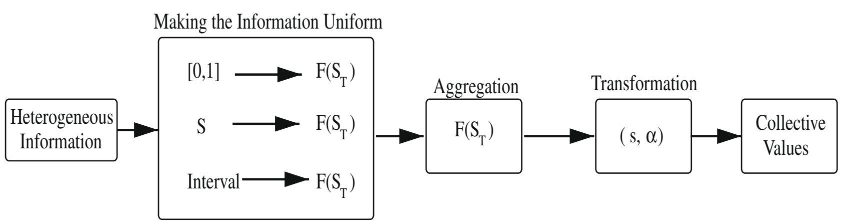

Fig. 2. Aggregation process for heterogeneous information.

Table 1
Table of suitability.

Degree of suitability	Recommendation
$\leqslant s_i$	Not install
$> s_i$ and $\leqslant s_j$	The installation is not suitable
$> s_j$ and $\leqslant s_k$	The installation is feasible
$> s_k$ and $\leqslant s_l$	The installation is suitable
$> s_l$	The installation is very suitable

5. Evaluating the installation of an ERP: applying the fuzzy model

Here, we apply the fuzzy evaluation model to a given company that is considering the possibility of installing an ERP. In this case, it takes into account nine parameters of the company, assessed in different domains, for evaluating the suitability of the ERP system:

- x_1 *Investment in information technologies for employee* is an interval value (max value of 6000).
- x_2 *Price of the implementation* is a numerical value (max value of 240,000).
- x_3 *Urgency in the implementation* is assessed in the linguistic term set A.
- x_4 *Standard degree* is assessed in the linguistic term set C.
- x_5 *Interrelation with other subsystems* is a numerical value assessed in [0, 1].
- x_6 *Capacity of the user to specify* is assessed in the linguistic term set C.
- x_7 *Requests of change by the user* is assessed in the linguistic term set B.
- x_8 *Availability of personnel* is assessed in the linguistic term set B.
- x_9 *Capacity of influence of the client in the provider* is assessed in the linguistic term set D.

The semantics of the linguistic term sets are showed in the Table 2:

In this example, four experts evaluate the suitability of the ERP providing their preferences on the parameters by means of utility vectors (See Table 3):

We can see that the evaluated parameters are in conflict because x_2, x_5, x_6, x_7, x_8 are parameters such that if they have a high value it indicates a low degree of acceptance (decreasing interpretation). However, in the other ones a high value indicates a high degree of acceptance. Then, x_2, x_5, x_6, x_7, x_8 will be inversely transformed before to make uniform the information. In this way, all parameters will have an increasing interpretation. In the Table 4 are shown the utility vectors provided by the experts after normalizing the numerical information and transforming the parameters in an increasing interpretation. Applying the evaluation process:

Table 2
Semantics of the linguistic term sets.

Term set A		Term set B		Term set C		Term set D	
a_0	(0, 0, 12)	b_0	(0, 0, .16)	c_0	(0, 0, .25)	d_0	(0, 0, 0, 0)
a_1	(0, .12, .25)	b_1	(0, .16, .33)	c_1	(0, .25, .5)	d_1	(0, .01, .02, .07)
a_2	(.12, .25, .37)	b_2	(.16, .33, .5)	c_2	(.25, .5, .75)	d_2	(.04, .1, .18, .23)
a_3	(.25, .37, .5)	b_3	(.33, .5, .66)	c_3	(.5, .75, 1)	d_3	(.17, .22, .36, .42)
a_4	(.37, .5, .62)	b_4	(.5, .66, .83)	c_4	(.75,1,1)	d_4	(.32, .41, .58, .65)
a_5	(.5, .62, .75)	b_5	(.66, .83, 1)			d_5	(.58, .63, .80, .86)
a_6	(.62, .75, .87)	b_6				d_6	(.72, .78, .92, .97)
a_7	(.75, .87, 1)					d_7	(.93, .98, .99, 1)
a_8	(.87, 1, 1)					d_8	(1, 1, 1, 1)

Table 3
Experts' utility vectors.

	e_1	e_2	e_3	e_4
x_1	[3500, 4000]	[2000, 2500]	[3100, 3800]	[4500, 5000]
x_2	12,000	18,000	10,000	16,000
x_3	a_5	a_6	a_5	a_4
x_4	c_2	c_2	c_3	c_1
x_5	.2	.35	.75	.3
x_6	c_1	c_1	c_2	c_3
x_7	b_3	b_4	b_3	b_4
x_8	b_4	b_5	b_5	b_3
x_9	d_1	d_6	d_5	d_5

Table 4
Normalized and increasing interpretation. Experts' utility vectors.

	e_1	e_2	e_3	e_4
x_1	[.58, .67]	[.33, .42]	[.52, .63]	[.75, .83]
x_2	.5	.25	.58	.33
x_3	a_5	a_6	a_5	a_4
x_4	c_2	c_2	c_3	c_1
x_5	.8	.65	.25	.7
x_6	c_3	c_3	c_2	c_1
x_7	b_3	b_2	b_3	b_2
x_8	b_2	b_1	b_1	b_3
x_9	d_1	d_6	d_5	d_5

Table 5
Unified information for experts 1 and 2.

	e_1	e_2
x_1	(0, 0, 0, 0, 0, 0, 0, .86, 1, .43, 0, 0, 0, 0, 0)	(0, 0, 0, 0, .43, 1, .86, 0, 0, 0, 0, 0, 0, 0, 0)
x_2	(0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0)	(0, 0, 0, .57, .43, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0)
x_3	(0, 0, 0, 0, 0, 0, 0, .36, .73, .89, .55, .2, 0, 0, 0)	(0, 0, 0, 0, 0, 0, 0, 0, .1, .45, .79, .84, .47, .09, 0)
x_4	(0, 0, 0, .12, .34, .56, .78, 1, .78, .56, .34, .12, 0, 0, 0)	(0, 0, 0, .12, .34, .56, .78, 1, .78, .56, .34, .12, 0, 0, 0)
x_5	(0, 0, 0, 0, 0, 0, 0, 0, 0, 0, .71, .29, 0, 0)	(0, 0, 0, 0, 0, 0, 0, 0, 0, .86, .14, 0, 0, 0, 0)
x_6	(0, 0, 0, 0, 0, 0, 0, .21, .43, .65, .87, .9, .68, .45, .21)	(0, 0, 0, 0, 0, 0, 0, .21, .43, .65, .87, .9, .68, .45, .21)
x_7	(0, 0, 0, 0, .12, .41, .7, 1, .69, .39, .08, 0, 0, 0, 0)	(0, 0, .24, .54, .83, .87, .58, .29, 0, 0, 0, 0, 0, 0, 0)
x_8	(0, 0, .24, .54, .83, .87, .58, .29, 0, 0, 0, 0, 0, 0, 0)	(.3, .97, .95, .75, .45, .16, 0, 0, 0, 0, 0, 0, 0, 0, 0)
x_9	(0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, .58, .87)	(0, 0, 0, 0, 0, 0, 0, 0, 0, 0, .35, .76, 1, .92, .33)

Table 6
Unified information for experts 3 and 4.

	e_3	e_4
x_1	(0, 0, 0, 0, 0, 0, 0, .71, 1, .86, 0, 0, 0, 0, 0)	(0, 0, 0, 0, 0, 0, 0, 0, 0, 0, .43, 1, .71, 0, 0)
x_2	(0, 0, 0, 0, 0, 0, 0, 0, .86, .14, 0, 0, 0, 0, 0)	(0, 0, 0, 0, .43, .57, 0, 0, 0, 0, 0, 0, 0, 0, 0)
x_3	(0, 0, 0, 0, 0, 0, 0, .36, .73, .89, .55, .2, 0, 0, 0)	(0, 0, 0, 0, 0, .29, .65, 1, .63, .26, 0, 0, 0, 0, 0)
x_4	(0, 0, 0, 0, 0, 0, 0, .21, .43, .65, .87, .9, .68, .45, .21)	(.21, .65, .68, .9, .87, .65, .43, .21, 0, 0, 0, 0, 0, 0, 0)
x_5	(0, 0, 0, 0, .57, .43, 0, 0, 0, 0, 0, 0, 0, 0, 0)	(0, 0, 0, 0, 0, 0, 0, 0, 0, .14, .86, 0, 0, 0, 0)
x_6	(0, 0, 0, .12, .34, .56, .78, 1, .78, .56, .34, .12, 0, 0, 0)	(.21, .65, .68, .9, .87, .65, .43, .21, 0, 0, 0, 0, 0, 0, 0)
x_7	(0, 0, 0, 0, .12, .41, .7, 1, .69, .39, .08, 0, 0, 0, 0)	(0, 0, .24, .54, .83, .87, .58, .29, 0, 0, 0, 0, 0, 0, 0)
x_8	(.3, .97, .95, .75, .45, .16, 0, 0, 0, 0, 0, 0, 0, 0, 0)	(0, 0, 0, 0, .12, .41, .7, 1, .69, .39, .08, 0, 0, 0, 0)
x_9	(0, 0, 0, 0, 0, 0, 0, 0, .5, 1, 1, 1, .61, .07, 0)	(0, 0, 0, 0, 0, 0, 0, 0, .5, 1, 1, 1, .61, .07, 0)

Table 7
Collective utility vector expressed by means of linguistic 2-tuples.

x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9
$(s_8, 0)$	$(s_6, -.2)$	$(s_9, -.2)$	$(s_7, -.1)$	$(s_9, -.3)$	$(s_8, -.2)$	$(s_6, 0)$	$(s_4, -.1)$	$(s_{11}, 0)$

Table 8
Example of table of suitability.

Degree of suitability	Recommendation
$\leqslant s_4$	Not install
$> s_4$ and $\leqslant s_6$	The installation is not suitable
$> s_6$ and $\leqslant s_9$	The installation is feasible
$> s_9$ and $\leqslant s_{11}$	The installation is suitable
$> s_{11}$	The installation is very suitable

(1) Aggregation phase:
 (a) Making the information uniform: Choose the BLTS. In this case, according to the rules presented in [9], we choose as S_T a symmetrical and uniformly distributed linguistic term set with 15 labels (further details in [9]). Now the transformation functions are applied to the input information to unify it (see Tables 5 and 6).

(b) Aggregation of the individual utility vectors. Here we shall apply as aggregation operator the arithmetic mean, but we can use other operators depending if we consider all the parameters equally important. The collective utility vector obtained and expressed by means of linguistic 2-tuples is (see Table 7).

(2) Exploitation phase: In this phase we obtain an overall suitability value for the installation of the ERP that will be evaluated according to Table 8.We use the 2-tuple arithmetic mean operator [7] to obtain the degree of suitability for the installation of the ERP:

$(s_7, -.07)$.

Therefore the installation of the ERP is **feasible**, we can then infer is not totally suitable.

6. Concluding remarks

In this contribution, we have presented a fuzzy evaluation model to evaluate the suitability of installing an ERP system in a company. We have proposed a decision-making based scheme dealing with heterogeneous information for our fuzzy evaluation model. The process evaluates several parameters, of the current conditions of the company, according to the opinions of the experts. These parameters are assessed in different information domains. The model proposed combines the heterogeneous information provided by the experts for obtaining an overall measurement of the suitability for the installation of the ERP. This process provides a greater flexibility than others that force to the experts to provide their opinions in a unique precise expression domain.

Acknowledgement

This work is partially supported by the Research Projects TIN-2006-02121, P08-TIC-3548, TIC2005-00602, TIN2007-61079 and FEDER Funds.

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