A Fuzzy Model to Evaluate the Suitability of Installing an ERP System

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Abstract

The use of Enterprise Resource Planning (ERP) as a foundation for the integration of the complete range of business's 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 may have different nature or the knowledge about them can be vague or imprecise. Thus, this implies that it would be suitable that the evaluation process can manage non-homogeneous 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 non-homogeneous information.

Key words: multi-expert decision-making, evaluation, heterogeneous information, ERP

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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 [15,20], Material Resource Planning [5], Electronic Data Interchange [17], 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 it should be evaluated carefully the installation of the ERP in order to avoid unsuccessful results in its implementation [15,20]. The use of decision analysis techniques in evaluation processes has provided successful results [3,4,6].

Our aim is to present a fuzzy evaluation model that study different parameters of a company to support the decision of installing an ERP system in such a company. To do so, we propose in this paper:

(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 ERP in a company. These parameters can have different nature (qualitative or quantitative) or the knowledge about them can be vague or imprecise. Therefore, the use of the Fuzzy Sets Theory [7] provides tools to deal with this type of information.

(2) **A fuzzy model for evaluating the suitability of an ERP system**: In this evaluation process different experts provide their knowledge about different parameters that are involved in the study of the suitability of an ERP system. In order to facilitate the experts the way to provide their information about the different parameters we shall present an evaluation model will be able to deal with non-homogeneous information [12]. Such that the information could be assessed in different domains numerical and interval-valued for quantitative parameters and linguistic for qualitative ones.

We propose a resolution process for this evaluation model based on a classical Decision Making resolution process [19], but slightly modified:

(a) *Aggregation phase*: it obtains a collective value for each parameter, but as this model deals with non-homogeneous information. This phase is a three-step process:

(i) *Make uniform the information*: The non-homogeneous input information is unified into fuzzy sets in a basic linguistic term set (BLTS) using different transformation functions [12].
(ii) Aggregation process: Once all the input information is expressed by fuzzy sets this process obtains a collective value for each parameter 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 [9].

(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 we shall 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 importance of an ERP system for a company and in addition present the evaluation scheme based on an ME-DM problem that we shall use 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 [15,20,23].

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 [14,23]. 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 [14]. So, this problem could be modelled as an ME-DM problem. An ME-DM problem has a finite set of experts $E = \{e_1, \ldots, e_n\}$, that assess m alternatives $X = \{x_1, \ldots, x_m\}$, by means of utility vectors:

$$e_i \rightarrow \{p_{i1}, \ldots, p_{im}\}$$

Let p_{ij} (i $\in$\{1,...,m\}, j $\in$\{1,...,n\}) 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 can provide non-homogeneous 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:

$$\{p_{i1}^k, \ldots, p_{im}^k\},$$

where p_{ij}^k 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 [12,21,22].

3 The 2-Tuple Linguistic Representation Model

This model was presented in [9] and has shown itself as a good model to deal with heterogeneous information [10–12]. 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.

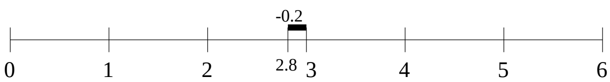

Fig. 1. Example of a Symbolic Translation

From this concept a new linguistic representation model is developed, which represents the linguistic information by means of 2-tuples (s_i, α_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,...,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:

$$\Delta : [0, g] \rightarrow S \times (-0.5, 0.5)$$

$$\Delta(\beta) = (s_i, \alpha), \quad with \begin{cases} s_i & i = round(\beta) \\ \alpha = \beta - i & \alpha \in [-0.5, 0.5) \end{cases} \tag{1}$$

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 = $\{s_0, \ldots, s_g\}$ 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 [9]:

(1) **Aggregation of 2-tuples**: The aggregation of linguistic 2-tuples consist 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 [9] 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 represented 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 the subsection 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 [8,12]:

(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 [12]:

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

Once the BLTS has been chosen each numerical, linguistic and interval-valued evaluation, p_{ij}^k, provided by the experts is transformed into a fuzzy set in S_T, F(S_T) using the respective transformation functions [12]:

(a) **Transforming numerical values**, $p_{ij}^N \in [0, 1]$, **into F(**S_T**)**:

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

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**, $p_{ij}^L \in S$, **into F(**S_T**)**:

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

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

(c) **Transforming interval values**, $p_{ij}^I \in [0,1]$, **into** $\mathbf{F}(S_T)$: Let $I = \left[\underline{i}, \overline{i}\right]$ 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 [13]:

$$\mu_I(\vartheta) = \begin{cases} 0 \; if \quad \vartheta < \underline{i} \\ 1 \; if \; \underline{i} \leq \vartheta \leq \overline{i} \\ 0 \; if \quad \overline{i} < \vartheta \end{cases} \tag{5}$$

The transformation function is:

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

where $\mu_{p_{ij}^I}(y)$ is the membership function associated with the interval-valued p_{ij}^I.

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 that represents the individual evaluations assigned by the experts using an aggregation operator. The collective utility vector is expressed by means of fuzzy sets on the BLTS as follows:

$$\{\vartheta_1 = \{(s_0, \gamma_0^{c1}), \ldots, (s_g, \gamma_g^{c1})\}, \quad \ldots \quad , \{\vartheta_m = (s_0, \gamma_0^{cn}), \ldots, (s_g, \gamma_g^{cn})\}\},$$

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

$$\gamma_0^{cj} = \mu(\gamma_0^{ij}), \; i \in \{1, ..., n\}$$

Being μ 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. This transformation is carried out using the 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:

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

In the Figure 2 can be seen graphically the working of the aggregation phase:

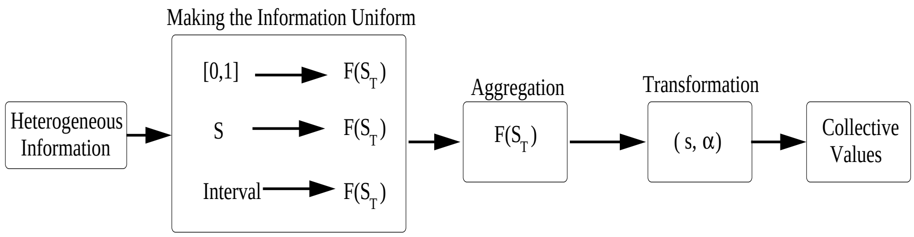

Fig. 2. Aggregation process for heterogeneous information

4.2 Exploitation phase

Using the collective preference vector the exploitation phase, usually, obtains the best alternative(s) applying different choice functions have been proposed in the choice theory literature [1,16,18]. 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 aggregating the collective value for each parameter (different aggregation operators can be used depending on the importance of the parameters). This degree of suitability will be evaluated in a predefined table, such that, according to its value it points out the suitability or unsuitability of installing the ERP system (see Table 1).

Table 1
Table of suitability

Degree of suitability	**Recommendation**
$\leq s_i$	Not install
$> s_i$ and $\leq s_j$	The installation is not suitable
$> s_j$ and $\leq s_k$	The installation is feasible
$> s_k$ and $\leq s_l$	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 and 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-valued (max value of 6000)
- x_2 *Price of the implementation* is a numerical value (max value of 240000)
- 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:

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)

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. On this way, all

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	12000	18000	10000	16000
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

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.

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

Applying the evaluation process:

(1) Aggregation phase:
   (a) Making the information uniform: Choose the BLTS. In this case, according to the rules presented in[12], we choose as S_T a symmetrical and uniformly distributed linguistic term set with 15 labels (further details in [12]) Now the transformation functions are applied to the input information to unify it (see Tables 5,6):

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	(0,0,0,0,0,0,0,0,0,0,0,.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)

(b) Aggregation 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):

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
$(s_8, 0)$	$(s_6, -.2)$	$(s_9, -.2)$	$(s_7, -.1)$	$(s_9, -.3)$	$(s_8, -.2)$	$(s_6, 0)$	$(s_4, -.1)$	$(s_{11}, 0)$

(2) Exploitation phase:

In this phase we obtain an overall suitability value for the installation of the ERP that will be evaluated according to the following recommendation table:

Table 8
Example of table of suitability

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

We use the 2-tuple arithmetic mean operator [9] to obtain the degree of suitability for the installation of the ERP:

$$(s_7, -.07)$$

Therefore the installation of the ERP is **feasible**, therefore we can 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 flexibly than other ones that force to the experts to provide their opinions in an unique expression domain [14].

7 Acknowledgements

This work is partially supported by the Research Project TIC2002-03348, and FEDER Funds.

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