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ERP selecting model in Food industry SME's using fuzzy multi-criteria decision-making method

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Abstract

Selecting an organizational system is a complex and time consuming process. Considering a systematic and comprehensive policy for selecting an ERP is crucial to the project's success.. Among the stakes that the organization must overcome prior to commencement and implementation of the project is improper selection of the system. The use of ERP in small and medium-sized organizations is a delicate matter. Fuzzy multi-criteria decision-making procedure can be employed to select the appropriate options according to various criteria and the weight of different conditions in the presence of uncertainty. This study aims to select proper ERP system for Food ERP SME's company active in production and exporting mushrooms to Persian Gulf district countries (namely Iraq and United Arab Emirates), using fuzzy multi-criteria decision-making method and Shannon entropy technique.

Keywords:
FOOD ERP;SMALL & MEDIUM ENTERPRISES;
FUZZY TOPSIS

1. Introduction

Enterprise Resource Planning (ERP) is a system designed to create a suitable platform to manage organizational affairs. With rapid development of information technologies and organizational softwares, ERP systems are increasingly being adopted by the SME's. ERP is more than an essential infrastructure for an organization [1]. Since SME's have fewer resources compared to larger corporations, they should adopt new technologies for their own survival. ERP is among the most recent managing softwares collecting data coherently from every area of organizational activity, providing results to various levels of organization, and improving the effectiveness of the organization, provided they are executed successfully. Evaluation and selection process of ERP for SME's organizations varies considerably, and thus discussing the previous research in this area could be beneficial.

In this study, the choice of proper ERP for Food ERP SME's company - is studied by employing fuzzy multi-criteria decision-making techniques (TOPSIS).

The remainder of the paper is as follows. in Section 3 and 4 After providing some preliminary descriptions about definitions, concepts and ERP systems characteristics, and Fuzzy Multi-Criteria Decision-Making Explained , in Section 5 crucial criteria concerning ERP selection for Asia Mushrooms Co. are identified, Superior options are chosen, and their weights criteria calculated using Shannon entropy technique . also, using TOPSIS multi-criteria decision-making procedure, these candidates are prioritized under uncertainty conditions. In section 6 the conclusions and future research will be discussed.

2. Literature review

Organizations are currently facing market globalization and rapid economic changes [2]. With the establishment of technologies and diminution of expenses [3] and saturation of large corporations' target markets, an increasing number of ERP system manufacturers and vendors are focusing on the growing market of SME's, and execution of ERP in SME's has popularized. Although SME's possess advantages such as organizational simplicity, implementation of ERP systems face numerous challenges [4]. Inaccuracy in selection, implementation and maintenance of ERP systems may lead to financial crisis and annihilation of the organization. Therefore, selecting proper ERP for SME's organizations is of great importance. In [5], a two-stage approach is proposed to assist in choosing an ERP package for small and medium businesses with high probability of successful implementation [5]; the first stage being product identification and the second involves product

evaluation. In 2014, Huseyin attempted to provide the best method to select ERP for SME's organizations using a combination of ANP and PROMETHEE [6]. Yan Zhua et al. provided the factors resulting in the success of the EPR implementation [7]. Moreover, Karoliina simulated ERP systems as a learning environment for small and middle-sized businesses [8]. Finally, in [9], ERP vendors ranking is performed based on a fuzzy multi-criteria decision-making method.

3. Planning the Enterprise Resources

Enterprise Resource Planning systems is defined as an integrated software consisting multiple components or modules in the field of organization operations such as planning, accounting, human resource management, project management, inventory management, maintenance and repair service management, and electronics management. The architecture and structure of such systems provide integrity and comprehensive organizational information that enable smooth information flow among various organization departments(Figure1)

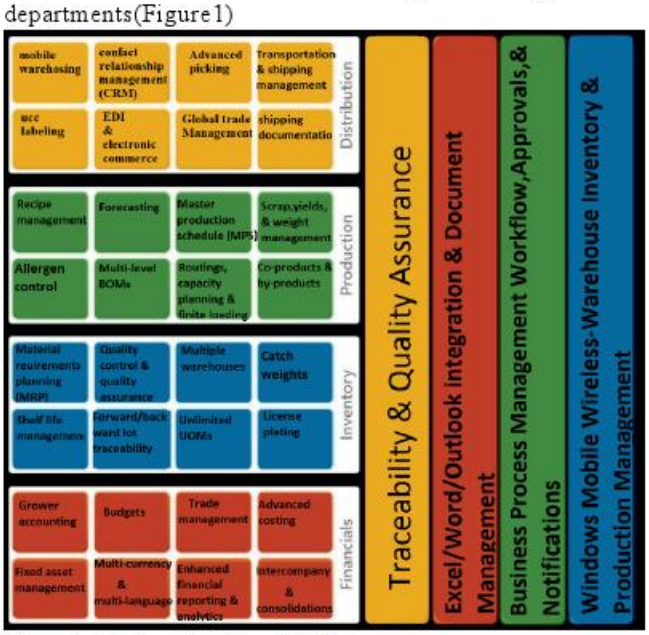

Figure1-Master plan Food ERP

As a result of the growing interest in ERP systems, numerous studies have conducted regarding selecting an ERP software [10]. ERP system life cycle consists of three stages, namely selection, implementation, and execution, in which selecting a proper ERP system is the main stage [11].

4. Fuzzy Multi-Criteria Decision-Making

When organizations decide to implement ERP system, they are not facing an easy task. With the wide variety of available ERP softwares, determining the distinguished system that meets organization demands could be challenging, where the evaluation and selection procedure might be time consuming. One example of a decision making technique using quantitative data, is called multi-criteria decision-making. Employing this technique enables the manager to perform rational decision makings, while considering different, sometimes inconsistent, criteria. Nowadays, decisions are made in an increasingly sophisticated environments, and in most cases there is a need for experts in various fields. Fuzzy decision-making can overcome such issues. Implementing ERP systems face a number of challenges. Any inaccuracy in selection, implementation and maintenance of ERP systems may lead to financial disasters and annihilation of the organization. Despite these challenges and inaccuracies, one could wonder how to choose the best ERP candidate, despite multiple inconsistent factors, for small and medium-sized organizations. And whether one could choose proper ERP for SME's using fuzzy multi-criteria decision-making methods.

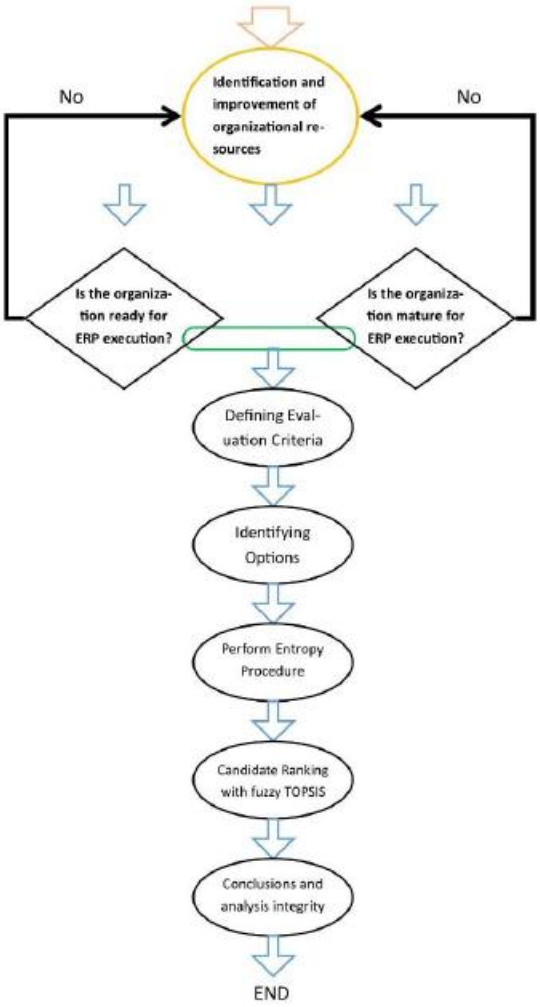

Figure 2- Steps in Choosing the Food ERP

5. ERP selecting procedure for Food industry

Understanding and improving organizational resources (most notably the ones with competitive advantages) helps focusing on the aspects of the organization which are vital to growth and business progress. First, it is investigated whether the organization is mature enough and ready for ERP implementation. If so, the evaluation criteria are specified afterwards. Afterwards, identifying distinguished candidates and adopting Shannon entropy technique - to compute criteria's weight, ranking and prioritizing candidates - are addressed using fuzzy multi-criteria decision-making schemes and fuzzy TOPSIS algorithm. Finally, the distinguished candidate is chosen based on analyzing and concluding the steps(Figure ۲)

After careful considerations and conducting research on papers and books, and by navigating the Internet, numerous criteria and options were achieved. By refinement of major criteria and candidates, the proper ERP was chosen for Food ERP, with the following characteristics:

1. **Implementability**: Different organizations have different requirements, which makes the selecting of proper implementable ERP vital. If an organization wanted to do structural changes, feasibility mistake may lead to irreparable problems in the organization.
2. **Maintenance**: The application must be supported by multiple companies and sections. To update the ERP should not be a problem, and immediately ERP should be updated.
3. **Vendor's reputation**: It is crucial to have prior knowledge about vendor's credit and the software supplier's reputation. The best source of information about the sellers and suppliers, users are previous bundle.
4. **User-friendly interface**: Ease of use for the end-user is significant.
5. **Cost**: The ultimate costs are substantial to ERP systems. Some of these costs include the costs of consulting, analysis, implementation, flexibility, maintenance, training, support, upgrades and continuous compliance with the process. All criteria have raised the cost impact.

After refinement of options and according to the mentioned advantages, the following candidates are chosen for final consideration for Food ERP:

1. **SAP**: The reason for selecting this ERP software is the capability to link all the company's functional sections.
2. **Oracle**: The application packages developed by Oracle for these markets are of great reputation. This company is second largest software developer company, just after Microsoft. Currently, this company holds a big part of the world's ERP market share.
3. **Douran Data Processing Group**: Some outstanding features of this candidate are process integration, data integration, message integration, universality, high security, high scalability, multi-institutional, and multi-environmental.
4. **Behko Co.**: Notable features of this company are extensive security, paper-less organization, circulation of business documents, Benefiting from Microsoft Windows capabilities, multi-branch and multi-company capabilities, and the ability to perform tans-company transactions.
5. **Sameh ara company** : Modules specializing in financial, supply chain, human resources, business intelligence, technical, successful experience of implementation, and support Iranian companies.

5.1. Entropy Technique

Entropy is a major concept in social sciences, physics and information theory. When the data in a decision matrix is defined, entropy technique can be employed to assess its' weights. At this point, criteria weightings to be used in the Fuzzy TOPSIS technique is determined using entropy and by devising a decision matrix (Table 1).

In this table three experts were asked to perform checks. According to their opinion, the decision matrix cells were filled. Using the following equations, Table 2 and Entropy values (E_j), uncertainty value (d_j) and standard weight (W_j) were obtained.

$$E_i = S(P_1, P_2, \ldots, P_n) = -k\sum_{i=1}^{n}[P_i - Ln\ p_i] \quad (1)$$

$$k = \frac{1}{Ln(m)} \quad (2)$$

$$P_{ij} = \frac{a_{ij}}{\sum_{i=1}^{m} a_{ij}}\ ;\ \forall_{i,j} \quad (3)$$

$$E_j = -k\sum_{i=1}^{m}[P_{ij}\ Ln\ P_{ij}]\ ;\ \forall_j \quad (4)$$

$$d_j = 1 - E_j\ ;\ \forall_j \quad (5)$$

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j}\ ;\ \forall_j \quad (6)$$

$$w'_j = \frac{\lambda_j w_j}{\sum_{j=1}^{n} \lambda_j w_j}\ ;\ \forall_j \quad (7)$$

Table 1 - Decision Matrix

	Implementability	Vendor's Reputation	User-Friendly Interface	Maintenance	Cost
Expert No.1	5	4	4	6	7
Expert No.2	6	6	5	4	6
Expert No.3	3	5	7	3	4

In table (2), entropy and uncertainty values are obtained. According to subjective weight considered for the criteria, adjusted weights for each criterion is calculated.

Table 2 - Entropy and Uncertainty Values

Order	Criteria	Entropy Value (E_j)	Uncertainty Value (d_j)	Standard Weight (W_j)	Subjective Weight	Justified Weight
1	Implementability	0.966	0.034	0.262	0.18	0.241
2	Vendor's Reputation	0.988	0.012	0.093	0.22	0.105
3	User-Friendly Interface	0.976	0.024	0.187	0.2	0.191
4	Maintenance	0.963	0.037	0.283	0.19	0.275
5	Cost	0.977	0.023	0.175	0.21	0.188

Figure3 shows the final weight criteria. Weights adjusted with respect to the amounts(w'_j) and subjective (λ_j)weights according to formula (7) is calculated.

Figure3 -final weight criteria

5.2.Candidate Prioritization by Fuzzy TOPSIS Technique

In Table 3, Criteria type is defined in the form of being positive or negative, and the score of each candidate is determined with respect to its' criteria. The last row contains values of the previous step, i.e. the Shannon entropy. Steps taken to achieve the distinguished candidate include:

1. Creating the decision matrix (Equation 8)
2. Normalization (At this stage fuzzy decision making matrix becomes a matrix phase be Scale. In order to comparable the different scales of measurement, of "be Scale" is used. Equations 9 to 12)
3. Creating Fuzzy weighted scale matrix (According to weigh various criteria, weighted fuzzy decision matrix multiplication factor of importance related to each criterion in the matrix is obtained fuzzy be Scale.Equations 13 to 16)
4. Determining the fuzzy positive and negative ideals (Here are fuzzy positive (۱۹)and negative(۲۰) ideal of the ideal value for all criteria used fuzzy introduced by Chen..Equations 17 to 20)
5. Calculating sum of distances from fuzzy positive ideal and fuzzy negative ideal for each candidate (If A and B be two fuzzy number below, then the distance between these two fuzzy number by equation (۲۲) is obtained .equations 21, 22, 23, 24 and 25)
6. Finally, computing proximity coefficient or similarity index (The similarity index variable between zero and one.and Whatever ideal option is more similar to its similarity index value will be closer to number one.Equation 26)

$$\tilde{R} = [\tilde{r}_{ij}]_{m\times n}\ i = 1,2,\ldots,m\ \ j = 1,2,\ldots,n \quad (8)$$

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right) \quad (9)$$

$$c_j^* = \max_i c_{ij} \quad (10)$$

$$\tilde{r}_{ij} = \left(\frac{a_j^\circ}{c_{ij}}, \frac{a_j^\circ}{b_{ij}}, \frac{a_j^\circ}{a_{ij}}\right) \quad (11)$$

$$a_j^\circ = \min_i a_{ij} \quad (12)$$

$$\tilde{V} = [\tilde{v}_{ij}]_{m\times n}\ j = 1,2,\ldots,n\ i = 1,2,\ldots,m \quad (13)$$

$$\tilde{v}_{ij} = \tilde{r}_{ij} \otimes \tilde{w}_j \quad (14)$$

$$v_{ij} = r_{ij} \times w_j = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right) \times (w_{j1}, w_{j2}, w_{j3}) = \left(\frac{a_{ij}}{c_j^*} \times w_{j1}, \frac{b_{ij}}{c_j^*} \times w_{j2}, \frac{c_{ij}}{c_j^*} \times w_{j3}\right) \quad (15)$$

$$v_{ij} = r_{ij} \times w_j = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right) \times (w_{j1}, w_{j2}, w_{j3}) = \left(\frac{a_j^-}{c_{ij}} \times w_{j1}, \frac{a_j^-}{b_{ij}} \times w_{j2}, \frac{a_j^-}{a_{ij}} \times w_{j3}\right) \quad (16)$$

$$A^+ = (v_1^*, v_2^*, \ldots, v_n^*) \quad (17)$$

$$A^- = (v_1^-, v_2^-, \ldots, v_n^-) \quad (18)$$

$$v_j^* = (1,1,1) \quad (19)$$

$$v_j^- = (0,0,0) \quad (20)$$

$$\tilde{A} = (a_1, a_2, a_3) \quad (21)$$

$$\tilde{B} = (b_1, b_2, b_3) \quad (22)$$

$$D(\tilde{A},\tilde{B}) = \sqrt{\frac{1}{3}[(a_2 - a_1)^2 + (b_2 - b_1)^2 + (c_2 - c_1)^2]} \quad (23)$$

$$d_i^* = \sum_{j=1}^{n} d(\tilde{v}_{ij} - \tilde{v}_{ij}^*) \quad (24)$$

$$d_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij} - \tilde{v}_{ij}^-) \quad (25)$$

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-} \quad (26)$$

As can be seen in figure 4, the decision matrix corresponding to Table 3 is entered in fuzzy TOPSIS software, consisting of five criteria and five candidates. Under each criteria, there is a square which determines whether the criteria is negative or positive (as the cost criteria is checked, being a negative criteria). The weight of each criteria is entered in fuzzy form over each column (three square spaces for each). As is observed in the figure, SAP was ranked first with the most points.

TABLE 3: Fuzzy scores of candidates' assessment

	Implementability	Vendor's Reputation	User-Friendly Interface	Maintenance	Cost
Criteria Type	Positive	Positive	Positive	Positive	Negative
Behko	(1,2,3)	(1,3,5)	(7,8,9)	(2,3,4)	(7,8,9)
SAP	(8,9,10)	(4,5,8)	(8,9,9)	(6,7,8)	(2,3,4)
Sameh Ara	(2,3,6)	(6,8,9)	(4,7,8)	(2,4,6)	(5,6,8)
Douran Group	(2,4,5)	(3,6,9)	(5,6,7)	(4,5,8)	(1,2,3)
Oracle	(3,6,7)	(1,3,5)	(2,4,6)	(5,6,8)	(3,4,6)
Stand. Weight	(0.12,0.24,0.48)	(0.05,0.1,0.21)	(0.09,0.19,0.38)	(0.13,0.27,0.55)	(0.09,0.18,0.37)

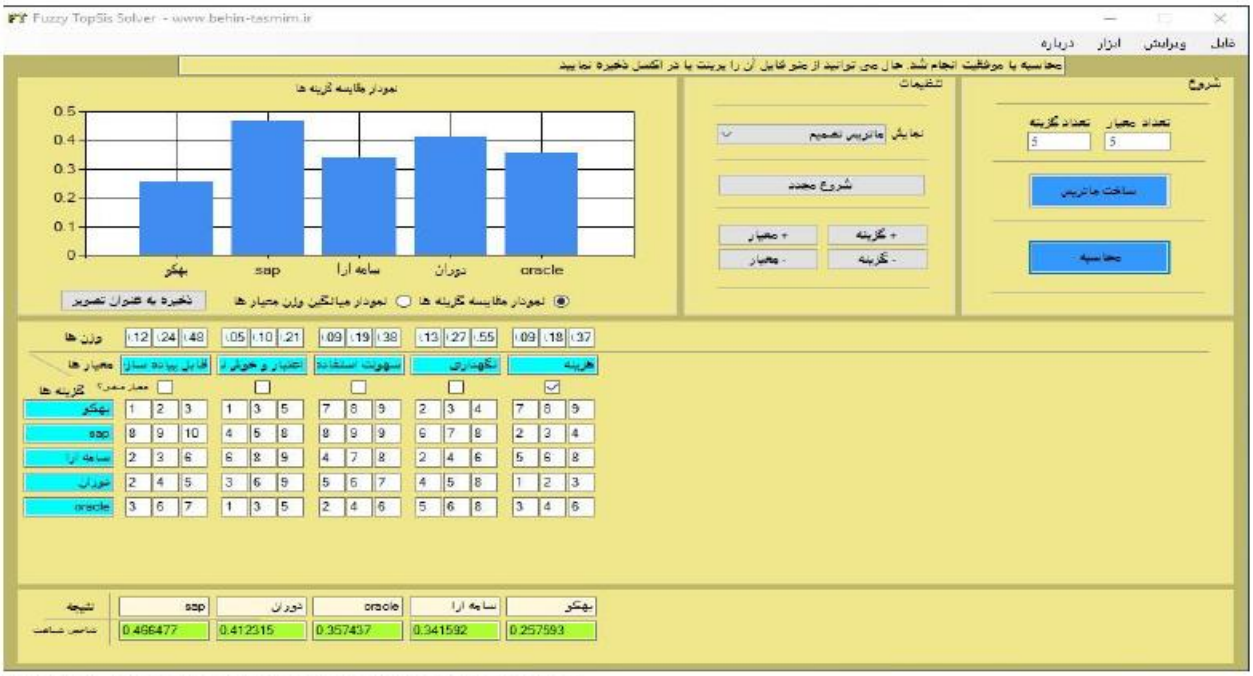

Figure 4- Decision Matrix in Fuzzy TOPSIS software

As seen in Table 4, SAP scored the most points with a proximity factor of 0.4664 with respect to other candidates. On second place, there is Douran Group with proximity factor of 0.4123. Following the top 2, there is Oracle Company in third place with a proximity factor of 0.3574, and places 4 and 5, with proximity factors of 0.3415 and 0.2575, are for Sameh Ara and Behko, respectively. According to the findings of this study, obtained based on analysis and fuzzy TOPSIS software outputs, SAP offers better conformity with criteria, goals and strategies of the Food ERP

Table 4: Candidates Ranking

Order	Candidates	Distance from Ideal positive	Distance from Ideal negative	Proximity coefficient	Rank
1	Behko	1.56	0.54	0.2575	5
2	SAP	1.22	1.06	0.4664	1
3	Sameh Ara	1.45	0.75	0.3415	4
4	Douran Group	1.36	0.95	0.4123	2
5	Oracle	1.42	0.79	0.3574	3

۱.Conclusion And Further Studies:

In this paper, we studied selecting a suitable ERP for SME's company (in our case Asia Mushroom Co.) using fuzzy TOPSIS technique. The reason behind adopting fuzzy techniques is the algorithm's input data, which are generally inaccurate. By employing Shannon entropy theory, we first computed weights for criterions such as Implementability, vendor's reputation, user-friendliness of the user interface, maintenance and cost, defined ideal positive and negative fuzzy solutions based on TOPSIS multi-criteria decision-making concepts afterwards, and calculated the distance between the two fuzzy numbers according to fuzzy numbers ranking approach. Finally, proximity factors for 5 most promising candidates, namely Behko, SAP, Sameh Ara, Douran Group, and ORACLE, were calculated, rendering SAP as the distinguished candidate amongst its' rivals.

Various methods targeting setting priorities have been

proposed recently. The major issues regarding such methods are lack of attention to factors such as uncertainties, imprecise formulation of problems with complex and ambiguous nature, and engaging decision makers with a large number of factors involving the decision-making process. In this study, we studied the use of fuzzy multi-criteria decision-making techniques to increase reliability factor in managerial decisions. This techniques have the advantage of assessing multiple candidates according to numerous criterions (with inconsistent units). Furthermore, these techniques enable simultaneous assessment of both quantitative and qualitative criteria.

Serious measures should be considered in software selection step, to ensure that responsiveness to further demands, procedure revisions, and passing of time areembedded in the system. In selecting such desired software, various people, including senior management, could be present. Careful consideration in this step is vital for organizations and companies, since it reduces implementation time and cost. Given that many similar organizations have the opportunity to employ ERP systems with generally equal capabilities, organizational excellence would be awarded to those which employ a system that is more compatible with their organizational strategic position and deals with demands in the best fashion.

Despite obstacles that ERP implementation in SME's face - e.g. cost and usage complexity - since these organizations benefit from more limited resources, as well as their inability to compete with large international corporations, and due to numerous advantages that ERP provides for the organization, implementation of ERP systems in SME's seems crucial. Therefore, in developed countries, in addition to increasing interest in employing such integrated information systems, SME's are moving towards utilizing these systems. Hence, they were able to benefit from its' direct and indirect advantages in global markets.

1. The studies conducted in this paper is limited on SME's companies, which are mostly implemented in developed countries (e.g. China, Turkey, Portugal, etc.). However, this study could be generalized to the countries with emerging economies.
2. Employing simultaneous and combinational weighting schemes, and incorporating the results in uncertainty situations (fuzzy), alongside with execution of factor assessment and organizational readiness in Iranian Organizations, to pave the way for successful implementation of ERP in Iranian SME's by eliminating obstacles and creating functional models.
3. Creating a common database and registering the data from local and national conducted implementations (independent from their succession or failure), along with their reasons and drawbacks (without naming the executing company and the company that implemented ERP), so that other national corporations would take advantage of them in excelling their future executions. Of course, many companies may refrain providing such information, hence government concessions should be presented to encourage them to do so.
4. In the field of selection erp systems in companies SME's, many issues unresolved. SME's companies in Iran due to the high percentage of risk-taking do not accept these systems. Field studies to facilitate the selection process, high success rate, reducing the time and cost of the project and the concrete experience of implementing successful SME's can make companies take steps on this path.
5. ERP choice in other areas, creation of various models more accurate and detailed review required for each module SME's organizations is suggested.

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