Proceedings of the 2013 International Conference on Information, Operations Management and Statistics (ICIOMS2013), Kuala Lumpur, Malaysia, September 1-3, 2013

A Comparison between Classical Statistical Method and Fuzzy Logic for Ranking Critical Success Factors of Implementing ERP in Iranian, Kalleh Food Products Company

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Abstract

In today's competitive world, creating organizational competitive advantage is subject to having enterprise information accurate and quick that this is achieved by using of Enterprise Resource Planning (ERP). Enterprise Resource Planning (ERP) is solution based on information technology that provides for various managers, organization information quickly and accurately. If it fails to implement of ERP, Benefits will be achieved shortly. Project managers often focus on technical and financial aspects but people and organizational issues are not considered so organizations are needing studied critical success factors (CSFs) in ERP implementation. The aim of this study was to ranking critical success factors on the implementation of ERP in Iranian Food Industry (case study is in Kalleh food Products Company with 12,000 employees and 300 products). The findings are based on a questionnaire, of which 105 managers and professionals using ERP were distributed and collected. Based on the research literature, 25 criteria were identified that were divided into three factors, technological, people and organizational. The model research presented and factors was ranking by both through the classical statistical method such as Friedman test and the software SPSS18 and fuzzy logic such as AHP and TOPSIS. Based on the results, there are differences in the final results of the two methods.

Keywords: Enterprise Resource Planning (ERP); Critical Success Factors (CSFs); Friedman Test; AHP; TOPSIS

1. Introduction

According to Davenport (1998), Enterprise Resource Planning (ERP) is an information system, which integrates most of the data than an organization can process and use in their operations, these improve organizational processes, increase productivity and efficiency and also to accelerate decision-making at all organizational units. Yusuf et al (2004) described that Companies expend millions of dollars and devote many working hours on starting the ERP software systems then ERP system is one the most difficult investment projects, because of the complexity of high expenses and compatibility risks. Al-Dammas and Al-Mudimigh (2011) argued ERP system is composed of a centralized database and four parts that (1) finance and accounting part including the cash and hand, accounts receivable, customer credit and revenue, (2) sale and marketing part including the orders, sales forecasts, return requests and price changes, (3) manufacturing and production part including the materials, production schedules, shipment dates, production capacity and purchases and (4) human resources part including the hours worked, labor cost and job skills. According to Zhang et al (2005), on average, ERP implementation projects took 2.5 times longer than projected, were 178% over budget.

2. A Review literature of ERP key Elements for Successful Implementation

Umble etal (2003) found that More than 90% of ERP implementation would breach the budget and appointed time. Research Study by several researchers in the past decade that there are eight key factors for successful implementation of ERP : Appropriate business and IT legacy system, Project team composition, Good project scope management, Top management commitment, Software development, testing and troubleshooting, Change management strategy, Business plan and vision, Management and evaluation of performance.

3. Critical Success Factors (CSFs) of ERP Implementation

Bullen and Rockart (1986) defined critical success factor (CSFs) for ERP as “the limited number of areas in which satisfactory results will ensure successful competitive performance for individual, department, or organization”. Ngai et al. (2008) defined that by identifying the most relevant CSFs an organization can take effective measures to eliminate or minimize the causes that are negatively affecting the ERP systems implementation. However we collected 25 the CSFs found in the ERP literature and classified the factors into three categories with: (1) technical factors including nine criteria, organizational fit, modularity, ease of use, flexibility, vendor support, functionality, customization or parameterization, latest technology, good performance, (2) people factors including six criteria, configuration management, skilled and sufficient vendor, end-user training provision, top management commitment, user involvement, good project scope management, (3) organizational factors including ten criteria, on-time communication between foreign vendors and local users, organization maturity level, Business Process Reengineering, appropriate development processes, effective monitoring and control, ERP implementation strategy, culture readiness, frozen requirement, effective communication and feedback, committed and motivated team. The conceptual research model of ERP implementation refers to Figure 1.

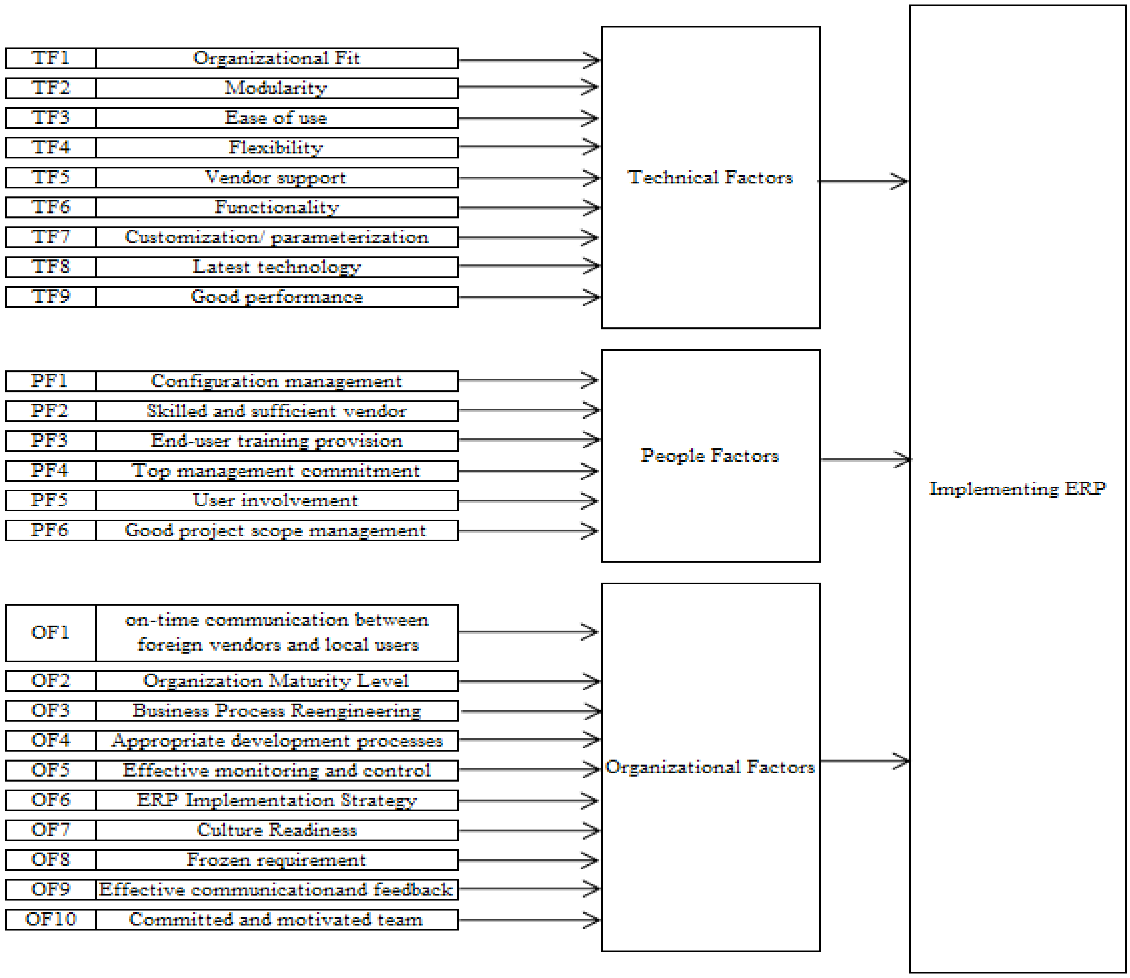


Fig.1: Conceptual research model of ERP implementation

4. Method

According to purpose this research is applied and according to methods for data collection is descriptive –

survey. The study population included all levels of management and professionals in the kalleh. Sampling method was census type that total 105 questionnaires distributed and collected in the Statistical population, the result indicated that 87.5% of the respondents were male and type of education degree 63.8% bachelor and 27.6% were masters. Note that in this paper, been used from two different research methods so we'll look at each of these separately, we have used of Friedman test through software SPSS18 in the classical statistical method. The measured scales of each construct were generated based on related studies, with modifications to the wording as appropriate for practices of this statistical population. The Cronbach alpha value is 0.799 for the three constructs. According to Gherbal et al (2012) the value 0.70 or more is significant and reliable, then this value indicating a high internal consistency. Various reliability test results are shown in Table 2.

Table 2: Summary of the measurement model

Construct Name	Construct identifier	Indicator	Mean	Std. Dev.	Item-to total correlation
Technological factors on Implementing ERP	TF	TF1	2.33	0.824	0.351
		TF2	2.92	1.111	0.191
		TF3	3.65	0.827	0.318
		TF4	2.82	1.011	0.308
		TF5	2.81	0.831	0.33
		TF6	3.19	0.949	0.447
		TF7	2.69	1.116	0.446
		TF8	3.01	1.007	0.288
		TF9	2.83	1.171	0.519
People factors on Implementing ERP	PF	PF1	2.8	1.017	0.427
		PF2	2.7	1.035	0.541
		PF3	2.39	1.067	0.473
		PF4	2.72	1.094	0.537
		PF5	3.01	1.262	0.057
		PF6	2.55	1.101	0.446
Organizational factors on Implementing ERP	OF	OF1	3.14	0.91	0.221
		OF2	2.98	0.892	0.504
		OF3	3.1	0.984	0.358
		OF4	3.01	0.751	0.336
		OF5	3.24	0.739	0.012
		OF6	3.15	0.904	0.481
		OF7	3.29	0.857	0.131
		OF8	2.65	0.887	0.282
		OF9	2.85	0.943	0.277
		OF10	3.76	0.936	0.013

According to chambers et al (1983), in many statistical analyses, normality is often conveniently assumed without any empirical evidence or test and understanding the distribution of data could provide more information on the requirement mechanisms for generating the data. Base on research of Ahad et al (2011) there are four statistical tests that are widely used for checking normality, namely, the Kolmogorov-Smirnov test (Kolmogorov 1956; Smirnov 1936), Anderson-Darling test (Anderson and Darling 1952), Cramer-von Mises test (Anderson 1962), and Shapiro-Wilk test (Shapiro and Wilk 1965). To select the appropriate statistical test should be done Normality test data in the first that used to Shapiro-Wilk or Kolmogorov-Smirnov test. It would be normal data distribution if the significance level is greater than 5%. The results shown in Table 3 indicate that the data distribution is not normal.

Table 3: Normality test data

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Indicator	Statistic	df	Sig.	Statistic	df	Sig.
TF1	.379	105	.000	.759	105	.000
TF2	.273	105	.000	.856	105	.000
TF3	.296	105	.000	.850	105	.000
TF4	.200	105	.000	.898	105	.000
TF5	.223	105	.000	.880	105	.000
TF6	.238	105	.000	.883	105	.000
TF7	.213	105	.000	.904	105	.000
TF8	.232	105	.000	.900	105	.000
TF9	.268	105	.000	.872	105	.000
PF1	.208	105	.000	.901	105	.000
PF2	.219	105	.000	.896	105	.000
PF3	.238	105	.000	.886	105	.000
PF4	.278	105	.000	.854	105	.000
PF5	.187	105	.000	.910	105	.000
PF6	.251	105	.000	.881	105	.000
OF1	.262	105	.000	.885	105	.000
OF2	.206	105	.000	.884	105	.000
OF3	.186	105	.000	.900	105	.000
OF4	.253	105	.000	.858	105	.000
OF5	.255	105	.000	.868	105	.000
OF6	.213	105	.000	.886	105	.000
OF7	.225	105	.000	.886	105	.000
OF8	.234	105	.000	.888	105	.000
OF9	.262	105	.000	.842	105	.000
OF10	.258	105	.000	.841	105	.000

According to the abnormal distribution, nonparametric tests should be used such as Friedman test. Garsia et al argued (2010) Friedman test is equivalent to ANOVA parametric test with repeated measures (within-group) which is used for comparison of the mean ranks among the K variables (Group). The first step in calculating the test statistic is to convert the original results. Thus, it ranks the algorithms for each problem separately. The best performing algorithm should have the rank of 1, the second best rank 2, etc., as shown in Table 4. In case of ties, average ranks are computed.

Table 4: Ranking criteria

Indicator	Critical Success Factors (CSFs)	Mean Rank
OF10	Committed and motivated team	18.14
TF3	Ease of use	18.00
OF7	Culture Readiness	15.72
OF5	Effective monitoring and control	15.13
TF6	Functionality	14.67
OF6	ERP Implementation Strategy	14.59
PF5	User involvement	14.37
OF1	on-time communication between foreign vendors and local users	14.13
OF4	Appropriate development processes	13.62
OF3	Business Process Reengineering	13.54
TF8	Latest technology	13.34
TF2	Modularity	12.85
OF2	Organization Maturity Level	12.83
TF4	Flexibility	12.80

TF9	Good performance	12.34
OF9	Effective communication and feedback	12.28
TF7	Customization/ parameterization	12.00
PF2	Skilled and sufficient vendor	11.94
TF5	Vendor support	11.80
PF1	Configuration management	11.78
OF8	Frozen requirement	11.00
PF4	Top management commitment	10.62
PF6	Good project scope management	9.49
PF3	End-user training provision	9.16
TF1	Organizational Fit	8.87

In the Fuzzy Logic method, data analysis so that first stage of weighting the criteria to be used fuzzy numbers, linguistic terms and AHP (Analytical Hierarchy Process) and then by using fuzzy TOPSIS variables are ranked. Base on Zadeh (1965) the use of fuzzy set theory allows the decision makers to use qualitative information, incomplete information, non-obtainable information and somewhat ignorant facts into decision model. According to Chang and Yeh (2002), Chung et al (2007) and Kahraman et al (2004) the current research uses triangular fuzzy number for fuzzy TOPSIS because of ease using a triangular fuzzy number for the decision-makers to calculate. Furthermore, it has verified that modeling with triangular fuzzy numbers is an effective way for formulating decision problems where the information available is subjective and inaccurate. A triangular fuzzy number can be defined as (a1, a2, a3) shown in Figure 2, which in this case, the interval is from 0 to 1.

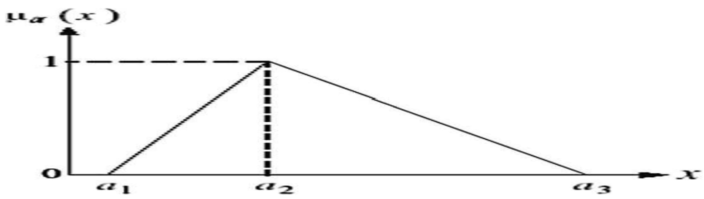


Fig.2: Fuzzy Number Membership Function

The membership function of the fuzzy number ã is defined as:

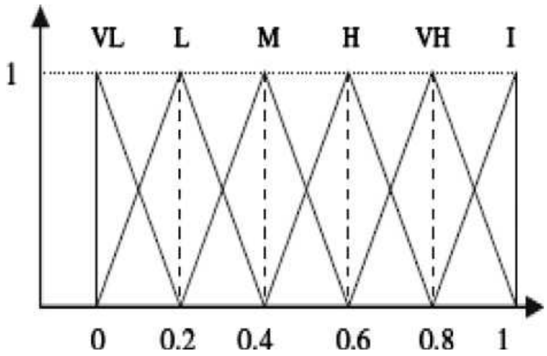
$$\mu a(x) = \begin{cases} 0 & X < a1 \\ \dfrac{X - a1}{a2 - a1} & a1 < X < a2 \\ 1 & X = a2 \\ \dfrac{X - a3}{a2 - a3} & a2 < X < a3 \\ 0 & X > a3 \end{cases} \qquad (1)$$

Fuzzy numbers can be defined for a linguistic expression that shown in Table 5. In this study, the non-quantitative indicators with 6 terms linguistic have become triangular fuzzy numbers.

Table 5: linguistic values and fuzzy numbers

Linguistic Variables	Fuzzy numbers	Fuzzy numbers
Very low (VL)	(0, 0, 0.2)	

Low (L)	(0, 0.2, 0.4)
Medium (M)	(0.2, 0.4, 0.6)
High (H)	(0.4, 0.6, 0.8)
Very high (VH)	(0.6, 0.8,1)
Excellent (E)	(0.8, 1,1)



Topsis method was suggested in 1981 by the Yoon and Hwang that is abbreviation of "Technique for Order Preference by Similarity to Ideal Solution". This method will evaluate N choice by M index, this technique is a method of compensating in MCDM and this means that exchange between the parameters in the model is allowed and the lack of an index be compensated by points other indicators. Base on Yoon and Hwang (1981), this technique is based on the concept that selected choice must be the minimum distance from the positive ideal solution and must be the maximum distance from the negative ideal solution, this means that utility index is uniformly increasing or decreasing, in this technique used of quantitative data and qualitative indicators should be used of appropriate scales be converted to quantitative data as well as because all criteria have not equal importance. TOPSIS technique has been found a series of weights from decision maker. The steps of topsis method are as a follow:

1. Normalize the decision matrix X= (xij) n×m using the equation below:

$$R_{ij} = \frac{X_{ij}}{\sum_{K=1}^{N} X_{Kj}^{2}} \qquad j = 1\ldots m \quad i = 1\ldots n \qquad (2)$$

Decision Matrix in this research is meaning Reviews of the study population and normalized decision matrix, shown in Table 6:

Table 6: Decision matrix and Normalized decision matrix

Indicator	Critical Success Factors (CSFs)	Technical Factor		People Factor		Organizational Factor	
TF1	Organizational Fit	3.32	0.267	2.40	0.178	2.05	0.154
TF2	Modularity	3.47	0.279	3.65	0.271	3.21	0.240
TF3	Ease of use	1.12	0.090	2.95	0.219	2.57	0.193
TF4	Flexibility	3.46	0.279	2.94	0.218	2.10	0.157
TF5	Vendor support	3.03	0.244	2.81	0.209	1.96	0.147
TF6	Functionality	3.01	0.242	3.16	0.235	2.58	0.193
TF7	Customization/ parameterization	3.73	0.300	2.80	0.208	1.69	0.127
TF8	Latest technology	2.36	0.190	3.02	0.224	1.26	0.094
TF9	Good performance	3.82	0.308	2.85	0.211	2.48	0.186

PF1	Configuration management	2.80	0.225	2.28	0.169	2.05	0.154
PF2	Skilled and sufficient vendor	2.78	0.224	4.22	0.313	2.01	0.151
PF3	End-user training provision	2.45	0.197	4.07	0.302	1.96	0.147
PF4	Top management commitment	2.64	0.212	3.74	0.278	2.15	0.161
PF5	User involvement	3.10	0.249	1.36	0.101	1.26	0.094
PF6	Good project scope management	2.43	0.196	3.67	0.272	2.09	0.157
OF1	on-time communication between foreign vendors and local users	1.58	0.127	2.13	0.158	3.15	0.236
OF2	Organization Maturity Level	1.20	0.097	2.25	0.167	2.93	0.220
OF3	Business Process Reengineering	1.35	0.109	2.19	0.163	3.00	0.225
OF4	Appropriate development processes	1.49	0.120	1.36	0.101	2.98	0.223
OF5	Effective monitoring and control	1.78	0.143	1.28	0.095	3.26	0.244
OF6	ERP Implementation Strategy	1.62	0.130	2.05	0.152	3.17	0.238
OF7	Culture Readiness	1.28	0.103	1.52	0.113	4.73	0.354
OF8	Frozen requirement	1.30	0.105	1.62	0.120	2.67	0.200
OF9	Effective communication and feedback	1.47	0.118	2.03	0.151	2.87	0.215
OF10	Committed and motivated team	1.52	0.122	1.41	0.105	3.75	0.281

2. Calculate the weighted normalized decision matrix V= (vij) n×m:

$$Vij = Wj * Rij \qquad i = 1\ldots n, \quad j = 1\ldots m \tag{3}$$

Wj is the relative weight of the jth criterion and ∑ wj =1.
To determine the weight of each construct used from method of paired comparisons matrix of AHP and Expert Choice software that results are in the Figure 3:

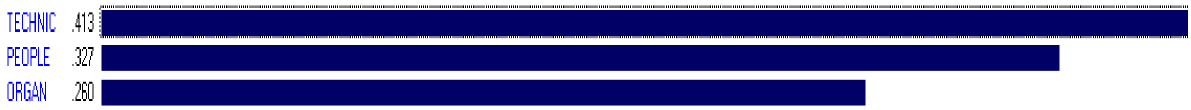


Fig.3: Weight of constructs

Can now be calculated weighted no scale matrix, in order to no scale matrix is multiplied by the square matrix that main diagonal elements are weights of constructs and the remaining elements are zero, the results shown in Table 7 :

Table 7: No scale matrix weight

Indicator	Critical Success Factors (CSFs)	Technical Factor	People Factor	Organizational Factor
TF1	Organizational Fit	0.110	0.058	0.040
TF2	Modularity	0.115	0.089	0.063
TF3	Ease of use	0.037	0.072	0.050
TF4	Flexibility	0.115	0.071	0.041
TF5	Vendor support	0.101	0.068	0.038
TF6	Functionality	0.100	0.077	0.050
TF7	Customization/ parameterization	0.124	0.068	0.033
TF8	Latest technology	0.078	0.073	0.025

TF9	Good performance	0.127	0.069	0.048
PF1	Configuration management	0.093	0.055	0.040
PF2	Skilled and sufficient vendor	0.092	0.102	0.039
PF3	End-user training provision	0.081	0.099	0.038
PF4	Top management commitment	0.088	0.091	0.042
PF5	User involvement	0.103	0.033	0.025
PF6	Good project scope management	0.081	0.089	0.041
OF1	on-time communication between foreign vendors and local users	0.053	0.052	0.061
OF2	Organization Maturity Level	0.040	0.055	0.057
OF3	Business Process Reengineering	0.045	0.053	0.058
OF4	Appropriate development processes	0.050	0.033	0.058
OF5	Effective monitoring and control	0.059	0.031	0.063
OF6	ERP Implementation Strategy	0.054	0.050	0.062
OF7	Culture Readiness	0.043	0.037	0.092
OF8	Frozen requirement	0.043	0.039	0.052
OF9	Effective communication and feedback	0.049	0.049	0.056
OF10	Committed and motivated team	0.051	0.034	0.073

3. Determination of the positive- ideal and negative-ideal solutions:

$$A+ = \{V1+\ldots Vm+\} = \{(\max_j Vij \mid j \in \Omega b), (\min_j Vij \mid j \in \Omega c)\} \quad (4)$$

$$A- = \{V1-\ldots Vm-\} = \{(\max_j Vij \mid j \in \Omega b), (\min_j Vij \mid j \in \Omega c)\} \quad (5)$$

In this step for each indicator calculated Positive and negative ideal:

A+ = [0.037, 0.102, 0.092]   A- = [0.127, 0.031, 0.025]

4. Calculate the Euclidean distances of each alternative from the positive-ideal solution and the negative-ideal solution:

$$Di+ = \sqrt{\sum_{J=1}^{M} (Vi\,j-Vj+)^2} \qquad i = 1\ldots n \quad (6)$$

$$Di- = \sqrt{\sum_{J=1}^{M} (Vi\,j-Vj-)^2} \qquad i = 1\ldots n \quad (7)$$

5. Determination the relative closeness of each alternative to the positive-ideal solution. The relative closeness of the alternative Ai concerning to A+ is characterized as below:

$$RCi = \frac{Di-}{Di- + Di+} \qquad i = 1\ldots n \quad (8)$$

After determining the values of the positive and negative ideal must be calculated distance of each indicator with ideals values and relative closeness of each indicator to the ideal solution that these shown in Table 8.

Table 8: Distance and relative closeness value

Indicator	Critical Success Factors (CSFs)	D -	D +	RC
TF1	Organizational Fit	0.035	0.100	0.261
TF2	Modularity	0.070	0.085	0.452
TF3	Ease of use	0.102	0.052	0.661
TF4	Flexibility	0.045	0.098	0.315
TF5	Vendor support	0.047	0.090	0.345
TF6	Functionality	0.059	0.080	0.425
TF7	Customization/ parameterization	0.038	0.111	0.256
TF8	Latest technology	0.064	0.084	0.433
TF9	Good performance	0.045	0.105	0.299
PF1	Configuration management	0.044	0.090	0.331
PF2	Skilled and sufficient vendor	0.081	0.077	0.513
PF3	End-user training provision	0.083	0.070	0.543
PF4	Top management commitment	0.074	0.072	0.505
PF5	User involvement	0.024	0.117	0.171
PF6	Good project scope management	0.076	0.069	0.525
OF1	on-time communication between foreign vendors and local users	0.086	0.061	0.583
OF2	Organization Maturity Level	0.096	0.059	0.618
OF3	Business Process Reengineering	0.092	0.060	0.603
OF4	Appropriate development processes	0.084	0.078	0.519
OF5	Effective monitoring and control	0.078	0.080	0.494
OF6	ERP Implementation Strategy	0.084	0.063	0.572
OF7	Culture Readiness	0.108	0.066	0.622
OF8	Frozen requirement	0.089	0.075	0.541
OF9	Effective communication and feedback	0.086	0.065	0.568
OF10	Committed and motivated team	0.091	0.072	0.557

6. Determining the final rank

Ranking criteria shown in Table 9 high to low.

Table 9: Ranking criteria

Indicator	Critical Success Factors (CSFs)	Rank
TF3	Ease of use	0.661
OF7	Culture Readiness	0.622
OF2	Organization Maturity Level	0.618
OF3	Business Process Reengineering	0.603
OF1	on-time communication between foreign vendors and local users	0.583
OF6	ERP Implementation Strategy	0.572
OF9	Effective communication and feedback	0.568
OF10	Committed and motivated team	0.557
PF3	End-user training provision	0.543
OF8	Frozen requirement	0.541
PF6	Good project scope management	0.525
OF4	Appropriate development processes	0.519
PF2	Skilled and sufficient vendor	0.513
PF4	Top management commitment	0.505
OF5	Effective monitoring and control	0.494
TF2	Modularity	0.452
TF8	Latest technology	0.433
TF6	Functionality	0.425

TF5	Vendor support	0.345
PF1	Configuration management	0.331
TF4	Flexibility	0.315
TF9	Good performance	0.299
TF1	Organizational Fit	0.261
TF7	Customization/ parameterization	0.256
PF5	User involvement	0.171

5. Conclusions

The main objective of this research is to comparison between Classical Statistical Method and Fuzzy Logic for Ranking Critical Success Factors of Implementing ERP in Iranian, Kalleh Food Products Company. The results indicate that there are differences between the responses of the two methods. The results were presented to managers and specialists in the population and external consultants, the majority agreed that phased approach is more correctly answer the Classical Method. Based on the ranked factors can be suggestions presented for successful implementation of ERP system that technological factors, adequate education and counselling to users, Select appropriate software package compatible with organizational needs, for people factors, increasing acceptance of criticism by directors and employees, managers to embrace the challenges and changes in the organization, corporate leaders to support the changes in employee attitudes and for organizational factors, being specialists in the discipline of their actual position, recognizing the importance of learning for all employees, performance-based incentive system created good and the fairly, open institutional environment for the people declaration.

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