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Effect of quality factors in Capability Maturity Model Integration with Six Sigma and Agile Manufacturing approaches using fuzzy AHP (A case of Manufacturing Automobile Parts)

Gholamreza Esmaeilian, Maryam Hamedi, Monireh Safaie

***Abstract*— The quality is one of the most important issues that organizations attend to use its different models to reach the continuous improvement. To achieve the quality and continuous improvement, a general model is required to provides accretion from old and new models. On the other hand, receiving agile manufacturing is one of the most important objects of automotive parts manufacturer companies. In this research, a unified model of quality techniques is presented with agile manufacturing approach and to reach the quality simultaneously. Therefore, the effective factors on quality are measured through the proposed model to determine its efficiency in automotive parts manufacturer companies. To this purpose, a questionnaire is designed with four main quality factors. To analyze the results, fuzzy AHP is used. All three mentioned models in the questionnaire are questioned and results show that the effectiveness of quality factors in CMMI model is 19.7%, six-sigma technique is 17.5%, and CMMI with six sigma and agile manufacturing (CбAMI) is 66.6%. Prioritizing quality factors is determined with their importance coefficient (organizing (36%), evaluation and feedback (36%), employees(16%) and systems and techniques (13%)).**

***Index Terms*— Capability Maturity Model Integration (CMMI), Six Sigma Model, Agile Manufacturing, Fuzzy AHP .**

I. INTRODUCTION

In the today competitive world, quality plays an important role in organizations. To create agile manufacturing, organizations need to reach customers satisfaction with products flexibility simultaneously [1-3]. Moreover agile manufacturing is required because of its attention to the customer's satisfaction, changes in market, organization information and science and flexibility of process for producing product in automotive parts manufacturer companies [4-5]. In the software industry, a technique appeared that unified the previous techniques [6-11]. This technique is tested in produce and service section (especially in automotive parts manufacturer industry) and is improved and spread in recent years. This technique is named CMMI model [12]. On the other hand, six sigma is one of the quality techniques in automotive parts manufacturer industry that is used most [13-16]. So, for testing models efficiency we used quality factors. Because customer's satisfaction has a great effect on organizations and there is a relation between quality and customer's satisfaction [17].

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Gholamreza Esmaeilian, Industrial Engineering, Assistant professor of Payame noor University, Esfahan, Iran.

Maryam Hamedi, Industrial Engineering, Assistant professor of Payame noor University, Esfahan, Iran.

Monireh Safaie, Industrial Engineering, MSC student of Payame noor University, Tehran Iran.

II. TELLING THE ISSUE

Automotive parts manufacturer companies needed unifying in organization to provide quality and reach to the agile manufacturing to destroy the distances in organization processes and have more quality and with providing quality, also reach to the agile manufacturing simultaneously. Therefore, in this study, it is tried to present a model that includes unifying between quality techniques and also can reach the agile manufacturing. Therefore, a model has been presented, which involves all three traits. To evaluate the efficiency of this model, quality factors and sub factors were determined and have evaluated for three models. In this research, 4 quality factors (organizing, systems and techniques, evaluating, feedback, and employees) have been determined and some sub factors have been determined for each to determine the efficiency more accurate. Then with using fuzzy AHP the importance of each model and factor was determined and the efficiency of each model in providing quality and continuous beneficiary was determined.

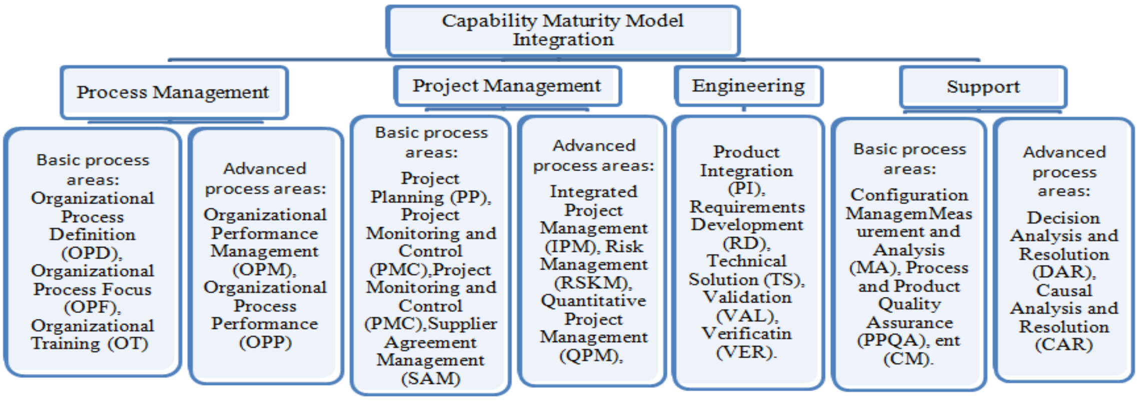
III. REVIEWING THE LITERATURE OF ISSUE

Six-sigma is a mix up of quality management and system engineering. The six sigma's philosophy is based on reducing swings and changes. It is said that six sigma is a regulate effort that closely evaluate the frequently processes of organizations in designing products, providers function, serving services, and others sections [18]. Six-sigma includes 5 steps (figure 1).

Figure 1: summery of Six Sigma steps [18]

On the other hand, today more than any other time, companies have considered the delivery of better, faster and cheaper products and try to move to the agile manufacturing[12,19-20]. For this matter the CMMI model, suggests buying some product parts provided by suppliers or organization. Therefore, all components will be gathered and assembled in the final product [6]. The problems of these organizations include the solution of importing the wide economic organization (investors) that need a unified method such as CMMI. The management effect and organization stocks for prosperity in trade, is sure and evident. In fact, these are organizations that need a solution for managing their improvement actions as provide a part of their trade goals. Most methods for improvement concentrate on a special part of trade and don't perform a systemic method for problems [12]. CMMI provides a chance for avoiding these setbacks and involves best ways that are: using actions for improving products as cover understandings of delivery and maintaining products in whole of product lifecycle [9-12]. As shown in figure 2, CMMI has 4 classifications in 22 areas.

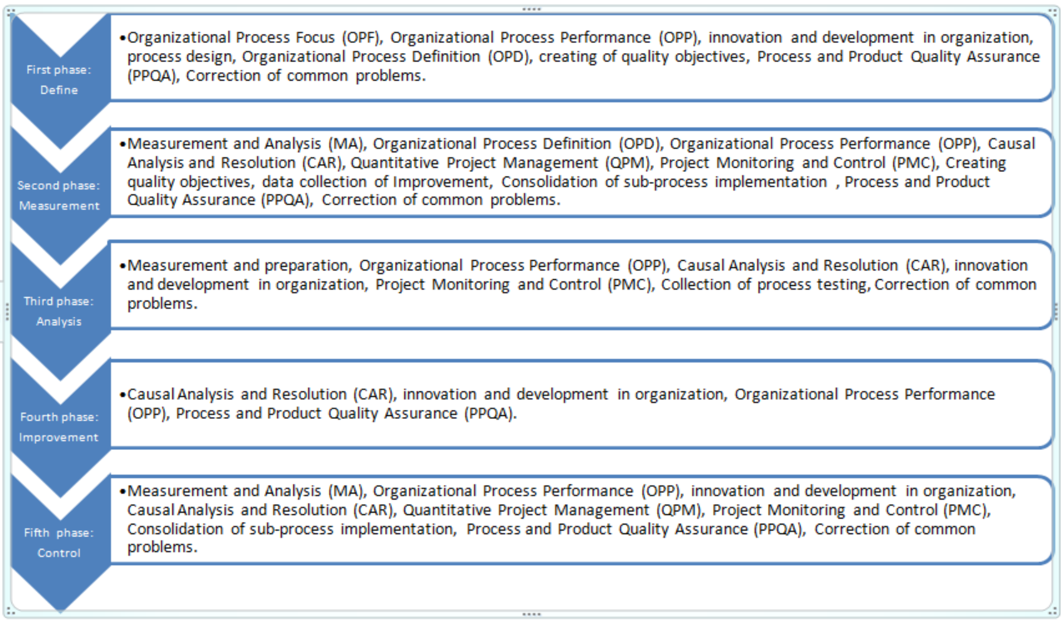
Figure 2: classification and process areas in Capacity Maturity Model Integration [12]



IV. PRESENTING CMMI MODEL WITH SIX SIGMA AND AGILE MANUFACTURING APPROACHES

According to the past researches in the literature [6,9-12,21], a model has been represented that could have unifying for six sigma technique and organization ability mature unifying model. Therefore, special methods and process areas from CMMI model have breakdown in six-sigma steps. For performing each step of six sigma's steps, the process areas and methods of CMMI model can be used and six-sigma's steps can be performed to achieve more efficiently for leading processes. Each process area can be assumed as a project for six sigma and manage it[21]. Therefore, for unifying quality models, represented model in figure 3 is suggested.

Figure 3: Proposal model of CMMI with approach Six Sigma and Agile Manufacturing



V. PROCEDURES AND RESEARCH METHODOLOGE

The research has been performed in 5 steps:

Step 1: identifying quality management factors and sub factors: using performed researches in this case, generally 4 factors and 16 sub factors have been identified[22].

Step 2: proportioning the factors and sub factors: factors and sub factors have been studied with Delphi model and decision team comments. At the end, collective aggregation was get at first step and collecting the comments of Delphi panel members was not necessary in next level.(the available questionnaire was prefabricate model).

Step 3: evaluating the importance of elements with fuzzy group AHP and normalized weigh designation to each factor: the decision team represented their comments about each even comparison in seven-point Likret spectrum from negative effect to great effect. Also each number of this spectrum based on the triangle rule could be explanatory of three numbers. For example number 2 is explanatory of three numbers (0.5, 1, 1.5) in calculations.

Step 4: because of specialty of questionnaire, it was given to 9 experts of car industry and management. this questionnaire was a mix up of three questionnaire for three models (CMMI model, six sigma model, CMMI model with six sigma and agile manufacturing approaches) and using SPSS software gave us the **Cronbach's alpha** number between (0.735, 0.811) that emphasis on inner parallelism and unifying people's answers with all factors of questionnaire[23].At the end, the average of sub factor's points of each factor, characterized the factor's point.

Step 5: appointment the final priorities for quality improvement: **because if the factor's weigh is more, will be in higher priority, also points should be like this**. For unifying this operation, the environment of excel software is used. Calculations of fuzzy AHP group for gradation and appointment importance coefficient were don with phase AHP [24-25].(the explanation information of participant team has been shown in table 1).

Table 1: Descriptive information about team participants in the questionnaire

	First org	Second org	third org	4th org	5th org	6th org	7th org	8th org	9th org
organizational status									
work experience	15 ages	27 ages	40 ages	20 ages	17 ages	18 ages	19 ages	8 ages	7 ages
Senior management	✓								
Quality management		✓	✓	✓	✓	✓	✓	✓	✓
Type of production									
Exporter	✓		✓	✓		✓	✓	✓	
Importer			✓	✓		✓		✓	
Consulting services		✓							✓

VI. EVALUATING OF MODEL, QUALITY FACTORS

A. *Identifying Quality Factors and Sub factors:*

Identifying quality factors and sub factors: with considering effective elements on quality, 4 factors have been introduced (Organizing, systems and techniques, evaluation, Feedback and employees). Each of these factors has sub factors that are shown in table 2.

Table 2: variables and sub-variables in quality

organizing	systems and techniques	evaluation and feedback	employees
Commitment of senior management	Focus on the Customer	Reward	training
Management and Leadership	Continuous Improvement	Communications	Teamwork
Landscape	Supplier management	Performance Evaluation	Employee participation
Strategic Planning	Process management and quality assurance		
Institutional constraints	Product Design		

B. *Final Stage*

A prefabricate questionnaire from quality techniques (including three questionnaire) was given to 9 experts and managers in producing car's.

VII. ANALYZING FOUNDS WITH FUZZY AHP

The durability of questionnaire was calculated with SPSS software and Cronbach's alpha achieved between (0.735, 0.811) (there were three questionnaires that each one's alpha was calculated separate). Then the information analyzing was done in forward.

A. *The even comparisons*

This system of triangle fuzzy numbers is used for even comparisons. With 1/9 to 9 hours spectrum we can have even comparison matrix as triangle numbers. In this step, the

decision maker tells his prefers with even comparisons of each level factors than higher level factors in fuzzy model. As the even comparisons matrix of scales than each other from decision maker perspective (all of them) is shown in table 4.

Table 3: even comparisons matrix of scales than each other in decision maker perspective(all of them)

Criteria	organizing	systems and techniques	evaluation and feedback	employees
organizing	(5,6,7)	(7,8,9)	(1,1,1)	(1,1,1)
systems and techniques	(5,6,7)	(7,8,9)	(1,1,1)	(1,1,1)
evaluation and feedback	(2,3,4)	(1,1,1)	(1/9,1/8,1/7)	(1/9,1/8,1/7)
employees	(1,1,1)	(1/4,1/3,1/2)	(1/7,1/6,1/5)	(1/7,1/6,1/5)

The tables of even comparisons of quality than each factor in decision maker perspective are shown in tables 4-7.

Table 4: even comparisons matrix of quality than organizing scale from decision maker perspective.

organizing	CMMI	Six Sigma	CбAMI model
CMMI	(1/3,1/2,1)	(1,1,1)	(1,1,1)
Six Sigma	(1/4,1/3,1/2)	(1,1,1)	(1,1,1)
CбAMI model	(1,1,1)	(2,3,4)	(1,2,3)

Table 5: even comparisons matrix of quality than systems and techniques scale from decision maker perspective.

systems and techniques	CMMI	Six Sigma	CбAMI model
CMMI	(1/4,1/3,1)	(1,1,1)	(1,1,1)
Six Sigma	(1/4,1/3,1)	(1,1,1)	(1,1,1)
CбAMI model	(1,1,1)	(1,3,4)	(1,3,4)

Table 6: even comparisons matrix of quality than evaluation and feedback scale from decision maker perspective.

evaluation and feedback	CMMI	Six Sigma	CбAMI model
CMMI	(1/3,1/2,1)	(1,2,3)	(1,1,1)
Six Sigma	(1/4,1/2,1)	(1,1,1)	(1/3,1/2,1)
CбAMI model	(1,1,1)	(1,2,4)	(1,2,3)

Table 7: even comparisons matrix of quality than employees scale from decision maker perspective.

employees	CMMI	Six Sigma	CбAMI model
CMMI	(1/4,1/3,1/2)	(1/3,1/2,1)	(1,1,1)
Six Sigma	(1,1,1)	(1,1,1)	(1,2,3)
CбAMI model	(1,1,1)	(1,1,1)	(2,3,4)

VIII. GRADATIONS IN FUZZY AHP

In this step, with definitions and understandings of fuzzy AHP, the coefficient of each even comparisons matrix will calculate. So, for calculating S_k :

$[\sum_{i=1}^{m}\sum_{j=1}^{n} Mij]^{-1}$= (32.81,37.91,43.12)$^{-1}$=(0.023,0.026,0.03) (1)

Then based on equation 1:

$S_K=\sum_{j=1}^{n} M_{kj} * [\sum_{i=1}^{m}\sum_{j=1}^{n} Mij]^{-}$ (2)

S_1=(14,16,18)* (0.023,0.026,0.03)=(0.32,0.41,0.54)

S_2=(14,16,18)* (0.023,0.026,0.03)=(0.32,0.41,0.54)

S_3=(3.22,4.25,5.28)* (0.023,0.026,0.03)=(0.07,0.11,0.16)

S_4=(1.59,1.66,1.84)* (0.023,0.026,0.03)=(0.036,0.043,0.034)

Then amplitude of [$V(S_i>S_k)$] of each above factors on other factors should be calculated on other factors. For amplitude of S_1 on S_3 there is no need to calculate because $m_1=0.41>m_3=0.11$ and this means that $V(S_1>S_3)=1$. Therefore:

$V(S_1\geq S_2)=1$ $V(S_1\geq S_3)=1$ $V(S_1\geq S_4)=1$ $V(S_2 \geq S_1)=1$

$V(S_2\geq S_3)=1$ $V(S_2\geq S_4)=1$ $V(S_3\geq S_4)=1$

$V(S_3\geq S_1)=\frac{u_3-L_1}{(u_3-L_1)+(m_1-m_3)}=0.35$ (3)

$V(S_3\geq S_2)=\frac{u_3-L_2}{(u_3-L_2)+(m_2-m_3)}=0.35$

$V(S_4\geq S_1)=\frac{u_4-L_1}{(u_4-L_1)+(m_1-m_4)}=0.44$

$V(S_4\geq S_2)=\frac{u_4-L_2}{(u_4-L_2)+(m_2-m_4)}=0.44$

$V(S_4\geq S_3)=\frac{u_4-L_3}{(u_4-L_3)+(m_3-m_4)}=0.35$

Also for calculating the amplitude of one S_i on other S_i:

$V(S_1\geq S_2,S_3,S_4)$=Min (1,1,1)= (4)

$V(S_2\geq S_1,S_3,S_4)$=Min (1,1,1)=1

$V(S_3\geq S_1,S_2,S_4)$=Min (1,0.35,0.35)=0.35

$V(S_4\geq S_1,S_2,S_3)$=Min (0.44,0.44,0.35)=0.44

These numbers show the abnormal weigh of x_1,x_2,x_3,x_4 indicators.

W'=(1,1,0.35,0.44) (5)

Based on the equation (6), the quantity of normal weighs of x_1,x_2,x_3,x_4 will be calculated :

$W_t = \frac{W_t}{\sum W_t}$ (6) ⟹ W=(0.36,0.36,0.13,0.16)

Also for organizing table based on above equations we have:

$[\sum_{i=1}^{m}\sum_{j=1}^{n} Mij]^{-1}$=(8.58,10.88,13.5)$^{-1}$=(0.074,0.092,0.12) (1)

Then:

$S_K=\sum_{j=1}^{n} M_{kj} * [\sum_{i=1}^{m}\sum_{j=1}^{n} Mij]^{-1}$ (2)

S_1=(2.33,2.5,3)* (0.074,0.092,0.12)=(0.17,0.23,0.36)

S_2=(2.25,2.33,2.5)* (0.074,0.092,0.12)=(0.17,0.21,0.3)

S_3=(4,6,8)* (0.074,0.092,0.12)=(0.29,0.55,0.96)

Then we amplitude of [$V(S_i>S_k)$] of each above factors should be calculated on other factors. Therefore:

$V(S_1\geq S_2)=1$ $V(S_3\geq S_1)=1$ $V(S_3\geq S_2)=1$

$V(S_1\geq S_3)=\frac{u_1-L_3}{(u_1-L_3)+(m_3-m_1)}=0.16$ (3)

$V(S_2\geq S_1)=\frac{u_2-L_1}{(u_2-L_1)+(m_1-m_2)}=0.87$

$V(S_2\geq S_3)=\frac{u_2-L_3}{(u_2-L_3)+(m_3-m_2)}=0.03$

Also for calculating the amplitude of one S_i on other S_i :

$V(S_1\geq S_2,S_3)$=Min (1,0.16)=0.16 (4)

$V(S_2\geq S_1,S_3)$=Min (0.87,0.03)= 0.03

$V(S_3\geq S_1,S_2)$=Min (1,1)=1

These values show the abnormal weigh of x_1,x_2,x_3,x_4 indicators.

$W' = (0.16, 0.03, 1)^t$: (5)

Based on the (equation (6)) the quantity of normal weighs of x_1,x_2,x_3,x_4 will be calculated :

$$W_t = \frac{w_t}{\Sigma w'_t} \quad (6) \quad \Longrightarrow \quad W = (0.13, 0.025, 0.84)$$

All of the above steps are done for evaluation and feedback, systems and techniques, and employees and will enter to the following table. After using the weighs in the main line, the importance coefficient of each option will be calculated. Importance coefficient of capacity mature unified model, six sigma and represented model (CбAMI) have been shown in table 8.

Table 8: importance coefficients of capacity mature unified model, six sigma and new model

Criteria / Alternative	Organizing 0.36	Systems and techniques 0.36	evaluation and feedback 0.13	employees 0.16	represented model
CMMI	0.13	0.2	0.38	0.18	0.197
Six Sigma	0.025	0.2	0.19	0.43	0.175
represented model	0.84	0.61	0.43	0.56	0.666

IX. DEDUCTION

Considering the calculated information analysis, this is denoted that the capacity mature unified model with six sigma and swift production technique with importance coefficient=66.6% is priority for providing quality. As we can consider the represented model as a functional model and use it for unifying quality techniques. On the other hand, importance coefficients of each factor and following that the importance coefficients of sub factors were determined as whether this quantity is more, this means that factor or sub factor is in higher priority and should be concentrated more. So, organizing factor and evaluation and feedback factor with importance coefficient=36% have the most effect on quality factors. The most important factor in organizations perspective that is discussed in organizing factors, is senior management warranty. As without senior manager support, project will fail. On the other hand, most important option that is discussed in evaluation and feedback factor, is function factor. The reason is that in all steps, support, control and surveillance operation is performed and then the defects of product and process will determined can help solving defects and improving products. Also, in employees factor with importance coefficient=16%, employees training and facing the changes and informing employees are considered as organization and group work goals. Systems and techniques with importance coefficient=13%, has prioritized the concentration on customer's idea and use the feedback quantity that is transport from customer to organization for improving product. The production design is also based on swift production and canonical the process based on the schematization to decrease the errors in designing. As based on this research, some cases are suggested:

In all steps, we use the support and control step for analyzing victory reasons, failing reasons, analyzing solutions, assuring quality, and configuration management. Also, quality goals are determined and based on quality goals, the quantity goals will determine to reach the trade goals. In other words, organization's perspective and business goals must be signaled and its results must echo through organization.

REFERENCES

[1] B, Shahaie; require the agility in organization management, Iran, today textile magazine, N 138, 2013,p:50.

[2] Gh, KhoshSima; system of agile manufacturing,Iran, Quality Control magezine, N59,2013,p:22.

[3] B, Azhdari; M, Saremi; Effect capabilities of agility on the performance manufacturing in automotive parts manufacturer companies with Bayes networked approach, Humanities Teacher Quarterly, Iran, N61, 2008,pp:181-209.

[4] B, Shahaie;Humany Aspect of Aility Organization, Meditate Monthly, Iran, N 175, 2006,p37.

[5] M, Fathian; M, Golchinpoor; Strategies for agility in manufacturing organizations, Meditate Monthly, Iran, N175, 2006,p37.

[6] Chrissis, M; Kon.RF, M; & Shrum, S; Relationships Among Process Areas in CMMI for Develoment, Pearson Education, 2011, pp:82-85.

[7] Keller, K; & Mach, B; Maturity Profile Reports, CMMI Institute, 2013

[8] Larmi; CMMI Benefits, Version 2. External - Larmi Ltd, 2013.

[9] Neal, M; The Important of Implementing CMMI, SEI Certified Lead Appraiser, 2010.

[10] Ask Process; CMM and CMMI: Show Me the Value, Ask Process, 2005.

[11] Sarin, V; Creating CMMI Process Performance Baselines and Models Using Risk, Excellence in Software Engineering, 2012.

[12] CMMIInstitute, CMMI for Development ,version1.3, Software Engineering Institute, 2010.

[13] N,Esfandiari; P, Mohammadpoor; Evaluate and improve production processes using Six Sigma methodology, Journal of management development, Iran, Vol1, N2, 2009,pp:75-84.

[14] H, Akbari Dizgah; Six Sigma is a necessity, not a choice, Economic Affairs and Finance Gilan's Organization, Iran, 2007.

[15] M, Mahdiar; A, PoorShirazi; Six Sigma with re-engineering approach, Third International Conference of Management,Iran, 2005.

[16] S, Rezaeeian; Six Sigma analytical role with re-engineering approach in the process, Iran, Vol 3, N 11-12, 2006, pp:58-69.

[17] H, KHanifer; Z, Heidarnia; The relationship between total quality management and customer satisfaction, Journal of Organizational Culture Management, Iran, fourth year, N 14, 2006, p:87.

[18] M, AliHaji; What is Lean Six Sigma?, Energy making Battery Joint Stock Company (Saba Battery), First International Congress on Lean Six Sigma,2006.

[19] E, P; Taking an Agile Organization to Higher CMMI Maturity, MCMahon, PEM Systems , 2012.

[20] Hurtado, J. A; & Bastarrica, M. C; Implementing CMMI Using a Combination of Agile Methods, CLEI Electroniv Journal, Vol.9, No.1,2006.

[21] [21]. Siviy, J; Penn, M; & Harper, E; Relationships Between CMMI and Six Sigma, Software Engineering Measurement and Analysis,2005, 9-10.

[22] SH, Nazemi; M, Kazemi;& A, Okhravi; Prioritize the key success factors in TQM to reduce the gap performance using fuzzy AHP; Case Study: An Industrial, Tehran: Strategic Management Thought, 2011, Vol. 4, N.2,

[23] Z, Sarmad; A, Bazargan;A, Hejazi; Research methods in behavioral science, Tehran: Agah, 1385, edition of 12.

[24] A. Azar;& H. Faraji, "Fuzzy Management Science", Mehraban of publication, vol:4, 2007.

[25] M.J, Asgharpoor; Multi-criteria decision, Iran, Tehran, publication in Tehran University,2009, Vol8.

Gholamreza Esmaielian, he has P.H.D degree in industrial engineering. He works in Payame Noor University of Esfahan as Assistant

Maryam Hamedi, she has P.H.D degree in industrial engineering. She works in Payame Noor University of Esfahan as Assistant

Monireh Safaie, She is MSC student in industrial engineering for M.A Degree in Payame Noor University of Tehran-Rey. She researched about quality and it's models