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The Selection of the Most Ideal Choice of Six Sigma Project Using GREY TOPSIS and its Improvement by TRIZ (Case Study: Municipality of Tehran)

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ABSTRACT

Nowadays, due to the increasing problems of quality problems arising in organizations, in the present paper, it was attempted to test a number of the problems in the municipality of Tehran. For this purpose, a number of projects that need to be improved are defined that through one of the method of multiple decision-making (MCDM) called TOPSIS, the most ideal project is chosen. To carry out this project, a number of problems were seen that their information is both known and unknown. To the solve problem, gray possibility degree was used and the most important problem was selected. Using the methodology of Six Sigma, Pareto diagram and Mini Tab Software, the main reasons of the problem are specified and then the problem is solved. Finally, using creative and innovative techniques Solving TRIZ problems is improved.

KEYWORDS: TOPSIS, Grey System Theory, TRIZ, Six Sigma

1. INTRODUCTION

Nowadays, organizations, through optimizing solutions, appropriate use of financial resources, time and manpower can be won in the arena of competition. With the closeness of the competitive environment in the modern era, we should be familiar with the leading methodology and approaches in engineering sciences .Projects are costly and time-consuming, and to carry out them, time, resources and more detailed planning are required, If they are carried out without prioritizing and planning, they will be confronted with the shortfall of budget and time .Therefore, selecting the most ideal project in organizations is of extraordinary importance. With the new approach of, organization is a set of processes that aim to create value for the customer and the need to create value for customers is creating it in the organization itself [1].

If an organization wants to follow this approach, at the first stage its first program is entrance to the field of Sigma and then at the next stage is taking improving steps to reach the sigma level namely 3.4 errors per million opportunities of error occurrence [2]. Six Sigma is a process that consists of a set of statistical tools that collects data according to the set goals and then analyze and improve them [3-6]. Six Sigma methodology first was founded in 1985 in Motorola and conducted that improving quality increases the speed of operations and reduces costs. America National Quality Award (Baldrige) was awarded to Motorola in 1987 owing to its use of approach [7]. TRIZ knowledge was founded by Greenish Altoshler in 1946 He defines this science as the theory of inventive problem solving. This approach can be considered one of the main branches of TRIZ and creativity of science is very important [8]. It can be mentioned that a TRIZ is an inventive approach and an algorithm for solving technical issues [8-12]. Grey system theory was first introduced by Deng in 1982 as GRA [13]. If information of a system is totally clearly marked with white, if Information visualization is totally unknown marked with black. In this case, there is some information that is not black or white; we called them gray systems [13]. The main feature of grey system is, a complete lack of information about the system [1]. TOPSIS method was presented in 1981 by Huang Vino. In this way, the options are evaluated by criteria. The purpose of this method is, maximizing target option from the ideal distance negative and minimizing the distance between the option and the positive ideal value simultaneously [14].

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2. MATERIAL & METHODS

2-1 Data Analysis Using TOPSIS

To determine the most ideal project in the municipality of Tehran, two criteria and ten options (projects) are examined.

Available criteria include: 1. Investment costs 2. Administrative costs

Options include:

1. The necessity of delegating some tasks to private sector contractors
2. The development of investment in urban management
3. The management of urban waste
4. The asphalt of roads and streets
5. The assignment of machines to municipalities
6. Stable income
7. Weakness in accounting operations
8. The existence of economic studies and research in the field of urban development
9. Research and Quality standards
10. The council and Ministry of Interior's supervision on the municipality's financial affairs and belongings

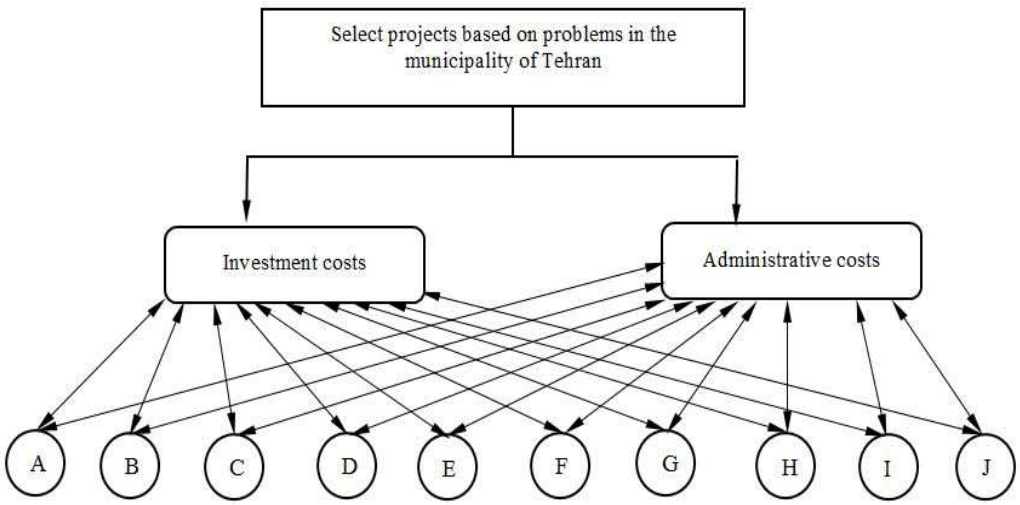

Fig. 1. Decision Network and Model

2.1.1. The relationship between options and indexes is obtained from soft descaling:

$$a_{ij}' = \frac{aij}{\sqrt{\sum_{i=1}^{n} aij^2}}$$

W= [0.4 , 0.6]

Table 1. Relation between options and criteria

	Investment cost X1	Administrative costs X2
A	10000	10000
B	50000	30000
C	70000	50000
D	15000	15000
E	25000	25000
F	20000	40000
G	40000	55000
H	55000	45000
I	35000	35000
J	20000	25000

	Investment cost X1	Administrative costs X2
A	.029	.030
B	.147	.090
C	.205	.151
D	.044	.045
E	.073	.075
F	.058	.121
G	.117	.166
H	.161	.136
I	.102	.106
J	.058	.075

2.1.2 Descaled matrix:

Y=N*W

Table 2. Descaled Table

	Investment cost X1	Administrative costs X2
A	.001	.018
B	.058	.054
C	.082	.090
D	.017	.027
E	.029	.045
F	.023	.072
G	.046	.099
H	.064	.081
I	.040	.063
J	.023	.045

2.1.3. Determine the ideal option:

$A^- = \{Ai \mid \max \; Yij \mid j \in J' , \min Yij \mid j \in J \}$

$A^+ = \{Ai \mid \max Yij \mid j \in J' , \min Yij \mid j \in J \}$

$A^- = \{0.001 , 0.018\}$

$A^+ = \{0.082 , 0.099\}$

2.1.4. Distance from the ideal positive or ideal negative:

$di^+ = \sqrt{(\sum(Yij-Yij+)^2}$

$di^- = \sqrt{(\sum(Yij-Yi^-)^2}$

$D_1^+=0$	$D_2^+=0.06$	$D_3^+=0.104$	$D_4^+=0.096$	$D_5^+=0.038$	$D_6^+=0.058$	$D_7^+=0.092$	$D_8^+=0.088$	$D_9^+=0.046$	$D_{10}^+=0.034$
$D_1^-=0.109$	$D_2^-=0.05$	$D_3^-=0.1126$	$D_4^-=0.096$	$D_5^-=0.075$	$D_6^-=0.032$	$D_7^-=0.034$	$D_8^-=0.025$	$D_9^-=0.053$	$D_{10}^-=0.079$

2.1.5. Determine the alternative option

$E_i = (di^-)/(d_i^+ + di^-)$

E1=1 E2=0.45 E3=0.54 E4=0.5 E5=0.66

E6=0.35 E7=0.26 E8=0.22 E9=0.53 E10=0.69

In this study, the selected option is option E1 (The necessity of delegating some tasks to private sector contractors). The selected projects will be improved.

2.2. Data Analysis using Grey System:

To perform this project, some problems arise that part of the data are known and some unknown. For this work, the analysis of grey system is used. These problems are identified in the form of four projects that are:

1. The time reduction of payments to contractors
2. Avoiding contractors visiting municipalities
3. Respecting Contractors
4. Reducing the duration of contracts

Criteria for carrying such projects include:

1. Financial savings = Q1
2. The increase of revenue = Q2
3. The use of maximum available resources = Q3
4. Integrated municipal development plans = Q4
5. Commitment Job = Q5
6. Avoiding wasting time = Q6

Using studies and surveys of ten experts and scholars, the criteria were determined for selecting the most appropriate project. Extracted criteria are qualitative, and people's uncertainties and judgments people in determining the level

of importance of each criterion has caused that one of the methods of decision making be applied under uncertainty P.
To determine the importance of the criteria, ten decision-makers' view and the expressive words of too much, almost high, medium, relatively low, low, very low are used with the use of Likert scale.

Table 3. Scale to determine the weight of criteria

very low	low	relatively low	Medium	almost high	high	Very high	Scale
VL	L	ML	M	MH	H	VH	
[0.0 , 0.1]	[0.1 , 0.3]	[0.3 , 0.4]	[0.4 , 0.6]	[0.6 , 0.7]	[0.7 , 0.9]	[0.9 , 1.0]	⊗W

2.2.1. Measurement Criteria

Criteria $\otimes W = \{\otimes W_1 , \otimes W_2 , . . . , \otimes W_n\}$
Determination of the criteria $\otimes Wj = \{\otimes W^1_j , \otimes W^2_j , . . . , \otimes W^k_j\}$
K is the number of experts and decision-makers
$\otimes W^k_j = (j = 1, 2, 3, \ldots, n)$
$\otimes W^k_j = [\underline{W}^k_j , \overline{W}^k_j]$
If k = 10 is the number of decision makers, the formula can be placed
The result will be as follows.

Table 4. Weight of criteria

Q_j	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Q1 Financial savings	VH	H	H	MH	M	M	M	H	H	MH
Q2 Revenue increase	M	H	MH	VH	M	M	H	H	MH	M
Q3 Maximum use of available resources	H	H	MH	M	VH	H	VH	MH	M	M
Q4 Comprehensive urban development plan	L	ML	M	MH	H	MH	M	VL	H	VL
Q5 Job commitment	VL	ML	L	VL	MH	M	M	H	M	VL
Q6 Avoiding wasting time	VH	H	VH	MH	H	M	H	VH	H	VH

Table 5. The weight of criteria for the decision-makers

Qi	⊗WQi
⊗W1	[0..64 , 0.81]
⊗W2	[0..58 , 0.75]
⊗W3	[0..63 , 0.79]
⊗W4	[0..38 , 0.53]
⊗W5	[0..29 , 0.44]
⊗W6	[0..74 , 0.89]

2.2.2. Identifying and ranking options

In this section, evaluating and ranking the options are dealt with. To evaluate the options, regarding any of the grey-scale values of the numbers 1 to 10 is used. Options in the research are projects.

Table 6. Scale for the assessment of options

Very weak	Weak	Nearly weak	Average	Nearly good	Good	Very good	Scale
VP	P	MP	M	MG	G	VG	
[0 , 1]	[1 , 2]	[3 , 4]	[4 , 6]	[6 , 7]	[7 , 9]	[9 , 10]	⊗G

To carry out the project of assigning municipal affairs to the private sector and foreign contractors, four important projects are defined that carrying out each of these projects has great influence on the conduct of municipal privatization projects. These projects will be presented in the form of options. To evaluate these options, Likert scale was used as words of expression that experts of municipality and the Ministry of Interior evaluated it. Grey numbers are used to evaluate this relationship:

$$\otimes G_{ij} = \frac{1}{k}\,[\otimes G_{ij}^{1} + \otimes G_{ij}^{2} + \ldots + \otimes G_{ij}^{k}]$$

$$\otimes G_{ij}^{k} = [a_{ij}^{k}\,,\, b_{ij}^{k}]$$

(Total options project) p = {P1 , P2 , P3 , P4}

In this case, the grey matrix of evaluating options (projects) is established as follows:

$$D = \begin{bmatrix} \otimes G11 & \otimes G12 & \cdots & \otimes Gin \\ \vdots & \vdots & & \vdots \\ \otimes Gm1 & \otimes Gm2 & \cdots & \otimes Gmn \end{bmatrix}$$

2.2.3. Evaluation of Municipality's Projects in Relation to Criteria:

Table 7. Evaluation of the project of payment of the contractor in relation to the criteria

Q	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Q1 financial savings	P	MP	F	F	MG	MG	G	P	MP	F
Q2 revenue increase	VP	P	MP	MP	P	P	P	MP	F	F
Q3 maximum use of available resources	MG	G	F	MP	F	MG	G	MP	F	F
Q4 comprehensive city development plan	VP	P	MP	MP	P	VP	P	F	VP	MP
Q5 job commitment	MG	F	MP	P	MP	F	MG	G	P	VP
Q6 avoid wasting time	VG	G	MG	VG	G	MG	M	G	VG	G

Table 8. Evaluation criteria to avoid visiting contractors

Q_j	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Q1 financial savings	MG	G	F	MP	MP	F	G	MG	G	MG
Q2 revenue increase	VP	P	MP	MP	P	F	VP	P	MP	P
Q3 maximum use of available resources	MG	G	MP	P	F	MP	G	MG	F	F
Q4 comprehensive city development plan	VP	VP	P	VP	MP	P	P	VP	MP	F
Q5 job commitment	VP	P	MP	MP	P	VP	F	P	F	VP
Q6 avoid wasting time	P	MG	G	F	P	F	MP	P	MG	G

Table 9. Evaluation of the project of respecting foreign contractors in relation to the criteria

Q_j	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Q1 financial savings	MG	G	F	VP	P	MP	P	F	F	P
Q2 revenue increase	VP	MG	P	F	MP	P	MG	G	F	F
Q3 maximum use of available resources	MG	G	F	F	MP	P	MP	F	F	P
Q4 comprehensive city development plan	VP	P	MP	F	MG	G	MG	F	MP	P
Q5 job commitment	MP	P	F	MG	G	F	P	VP	MP	G
Q6 avoid wasting time	VP	P	MP	MP	F	MG	G	MP	F	P

Table 10. Project's evaluation criteria to reduce the duration of contracts

Q_i	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Q1 Financial savings	VG	G	MG	F	G	VG	G	VG	MP	P
Q2 Revenue increase	VG	G	MG	G	G	MG	G	F	G	MG
Q3 Maximum use of available resources	VG	G	MG	G	G	VG	G	F	F	G
Q4 Ccomprehensive city development plan	F	F	MP	G	VG	G	MG	VG	G	MG
Q5 job commitment	VG	G	MG	MG	G	VG	MP	F	F	G
Q6 Avoiding wasting time	VG	MP	P	F	MG	G	VG	F	VG	G

2.2.4. Grey Decision matrix:

Table 11. Grey Decision matrix

Qi	P_1	P_2	P_3	P_4
Q1	[5.5 , 3.9]	[6.8 , 5.3]	[4.8 , 3.1]	[7.7 , 6.3]
Q2	[3.7 , 2.1]	[5.0 , 3.5]	[4.9 , 3.3]	[8.2 , 6.6]
Q3	[6.4 , 4.8]	[6.1 , 4.5]	[5.8 , 4.0]	[8.4 , 6.7]
Q4	[3.0 , 1.6]	[6.3 , 4.9]	[4.8 , 3.8]	[7.9 , 6.2]
Q5	[5.0 , 3.5]	[5.9 , 4.4]	[5.2 , 3.4]	[7.7 , 5.9]
Q6	[8.7 , 7.3]	[5.7 , 4.0]	[4.7 , 3.2]	[7.4 , 5.9]

2.2.5. Normalized grey matrix:

Since, all parameters are positive, the normalized decision matrix can be formed, Where $\otimes G^*_{ij}$ is calculated by the following:

$D^* = [\ \otimes G^*_{ij}\ ]$ **6x**

$\otimes G^*_{ij} = \left[\frac{\underline{G}^k_{ij}}{G_i^{max}} \quad \frac{\overline{G}^k_{ij}}{G_i^{max}} \right]$ $G_i^{max} = \text{Max}_{1 \le j \le 4} \{ \underline{G}_{ij} \}$

Table 12. Grey normalized matrix.

	P_1	P_2	P_3	P_4
Q_1	[0.506,0.714]	[0.688,0.883]	[0.402,0.623]	[0.818,1.000]
Q_2	[0.256,0.451]	[0.426,0.609]	[0.402,0.597]	[0.804, 1.000]
Q_3	[0.571,0.761]	[0.535,0.726]	[0.476,0.690]	[0.797, 1.000]
Q_4	[0.202,0.379]	[0.620,0.797]	[0.481,0.607]	[0.784, 1.000]
Q_5	[0.454,0.649]	[0.571,0.766]	[0.441,0.672]	[0.766, 1.000]
Q_6	[0.839, 1.000]	[0.459,0.655]	[0.367,0.540]	[0.678,0.850]

2.2.6. Grey normalized weighted matrix:

$\otimes V_{ij} = \otimes W_{Qi} \times G_{ij}^*$

$\otimes G_{ij}^* = [\underline{G}_{ij}, \overline{G}_{ij}]$

$\otimes W_{Qi} = [\ \underline{W}_{Qi}, \overline{W}_{Qi}\ ]$

i= 1,2,…,6

j= 1,2,3,4

$\otimes V_{ij} = \otimes W_{Qi} \times G_{ij}^* =$

$=\{\min[(\underline{W}_{Qi} \times \underline{G}_{ij}), (\underline{W}_{Qi} \times \overline{G}_{ij}), (\overline{W}_{Qi} \times \overline{G}_{ij}), (\overline{W}_{Qi} \times \underline{G}_{ij})], \text{Max}[(\underline{W}_{Qi} \times \underline{G}_{ij}), (\underline{W}_{Qi} \times \overline{G}_{ij}), (\overline{W}_{Qi} \times \overline{G}_{ij}), (\overline{W}_{Qi} \times \underline{G}_{ij})]\}$

Table 13. Grey normalized and weighted matrix

	P_1	P_2	P_3	P_4
V_1	[0.323,0.578]	[0.440,0.715]	[0.257,0.504]	[0.523,0.810]
V_2	[0.148,0.338]	[0.247,0.456]	[0.233,0.447]	[0.466, 0.750]
V_3	[0. 359,0.601]	[0.338,0.573]	[0.299,0.547]	[0.502, 0.790]
V_4	[0.107,0.200]	[0.302,0.422]	[0.182,0.320]	[0.297, 0.530]
V_5	[0.131,0.285]	[0.165,0.337]	[0.127,0.295]	[0.222, 0.440]

2.2.7. The Determination of the Alternative Option:

$\otimes Smax = \{\otimes V1max , \otimes V2max , \dots . \otimes Vimax \}$

$Vimax = [\max \underline{V}ij , \max \overline{V}ij]$

2.2.8. Calculate the grey degree possible and likely the ideal choice for each option:

$P \{ P_j < P^{max} \} = \frac{1}{6} \Sigma P (\otimes V_{ij} < V_i^{max})$

$P (\otimes Vij < \otimes V_j^{max}) = \frac{Max(0, l^* - \max(0, \overline{V}_{ij} - \underline{V}_i^{max}))}{l^*}$

$L^* = L (\otimes V_{ij}) + L \otimes V$

Table 14. Calculation of possible grey for the project:

P_1	P_2	P_3	P_4
1	0.658	1	0.5
1	1	1	0.5
0.813	0.864	0.920	0.5
1	0.655	0.950	0.505
0.83	0.7	0.706	0.5
0.5	1	1	0.741

2.2.9. Ranking Projects:

Ratings would be in the case that every option being less than the ideal option or it's the possibility of its smallness is less than the ideal option, is placed at a higher level: $P_4 > P_2 > P_1 > P_3$

2.3. Six Sigma:

The Six Sigma methodology is the best and most powerful tool to solve the problem

To solve the problem of reducing the duration of the project, contracts are entered into Six Sigma.

Six Sigma has 5 phases and steps including: Definition, measure, analysis, improvement and control

2.3.1. Definition Phase:

Defining the problem is the first step. The steps are as follows:

1. Determining the project' title form and filling out the verification form of project's title by project experts
2. Selecting project's title
3. Filling out project charter form
4. Calculating the profit from the project and financial approval
5. Preparing flow charts and map of process
6. Preparing SIPOC
7. Preparing CTQ TREE and listening to the customer
8. Preparing the schedule CTQ

2.3.2. Measurement Phase:

In this phase, the following actions are performed:

2.3.2.1. Collecting basic data: The data have been collected in the statistics of the tenders of 2012, 2013 and 2014

2.3.2.2. Preparation of Sampling Strategy: Since sample are individual, histogram is used. For this purpose, the data must be less than 30. Quantitative parameters are continuous

Table 15. A sample of data collected

↓	C2-T	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
	name gharardad	dastor shahrdar t1	dastor maven t2	darkhaste agahi t4	chap agahi t5	bargozari monagh t6	takmile madarek p t7	emzae gh t8	dabirkhane t9	sal payan	T 91+92
1	tamir negahdari traffic	45	1	15	7	16	74	8	1	91	164
2	khrid makhazen	21	0	2	7	20	68	5	0	91	132
3	kharid tajhizat	20	5	16	7	9	41	15	0	91	117
4	tahye mavane o narde	24	1	16	7	19	11	2	0	91	84
5	tahye pol havaee	23	1	19	7	19	11	3	0	91	84
6	rangamizi moblman	11	0	16	12	26	28	62	1	91	131
7	hafr chah jazbi	1	1	0	6	26	56	10	0	91	101
8	shostesho o paksazi nama	11	1	16	12	26	53	13	0	91	134
9	kharid tablo	22	1	2	25	20	83	11	0	91	164
10	tahye masale o khatkeshi	22	1	0	14	19	6	57	0	91	132
11	takhrib o ehdas	4	0	0	13	24	7	23	0	91	72
12	negahdari fazaye sabz	4	0	5	7	6	0	29	0	91	52
13	kharid dariche	4	1	1	7	18	62	27	2	91	123
14	layrobi	1	0	0	7	18	62	27	2	91	118
15	tamin derakht o derakhtche	1	1	0	13	23	83	2	0	91	126
16	mobareze ba mosh	17	0	0	0	14	80	3	0	91	112
17	negahdari fazaye sabz	2	0	0	19	10	48	13	0	92	90
18	kharid gol o giah	11	0	35	14	61	28	7	0	92	155
19	rang amizi mobleman	11	3	39	10	20	28	45	0	92	163
20	shostesho o paksazi nama	1	0	50	11	10	38	34	0	92	160
21	moshaver nezarat kargahi rah o band	8	0	0	15	16	11	51	0	92	127
22	tahye o nasb darbast	5	1	0	21	9	100	8	0	92	144
23	khatkeshi alaem ofoghi	4	0	0	9	11	27	4	1	92	77
24	negahdari fazaye sabz	0	1	0	6	14	22	15	3	92	84

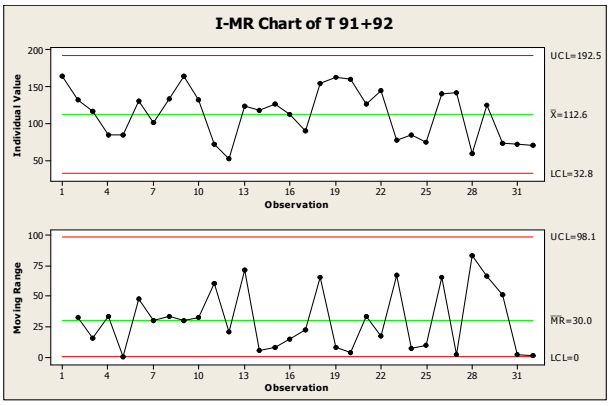

Fig2.GraphI-MR

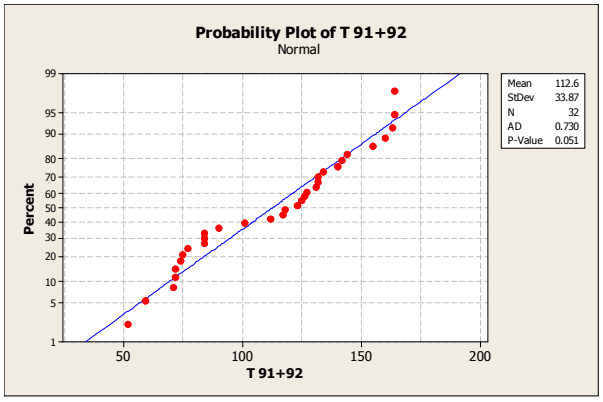

Fig3. Graphof normal

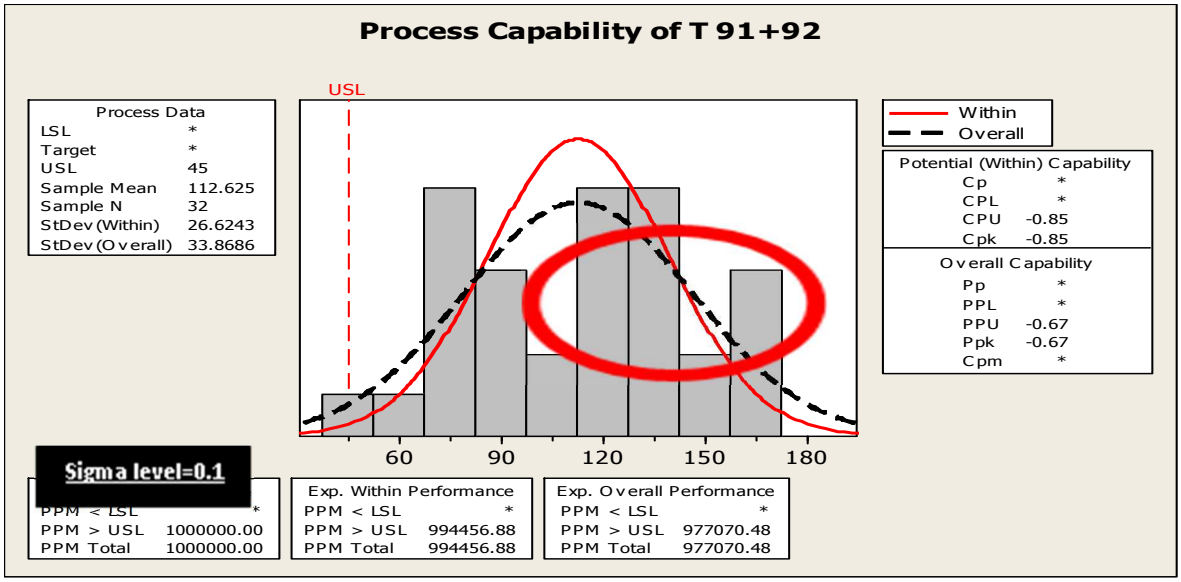

Fig 4. Capability Graph

2.3.3. Analysis Phase:

Actions in this phase are as follows

1. For each t, brainstorming is conducted.
2. Change any t, the change total target T

In this phase, the data are compared with each other in a good way.

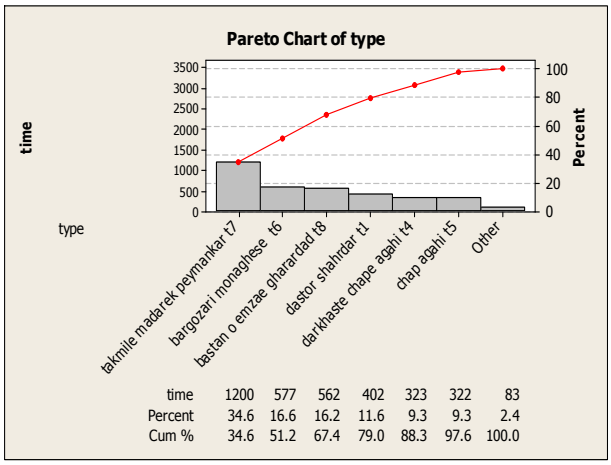

Fig 5. Pareto chart Graph

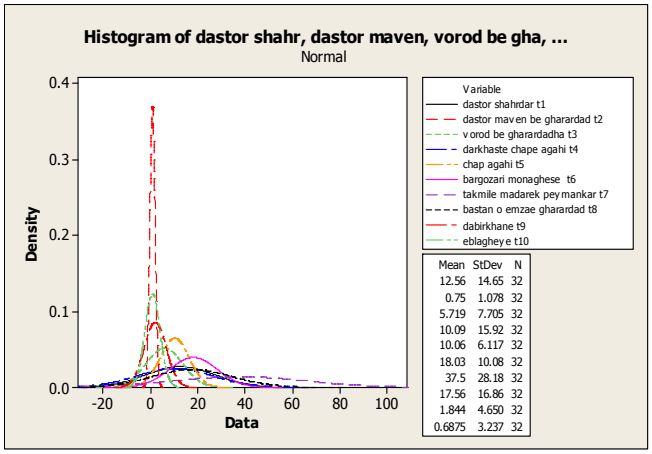

Fig 6. Histograms

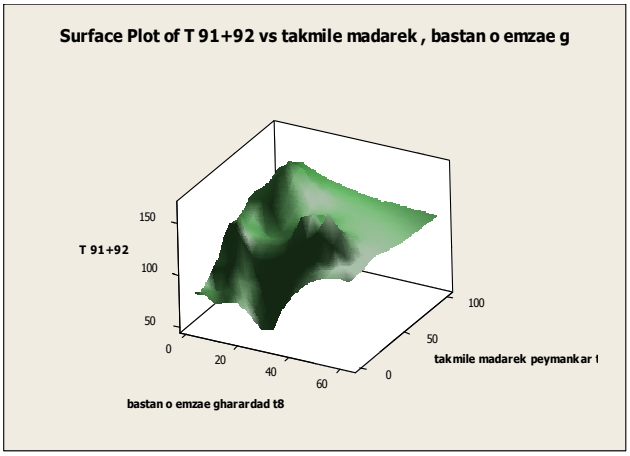

Fig 7. Surface plot Graph

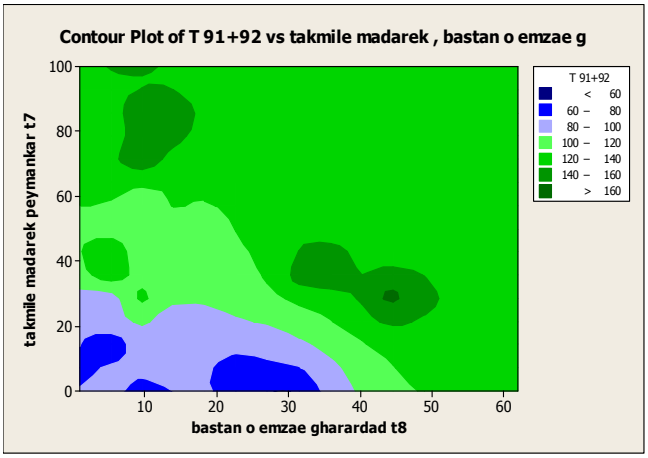

Fig 8. counter plot Graph

In all comparisons, it can be observed that the factor of the longer duration of the contract is t7. Flowchart t7 is drawn and it is observed that mentioning guarantee and constitution by the contractors allocates the maximum time to itself.

2.3.4. Improvement Phase:

Data are entered into the recovery phase. Thus, to solve this problem TRIZ contradiction matrix is used. The intersection of rows and columns of data loss and wasted time are 4, 24, 26 and 28 respectively. The following results are obtained:

Principle 4 asymmetry: We must prepare before. Czech lists can be used for this purpose. Documents already completed by the contractor.

Principle 24 mediator: A mediator is used to perform the work. For example, one collects information first. The first the contractor's contract enforcement domains receive full evidence and documentation completed delivery to contracts for the signing.

Principle 26 copying: To improve the use of copies of the original contractors. Instead of the original documents, such as articles of incorporation or warranty a copy of it can be given.
Principle 28 replacement of mechanical system: This principle can be used to improve phase the lot. For example, the Internet, fax, etc. can be used instead of calling the contractor. Another way is the change of whole system. The deadline for providing the guarantee period after the contract is renewed.

2.3.5. Control Phase:

Results obtained in the project are of data of 2014, which are as follows:

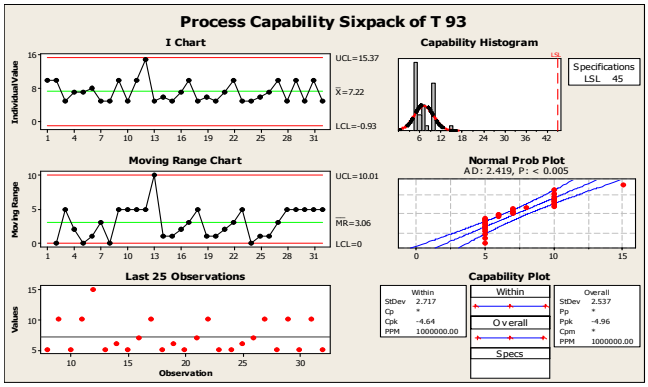

Fig 9. Six pack Graph

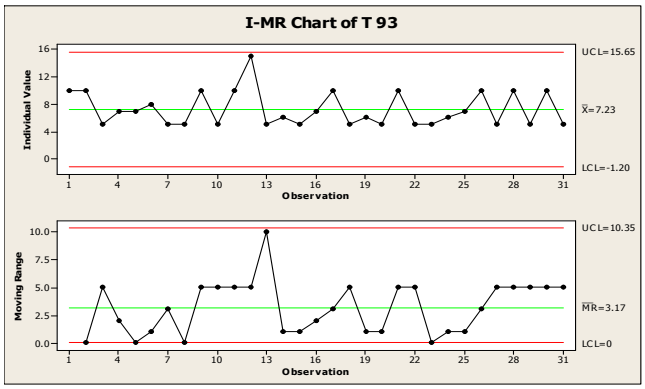

Fig 10. I-MR chart

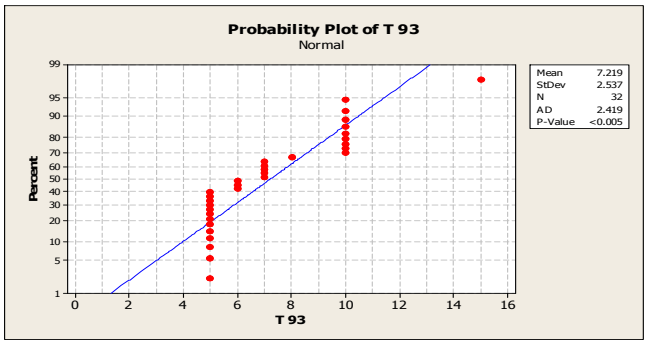

Fig 11. Diagram of normal

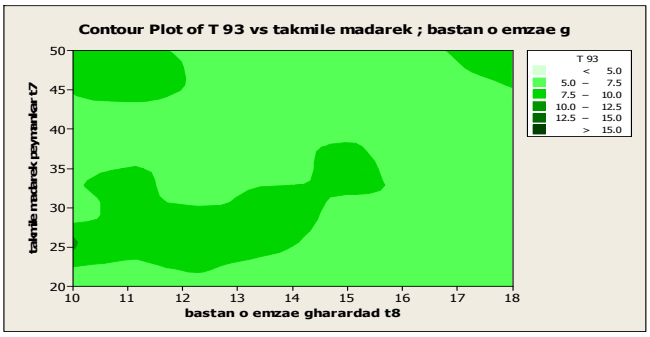

Fig 12. Counter plot Graph

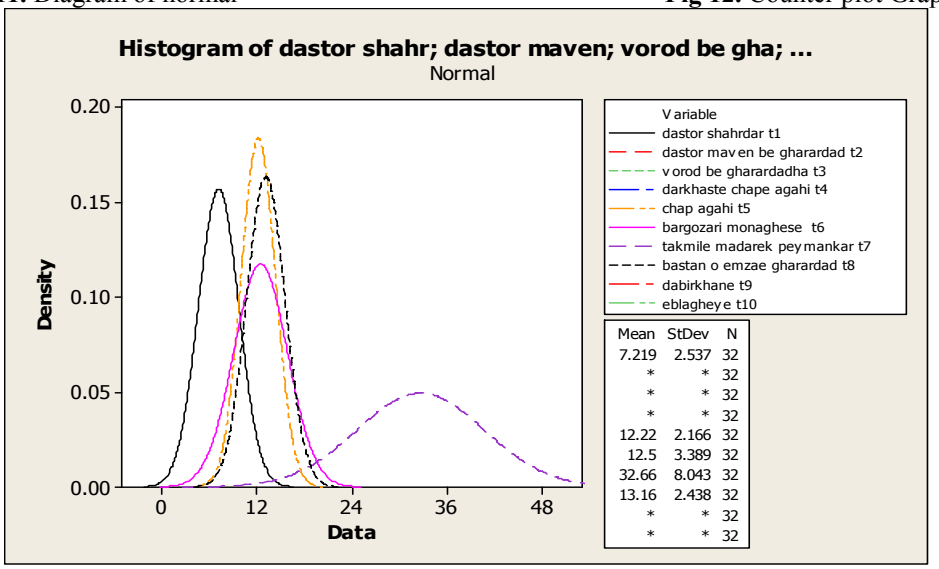

Fig (13): Histograms Chart

Sigma value derived from the PPM. It can be seen that for 93 years data risen one sigma level. That amount is less than 1.0 sigma level risen the level of one. This improvement is impressive

8. The results of the implementation the Model in Tehran Municipality:

After the implementation of model Six Sigma project results are very important and valuable work assignment was made to contractors, including:

1. Reducing the time of contract
2. conducting works systematically and electronic
3. The decrease of reinventing in the contracts
4. Increasing fiscal revenues at the end of the project

9. Suggestion for Future Researches

The issues that seem analyzable for the future researches are as follows:

1. Prioritizing Six Sigma projects using TRIZ and combining them with value engineering
2. In the future researches, the factor of the time reduction of contractors' payments can be taken into account in addition to the factor of the time reduction of contract period.
3. Improving constructing projects of the Municipality of Tehran using the combination of TRIZ and Six Sigma
4. In this research, the problem arisen from contractors' visit is ignored that it can be regarded in the future researches.
5. In the future researches, the problem of the air pollution of Tehran can be solved through Six Sigma techniques and improved by TRIZ.

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