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Analyzing the Driving Affecting Factors on Investment Efficiency on IT Projects

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ABSTRACT

The purpose of writing this paper is to identify, analyze and categorize the driving affecting factors on IT investment efficiency. For the purpose, 2 separated questionnaires by the same main questions were designed. The driving affecting factors include "overall questionnaire", "intangible variables", "financial requirements", "nonfinancial requirements", "strategic requirements", "tactical requirements" and "operational requirements".
The results of applying Chi-Square test show that there are positive and meaningful correlations between the variables above and investment efficiency on IT. Also Binomial test was used to survey the variables levels in which all of them were placed in favorable levels.
Finally the results of utilizing fuzzy TOPSIS technique show that "work time", "job enrichment" and "competitive advantages" were selected as the most important sub criteria.
KEYWORDS: information technology, investment, efficiency, multi criteria decision making, fuzzy TOPSIS technique.

1. INTRODUCTION AND PROBLEM STATEMENT

Increasing competition and complexity of organizations' environment and problems make them more eager to apply more effective and efficient methods in their plans. Most of the organizations use information technology (IT) to adapt with the complex environment. Among 1980- 1992 annual investment on IT enhanced from 60 milliards $ to 160 milliards $. Instead, investment on other resources like labor increased less then 10 percent. Nowadays the organizations consider most of their capital budget for IT investment.

The rate of organizations' investment growth on computer, relational equipment and software was very high among the years 1990-2000. From 1995 to 2000 real investment growth on IT was 24 percent averagely which leads to increase GDP growth to 3-4 percent. At 2001 investment on IT decreased immediately to 11 percent. Improving the growth was at 2002 and it enhanced to 21 percent at 2003 (Doms, 2004).

Definitely one of the most important indices for measuring the organizations' effort to industrializing and growth is their investment on information technology and related technologies. The investor organizations on information technology need to identify the driving affecting factors on it and utilize the most important ones.
So the main questions of the research are:

- Which factors are affected on organizational investment on information technology?
- Which index is the most important one?

2. LITERATURE REVIEW

2.1. Investment efficiency on information technology

The influence of investment on information technology on organizations' business performance has been studied in resent 20 years, but the results of studies were not useful (Rostami, 2008).

Some of recent studies did not illustrate the impact of information technology on increasing organizations' productivity which leads to "productivity paradox" appearance. Roach (1991) found that computers have had little impact on human resource productivity. Indeed some of studies show that there is negative relationship between investment on information technology and productivity (Franke, 1987). Meanwhile some of other researches described the positive correlation between them (Brynjolffson and Hitt, 1996).

The researchers in recent studies tried to develop the findings of productivity paradox theory.

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Brynjolffson and Hitt (1996) moderate traditional indices for information technology productivity and suggested that productivity should be determined by applying organizational IT value. They preferred that IT value is separated into tangible and intangible assets which are created by IT. They also discuss investment on information technology may leads to intangible assets which affect on organizational productivity positively.

Grover et al (1988) emphasize on the role of organizations on IT investment by identifying the driving affecting factors on organizations' investment priorities (Grover et al, 1988).

Guimaraes (1997) found that the costs which emphasizes on final consumer, can decrease organizational efficiency and effectiveness (Guimaraes, 1997).

Also Mitra and Chaya (1996) surveyed the impact of information technology on organizations' costs structure. These researches illustrate that investment on information technology decrease production average costs and overall average costs and finally increase organizations' overhead costs (Mitra and Chaya, 1996).

2.2. The models for effective investment on information technology

These techniques are applied for the situations that some input and output indices be exist for one or more organizations. One of the problems ahead of organizations to invest on information technology is their disability on measuring output (Rostami, 2008).

To measure the impact of investment on IT on organizational productivity different models were utilized. One of these models is Regression. Canonical Correlation Analysis (CCA) and Data Envelopment Analysis (DEA) are the other ones (Charnes et al, 1978).

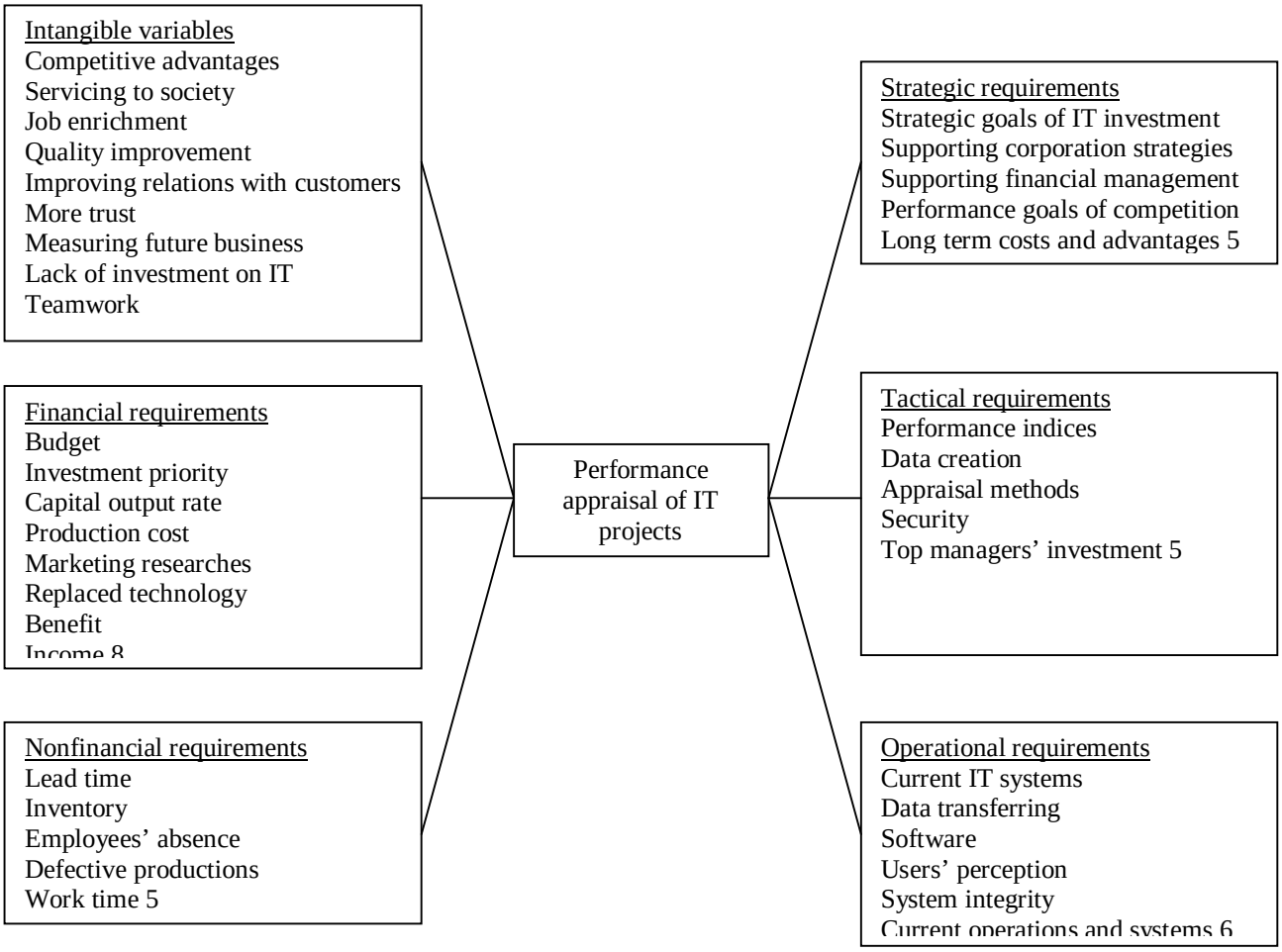
Another technique which uses in the current study is Fuzzy logic. In this research we utilize fuzzy TOPSIS technique to prioritize the sub criteria of performance appraisal of IT projects.

2.3. Conceptual framework of research and hypotheses

Current techniques and methods of performance appraisal have some imperfections (like ignoring organizations' strategies and neglecting intangible performance indices). The model below presented to compensate the mentioned faults.

In the model intangible variables, financial and nonfinancial requirements, strategic requirements, tactical requirements and operational requirements are considered as independent variables and performance appraisal of IT projects is spotted as dependent variable.

It is important to mention these 6 main criteria have 39 sub criteria.



Conceptual framework of research (Rostami, 2008)

1- Intangible variables are affected on Performance appraisal of IT projects.
2- Financial requirement are affected on Performance appraisal of IT projects.
3- Nonfinancial requirement are affected on Performance appraisal of IT projects.
4- Strategic requirement are affected on Performance appraisal of IT projects.
5- Tactical requirement are affected on Performance appraisal of IT projects.
6- Operational requirement are affected on Performance appraisal of IT projects.

3. RESEARCH METHODOLOGY

The current study was done in a society includes 22 top managers of organizations and employees who work at financial and accounting department of Security and Exchange Organization. As this number seems to be too low, so no sampling strategy was applied. We applied 2 questionnaires to gather data from participants. One of them by likert 5 point scale and the other one 7 point scale in base of Chen (2000) research.

Both questionnaires have 38 questions, but in the first one 4 questions about demographic characteristics and an open question were prepared.

Distributions of each variable were presented in table 1:

Table 1: Distribution of variables questions

Number of questions	Variables
9	Intangible variables
8	Financial requirements
5	Nonfinancial requirements
5	Strategic requirements
5	Tactical requirements
6	Operational requirements

To analyze the data SPSS 17 (Chi-square and Binomial tests) and fuzzy TOPSIS technique were utilized. The management experts were being asked to evaluate the questionnaires validity. For this purpose, the questionnaires were given to some professors and experts in management, and after their modifications were being utilized and they confirmed it, the questionnaires were given to the participants. For determining the questionnaires' reliability, the 'Cronbach Alfa technique' was utilized. For this purpose, 30 people were selected by random and the first questionnaire was given to them. The 'Cronbach Alpha' values for the questionnaire were calculated in table 2:

Table 2: Reliability results

Cronbach's Alpha	Variables
0.88	Overall questionnaire
0.81	Intangible variables
0.78	Financial requirements
0.94	Nonfinancial requirements
0.89	Strategic requirements
0.92	Tactical requirements
0.91	Operational requirements

As Cronbach's alpha for all variables were calculated more than 0.7, so the reliability of questionnaire was proved.

Fuzzy situation is a kind of decision making space in which gathered data is almost ambiguous. Ambiguous data does not have specified restriction and is defined as fuzzy data. So decision making in terms of the mentioned data is recognized as decision making in fuzzy condition. Fuzzy TOPSIS is a new technique in which decision making process will lead to more accurate results in indeterminate situation. As the results of applying Fuzzy TOPSIS technique are more accurate than traditional ones (Mirzaei, 2010), so in the current paper Fuzzy TOPSIS technique was used to prioritize investment efficiency indices.

3.1. Fuzzy TOPSIS technique

Decision making process steps by fuzzy TOPSIS technique are shown below (Hwang and Yoon, 1981):

Step 1: calculating weights vector w~j

$$\tilde{R} = \left[\tilde{r}_{ij} \right]_{m \times n} \quad (1)$$

Normalizing the calculated matrix

$B \subseteq \{1,...,n\}$ is related to benefit-based indices and $C \subseteq \{1,...,n\}$ is related to cost-based indices.

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{d_j^*}, \frac{b_{ij}}{d_j^*}, \frac{c_{ij}}{d_j^*}, \frac{d_{ij}}{d_j^*} \right), \quad j \in B \qquad (2) \qquad (3) \qquad \tilde{r}_{ij} = \left(\frac{a_j^-}{d_{ij}}, \frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}} \right), \quad j \in C$$

Step 2: so normalized weighted matrix is calculated as formula 4:

$$\tilde{V} = \left[\tilde{v}_{ij} \right]_{m \times n}, \quad i = 1,2,...,m, \; j = 1,2,...,n \qquad \tilde{v}_{ij} = \tilde{r}_{ij} \otimes \tilde{w}_j \qquad (4)$$

Step 3: determining the fuzzy positive ideal solution $\tilde{v}_j^*$ (FPIS) and fuzzy negative ideal solution $\tilde{v}_j^-$ (FNIS) (formulas 5, 6):

$$\tilde{v}_j^- = \begin{cases} \min\limits_{i=1,...,m} \tilde{v}_{ij} ; \; j \in B \\ \max\limits_{i=1,...,m} \tilde{v}_{ij} ; \; j \in C \end{cases} \qquad (5) \qquad \tilde{v}_j^* = \begin{cases} \max\limits_{i=1,...,m} \tilde{v}_{ij} ; \; j \in B \\ \min\limits_{i=1,...,m} \tilde{v}_{ij} ; \; j \in C \end{cases} \qquad (6)$$

$$FNIS = \{\tilde{v}_j^- \mid j = 1,...,n\} \qquad FPIS = \{\tilde{v}_j^* \mid j = 1,...,n\}$$

Step 4: calculating the alternatives from positive and negative ideal by applying formulas 7, 8 and 9:

$$D(\tilde{a},\tilde{b}) = \sqrt{\frac{1}{4}\left[(a_1 - b_1)^2 + (a_2 - b_2)^2 + (a_3 - b_3)^2 + (a_4 - b_4)^2 \right]} \qquad (7)$$

$$d_i^* = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^*), \; i = 1,...,m \qquad (8)$$

$$d_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^-), \; i = 1,...,m \qquad (9)$$

Step 5: Calculating the relative closeness to the ideal solution:

$$Cc_i = \frac{d_i^-}{d_i^- + d_i^+} \qquad (10)$$

4. DATA ANALYSIS AND DISCUSSION

4.1. Chi Square test

To identify the driving affecting factors on investment efficiency on information technology, Chi Square test was applied. The results are shown in table 3:

Table 3: Results of using Chi-square test

Independent Variable	P-Value	Sig	Results
Intangible variables	5.76	0.000	Accepted
Financial requirements	8.43	0.000	Accepted
Nonfinancial requirements	6.74	0.000	Accepted
Strategic requirements	9.27	0.000	Accepted
Tactical requirements	7.62	0.000	Accepted
Operational requirements	8.54	0.000	Accepted

Table 3 shows that there are positive and meaningful relationship between independent variables and investment efficiency on information technology.

4.2. Binomial test

To understand the variables levels, Binomial test was used. The results are presented in table 4:

Table 4: Results of using Binomial test

Variables	Observed prop	Test prop	Sig	Results
Intangible variables	0.7	0.5	0.000	High level
Financial requirements	0.9		0.000	High level
Nonfinancial requirements	0.7		0.000	High level
Strategic requirements	0.6		0.000	High level
Tactical requirements	0.6		0.000	High level
Operational requirements	0.7		0.000	High level

4.3. Ranking indices by Fuzzy TOPSIS technique

Because of imperfect and inaccessible data in real world, they are not certain. So the researchers should change them into fuzzy one. In this paper, we are trying to prioritize the driving affecting factors on information technology investment by fuzzy TOPSIS technique (Chen, 2000).
Linguistic variables for the important weight of each criterion are shown in table 5:

Table 5: Linguistic variables for the importance weight (Chen, 2000)

Very Low	VL	(0, 0, 1, 2)
Low	L	(1, 2, 2, 3)
Medium Low	ML	(2, 3, 4, 5)
Medium	M	(4, 5, 5, 6)
Medium High	MH	(5, 6, 7, 8)
High	H	(7, 8, 8, 9)
Very High	VH	(8, 9, 10, 10)

To prioritize indices of investment efficiency on IT fuzzy TOPSIS technique was utilized. Decision making matrix and fuzzy weights are presented in table 6:

Table 6: Decision making matrix and fuzzy weights

	8	**9**	**10**	**10**	**4**	**5**	**5**	**6**	**7**	**8**	**8**	**9**	**4**	**5**	**5**	**6**	**7**	**8**	**8**	**9**	**8**	**9**	**10**	**10**
	Intangible variables				Financial requirements				Nonfinancial requirements				Strategic requirements				Tactical requirements				**Operational requirements**			
P1	8	9	10	10	7	8	8	9	5	6	7	8	7	8	8	9	7	8	8	9	7	8	8	9
P2	2	3	4	5	7	8	8	9	0	0	1	2	8	9	10	10	7	8	8	9	5	6	7	8
P3	5	6	7	8	8	9	10	10	4	5	5	6	2	3	4	5	7	8	8	9	0	0	1	2
P4	2	3	4	5	2	3	4	5	7	8	8	9	5	6	7	8	8	9	10	10	4	5	5	6
P5	0	0	1	2	1	2	2	3	4	5	5	6	2	3	4	5	2	3	4	5	7	8	8	9
P6	7	8	8	9	7	8	8	9	7	8	8	9	0	0	1	2	2	3	4	5	7	8	8	9
P7	7	8	8	9	7	8	8	9	7	8	8	9	2	3	4	5	7	8	8	9	0	0	1	2
P8	8	9	10	10	7	8	8	9	5	6	7	8	7	8	8	9	7	8	8	9	7	8	8	9
P9	5	6	7	8	7	8	8	9	0	0	1	2	2	3	4	5	2	3	4	5	8	9	10	10
P10	0	0	1	2	8	9	10	10	2	3	4	5	0	0	1	2	0	0	1	2	2	3	4	5
P11	5	6	7	8	2	3	4	5	7	8	8	9	2	3	4	5	4	5	5	6	5	6	7	8
P12	2	3	4	5	7	8	8	9	8	9	10	10	8	9	10	10	2	3	4	5	4	5	5	6
P13	8	9	10	10	7	8	8	9	7	8	8	9	8	9	10	10	7	8	8	9	1	2	2	3
P14	2	3	4	5	2	3	4	5	7	8	8	9	2	3	4	5	0	0	1	2	7	8	8	9
P15	5	6	7	8	8	9	10	10	8	9	10	10	7	8	8	9	8	9	10	10	8	9	10	10
P16	4	5	5	6	5	6	7	8	2	3	4	5	7	8	8	9	4	5	5	6	8	9	10	**10**

P17	2	3	4	5	0	0	1	2	5	6	7	8	8	9	10	10	8	9	10	10	8	9	10	**10**
P18	8	9	10	10	2	3	4	5	5	6	7	8	7	8	8	9	7	8	8	9	4	5	5	**6**
P19	8	9	10	10	5	6	7	8	4	5	5	6	2	3	4	5	8	9	10	10	8	9	10	**10**
P20	8	9	10	10	0	0	1	2	0	0	1	2	7	8	8	9	4	5	5	6	4	5	5	**6**
P21	0	0	1	2	5	6	7	8	7	8	8	9	7	8	8	9	5	6	7	8	7	8	8	**9**
P22	8	9	10	10	4	5	5	6	7	8	8	9	2	3	4	5	0	0	1	2	8	9	10	**10**
P23	5	6	7	8	5	6	7	8	2	3	4	5	8	9	10	10	7	8	8	9	7	8	8	**9**
P24	2	3	4	5	4	5	5	6	2	3	4	5	5	6	7	8	8	9	10	10	8	9	10	**10**
P25	7	8	8	9	8	9	10	10	4	5	5	6	0	0	1	2	4	5	5	6	5	6	7	**8**
P26	8	9	10	10	0	0	1	2	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	**5**
P27	7	8	8	9	4	5	5	6	7	8	8	9	7	8	8	9	5	6	7	8	4	5	5	**6**
P28	8	9	10	10	2	3	4	5	4	5	5	6	5	6	7	8	2	3	4	5	5	6	7	**8**
P29	5	6	7	8	4	5	5	6	2	3	4	5	4	5	5	6	2	3	4	5	4	5	5	**6**
P30	2	3	4	5	2	3	4	5	8	9	10	10	8	9	10	10	8	9	10	10	8	9	10	**10**
P31	4	5	5	6	5	6	7	8	4	5	5	6	7	8	8	9	0	0	1	2	5	6	7	**8**
P32	8	9	10	10	2	3	4	5	2	3	4	5	8	9	10	10	1	2	2	3	2	3	4	**5**
P33	2	3	4	5	4	5	5	6	7	8	8	9	5	6	7	8	4	5	5	6	4	5	5	**6**
P34	2	3	4	5	2	3	4	5	2	3	4	5	8	9	10	10	4	5	5	6	2	3	4	**5**
P35	7	8	8	9	8	9	10	10	8	9	10	10	4	5	5	6	5	6	7	8	5	6	7	**8**
P36	7	8	8	9	4	5	5	6	8	9	10	10	1	2	2	3	2	3	4	5	2	3	4	**5**
P37	8	9	10	10	8	9	10	10	8	9	10	10	4	5	5	6	4	5	5	6	8	9	10	**10**
P38	**4**	**5**	**5**	**6**	**4**	**5**	**5**	**6**	**0**	**0**	**1**	**2**	**4**	**5**	**5**	**6**	**2**	**3**	**4**	**5**	**4**	**5**	**5**	**6**

And finally by applying formulas 8, 9 and 10 positive and negative ideal solution, closeness index and final ranks of variables were calculated as:

Table 7: Positive and negative ideal solution, closeness index and final ranks of variables

Variables	D_i^+	D_i^-	Cc_i	Rank
Competitive advantages	*2.021935128*	*1.835053777*	*0.475773673*	*3*
Servicing to society	*2.219800731*	*0.870365701*	*0.281656577*	*24*
Job enrichment	*1.562851582*	*1.522391616*	*0.493442986*	*2*
Quality improvement	*1.873840041*	*1.210723643*	*0.392510503*	*10*
Improving relations with customers	*4.253785989*	*0.643324092*	*0.131368109*	*38*
More trust	*3.222392393*	*1.825512096*	*0.361637606*	*12*
Measuring future business	*3.381181824*	*1.825512096*	*0.350608683*	*15*
Lack of investment on IT	*2.555188437*	*1.835053777*	*0.417984632*	*7*
Teamwork	*3.705232768*	*1.142628168*	*0.23569739*	*29*
Budget	*4.768630212*	*0.899126614*	*0.158638883*	*37*
Investment priority	*3.455154129*	*1.48298611*	*0.300312676*	*23*
Capital output rate	*3.371004939*	*1.527191627*	*0.311786513*	*20*
Production cost	*2.90658343*	*1.945654615*	*0.400980866*	*9*
Marketing researches	*3.916904958*	*1.210723643*	*0.236117655*	*31*
Replaced technology	*2.333833344*	*1.862374927*	*0.443823282*	*5*
Benefit	*3.346203058*	*1.134778248*	*0.253243245*	*27*
Income	*3.158927169*	*0.96581149*	*0.234150953*	*32*
Lead time	*3.032763969*	*1.619033898*	*0.348044766*	*16*
Inventory	*2.789358126*	*1.63824325*	*0.370006943*	*11*
Employees' absence	*3.846340264*	*1.038945602*	*0.212668333*	*34*
Defective productions	*1.976408669*	*1.114124831*	*0.360495957*	*13*
Work time	*1.324522026*	*1.794993027*	*0.575407715*	*1*
Strategic goals of IT investment	*1.815356087*	*1.285334619*	*0.41453171*	*8*
Supporting corporation strategies	*2.149636834*	*0.930286724*	*0.302048641*	*21*
Supporting financial management	*3.407418753*	*1.648897723*	*0.326106511*	*18*
Performance goals of competition	*4.106456141*	*1.249528213*	*0.233295717*	*33*
Long term costs and advantages	*3.039906289*	*1.674850508*	*0.355235822*	*14*
Performance indices	*3.4423836*	*1.490099531*	*0.302099265*	*22*
Data creation	*3.900449992*	*1.202549191*	*0.235655376*	*30*
Appraisal methods	*2.814160007*	*1.311171748*	*0.317834256*	*19*
Security	*3.777928618*	*1.241038252*	*0.247269664*	*28*

Top managers' investment	***3.806187334***	***1.383839527***	***0.266634367***	***25***
Current IT systems	***3.619906286***	***1.276081934***	***0.260638277***	***26***
Data transferring	***4.046529923***	***0.864928433***	***0.176104198***	***35***
Software	***2.767733793***	***1.988881034***	***0.418129511***	***6***
Users' perception	***3.613468887***	***1.775298613***	***0.329444277***	***17***
System integrity	***2.583196502***	***2.109023553***	***0.449472431***	***4***
Current operations and systems	***4.240055233***	***0.841410209***	***0.165584164***	***36***

As table 6 shows "work time", "job enrichment" and "competitive advantages" were posed in places 1, 2 and 3.

5. Conclusion and suggestions

The study with purpose of identifying and categorizing the driving affecting factors on investment efficiency was done in a society include 22 top managers and financial employees.

First of all by applying Chi Square test positive and meaningful correlations between all variables (include intangible variables, financial requirements, nonfinancial requirements, Strategic requirements, tactical requirements, operational requirements) with investment efficiency were proved.

After that the results of using Binomial test show that all variables were placed in high levels.

And finally by utilizing Fuzzy TOPSIS technique the indices were ranked in which "work time", "job enrichment" and "competitive advantages" were selected as the most important ones.

The recommendations for managers to improve "work time", "job enrichment" and "competitive advantages" are:

- As working time was placed in first place, so the managers are advised that consider raise to motivate their employees to work. Making performance appraisal for better usage of working times is another suggestion to enhance investment efficiency on information technology.
- Job enrichment was placed in second place which indicates high importance of this index . . . . . .
- Competitive advantage was posed in 3rd place. As just a few firms are the rivals of Security and Exchange Organization, so SEO competitive advantage are latent on attracting more competency and human resource productivity. In this case, the role of human resource manager is highlighted more than before. Managers can improve human resource productivity by utilizing motivational systems like enhancing job satisfaction, making employees more committed to the organization, high quality of work life and periodic education. And to attract more customers managers are able to apply more advertising and consider financial stimulus.

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