



**International Journal of Biology, Pharmacy
and Allied Sciences (IJBPAS)**

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

**THE APPLICATION OF VALUE ENGINEERING WITH THE APPROACH OF FUZZY
MULTI-CRITERIA DECISION MAKING IN IMPROVING THE CONSTRUCTION OF
MEHRHOUSING (MASKAN-E-MEHR)**

¹EHSAN KHEIREKHAH, ²MOHAMMAD REZA SHAHRAKI

¹Department of industrial Engineering, Zahedan Branch, Islamic Azad University, Zahedan, Iran

²PhD, Assistant Professor, Industrial Engineering Dept., Faculty of Engineering, University of Sistan and
Baluchestan, Zahedan, Iran

¹Kheirkhahehsan62@yahoo.com, +989155550204; ²m.reza.shahraki@gmail.com

ABSTRACT

This research discusses the application of value engineering with the approach of fuzzy multi-criteria decision making in improving the construction of Mehr residence. The case study of the research is Sistan and Balouchestan province. The population of research consists of 35 experts (including University professors and experts of industry) during 2010- 2013. The research is an applied research in terms of methodology and is a correlative one in terms of classification. In order to study the model and the results of hypotheses testing, we have used binominal test and Friedman test and the classification is performed by fuzzy electre method. In order to document the results of statistical analysis and offering final solutions, the researcher has analyzed the questions and hypotheses using SPSS software. According to the questionnaires, the research results reveals that implementing value engineering and applying fuzzy multi-criteria decision making is effective in improvement of Mehr housing construction in Sistan and Balouchestan province. Also, we proved that there is a positive significant relationship between using value engineering technique, increase of added value of Mehr residence, identifying its effective factors, and cost reduction.

Keywords: Value engineering, multi-criteria decision making, fuzzy variables, Mehrhousing

INTRODUCTION

Construction projects are implemented with the cooperation of various elements which do not have single legal personality. On the other hand, civil engineering activities in these projects have different interactions with each other, so that they are dependent on each other technically, economically, etc. Consequently, a construction project is composed of diverse activities done by different legal personalities which necessitate the interrelationship among activities and the cooperation of different elements. Also, the realization of qualitative goals of projects in a destined time and with a proper cost according to the activities and complexity of their relationship requires a disciplined structure in which all activities interrelate with each other [1]. Considering the cost increase and the time of implementing country's construction projects and the important role of external factors and the lack of access to the desired values in comparison with consumed resources, the question is: are the expected needs and demands are met in exchange for used financial and human resources?

The study results show that the aforementioned statement is not true in the majority of construction projects and the situation is not better in the field of service

and industry. The time and cost of projects sometimes exceed more than two times what has been predicted. Using effective parameters in value engineering in construction industry considering the value indicator and their effect can play a pivotal role in allocating the resources and accelerating the process of construction projects [2].

Value engineering is an organized effort which aims at studying and analyzing all activities of a plan, from the formation of first ideas to the design and implementation and operation step. It is known as one of the most efficient and important economic methods in field of engineering activities. Value engineering in the framework of project management focuses on all components of the design, although it does not take any part of the job for granted. The aim of value engineering is to spend less time for reaching operation stage, without adding the costs or decreasing the quality of the job [3]. Designs such as dams or tunnel which are directly related to the nature are required to be exposed to value engineering to achieve more detailed information in the course of implementation. In our country, huge expenses are spent annually to implement construction projects in the form of civil,

non-civil and private projects. One of the reasons for delaying the implementation of construction projects is the lack of proper cost management. Project cost management is an activity which involves prediction, planning, control, cost-estimation, analysis and evaluation [4]. Using management techniques can significantly reduce these costs. Value engineering is a systematic method which aims at optimizing the value indicator of a given project. The results of implementing value engineering in various construction projects show that value engineering not only reduces the costs along with maintaining the desired quality, but also decreases the time of completion and increases the quality of construction projects. These transformations in construction projects are more than the ones of other projects [5]. One of the major transformations in construction project management is the function of value engineering in these projects. The development of value engineering in designing and implementing architecture projects, especially housing, demonstrates the strength of this approach in decreasing the cost and improving the quality of housing, and creating added values which can be used in the procedure of designing and its following stages. Prevalence and using various models in each engineering

step and benefitting from its advantages in our country with several ongoing projects seems mandatory [6]. In the field of scientific transformations, the traditional methods do not seem to be capable anymore, and relying on these procedures will probably result in failure in project management. Inefficiency of Mehr housing projects management in some regions of the country made the employers put their effort in increasing the value of buildings of Mehr housing by improving their architecture. The quality of building design has a significant effect on increasing its value. A proper strategy for employers is to hold designing contests or sessions about value engineering in order to select the most valuable option to take a big step toward its primary goal, i.e. improving the quality of Mehr housing [7]. Better options are chosen with respect to employer's particular needs and with focus on missing links of value, which requires a model to evaluate the designing options based on his/her real criteria and requirements. The value engineering process has not undergone many transformations in terms of content, techniques or application; but its application conditions, development of legal context and removing the barriers of project implementation has changed significantly. One of effective factors used in

value engineering discussions in construction projects is Multi-criteria decision making model. Currently, there is not an efficient and regulated method based on new management principles for selecting construction projects contractor [8].

The purpose of this research is the application of value engineering in order to improve the quality of Mehr housing, or in other words, increasing its value. Thus, the effective factors in increasing the value of Mehr housing in Sistan and Balouchestan province are identified and ranked using MCDM.

The history of value engineering

As a special technical method, value analyzing started to become popular in the years after WWII. Designing and regulating this method was initiated with the order of Henry Erlicher, the technical assistant of General Electric Purchase Department. He opined that some of alternative materials and designs which were being used inevitably due to the shortages of war period were of better performance with less costs. Upon his order, a significant effort was made in the company in order to promote the production efficiency by providing alternative materials and offering new methods. In 1947, this task was assigned to Lawrence Miles, senior engineer of General Electric. Miles examined

the available techniques and methods and applied some of conventional methods, combined with his “step by step” technique to analyze the value. Miles, who is considered as the founder and initiator of value engineering, operated an official method during which several groups of company engineers were bound to examine the performance of General Electric products. Relying on creative group methods and without product quality loss, they induced changes in company products, effectively reducing the production costs. “value analysis” was accepted as a standard in General Electric and this encouraged other enterprises and some of public organization to apply this new technique as a tool for reducing their costs, resulting in the emergence of “value engineering” [9].

Research hypotheses

1. Using value engineering technique will result in increase of Mehr housing added value.
2. Using fuzzy MCDM in value engineering causes the increase of Mehr housing quality.
3. Using value engineering and identifying its effective factors reduces the costs related to Mehr housing.

Data collection method

In the present research, required data and information are collected in two ways:

- Library method: in this step, studying various Persian or English texts and articles relevant with the subject is focused on. Using library studies and various English or Persian books or journals, and using different relevant websites, the required background is collected. Also, the latest information about the research subject can help enrich the literature review and facilitate the process of preparing questionnaire.
- Field method: in this method, the required data is gathered by interviews, observations and questionnaire in accordance with research subject. The major technique used in this research is the questionnaire.

MATERIALS AND METHODS

Population

The research population consists of 35 experts (including University professors and experts of industry) working in Sistan and Balouchestan province during 2010-2013.

Data analysis method

In the present study, the research questions are prepared considering the desired purposes and the questionnaire is circulated among the

experts to achieve the required criteria of value engineering from their answers in order to improve the quality of constructing Mehr housing. The obtained results from the questionnaire form the decision making matrix. Then it is descaled in a normalized way and the descaled matrix is solved by a multi-criteria decision making to rank the effect of the factors in decreasing order. Selection is done using multi-criteria modeling process and the proof of stated hypotheses is done by SPSS software.

Findings of analysis:

In this part, the research hypotheses are analyzed and their accuracy or inaccuracy is examined with the use of obtained results from the questionnaire.

Based on the process of research in 3.3, all essential steps of the research, from the very first to inferring the results are examined. Thus, the research process will be studied in following steps:

Hypothesis 1: using value engineering techniques increases the added value of Mehr housing.

Considering that the data size is over 30 samples and the population distribution can be assumed normal according to central limit theorem, one-sample t test with confidence interval of 95% in order to determine and interpret the variables of the research. In the

mentioned test, if P-value is less than 5%, there is a significant relationship between studied variables. Otherwise, the studied variable is significantly present in the

population. So, according to the following outputs which are obtained from processing the questionnaires using SPSS 21, we can have table 4.4:

Table 1: the results of primary statistical analysis of main factors

	Necessary capabilities	Organization importance and acceptance	The area of the effect	The aspect of the effect
Mean	4.25	3.99	4.49	4.18
Standard deviation	0.55	0.15	0.23	0.41
P-Value	0.037	0.042	0.025	0.031

Using the calculation by software and the obtained output from stated variables in table 4.4, since P-value is less than 5%, there is a significant relationship between the studied variables. So, we can assume that all factors affect directly on the subject.

In order to rank the effective factors to identify the synchronous application of research variable developments, a questionnaire was prepared and circulated among the population to collect required data. In this questionnaire, the criteria for ranking the effective factors on mutual effect of main factors were compared in pairs and then this comparison was made

using each one of the criteria. The important steps for analyzing fuzzy electre model based on information of a questionnaire which is circulated in the studied population are described as follows. Further, the final analysis is done based on all questionnaires. This process requires large space and numerous calculations. So, we have to describe the prioritization steps of the main strategies step by step and confine ourselves to the extracted results from the software. To prioritize the effective factors, the criteria used by respondents for weighting the effective factors separately should be prioritized first.

Table 2: matrix of paired comparison from different people's view

ni	M1	M2	M3
M1	1	A12	A13
M2	A21	1	A23
M3	A31	A32	1

After drawing the matrix, we place "1"s in its diameter and considering the relative importance of each factor to the other one

(from each respondent's view) quantitative data are used in order to fill in other arrays. Based on questionnaire information, the

table for paired comparison of the five factors from first person’s view is as follows:

First, descaled matrix was designed according to the information of the questionnaire make a comparison among the criteria.

Table 3: The primary matrix of paired comparison of criteria from first respondent’s view

First respondent	The aspect of the effect	The area of the effect	Organization importance and acceptance	Necessary capabilities
The aspect of the effect	1	1.15	1.25	2.5
The area of the effect	0.7	1	1.15	3.33
Organization importance and acceptance	0.8	0.7	1	2.5
Necessary capabilities	0.4	0.3	0.4	1

After completing the first descaled matrix from the view of each respondent, the matrix above is normalized.

Hypothesis 2: using fuzzy multi-criteria decision making in value engineering increases the quality of Mehr housing.

Based on questions asked from the experts, we analyze the data using the software. In

the next step, we can realize the weights considered for each criterion based on first respondent’s view. According to his/her view, we develop the weighted descale matrix and coordinated and uncoordinated fuzzy matrices should be created.

Table 4: The vector of criteria weights from first respondent’s view

Indicator	Fuzzy weight
The aspect of the effect	(0.553,0.733,0.933)
The area of the effect	(0.4,0.6,0.8)
Organization importance and acceptance	(0.467,0.667,0.867)
Necessary capabilities	(0.4,0.6,0.8)

Accordingly, the respective calculations for performing and updating coordinated and

uncoordinated fuzzy matrices are done as follows and its outputs are determined:

	Necessary capabilities	Organization importance and acceptance	The area of the effect	The aspect of the effect
First criterion	(0.538,0.769,1)	(0.538,0.769,1)	(0.571,0.768,1)	(0.5,0.714,0.929)
Second criterion	(0.308,0.538,0.769)	(0.385,0.615,0.846)	(0.571,0.786,1)	(0.571,0.786,1)
Third criterion	(0.077,0.308,0.538)	(0.308,0.538,0.769)	(0.429,0.643,0.857)	(0.286,0.5,0.714)
Fourth criterion	(0.308,0.538,0.769)	(0.385,0.615,0.846)	(0.143,0.357,0.571)	(0.5,0.714,0.929)
Fifth criterion	(0.462,0.692,0.923)	(0.538,0.769,1)	(0.286,0.5,0.714)	(0.286,0.5,0.714)

After completing the matrix of primary paired comparison from each respondent’s

view, the matrix will be normalized. To do so, the numbers of each column in table are

added together and the numbers of cells of each column are divided by the sum of that column. Finally, the numbers of each line in normalized matrix are added together and its

mean is calculated. The resultant matrix shows a more significant comparison between the elements.

Table 5: The normalized weighted fuzzy decision matrix for six criteria

	Necessary capabilities	Organization importance and acceptance	The area of the effect	The aspect of the effect
First criterion	(0.287,0.564,0.933)	(0.215,0.462,0.8)	(0.305,0.576,0.933)	(0.233,0.476,0.805)
Second criterion	(0.164,0.395,0.718)	(0.154,0.369,0.677)	(0.305,0.576,0.933)	(0.267,0.524,0.867)
Third criterion	(0.041,0.226,0.503)	(0.123,0.323,0.615)	(0.229,0.471,0.8)	(0.133,0.333,0.619)
Fourth criterion	(0.164,0.395,0.718)	(0.154,0.369,0.677)	(0.076,0.262,0.533)	(0.233,0.467,0.805)
Fifth criterion	(0.246,0.508,0.862)	(0.215,0.462,0.8)	(0.152,0.367,0.667)	(0.133,0.33,0.619)

The questionnaire results obtained from the experts and data tables revealed that there is a significant relationship between research variables in hypothesis 2. So, the variables have positive correlation and hypothesis 2 is confirmed.

Now, with geometrical averaging, the final ranking and weight of all items from all

respondents' view are achieved. So, the relative priority percentage of each criterion is recognized. "Project" criterion has the highest and "necessary capabilities" have the lowest effect.

The final matrix is as follows:

Table 6: Distance between each pair of items (g and f matrices) according to each criteria

	X11	X21	X31	X41
X11	-	(0,0.05)	(0,0.09)	(0,0.05)
X12	-	-	(0,0.05)	(0,0)
X13	-	-	-	(0.05,0)
X14	-	-	-	-

	X12	X12	X13	X14
X12	-	(0,0.03)	(0,0.05)	(0,0.03)
X22	-	-	(0,0.02)	(0,0)
X32	-	-	-	(0.02,0)
X42	-	-	-	-

	X13	X23	X33	X43
X13	-	(0,0)	(0,0.03)	(0,0.09)
X23	-	-	(0,0.03)	(0,0.03)
X33	-	-	-	(0,0.06)
X43	-	-	-	-

	X14	X24	X34	X44
X14	-	(0.01,0)	(0,0.04)	(0,0)
X24	-	-	(0,0.06)	(0,0.01)
X34	-	-	-	(0.04,0)
X44	-	-	-	-

	X15	X25	X35	X45
X15	-	(0.02,0)	(0.08,0)	(0.02,0)
X25	-	-	(0.06,0)	(0,0)
X35	-	-	-	(0,0.04)
X45	-	-	-	-

Step 1: coordination calculation

In this step, the coordination parameter of strategies should be calculated as (cj (a,b)) according to the following table. Based on this, equal to number of five pairs in lieu of each indicator (remained indicator) the

strategies are compared in pairs according to the respective indicators after C. Then, the composing elements of total coordinated matrix are calculated and coordination index is calculated for both items based on each indicator.

Table 7: Coordinated matrix

	First criterion	Second criterion	Third criterion	Fourth criterion	Fifth criterion
First criterion	-	(1.8,2.6,3.4)	(2.67,3.27,4.24)	(2.27,3.27,4.27)	(1.93,2.73,3.53)
First criterion	(1.4,2,2.6)	-	(2.67,3.27,4.24)	(2.67,3.87,5.07)	(1,1.4,1.8)
First criterion	(0.4,0.6,0.8)	(0.4,0.6,0.8)	-	(0.93,1.33,1.73)	(1.4,2,2.6)
First criterion	(0.86,1.26,1.66)	(1.67,2.46,3.27)	(1.73,2.53,3.33)	-	(0.47,0.67,0.87)
First criterion	(1.13,1.73,2.33)	(1.67,2.46,3.27)	(1.73,2.53,3.33)	(2.2,3.2,4.2)	-

Step 2: In coordination calculation

The in coordination parameter of both strategies should be calculated according to each indicator by table 7. Therefore, the same as coordination calculation, five in coordination matrices are achieved in which the strategies are compared together in pairs

with respect to an indicator. Here, items incoordination matrix for one of the indicators is presented in table 8.

Table 8: Uncoordinated matrix

	First criterion	Second criterion	Third criterion	Fourth criterion	Fifth criterion
First criterion	-	0.4	0.88	0.22	0.5
First criterion	1	-	1	0	0.5
First criterion	1	1	-	0.83	1

First criterion	1	1	1	-	0.75
First criterion	1	1	0.63	1	-

Table 9: The formation of matrix B (0 and 1) based on minimum of coordination

	First criterion	Second criterion	Third criterion	Fourth criterion	Fifth criterion
First criterion	-	1	1	1	1
First criterion	0	-	1	1	0
First criterion	0	0	-	0	0
First criterion	0	1	1	-	0
First criterion	0	1	1	1	-

Table 10: Formation of matrix H (0 and 1) based on minimum of incoordination

	First criterion	Second criterion	Third criterion	Fourth criterion	Fifth criterion
First criterion	-	1	0	1	1
First criterion	0	-	0	1	1
First criterion	0	0	-	0	0
First criterion	0	0	0	-	1
First criterion	0	0	1	0	-

Hypothesis 3: using value engineering technique and identifying its effective factors decrease the cost of the construction cost of Mehr housing.

Now we have to achieve the results of determining the weight of each factor or sub-factor using fuzzy electre technique and MATLAB software. So we have:

Table 11: Variables of value engineering

Factor	Weight
Presence of clear program for value engineering	0.81
The rate of managers' understanding of value engineering	0.9
The number of organizational layers	0.91
Public participation	0.63
Employees' understanding of value engineering	0.1
The possibility of change in order to coordinate with new system	0.28
Cultural accordance with new system	0.55
Organizational structure accordance with new system	0.96
The presence of external obligations	0.96
The existence of old methods for meeting the needs and not trying to improve them	0.16

Need for reducing the projection costs	0.97
Need for improving the current satisfaction with stabilizing or reducing the cost	0.96
Necessary specialized knowledge	0.49
Challenge/agreement between providers and counselors	0.8
The presence of a professional team of value engineers	0.14
Morale, perseverance and knowledge of project team	0.42
The experience of project manager	0.92
The number of counseling sessions with training workshops of value engineering	990.
Project structure	0.96
The motivation of project members	0.66
Permanent development/clarity of project domain	0.04
Elevators	0.85
Fire extinguishing	0.93
Foundation	0.68
Roofing	0.76
Stairs building	0.74
Decoration	0.39
Equipment	0.66
Doors	0.17
Partitions	0.71
Joinery	0.03
Windows	0.28
Pipeline	0.05
Wiring	0.1
Cabinetry	0.82
Landscaping	0.69
Structure erecting	0.32
Wall building	0.95
Improvement of operational performance	0.03
Improvement of element flexibility	0.44
Convenience in using and installing	0.38
Being repairable	0.77
Appropriate cost efficiency	0.8
The possibility of offering a disciplined and structured program	0.19
Security	0.49
Competitiveness	0.45
Engineering performance	0.65

Extracted results from analysis reveal that indices of value engineering including engineering performance, the possibility of offering disciplined programs and other items are positively and significantly correlated with each other. The obtained numbers in the confidence level of 5% confirms the relationship among the variables, so the

relationship between research variables has confidence level. Also, the effect of engineering value performance and identifying it results in reducing the costs and saving the resources. Moreover, the variables of “need for improving current satisfaction”, “stabilizing or reducing the cost” and “the number of counseling sessions with training

workshops of value engineering” have a high rate in terms of value engineering and have significant effect on this field. So, hypothesis 3 is correlated with the research and is confirmed.

RESULTS AND DISCUSSION

Here, the findings and result analysis of research hypotheses is presented in details.

Hypothesis 1: using value engineering increase the added value of Mehr housing.

The conducted studies during 2010 till spring of 2013 and the findings presented in tables 1 and 4 indicate that there is a significant and positive relationship between using value engineering and increasing added value of Mehr housing, since value engineering is a strategy applied to study the cost and performance from all practical and theoretical aspects. It does not take anything for granted and examines every item of a given system, even its inherent characteristics. Value engineering is defined as the most cost-effective method for implementing the desired items.

Hypothesis 2: using fuzzy multi-criteria decision making in value engineering increases the quality of Mehr housing.

According to conducted studies during 2010 to 2013 and findings of tables 6 to 8 and the extracted answers from the questionnaires, it is revealed that there is a significant and

positive relationship between fuzz multi-criteria decision making in value engineering and the quality of construction of Mehr housing. The common characteristics of construction and many other industries are instability and interdependence, so applying value engineering will gradually improve the quality of Mehr housing.

Hypothesis 3: using value engineering technique and identifying its effective factors decreases the construction cost of Mehr housing.

Conducted studies during 2010 to spring of 2013 and findings of table 6 to 8 demonstrate a significant and positive relationship between value engineering technique and identifying its effective factors, and the cost reduction. It is stated that value is equal with performance, so improving the value implies the development of performance, cost reduction, or both of them.

Traditional methods of cost reduction have rarely focused on the concept of function. Function analysis is a pivotal part of value engineering and explains why a given item is necessary and required instead of just thinking about and considering that item. This method is function-oriented rather than being item-oriented. The results of this hypothesis are correlated with other previous relevant works.

CONCLUSION

It is suggested that a study with focus on the effect of using value engineering and identifying its effective factors on reducing construction costs of Mehr housing.

Based on the results of this statistical research and according to the results of first hypothesis, it is suggested that other various methods such as classification, clustering network, relationship establishing (such as non-linear regression, etc.) which can be used in combination with artificial intelligence algorithms such as genetic algorithm, especially fuzzy systems like fuzzy neural network in order to use value engineering in construction of Mehr housing in an optimal way and reveal unknown aspects of this field. For instance, we can expect that a certain relationship between each of the components of value engineering and construction elements of Mehr housing is found out, or we can determine which construction elements are highly focused in which urban and rural areas, and offer useful suggestions on the subject.

Although the present dissertation aims at studying the most important engineering concepts reported in the relevant literature, but the authors believe that it is just the beginning and the presented concepts in this research should be seen as initiation. The

research results show that the design and construction results are of utmost importance among the experts of this field. It is suggested that a mathematical programming model, especially a fuzzy logic-based model with the ability of transforming lingual variables to breakable data be used to model this problem under several synchronous target functions and from different views. This research applied fuzzy multi-criteria technique in order to identify and rank value engineering components. Other methods such as Vikor, AHP and other decision making methods can be used and its results can be compared with the ones of this method.

According to the results of hypothesis 3, the contractors can consider the consumed cost, time and effort for developing value engineering suggestions in constructing Mehr housing as an irreversible risk, as the suggestions may not be welcomed or even be neglected. This is considered a huge barrier for implementing value engineering more extensively. It is suggested that other calculation and decision making methods such as TOPSIS and ANP are used as well as value engineering techniques in order to reduce the costs of constructing Mehr housing.

REFERENCES

1. A., A. Determining the effective factors on organizational efficiency using multi-criteria decision making models. *Daneshvar, scientific bimonthly*, volume 10. No. 42, 2002. Pages 1-1646.
2. J. A., M. S.; A., M... The status of value engineering in project management. *Iran's management and planning organization publication*. Tehran. *Human Science Instructor quarterly*. Course 13. No. 2, 2004.
3. N H.,S. A. Analytic examination of three factors of quality, cost and time on construction industry. M.A dissertation, faculty of civil engineering, University of Amir Kabir. 2001.
4. G., Y.; B., H.The principles of value engineering. 1st edition. *Termeh publication*. 2004.
5. K., K.Value engineering application in designing, implementing and operation. Translated by Mahab-e-ghods consulting engineers company, Tehran. *Mahab-e-ghods publication*. 1999.
6. F.,N. Fuzzy control of maintenance and repairing planning. *Navid-e Shiraz publication*. 2010.
7. T., A. A review on the most prevalent methods of maintaining, repairing and monitoring the machinery, fourth special conference of status monitoring and machinery trouble shooting in Iran, Tehran. *University of Sharif*. 2009.
8. S., H.The theory of fuzzy sets and its application is industrial and management engineering. 1st edition. Tehran. *Basic sciences development*. 2006.
9. I., M.Presenting pattern of efficiency using fuzzy DEA model. M.A dissertation. *Azad University, Zahedan branch*. 2011.