Latif Onur UĞUR[1]
Düzce University
Faculty of Technology, Department of Civil Engineering

Rıfat AKBIYIKLI
Düzce University
Faculty of Technology, Department of Civil Engineering

Esra DURMAZ
Düzce University
Faculty of Technology, Department of Civil Engineering

USING THE UTA METHOD IN OPTIMIZED BUILDING SELECTION FROM THE COST OF APPLICATION OF HOUSING PROJECTS

Keywords: multiple criteria decision making, UTA method, housing selection

Abstract

In today's economic conditions, the costs of housing projects affect investment decisions at a primary level. Location of land, zoning regulations, topographic and geological conditions, etc. as well as one of the most important parameters affecting the cost of housing, are the design dimensions of the structure. Different alternatives should be created in order to select the optimum design in terms of cost in the design of the house. For this selection, many criteria such as floor height, total building area, exterior area, room and number of wet spaces are considered. The combination of qualitative and quantitative values at the time of the selection process is the primary factor for the final decision to be healthy. In this study, for the selection of the cost-effective reinforced concrete duplex villa design; UTA method was used for multi - criteria decision making methods. Selection of this method; It is based on regression, linear programming techniques, and the ability to provide continuity between choice. VisualUTA program was used in the implementation of this approach and the calculations were made by making the necessary calculations. With the use of this approach, a numerical solution has been provided for the selection of the optimum size housing in terms of cost and this has provided an important convenience in making the decision.

[1] latifugur@duzce.edu.tr

1. Introduction

Housing projects, which are the building blocks of the construction industry, offer many options with developing technology and design models. The relations of individuals in the urban structure with each other, the shaping of the urban space, architectural structuring, the emergence of living areas etc. are examples of this transformation. In this process, there is a transformation in the functions of the "residence" where people spend a significant part of their lives and the functions they own. In parallel with the changes in the functions of the house, the preferences of the individuals have started to change. [1]

In this context, today, as well as being an economical tool that meets the need for housing, it has started to be accepted as a tool by which people determine their lifestyle and organize their social relations [2]. Many parameters such as cost, design, space area, number of rooms and number of floors affect primarily the choice of housing for individuals and it is desired to choose the most optimal among these factors. At this point, the individual chooses among many criteria.

The decision is called "the final judgment given by thinking about a job or problem" or "the final judgment given by discussing for any situation". The action of choosing one of the alternatives available for the realization of the goals and objectives is also one of the definitions used for the "decision concept". Decision making has become a wide-ranging branch of science with many cross-sections of science. [3]

Multi-criteria decision-making problems can be defined as problems in which multiple criteria are optimized and the best alternative is chosen from among the possible solutions. Increasing competition over time, cost, mixed relationships etc. For rational decisions, the decision process must be analyzed analytically.

In Athawale et al., in their study "Decision making for material selection using the UTA method", basically, using the auxiliary contribution (UTA) method, which is a multi-criteria decision making method to solve complex decision making problems; focused on solving the material selection problem. The ranking performance of the UTA method was found to be quite high and it was concluded that it was comparable to other multi-criteria decision-making methods accepted by previous researchers. [4]

Siskos, In his study titled "Evaluation of a furniture retail system using an interactive sequential regression method", to evaluate the start of a new furniture line of retail stores with a certain sales network in France; A multi-criteria evaluation model based on many qualitative and quantitative

criteria has been proposed, taking into account the company's commercial policy and the preferences of decision makers. The UTA method was used interactively in the trial and error process to model the decision maker's choice system. [5]

Beuthe and Scannella compared the UTA method in the classification of highway investment projects in the study of "Comparison of multi-criteria analytical methods: UTA applications". They made various suggestions to minimize the differences that occurred. [6]

Within the scope of this study, it was investigated to choose "the most cost-effective" among 10 different housing types, which are defined as villas, by using UTA Method, which is a multi-criteria decision making method.

2. Purpose and Method

In this study, it was aimed to reach the optimum result in terms of cost by making decision analysis by using UTA method, which is one of the multi-criteria decision making methods among 10 villas. Projects of the housing types to be selected have been reached. Firstly, the costs of the project of 10 villas have been calculated, basement floor area, ground floor area, 1st floor area, building height, exterior area, exterior space area, total wet area, number of bathrooms, number of wc, number of kitchens, balcony number and hall number data were determined. The information obtained was evaluated by using the VisualUTA program and the necessary calculations. Information on the data obtained is given in Table 1.

Table 1. *Criterion data obtained from the projects*

Sequence No.	**Type1**	**Type2**	**Type3**	**Type4**	**Type5**	**Type6**	**Type7**	**Type8**	**Type9**	**Type10**
Construction Cost with 2017 Unit Price (TL)	736.624	528.537	354.416	152.523	238.075	155.757	169.874	230.064	524.161	238.735
Number of Halls (piece)	1	1	1	2	2	2	2	2	2	2

Sequence No.	**Type1**	**Type2**	**Type3**	**Type4**	**Type5**	**Type6**	**Type7**	**Type8**	**Type9**	**Type10**
Number of rooms (piece)	8	8	10	6	6	6	5	4	10	8
Balcony Number (piece)	4	3	2	2	2	4	2	1	2	2
Total Wet Area (m2)	79,80	67,75	43,40	45,52	54,58	29,40	43,73	10,68	21,26	36,00
Number of Kitchen (piece)	1	1	1	2	2	2	1	1	2	1
Number of WC (piece)	2	4	3	2	3	2	2	1	2	2
Number of bathrooms (piece)	3	4	3	4	3	2	3	1	2	2
Exterior Space (m2)	105,60	122,00	136,70	79,58	31,63	38,57	52,00	61,93	55,34	45,00
Exterior Area (m2)	84,00	648,20	567,50	196,96	276,88	333,12	435,20	443,29	302,40	450,00
Building height (m)	9,00	8,70	9,20	6,00	5,80	6,40	9,50	6,00	8,80	7,05
1st Floor Area (m2)	280,00	183,79	143,91	117,00	162,58	116,44	120,00	100,00	185,00	100,00
Ground Floor Area (m2)	280,00	177,70	142,29	133,00	128,42	123,91	120,00	100,00	176,30	120,00
Basement Floor Area (m2)	200,00	169,24	156,00	107,80	115,00	110,75	81,71	0,00	117,23	149,70

3. UTA Method

The UTA (Utilités Additives) method proposed by Jacquet-Lagrèze and Siskos aims to subtract one or more value-added functions from a given sequence on a reference set AR. The method uses special linear programming techniques to evaluate these functions. Thus, the sequence (s) obtained through these functions on AR are as consistent as possible with the data.

Comprehensive preference information is pre-ordered in a subset of $A^R \subseteq$ A reference alternatives. It is considered as a contribution to the criteria collection model in UTA. Value function of the form below (Jacquet-Lagrèze and Siskos, 1982):

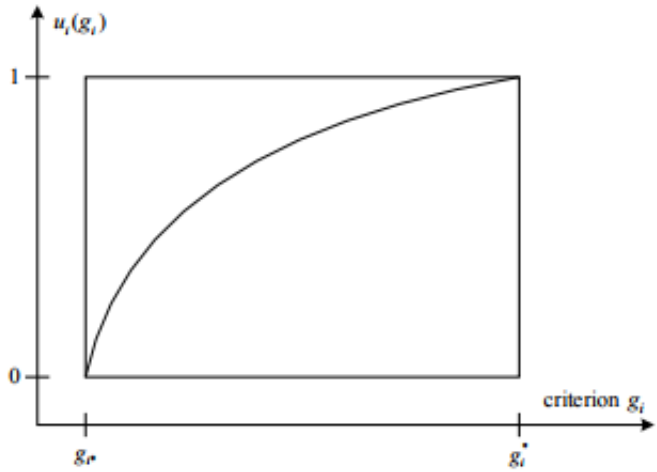
$$u(g) = \sum_{i=1}^{n} p_i u_i(g_i) \quad (1).$$

when subject to normalization restrictions:

$$\begin{cases} \sum_{i=1}^{n} p_i = 1 \\ u_i(g_{i^*}) = 0,\ u_i(g_i^*) = 1\ \forall_i = 1,2,\dots,n \end{cases} \quad (2).$$

Here, u_i, i = 12,… n are the declining real-value functions that are normalized between 0 and 1, called marginal value or useful functions, and the weight of $i_p u_i$"as in Figure 1'.

Fig. 1. Normalized Marginal Value Function



Both marginal and global value functions have the monotony property of the real criterion. For example, the following properties apply to the global value function:

$$\begin{cases} u[g(a)] > u[g(b)] \Leftrightarrow a\ h\ b\ (preference) \\ u[g(a)] = u[g(b)] \Leftrightarrow a : b\ (indifference) \end{cases} \quad (3).$$

The UTA method specifies the value-added function in the weightless form, as follows, equivalent to Figure 1:

$$u(g) = \sum_{i=1}^{n} u_i(g_i) \quad (4).$$

subject to normalization restrictions:

$$\begin{cases} \sum_{i=1}^{n} u_i\ (g_i^*) = 1 \\ u_i(g_{i^*}) = 0\ \forall i = 1,2,\dots,n \end{cases} \quad (5.)$$

Of course, the existence of such a choice model assumes the preferential independence of the criteria for the decision maker (Keeney and Raiffa, 1976), while other conditions of participation were proposed by Fishburn (1966, 1967). This assumption does not pose significant problems in a posteriori analysis such as decomposition analysis. [7]

4. Application

A selection will be made using the UTA method to choose from many different villa projects. The factors affecting the selection and the desired criteria were determined as in Table 2. after the research process of the UTA method was solved with the help of the VisualUTA [8] program and the necessary researches were made to choose from 10 different villa projects;

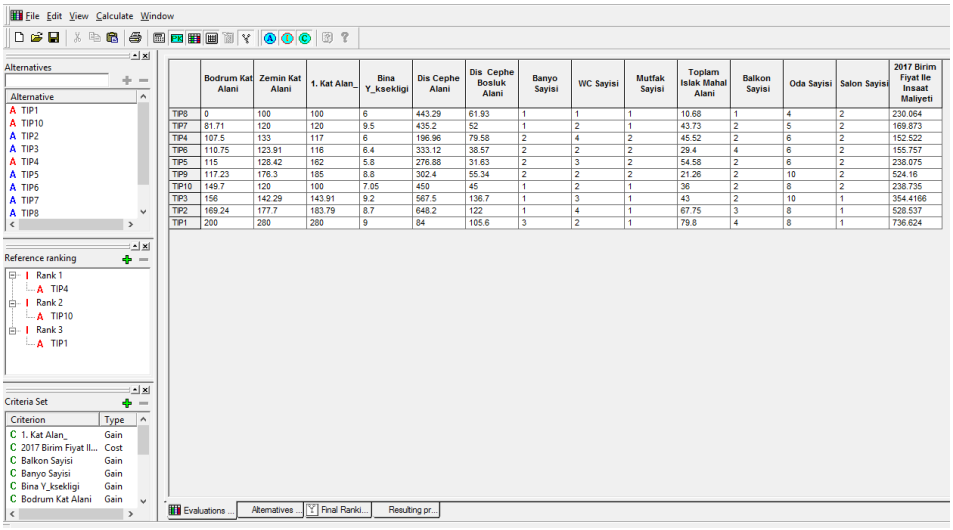
Table 2. *Factors Affecting Selection and Required Criteria*

FACTORS AFFECTING SELECTION	**REQUIRED CRITERIA**
Construction Cost with 2017 Unit Price	The minimum possible cost is expected

FACTORS AFFECTING SELECTION	REQUIRED CRITERIA
Basement Floor Area	The highest one will be chosen as m^2
Ground Floor Area	The highest one will be chosen as m2
1st Floor Area	The highest one will be chosen as m2
Building height	The highest one will be chosen as m2
Exterior Area	The highest one will be chosen as m2
Exterior Space	The highest one will be chosen as m2
Number of bathrooms	the highest one will be selected
Number of Wc	the highest one will be selected
Number of Kitchen	the highest one will be selected
Total Wet Area Area	The highest one will be chosen as m2
Balcony Number	the highest one will be selected
Number of rooms	the highest one will be selected
Number of Halls	the highest one will be selected

The qualitative criteria of 10 different villas mentioned above were determined and the data such as in Figure 2. were entered into the VisualUTA program to be solved by the UTA method. The program expects the user to make a ranking after entering the types and criteria, firstly trying to determine the most optimal in terms of cost and trying to determine the most cost-opt villa type Rank1 Type4, near optimal, Rank2 Type10 and farthest to optimum and cost The highest Rank3 is defined as Type1 and quantitative criteria are determined.

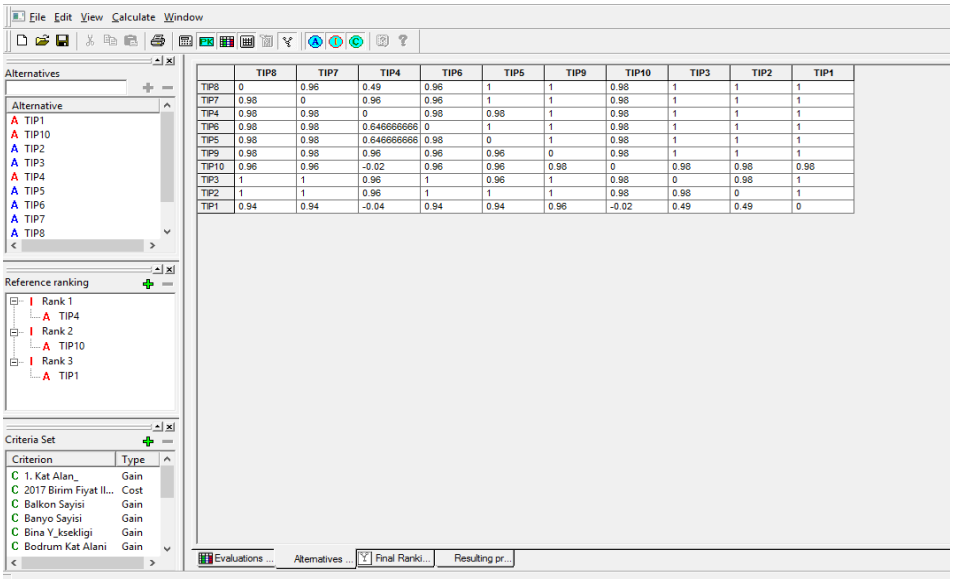
Fig. 2. Entering data in VisualUTA program



	Bodrum Kat Alani	Zemin Kat Alani	1. Kat Alan_	Bina Y_ksekligi	Dis Cephe Alani	Dis Cephe Bosluk Alani	Banyo Sayisi	WC Sayisi	Mutfak Sayisi	Toplam Islak Mahal Alani	Balkon Sayisi	Oda Sayisi	Salon Sayisi	2017 Birim Fiyat Ile Insaat Maliyeti
TIP8	0	100	100	6	443.29	61.93	1	1	1	10.68	1	4	2	230.064
TIP7	81.71	120	120	9.5	435.2	52	1	2	1	43.73	2	5	2	169.873
TIP4	107.5	133	117	6	196.96	79.58	2	4	2	45.52	2	6	2	152.522
TIP6	110.75	123.91	116	6.4	333.12	38.57	2	2	2	29.4	4	6	2	155.757
TIP5	115	128.42	162	5.8	276.88	31.63	2	3	2	54.58	2	6	2	238.075
TIP9	117.23	176.3	185	8.8	302.4	55.34	2	2	2	21.26	2	10	2	524.16
TIP10	149.7	120	100	7.05	450	45	1	2	1	36	2	8	2	238.735
TIP3	156	142.29	143.91	9.2	567.5	136.7	1	3	1	43	2	10	1	354.4166
TIP2	169.24	177.7	183.79	8.7	648.2	122	1	4	1	67.75	3	8	1	528.537
TIP1	200	280	280	9	84	105.6	3	2	1	79.8	4	8	1	736.624

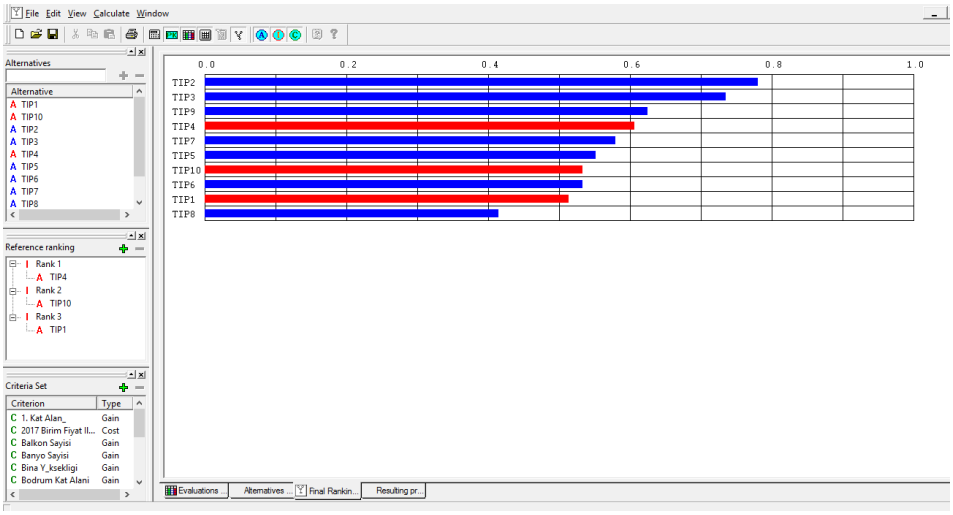
After the rank determination, the analysis was performed and the alternative comparison matrix Figure 3. and final ranking UTA MD results Figure 4. obtained by working with UTA GMS were obtained.

Fig. 3. Alternative comparison matrix



	TIP8	TIP7	TIP4	TIP6	TIP5	TIP9	TIP10	TIP3	TIP2	TIP1
TIP8	0	0.96	0.49	0.96	1	1	0.98	1	1	1
TIP7	0.98	0	0.96	0.96	1	1	0.98	1	1	1
TIP4	0.98	0.98	0	0.98	0.98	1	0.98	1	1	1
TIP6	0.98	0.98	0.646666666	0	1	1	0.98	1	1	1
TIP5	0.98	0.98	0.646666666	0.98	0	1	0.98	1	1	1
TIP9	0.98	0.98	0.96	0.96	0.96	0	0.98	1	1	1
TIP10	0.96	0.96	-0.02	0.96	0.96	0.98	0	0.98	0.98	0.98
TIP3	1	1	0.96	1	0.96	1	0.98	0	0.98	1
TIP2	1	1	0.96	1	1	1	0.98	0.98	0	1
TIP1	0.94	0.94	-0.04	0.94	0.94	0.96	-0.02	0.49	0.49	0

Fig. 4. Final Order UTA MD Results



The UTA method is intended to be used interactively with an increasing subset of A ^ R and increased binary comparisons. It is expected that the most suitable option will be chosen by comparing the reference alternatives with each new pair, enriching the required relationship and developing the possible relationship to combine with the growth of preferred information. With this method, Type2 has been chosen as the most suitable option in the comparison made as a result of the determined values.

5. Results

In today's economic conditions, the costs of housing projects primarily affect investment decisions. The location of the land, zoning arrangements, topographic and geological conditions etc. Besides, one of the most important parameters affecting the housing cost is the dimensions of the building in question. Among the many options, a selection is made by taking into consideration the main elements such as the cost, area, number of rooms, floor height, architectural details, number of balconies, number of kitchens, number of bathrooms, number of floors. Qualitative and quantitative criteria should be evaluated together during the selection criteria.

In this study, in choosing the most optimum cost and design sizes among 10 villas; UTA approach, which is one of the multi-criteria decision making methods. Using a linear interpolation approach to calculate the relevant marginal value function in a partial linear form provides benefits in

determining the potential error. The numerical solution of this method with the VisualUTA program was made on the computer. With the use of this method, a significant solution has been provided for decision making by bringing a numerical solution for the most cost-effective choice among 10 villas.

As a result of the calculations, the type of housing Type 2, which ranks first according to the UTA approach, was chosen as the most suitable option.

There are many application and material options in the types of housing built in the construction area. It is necessary to choose the fastest and most accurate among these applications. Multi-criteria decision making methods will direct the designer / decision maker to make the right decision quickly as a result of numerical analysis. With this study, the usability of multi-criteria decision making methods has been demonstrated in the areas to be decided.

References

[1] Ş. Çıkış, F. İ. Ek. " Imaginary Transformation of the Concept of Luxury in Housing: Multi-Storey Luxury Houses in Izmir City Center," Journal of *Architecture,* p.348, 2009.

[2] E. K. Tosun ve Z. Fırat, " Changes in Urban Space and Housing Preferences of Persons: The Case of Bursa," *Business and Economics Research Journal, v.*3, i.1, p.173-195, 2012.

[3] Uğur L. O., "Construction Project Manager Selection with MOORA Optimization Approach: A Multiple Criteria Decision Making Practice", Jornal of *Polytechnic*, v.20, i.3, p.717-723, 2017.

[4] V. Athawale. M., Kumar, R., & S. Chakraborty, "Decision Making for Material Selection Using UTA Method," *International Journal of Advanced Production Technologies*, v.57, i.11, p.1-4, 2011

[5] J. Siskos, "Evaluation of a Furniture Retail System Using Interactive Sequential Regression Method," *European Journal of Operational Research*, v.23, i.2, p.179-193, 1986.

[6] M. Beuthe, ve G. Scannella,," Comparison of Multiple Criteria Analytical Methods: UTA Applications," *RAIRO-Operations Research Journal*, v.30, i.3, p.293-315, 1996.

[7] J. Siskos, Y., Grigoroudis, E. and Matsatsinis, N.F., *UTA Method*. "In multi-criteria decision analysis: Latest technology surveys", Springer, New York, p.297-334, 2005.

[8] Accessing VisualUTA Program: http://idss.cs.put.poznan.pl/site/visualuta.html