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MULTI-ATTRIBUTE DECISION MAKING METHOD USED IN AN ACQUISITION OF REAL ESTATE

Summary

The real estate market is constantly changing and there are more and more factors to be taken into account. Hence it is often necessary to seek new tools of analysis. The aim of the paper is to draw attention to the possible use of multi-attribute decision making method in the study of complex phenomena connected with an acquisition of real estate. A general outline of decision analysis is presented, including its orientation and model, as well as general characteristics of the method – ELECTRE III. The author believes that this paper is a good basement to lead the further researches showing an assessment of this method applicability and of possible domains where can be of use.

Keywords: decision making, ELECTRE III, real estate, MCDA method

Introduction

The process of real estate acquisition is characterized by many factors, both of easily and hardly measurable nature. Therefore, it is the multi-criteria problem. So far, many decisions and choices of appropriate solutions for specific issues and practical situations based on intuition or experience of individual brokers, developers or expert teams. Unfortunately, many of these decisions are subjective opinions. Support for this process may be the use of multi-attribute methods that significantly contribute to solving the problems with objective and credible assessment (Buchanan et al. 1998). This paper focuses on the above mentioned approaches, in which the development scenario of the simple real estate problem is constructed. It is evaluated by a set of criteria with an application of a selected

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MCDA (*Multiple Criteria Decision Analysis*) method. The results of research focused on selection and application of the most appropriate ranking method for the multiple criteria evaluation are presented. The novelty and originality of this paper is the fact that so far no one has used ELECTRE III to solve any of real estate problems.

The paper is composed of five sections. The first one presents the introduction. In the second section the characteristic of MCDA is presented, selected MCDA method ELECTRE III (Roy 1996; Vincke 1992) is characterized and finally the methodology of solving multi-criteria decision problems is described. Sequent section draws attention to the factors that should be taken into account in an acquisition of real estate process. In the next section a simple decision problem is formulated and its alternative development scenarios are presented. The evaluation criteria and decision maker's preferences are defined. The computational experiments carried out with an application of ELECTRE III method and its results are presented, as well. Due to the lack of open source application of ELECTRE III, all calculations have been made in own prepared application in Matlab. The last section presents conclusions and further research directions.

1. The methodological background of MCDA

Multiple criteria decision theory is a field, which aims to give the decision maker some tools in order to enable this person to solve a complex decision problem where several points of view must be taken into account (Roy 1996). MCDA concentrates on suggesting "compromise solutions", taking into consideration the trade-offs between criteria and the decision maker's preferences. The decision maker is a person, who has a great impact on the decision making process – expressing preferences, evaluating the situation, considering different solutions and approving final results. In many decision situations not only decision maker is involved but analyst as well. An analyst is an expert responsible for recognition of the decision problematic, construction of the decision model of the considered situation, explanation of consequences of decisions and selection of the appropriate decision aiding methods and tools. Decision aiding methods and tools support the decision maker and the analyst in solving multiple criteria decision problems. These methods are often divided into three major groups (Henig, Buchanan 1996):

- choice (optimization) methods, providing optimal solution of the decision problem,
- sorting methods, providing the allocation of alternatives into predefined classes,
- ranking methods, providing the rank/ hierarchy of alternatives from the best to the worst.

In many academic positions two major streams of MCDA methods are distinguished: the European school based on the outranking relation and the American school based on multi-attribute utility theory. The most popular representatives of those streams are: AHP, Promethee methods, UTA methods, and ELECTRE. The author of this paper concentrates on one of MCDA methods – ELECTRE III and its algorithm is presented below.

First step of ELECTRE III method is to describe the set of alternatives A construction and the set of consistent family of criteria F definition. The definition of decision maker's preferences is based on the modeling of indifference q, preference p and veto v thresholds for each criterion. Every criterion should also have defined a weight, which determines its significance in the decision making process (Roy 1991). The ranking of alternatives is based on two classification algorithms: descending and ascending distillations. They provide the ranking of alternatives from the best to the worst option. In the descending distillation the best alternative is placed on the top of the ranking, while in the ascending distillation at the bottom. At the end of the algorithm based on the two distillations, the final ranking is formulated.

The selected MCDA method is applied to rank alternatives of one main problem. In this case, the following methodology of solving multi criteria decision problems presented in this paper is used to:

- identification of the decision problem and its verbal characteristic,
- construction of the mathematical decision model,
- analysis of the method and algorithm to solve decision problem,
- computational experiments,
- analysis and evaluation of the results, choice of the most satisfactory, compromise solution.

2. The acquisition of real estate – description of selected criteria

Most people have some idea about where they would like to live in the future. For some, it is a split-level apartment in the center, for other a property on the outskirts of the city or a small house in the countryside. There are many factors that determine the acquisition of real estate and an overview of the most important factors is shown below. According to different sources and research positions, two of the most important factors are price and location (Raport 2011). The high importance of the price factor seems to be fully justified in the circumstances, when the average price per sqm in Szczecin is nearly twice bigger than the average monthly net salary. Furthermore, observing the current situation in the real estate market, it can be found a relationship between the size of a flat, and its price. This is obviously not a linear relationship but it is characterized by a decline in prices with the increase in the size of a flat (Hozer 2008). The next most important factor – good location, means better access, less time in a traffic jam or in a public transport. It is obvious that the flat located in a good neighborhood has often facilitated access to kindergartens and schools, health centers, parks or sports center as well. Among the elements affecting the choice of location of the flat can be distinguished: the availability of public transport, easily access by car, district, distance to: the city center, parks and recreation, the workplace, the shopping center. Other often mentioned factors are standard of a flat and its accommodation plan. Most people are interested in housing that:

– has a bright kitchen,
– has a balcony/terrace,
– has a living room which is connected to the kitchen,
– has a bedroom in the east, because it is easier to get up in the morning.

In addition to these factors, very often an important issue is the height of a residential building and the material from which it was built. Among the potential buyers the most popular buildings are those which have no more than four floors. Hence, the next factor is the floor on which a flat is located. It turns out that the cheapest flats are on the ground floor and the top floor – especially when the block has no lift. A new trend is also taking into account additional facilities. Among them we can distinguish: garage/parking, additional storerooms and recreational facilities on the estate include a swimming pool and tennis court, designed exclusively for the residents. Figure 1 presents six the most important factors among clients during the real estate trade.

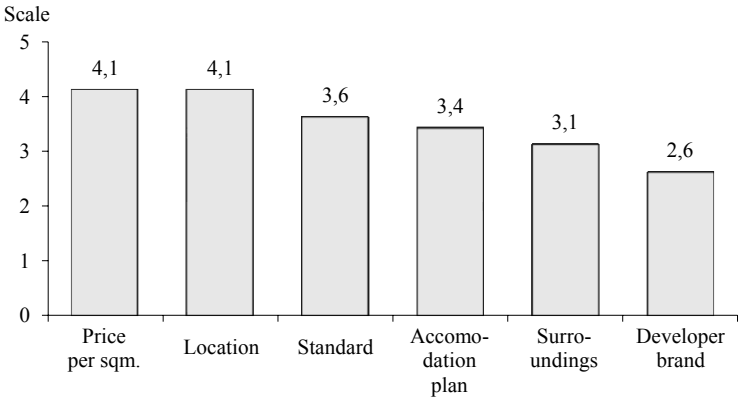

Figure 1. The ranking of factors

Source: own work based on Raport of CB Richard Ellis and Murator, 2011.

It is important to know which factors actually increase the value of the property, and which only serve to raise prices. With this knowledge, the buyer can not only save a lot, but also find an appropriate house. As it can be seen, the process of acquisition is multi-criteria task and using MCDA methods can facilitate this process, what will be shown in next section.

3. The ELECTRE III – implementation

The first important thing in decision process is to define the main problem. In this case it is the choice of the best flat available on the market. For many people, who do not have sufficient knowledge in this field, this kind of problem is difficult and they make a choice based on the others suggestions or real estate agents' help, which is often very expensive. Therefore, the tool which can solve this problem is presented below. At the beginning of this implementation, using ELECTRE III method, the alternatives are defined. The set of variants – denoted by A – was constructed on the basis of offers on the secondary market in Szczecin.

Finally, only eight of them are selected and presented in Table 1.

Table 1

The set of variants

	Description
Flat 1	Rezedowa street, Gumieńce, 52 m^2, 4100 PLN/m^2, 3 rooms, 4 floor, 1985 year, cellar and balcony
Flat 2	Wojska Polskiego street, Centrum, 47 m^2, 4250 PLN/m^2, 2 rooms, 6 floor, 1970 year, elevator and balcony
Flat 3	Mickiewicza street, Pogodno, 50 m^2, 4650 PLN/m^2, 3 rooms, 2 floor, 1998 y ear, garage, cellar and terrace
Flat 4	Z. Krasińskiego street, Niebuszewo, 40 m^2, 4550 PLN/m^2, 2 rooms, 2 floor, 1970 year, cellar
Flat 5	Mieszka I street, Pomorzany, 51 m^2, 4140 PLN/m^2, 3 rooms, 6 floor, 1989 year, elevator and balcony
Flat 6	H. Sucharskiego street, Świerczewo, 48 m^2, 4610 PLN/m^2, 3 rooms, 3 floor, 2001 year, cellar and balcony
Flat 7	Krakowska street, Gumieńce, 55 m^2, 4320 PLN/m^2, 3 rooms, 2 floor, 2002 year, cellar and balcony, parking place
Flat 8	Santocka street, Pogodno, 47 m^2, 4290 PLN/m^2, 3 rooms, 4 floor, 1974 year, balcony

Source: own work.

The alternatives are evaluated by the set of criteria. Taking into account the advice of experts in this field, seven criteria are selected (each of them has index g):

- **g1** – *Location* – depending on the area in which it is located in Szczecin and immediate surroundings (including also access to public transport). The rating scale is from 1 to 10, where 10 is the best rating.
- **g2 –** *Price per sqm.* – calculated on the basis of the ratio of the total price of the flat by the size of the flat.
- **g3** – *Standard* – during the site inspection a flat got points to determining the standard of living in a scale of 1 to 5, where 5 is the best score. The elements that enter the evaluation are: walls, doors and windows, equipment.
- **g4** – *Accommodation plan* – during the site inspection a flat got points in a scale of 1 to 5, where 5 is the best score. If in the flat are interconnecting rooms, or very small rooms, then the score is lower.
- **g5** – *Floor* – due to the fact that there isn't a ground floor in any of the variants, the lower floor is the better then higher.

– **g6** – *Year of building construction* – the year of commissioning of the building and it is also strictly associated with the material from which the building is made.
– **g7** – *Additional facilities* – assessed on the basis of additional elements, such as the basement, garage, balcony/terrace, recreational facilities. Applied scale from 1 to 5, where 5 is the best score.

Table 2

Matrix of performances for the problem

g	Flat 1	Flat 2	Flat 3	Flat 4	Flat 5	Flat 6	Flat 7	Flat 8
g1	7	9	8	6	7	8	7	8
g2	4100	4250	4650	4550	4140	4610	4320	4290
g3	4	5	5	3	4	5	4	3
g4	5	4	5	4	5	4	3	5
g5	4	6	2	2	6	3	2	4
g6	1985	1970	1998	1970	1989	2001	2002	1974
g7	3	2	5	1	2	3	4	1

Source: own work.

Next step is to define the thresholds and weights for each criterion. A threshold is a limit that is chosen to establish the point from which an element changes its class. Thresholds are used to take into account hesitation. Within ELECTRE III method three types of thresholds are used (Rogers, Bruen 1998).

– The **Preference Threshold**, denoted by **p**, defines the point from which an element is strictly preferred in relation to another element. For example, a price per sqm. is 4100 PLN and it is strictly preferred to a price of 4650 PLN.
– The **Indifference Threshold**, denoted by **q**, defines an interval within two elements which are considered equal. For example, a price per sqm. is 4250 PLN, can be considered, for comparison purposes, equivalent to a price of 4290 PLN.
– The **Veto Threshold**, denoted by **v**, is a limit beyond which the credibility of the outranking relation of two alternatives is refused. For example, if the difference of price per sqm. of two flats is bigger than 1000 PLN, then the credibility of that outranking relation is refused.

Weights are substitution rates and assess relative preference among criteria. Weights in ELECTRE III are "coefficients of importance" and, as Vincke (1992) points out, are like votes given to each of the criterion "candidates". Weights (**k**) are differentiated in the scale from 0.01 to 1, where 1 is assigned to the most preferable criterion by the decision maker. In the problem considered in this paper the highest value of weights has g2 – 0.275 points, while the lowest weight has g6 – 0.05 points. Sum of the weights is 1 in order to facilitate the calculation. It should be also added that the criteria g1, g3, g4, g6, g7 are maximized, while the criteria g2 and g5 are minimized. The matrix of preferences is constructed (see Table 3).

Table 3

Matrix of preferences for the problem

g	*q*	*p*	*k*	*dp*	*v*
g1	1	3	0.225	max	8
g2	100	500	0.275	min	1000
g3	0	2	0.15	max	4
g4	1	2	0.1	max	4
g5	1	3	0.075	min	10
g6	5	20	0.05	max	50
g7	1	2	0.125	max	4

Source: own work.

In the next step of EL ECTRE III method, the outranking relation is constructed and then exploited. Firstly, a measure of concordance is developed, as contained in the concordance matrix $\boldsymbol{C}(a, b)$, for every pair of alternatives $(a, b) \in A$. Let k_j be the importance coefficient – weight for criterion j. A valued outranking relation is valued as follows (Roy 1996):

$$C(a,b) = \frac{1}{K}\sum_{j=1}^{7} k_j \, C_j(a,b), \text{ where } K = \sum_{j=1}^{7} k_j \tag{1}$$

$$C(a,b) = \begin{cases} 1 & \text{if} \quad g_j(a) + q_j(g_j(a)) \geq g_j(b) \\ 0 & \text{if} \quad g_j(a) + p_j(g_j(a)) \leq g_j(b) \end{cases} \tag{2}$$

The concordance calculations for Flat1 and Flat2 are:

c1 (Flat1, Flat2) = 0,5 since $7 + 1 \leq 9$ and $7 + 3 \geq 9$ then $\frac{3+7-9}{3-1} = 0.5$

c2 (Flat1, Flat2) = 1 since $4100 + 100 \leq 4250$

c3 (Flat1, Flat2) = 0.5 since $4 + 0 \leq 5$ and $4 + 2 \geq 5$ then $\frac{2+4-5}{2-0} = 0.5$

c4 (Flat1, Flat2) = 1 since $5 + 1 \geq 4$

c5 (Flat1, Flat2) = 1 since $4 + 1 \leq 6$

c6 (Flat1, Flat2) = 1 since $1985 + 5 \geq 1970$

c7 (Flat1, Flat2) = 1 since $3 + 1 \geq 2$

C (Flat1, Flat2) = $0.5 \cdot 0.225 + 1 \cdot 0.275 + 0.5 \cdot 0.15 + 1 \cdot 0.1 + 1 \cdot 0.075 + + 1 \cdot 0.05 + 1 \cdot 0.125$

C (Flat1, Flat2) = **0.8125**

Table 4

The Concordance Matrix

	Flat 1	Flat 2	Flat 3	Flat 4	Flat 5	Flat 6	Flat 7	Flat 8
Flat 1	1.0000	**0.8125**	0.6983	0.9250	0.7250	0.8233	0.8983	0.9250
Flat 2	0.6233	1.0000	0.7500	0.9250	0.6233	0.8750	0.4750	0.6500
Flat 3	0.7250	0.7250	1.0000	0.6500	0.7250	0.7250	0.6500	0.7250
Flat 4	0.4983	0.3500	0.6000	1.0000	0.6233	0.4000	0.4000	0.7250
Flat 5	0.6500	0.8500	0.6983	0.9250	1.0000	0.8233	0.7733	0.9250
Flat 6	0.7250	0.7250	0.5250	0.6500	0.7250	1.0000	0.6500	0.7250
Flat 7	0.6250	0.6500	0.7500	0.9250	0.6250	0.9250	1.0000	0.6250
Flat 8	0.4233	0.5750	0.6000	0.9250	0.6233	0.6000	0.4000	1.0000

Source: own work.

In this matrix pairwise comparisons between alternatives are presented, that is why on the diagonal there is always value 1. These concordance values are easily interpreted. The value 0.9250 in concordance matrix between Flat 5 (row) and Flat 4 (column) indicates that there is a clear evidence that alternative Flat 5 outranks alternative Flat 4, while the value 0.3500 between Flat 4 and Flat 2 proves that there is a poor evidence that Flat 4 outranks Flat 2. Computational experiments of the values presented in concordance matrix do not include veto threshold. The results of outranking relations, which include v are presented in discordance matrix. The discordance index for each criterion j, $D_j(a, b)$ is calculated as:

$$D_j(a,b) = \begin{cases} 1 & if \quad g_j(a) + v_j(g_j(a)) \le g_j(b) \\ 0 & if \quad g_j(a) + p_j(g_j(a)) \ge g_j(b) \end{cases} \tag{3}$$

For each pair of flats $(a, b) \in A$, there now exists a concordance and a discordance measure. The final step in the model building phase is to combine these two measures to produce a measure of the degree of outranking; that is, a credibility matrix which assesses the strength of the assertion that "*a* is at least as good as *b*." The credibility degree for each pair $(a, b) \in A$ is defined as:

$$S(a,b) = \begin{cases} C(a,b) \Rightarrow D_j(a,b), \forall j \\ C(a,b) \cdot \prod\limits_{j \in J(a,b)} \dfrac{1 - D_j(a,b)}{1 - C(a,b)} \end{cases} \tag{4}$$

This formula assumes that if the strength of the concordance exceeds that of the discordance, then the concordance value should not be modified. If the discordance is 1 for any $(a, b) \in A$ and any criterion *j*, then $S(a, b) = 0$. The credibility matrix for this example is:

Table 5

The Credibility Matrix

	Flat 1	Flat 2	Flat 3	Flat 4	Flat 5	Flat 6	Flat 7	Flat 8
Flat 1	1.0000	0.8125	0.6983	0.9250	0.7250	0.8233	0.8983	0.9250
Flat 2	0.6233	1.0000	0.7500	0.9250	0.6233	0.8750	0.4750	0.6500
Flat 3	0.7250	0.7250	1.0000	0.6500	0.7250	0.7250	0.6500	0.7250
Flat 4	0.4983	0.3500	0.0000	1.0000	0.6233	0.4000	0.3333	0.7250
Flat 5	0.6500	0.8500	0.6983	0.9250	1.0000	0.8233	0.7733	0.9250
Flat 6	0.7250	0.7250	0.5250	0.6500	0.7250	1.0000	0.6500	0.7250
Flat 7	0.6250	0.6500	0.7500	0.9250	0.6250	0.9250	1.0000	0.6250
Flat 8	0.4233	0.5750	0.0000	0.9250	0.6233	0.6000	0.3333	1.0000

Source: own work.

Only remarked results are different as in Concordance Matrix, cause of increased D_j. The last step in the ELECTRE III method is to exploit the model and produce a ranking of flats from the credibility matrix. The general approach for exploitation is to construct two preorders Z1 and Z2 using a descending and

ascending distillation process and then combine these to produce a partial preorder $Z = Z1 \cap Z2$. Finally, the ranking of alternatives is computed (see Figure 2).

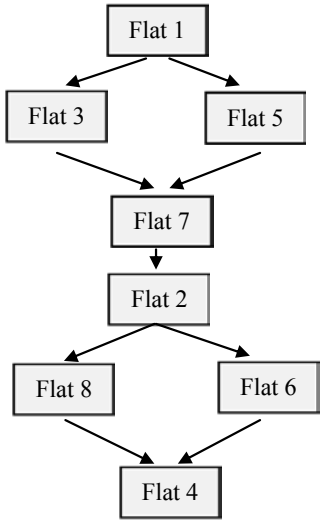

Figure 2. Final ranking of alternatives

Source: own work.

Based on the final ranking of eight competing flats, can be concluded that:

- The best option of the adopted criteria and with the assumed preference model is Flat1 – relatively low price per sqm., good standard and very good accommodation plan, and also it has a basement and a balcony. Rezedowa street is on a quiet housing estate with a playground for children and good access to public transport.
- The worst solution has proved to be Flat 4.

The used method made it possible to rank the eight proposals for alternative solutions of choosing the best flat to living. ELECTRE III method gives the flexibility to model the expectations of the decision maker, expressed in the form of evaluation criteria, and its preferences in the form of threshold values. The presented approach is universal and can be applied to different multi criteria problems in real estate market.

Conclusions

This paper presents the application of selected MCDA method for an acquisition of real estate. In the case, the problem is relatively complex, because simple methods of MCDA could not be used (such as MAXMIN or even the methods of elimination (Vincke 1992)). In addition, each issue of decision problem was well defined, which facilitated the creation of a mathematical model. The biggest problem of tested method was the scope of decision alternatives. This problem resulted from a large number of combinations, and even at eight studied variants, mathematical models greatly expanded. Focusing on the observed defects studied method, the described – ELECTRE III, is characterized primarily large computational complexity. Moreover, it is difficult to access any tools to assist its entire process. The disadvantage of this method may also be difficulty in choosing the thresholds and weights for the criteria, which even for experts may not be easy task. If this task is made without the assistance of systematic preference model, the output can be misleading and values may be arbitrary. The presented method has not only drawbacks, but advantages as well. One of the advantages of ELECTRE III is its versatile usability. It has been shown as a solution to the problem of choosing the best flat for decision maker, but there are no obstacles to create a mathematical model used in valuation of the property. By imposing certain restrictions and well-defined assumptions, this method has achieved the goal and made it possible to identify the best available options. It precisely calculates the final result in the form of an ordered list. Nothing precludes that it has been used for other problems that arise in a real estate market. This work can help to create an expert system or datebase in a real estate office. The effective use of the information which described models provide depend on experience, knowledge and intuition of the decision maker.

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ZASTOSOWANIE METODY WSPOMAGANIA PODEJMOWANIA DECYZJI PRZY ZAKUPIE NIERUCHOMOŚCI

Streszczenie

Rynek nieruchomości ciągle się zmienia i pojawia się coraz więcej czynników, które należy brać pod uwagę, dlatego konieczne jest poszukiwanie nowych narzędzi do analizy. Celem artykułu jest zwrócenie uwagi na możliwość wykorzystania wieloatrybutowej metody podejmowania decyzji w badaniu złożonego procesu związanego z zakupem nieruchomości. W artykule przedstawiono ogólny zarys procesu decyzyjnego, w tym model decyzyjny, a także charakterystykę użytej metody – ELECTRE III. Autorka uważa, że artykuł ten może być dobrą podstawą do prowadzenia dalszych badań, pokazując użyteczność tej metody i wskazując możliwe kierunki wykorzystania.

Słowa kluczowe: podejmowanie decyzji, ELECTRE III, nieruchomość, wieloatrybutowe metody wspomagania decyzji