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A SELECTION OF OFFERS ON THE SZCZECIN RESIDENTIAL MARKET WITH THE AHP METHOD

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Abstract

This article presents the application of the AHP method (Analytic Hierarchy Process) for a multi-criteria decision analysis of the offers of residential premises. The rankings of the offers are the result of the study which takes into account the preferences of specific social groups (consumer profiles). The study has verified the view that the widespread use of the AHP method for the complex issue of multi-parametric selection and the choice of the preferred residential offers – from among a large number of distributed adverts in different websites – requires the development of the specialised computer system.

Keywords: residential real estate market, preferences, analytic hierarchy process

JEL classification: R31, C39

Introduction

An apartment provides a sense of security and shapes the material and social conditions of human life. The frames of existence of an individual, family, and even society are created by such features of an apartment, such as its: size, layout, location and surroundings. Suitable residential conditions are conducive to the stabilisation of life, and stimulate socio-economic and cultural development (Szyszka, 2008, p. 149). What an apartment provides is the provision of opportunities for rest, eating meals, maintaining personal hygiene, and exercising care over the family members. An apartment enables the development of family and social life, and the maintenance of neighbourhood bonds. It gives a sense of belonging to a particular community, is a place for learning and upbringing, and also for some a workplace (Turnowiecki, 2008, p. 91).

Residential properties play an important social role, which is to satisfy human needs. The level of satisfaction depends on the implementation of the preferences held. The knowledge of the preferences of the buyers of residential premises and criteria, which guide them, while making choices facilitates the smooth functioning of business entities serving the real estate market. Consumer preferences reflect his taste and depend on contentment, satisfaction, and habits. The buyer places such combinations of goods, which maximise its usefulness, i.e., satisfaction drawn from their consumption (Ostasiewicz, 2003, p. 31). In formal terms, the preferences mean pre-order (the binary feedback and transitive relation) or linear pre-order (the binary feedback, transitive and consistent relation) specified in the space of the profiles for goods or services. The relation of preferences enables the consumer to assign an individual scale of preference, on which it is possible to value the profiles of products and to optimise choices (Bąk, 2005).

The aim of the article is to rank the offers of residential premises in accordance with the need profiles of specific social groups. The empirical material used in the study came from the websites of selected real estate offices in Szczecin. The analysis was conducted by using the multi-criteria decision ordering method AHP (*Analytic Hierarchy Process)*, which allowed us to order the comparable offers and the selection of the one, which best reflects the buyer's expectations.

1. The AHP method

The AHP method takes into account the specifics of psychological evaluation processes, which most of all have a relational and hierarchical nature. Numerous applications of this method in supporting economic, technical or social decisions confirm its suitability for solving decision

problems, especially in situations, when criteria are qualitative in nature, and evaluations are subjective and result from the knowledge and experience of the analyst (Downarowicz, Krause, Sikorski, Stachowski, 2000). The discussed procedure is used for ranking decision variants and indirectly for supporting their choice. The AHP method was developed by Prof. T.L. Saaty, who started working on the construction of the algorithm in the 1970s (Saaty, 1977, 1980). It is used for solving decision problems, which can be presented in the form of a multi-level hierarchical structure.

Using the AHP procedure, we begin by defining the purpose and by defining a coherent family of criteria relevant to the decision problem. Given the *m* set of decision variants, marked as $\mathbf{a}^i$ ($i = 1, \ldots, m$) the calculation process can be performed in four steps (Trzaskalik, 2006).

1. Construction of a criteria comparison matrix. Finding a vector of scale for the criteria, which is marked as $\overline{\mathbf{b}} = \left[\overline{b}_1, ..., \overline{b}_n\right]^{\mathrm{T}}$, requires the use of the Saaty method. This method enables the calculation of accurate values of a vector for a consistent matrix and an approximation of this vector in the case of the proportional comparison matrix. For the comparison of pairs, Saaty proposes the use of a nine-point scale, which was presented in Table 1.

Table 1. Numerical and verbal evaluations in the AHP method

Validity scale	Definition	Explanation
1	Equal importance	Equivalence of the compared elements (decision variants or criteria)
3	Weak or moderate advantage	Weak (or moderate) preference for one element over another
5	Great advantage	Strong preference of one element over another one
7	Very strong advantage	The dominant meaning or a very strong preference of one element over another one
9	Extreme or absolute advantage	The vast predominance of one element over another one − it is at the highest level possible to determine
2, 4, 6, 8	For a compromise of comparisons between the values 1, 3, 5, 7, 9	Used in a situation, where there is a need for numerical interpolation of the compromised opinions
1.1–1.9	For elements of imminent importance	Used when the significance of the elements are close and almost indistinguishable
The inverse of the validity scales	Transitivity of assessments	If the element *i* and it has one of the numerical ratings indicating the result of a comparison with the element *j*, then *j* has the inverse value, when we compare it with the element *i*

Source: own study based on Adamus, Gręda (2005), p. 16.

2. For each criterion $j = 1, \ldots, n$ the construction of a comparison matrix of decision variants with respect to this *j*-th criterion. We can observe a method: Saaty or power, and the found vector can be marked as $\mathbf{b}^j = \left[b_1^j, b_2^j, ..., b_m^j\right]$.

3. Determination of the matrix, where the columns are formed in the scale vectors of suitable criteria.
4. The emergence of the final vector of the acceptable solutions scale:

$$\mathbf{b} = \mathbf{C}\bar{\mathbf{b}} \tag{1}$$

The aggregation of assessment in the AHP method takes place according to the additive utility function, synthesising the weight fractions or criteria and the values of the degree of fulfilment for the fractional objective function by each criteria. Assessment of the degree of the fulfilment of these criteria for the considered decision variants are obtained by the method of pair comparisons (Downarowicz et al., 2000).

The Saaty method used to determine the normalised eigen vector takes place in the following sequence (Trzaskalik, 2006):

– summing up the rating α_{ij} in each column of the comparison matrix $\mathbf{A} = \left[\alpha_{ij}\right]_{i,j=1,\ldots,m}$ according to the record:

$$\sigma_j = \sum_{i=1}^{m} \alpha_{ij} \tag{2}$$

where: α_{ij} – the number which is the result of the pair comparison of decision variants;

– construction of the normalised matrix $\mathbf{B} = [\beta_{ij}]_{ij=1,\ldots,m}$ – where:

$$\beta_{ij} = \frac{\alpha_{ij}}{\sigma_j} \tag{3}$$

– calculation of the approximate scale vector $\mathbf{b}$ according to the formula:

$$b_i = \frac{1}{m}\sum_{j=1}^{m} \beta_{ij} \tag{4}$$

– determination of the approximate value of matrix **A**:

$$\lambda_{\max} = \frac{1}{m}\sum_{i=1}^{m} \frac{(\mathbf{Ab})_i}{b_i} \tag{5}$$

In order to determine the extent to which the assessment of the decision-maker recorded in the matrix $\mathbf{A} = \left[\alpha_{ij}\right]_{i,j=1,\ldots,m}$ are consistent, we should calculate the compliance rate:

$$c = \frac{\lambda_{\max} - m}{r(m-1)} \tag{6}$$

where: $\lambda_{\max}$ – the highest eigenvalue of the comparison matrix, m – the size of the comparison matrix, r – the random index of compliance calculated from a randomly generated matrix with dimensions m, where the figures are contained in Table 2.

Table 2. Values of the random index

Rząd macierzy (m)	2	3	4	5	6	7	8	9	10
Losowy indeks (r)	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Source: own study based on Trzaskalik (2006), p. 69.

If the compliance rate $c \leq 0.1$ the occurrence of the assessment compliance is approved, we should perform the pair comparisons again.

2. The situation on the residential real estate in 2016

In 2016, the situation on the residential real estate market in Szczecin, as in most large Polish agglomerations, remained balanced. The rates of the estimated availability of loans and housing increased. This impact on this situation came, among others, from: the constant price per square metre of housing, rising nominal household income, as well as the stable interest rates of the new PLN mortgage loans. Residential property prices in the primary market were higher compared to the offers on the secondary market. In Szczecin, the average price per square metre in the primary market was 4,839 PLN, while in the secondary market 4,384 PLN. The residential investment in the discussed period was seen as profitable in the short term compared to the bank deposit, 10-year treasury bonds or commitment to the commercial real estate market (NBP, 2017, p. 1–2).

Again, a significant share of the population's own funds have been noted in financing housing transactions. There was also a further decline in the share of foreign currency loans in financing housing investments. Due to the depletion of funds, fewer loans were paid under the "Houses for the young" program. The value of newly issued housing loans in PLN was still high. In general, at the end of 2016, banks were experiencing an increase in demand for housing loans. The decision to purchase an apartment by buyers was accelerated by the prospect of new provisions of the S Recommendation entering into force (from January 2017). There was an increase in the minimum contribution of the borrower up to 20%.

It has been observed that there was a high profitability of residential investment projects which were maintained in 2016. This was due to the relation which was favourable for developers in terms of housing price to the low costs of materials and construction work, accumulated land resources for the construction of new residential projects and high demand. At the same time, the number of newly built apartments decreased, and the number of permits for the construction

of new apartments increased. Compact apartments enjoyed the largest demand that is two-room apartments with a small area. On the other hand, the demand for larger apartments with an area of over 60 m^2 was similar to that of previous years.

The "Houses for the young" program was gradually phased out. In September 2016, the Polish government launched the National Housing Program. It was intended to comprehensively address the issues that comprise the national housing policy. At the end of 2016, the National Housing Fund was established at the Bank of National Economy (BNE). The local governments, state treasury, companies and housing co-operatives are to provide land for it. The Property Fund for Rent for the BNE was also very active. The borrower Support Fund started functioning from February 2016, directed, among others, to borrowers, who had a temporal problem with the repayment of the loan (NBP, 2017, p. 4–5).

3. The scope of research and empirical material

In the web space there is a very large group of specialised, national and regional sites, which advertise the sale of residential properties. The content of the advertisements in these websites are not standardized. Often they lack the full specification of the parameters of the residential offer, or it occurs in the form of a verbal description. This fact makes searching for offers very tedious, because it involves browsing (including reading descriptions) in multiple sites.

The study verifies the view that the use of the AHP method for the complex issue of multi-parametric selection and the choice of offers requires the development of the specialised computer system (which is made available in the form of a website). The system should provide the users with: the reference sets of criteria and preference (consumer profiles), the possibility to define individual profiles, select offers, their arrangement and grouping, and notifying the user about new proposals occupying high positions in the ranking.

The empirical material used in the study came from the offices of real estate agents, as of 5.06.2016. 15 offers recommended by the following agencies were selected: Bonus, World of Real Estate and Real Estate Rent. Preliminary calculations – involving the standardising of the offer data, defining and visualising the consumer profiles – were performed in a spread sheet of the MS Excel program, while the fundamental part of the study (ranking) was performed using the DSS 2.0 system (Becker, Budziński, 2015; Becker, 2015).

Table 3. Structure of the assessment criteria of the residential real estate

Criteria		Sub-criteria
D1	Costs	K11 – purchase costs [PLN]
		K12 – future operating costs (the amount of rent) [PLN]
D2	Type of the market (2p. primary, 1p. secondary)	
D3	Cubic area of the residential property	K31 – surface [m^2]
		K32 – number of rooms (M2, M3, M4, M5 – points issued separately for each profile)
		K33 – condition (5p. very good, 4p. good – requires a few changes, 3p. requires finishing, 2p for partial renovation, 1p. for full renovation)
		K34 – additional space (balcony, terrace, porch, garden – **points issued separately for each profile**)
D4	Building structure	K41 – age of the building (5p. new or several years, 4p. a dozen or so years, 3p. moderate 20–60 years, 2p. old 61–100 years, 1p. very old, over 100 years)
		K42 – type of the building material (1p. plate, 2p. brick)
		K43 – number of floors (5p. – ground floor or 1 floor, 4p. – 2 floors; 3p. – 3 floors, 2p. – 4 floors, 1p. – over 4 floors)
D5	Building surroundings (level or availability 1–5p.)	K51 – security level
		K52 – garages
		K53 – playgrounds
		K54 – public utility (clinic, chemists, offices)
		K55 – service points, shops
		K56 – education (kindergarten, school)
		K57 – green areas (park, forest)
		K58 – public transport

Source: own study.

The multi-criteria analysis of offers was conducted from the point of view of three different consumer groups (preference profiles). In the study it was assumed:

- P1-DM (mature married couples) – married couples with many years of experience; people aged over 50, with savings and a stable professional situation, no family obligations; the couple want to exchange a big apartment for a smaller one, with 2 or 3 rooms (down size);
- P2-MM (young married couples) – married couples aged over 30, with management positions, showing a credit score, with children at preschool or school age, who because of this desire to exchange small apartments for a bigger one, with 3 or 4 rooms (upgrade);
- P3-MS (young "singles") – single people, professionally active, without children, aged from 24 to 30, with their own business activity or a well-paid job in the budget sector, with savings, which they want to complete with borrowed money or purchase their own apartment with 1 or 2 rooms.

The decision to buy an apartment is one of the most important life decisions. We can list a few requirements, which determine future choices. These include, above all: location, price,

surface, number of rooms in the flat and the type of the market – primary or secondary. In the task of scheduling the offers of flats sales 5 main criteria were determined, from among which 4 were decomposed to one level of sub-criteria. The assumptions are summarised in Table 3.

For each consumer group, using the Saaty method (by way of comparison of the criteria in pairs) we determined separate preference vectors at individual levels of the criteria tree. At the general level (main criteria) it was assumed that preferences do not differ significantly in individual profiles. The most preferred criteria for each group included: D1 – Costs (P1-DM 28%, P2-MM and P3-MS by 27%) and D5 – Building surroundings (P1-DM 28%, P2-MM 25% and P3-MS 27%), then D3 – Cubic area of the apartment (P1 and P2-MM by 22%, P3-MS 24%). A relatively smaller importance was defined for criteria D4 – Building construction (P1-DM 14%, P2-MM 17% and P3-MS 16%), and the least significant D2 – Market type (P1-DM 8%, P2-MM 9%, P3-MS 5%).

4. Arranging offers according to the defined consumer profiles

The determined preferences on the sub-criteria reflect the characteristics of individual consumer profiles. The analysis results were summarised in the form of bar graphs in Figure 1. For example, in a group of sub-criteria, the cubic area of the apartment (D3) for profile P2-MM

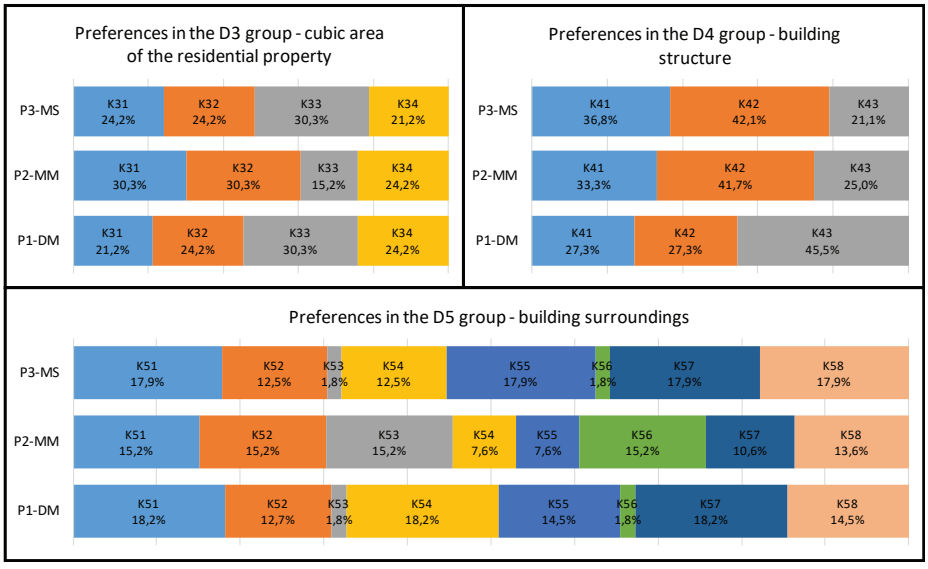

Figure 1. Sub-criteria preference in the consumer profiles

Source: own study.

(young married couples with children) the highest ranks were assigned to the surface of the apartment (K31) and the number of rooms (K32). While the lowest importance was given to the technical condition of the apartment (K33). It was assumed that a family is willing to bear the additional costs of the renovation of the apartment, which meets the requirements in terms of the size and number of rooms. In other consumer profiles the assumption was to the contrary, the technical condition of the apartment (K33) is the most important. Figure 1 omits the structure of costs (D1), because it was assumed that from the point of view of the defined consumer profiles, the purchase costs (K11) and operating costs (K12) of the apartment have the same rank.

Giving rank to the evaluation criteria is not the only way to take into account the preferences in the AHP method. It is also possible to determine the qualitative values (or numerical subjected to quantization), characterising the housing offers at the given criterion, numerical values of the scale vector using the pair comparison method (used in analogy to the criteria). In order to increase the usability values, the calculated values were transported to the selected, ordinal rating scale. In the study, separately for each consumer profile, this way determined the scales for the sub-criterion value, the number of rooms (K32) and the extra space (K34). The results are included in Table 4. It was also assumed that the rating scales for the other sub-criteria of the qualitative nature are the same in all profiles (Table 3).

Table 4. Individual assessment scales for consumer profiles

Sub-criterion name	Sub-criterion value	Profile P1-DM		Profile P2-MM		Profile P3-MS	
		scale vector	p.	scale vector	p.	scale vector	p.
K32 – extra space	balcony	0.133	2	0.267	4	0.200	3
	terrace	0.200	3	0.333	**5**	0.333	**5**
	garden	0.333	**5**	0.067	1	0.133	2
	cellar	0.333	**5**	0.333	**5**	0.333	**5**
K34 – number of rooms	1 room	0.058	1	0.045	1	0.359	8
	2 rooms	0.337	7	0.068	1	0.447	**10**
	3 rooms	0.516	**10**	0.296	5	0.124	3
	4 rooms	0.089	2	0.592	**10**	0.069	2

Source: own study.

In accordance with the established point scale, the source data was coded, which described the residential offers. As a result, for the profiles specified in the study we prepared a total of three sets of data (values of criteria and preferences), which were introduced to the DSS 2.0 system and subjected to the AHP method calculations. The comparison of the results of the multi-criteria assessment and ordering of the housing offers for individual profiles was presented in Figure 2.

Mature marriages (P1-DM)			Young marriages with children (P2-MM)			Young single people (P3-MS)		
Obiekt	Nazwa potoczna	Preferencje	Obiekt	Nazwa potoczna	Preferencje	Obiekt	Nazwa potoczna	Preferencje
CC0004	O14/Warszewo	Nnjwyższy	CC0009	O24/Warszewo	Nnjwyższy	CC0004	O14/Warszewo	Nnjwyższy
CC0012	O32/Gumieńce	Nnjwyższy	CC0004	O14/Warszewo	Nnjwyższy	CC0006	O15/Bukowe	Nnjwyższy
CC0009	O24/Warszewo	Nnjwyższy	CC0012	O32/Gumieńce	wysoki	CC0012	O32/Gumieńce	Nnjwyższy
CC0015	O35/Bukowe	wysoki	CC0002	O12/Gumieńce	wysoki	CC0015	O35/Bukowe	Nnjwyższy
CC0006	O15/Bukowe	wysoki	CC0006	O15/Bukowe	wysoki	CC0009	O24/Warszewo	Nnjwyższy
CC0002	O12/Gumieńce	wysoki	CC0015	O35/Bukowe	wysoki	CC0002	O12/Gumieńce	wysoki
CC0008	O23/Pogodno	wysoki	CC0005	O15/Bukowe	wysoki	CC0005	O15/Bukowe	wysoki
CC0005	O15/Bukowe	średni	CC0008	O23/Pogodno	średni	CC0008	O23/Pogodno	średni
CC0014	O34/Warszewo	średni	CC0007	O22/Gumieńce	średni	CC0014	O34/Warszewo	średni
CC0013	O33/Pogodno	niski	CC0014	O34/Warszewo	średni	CC0013	O33/Pogodno	niski
CC0007	O22/Gumieńce	niski	CC0010	O24/Warszewo	średni	CC0007	O22/Gumieńce	niski
CC0001	O11/Śródmieście	niski	CC0013	O33/Pogodno	niski	CC0003	O13/Pogodno	niski
CC0010	O24/Warszewo	niski	CC0003	O13/Pogodno	najniższy	CC0001	O11/Śródmieście	niski
CC0003	O13/Pogodno	niski	CC0001	O11/Śródmieście	najniższy	CC0010	O24/Warszewo	najniższy
CC0011	O31/Śródmieście	najniższy	CC0011	O31/Śródmieście	najniższy	CC0011	O31/Śródmieście	najniższy

Figure 2. Summary of the results of the housing offers ranking for consumer profiles

Source: reports from the calculations performed in the DSS 2.0 system.

Differences in the order of occurrence of the offers in individual rankings are noticeable, and in the case of several offers quite significant. For example, for the profile of young marriages with children (P2-MM) for the first place the system recommended the offer no. CC0009. This number conceals an apartment located in the district of Warszewo. It is new, but comes from the secondary market, with a high standard; it has got 3 rooms and additional utility rooms. In the close proximity of this property, there are: a garage, playground, green areas and kindergartens and a school. In the ranking for mature marriages (P1-DM) this offer took 3rd place, and in the combination for young, single people (P3-MS) – fifth place.

Structures of the variation of the values of the aggregated assessments in individual rankings are different. The highest mark obtained in the given ranking was the local standard and the results from other offers referred to it, dividing their assessments by the value of the standard. The calculated interests were quantized to five categories (the lowest – to 20%, low – over 20 to 40%, medium – over 40 to 60%, …, the highest – over 80%) and presented in Figure 2. In the studied population, the largest number, that is five most recommended housing offers, was obtained for the profile P3-MS, for P1-DM three offers, and for P2-DM only two. It is worth mentioning that Saaty also proposed the reference of the assessments in the AHP ranking to the external standard, and in this case a perfect housing offer, declared by the consumer.

Conclusions

After the introduction of a certain simplification – resignation from the stage of the pair comparison of the alternatives of choice and the use of individual assessment scales reflecting the decision-maker's preferences – it is possible to use the AHP method for solving mass problems (e.g. with a very large number of assessed housing offers). The analytical hierarchical process can constitute a basis for the construction of a computer system recommending offers, e.g., as a multi-criteria ranking made available in the form of an Internet service. An important element of this system will involve the adoption of the adequate standard for obtaining data. The information contained in the Internet advertisements of the offers for selling housing properties is largely non-standardised (a large part of data is included in the form of verbal descriptions).

At the core of the AHP method lies the assumption of the independence of criteria, which in fact does not always take place. Then it is worth using the expansion of this method – ANP (Analytic Network Process). The super matrix used in the ANP of the limited values (limited super-matrix) takes into account all dependencies, and also the indirect ones (Saaty, 2004).

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