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Comparative Analysis of Urban Condition the Residential Market Area with the Use of GIS Tools

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Abstract. Analysis of the significance of structural and spatial similarities aims to identify homogeneous categories of real estate markets on the basis of the urban features of the area. Real estate markets play an increasingly important role in the global economy and investment, which is why the reliable view of residential market area became an essential tool in the process of investment planning. The positions of particular cities that will be developed by themselves according to established criteria can be crucial when choosing an investment location, and can affect the range of influence of the central site for the entire region.

The aim of the research is to conduct the comparative analysis of the condition of residential market area in relation to their urban features. The social, spatial, economic and residential factors will be analysed taking into consideration their exogenous structure. The assessments of coherence and diversification of esidential markets similarities in terms of their mutual location will be shown in the article. The developed methodology will be presented on the example of the largest residential markets centers in Poland. Due to the dynamic and complex nature of the information related to real estate (in various residential regions), and increase the objectivity of the results, the assumptions of data mining analysis and GiS tools will be used.

Keywords: residential market, similarities or urban area, ranking of area condition.

Conference topic: sustainable urban development.

Introduction

The specific character of the real estate market, the availability of market information and the sudden, and unpredictable changes that often occur on that market, as well as the investments are affected by considerable risks and uncertainties. Objective monitoring of the real estate market as a requirement to maintain balance, increase security and minimize the risk of crisis in urban spaces. The main type of market considering by authors is residential market due to the fact that it is an issue that sooner or later everyone has deal with due to the need to have a place to live as one of the basic human needs. At the same time, it is necessary to emphasize that the broad and varied needs which may be fulfilled by real estate remain in inseparable relation to the expectations and needs determined with respect to the space surrounding us. Nowadays, studies about market condition, its structure and characteristics, are crucial to determine not only the attractive prospects and the potential growth of an area but also the criteria to choose an investment location. Furthermore, the residential market cannot be analyzed without considering its relationship with the quality of life or the state and condition the surrounding urban areas. The link between real estate markets and potential of urban growth is highlighted by many researchers e.g. (D'Arcy, Keogh 1999; Leung 2004; Foryś 2011; Kotler *et al.* 1993; Renigier-Biłozor *et al.* 2015). Real estate markets play an increasingly important role in the global economy and attract a growing number of international investors, which is why the demand for reliable classification and scoring systems will continue to grow and become an essential tool in the process of investment planning. Combining spatial analysis and property market analysis increase the reliability and quality of analysis. For example d'Amato *et al.* (2016), proposed a model to address risk premium maps considered a spatial approach to cap rate and risk premium determination. The role of spatially modelled variable on real estate markets has been highlighted in many different works for example: Des Rosiers *et al.* (1999, 2003); Cellmer 2014; Sivitanides, Sivitanidou 1996; Renigier-Biłozor *et al.* 2015. The positions of particular cities that will be developed according to established criteria can be crucial when choosing an investment location, and can affect the range of influence of the central site for the entire region. Considering this in work Constantino *et al*. (2009) presets solutions analysis of hope value for Appraising the Effect of an Urban Infrastructure on Surrounding Lands.

Classification of real estate markets according to condition the location of urban space is very useful especially in the context of decision-making investment processes in housing markets. That classification can be used then in property markets rankings as a tool providing objective comparability criterion in the adopted reference perspective, thus help in making rational (procedural) decision on the real estate market. The selection and application of

appropriate methods is not easy in the context of the real estate market due to the specificity of the object of analysis. The use of analytical models taking into account the aspect of spatial dependency of variables can give reliable results particularly in the context of the phenomenon depending on the quality of life and investment decisions on housing market (Renigier-Biłozor *et al*. 2015). The structure of the spatial interaction model can be represented with the use of GWR models belonging to the group of spatial heterogeneity. The use of spatial econometric models is quite commonly used for various types of analysis taking into account the spatial dependence (Fotheringham *et al*. 2002; Cellmer 2014; Lloyd 2007). In the field of real estate markets the models are generally used in the analysis of real estate prices. However the authors proposed procedure for classification of markets in the form of ranking on the basis of aggregated information about state and condition of location the urban space. The proposed procedure used the assumption of the decision making theory, technology of data mining and GWR method. This allow to conduct comparative assessment the diagnosis of the market condition and increase the efficiency of decision making on the market. The study was conducted on the basis of the biggest markets in Poland – capitals of the regions within the time of in 2015.

Methodology of the research

Decision-making on the real estate market is complicated from the point of view of the needs that the property is supposed to satisfy. The difficulty also lies in the diversity and imprecision of space attributes, a large and multidimensional scope of data to be analyzed, the sensitivity of properties to environmental or economic changes and fashion, as well as heterogeneity with respect to the nature and type of individual objects. The same time it is obvious that decision-making on the real estate market is difficult and it may result in great risk and uncertainty. In order to minimize risk and facilitate the process, various kinds of systems supporting decision-making processes are recommended. The typical components of systems supporting decision-making with the use of data mining techniques (Hand *et al.* 2005; Słowiński 1992; Zavadskas, Turskis 2011; Kaklauskas *et al.* 2011) consist in: a model, a structural formula of a database, scoring functions of the adjustment of a model to reality, a choice and optimization of an analytical method used in data exploration, a strategy of data management in their availability and updates.

The consideration of the general condition of a spatial unit (the real estate market) is increasingly discussed in theoretical and practical aspects. In order to make the information more comprehensible, various types of classifications and segmentations are used. Market classifications can be divided into two main categories. The first category is related to the markets sharing depending on the subject, object or condition of the property e.g. (Razzak 2015; Goodman, Thibodeau 1998). The second way involves a classification is ranking and rating of real estate markets allowing for a mutual review of individual markets, their quantitative and qualitative comparison in terms of hyper-local and/or global approach. In this group one of this is the subject of this study. This classification allows for comparative assessment of the real estate market states and condition. The potential and power of classifying the real estate market in this second form was indicated among others by: Anglin and Yanmin (2011); Kalberer (2012); Kaklauskas *et al.* (2015).

Considering these assumptions, the authors proposed the procedure to assess condition of residential urban space in the form of ranking. The procedure consisted of several stages that were methodologically opened. It contained the following stages: definition of the rating subject that was established as a set of information to be evaluated, determination of the range and category of information, determination of the pattern of the database structure and verification of the available sources of information, unification and normalization of the data in the database, data significance verification and their relation, establishing ranking classification for information category in the subset, elaboration on levels of ranking for the information category in the subset, application GWR methods attempts to capture spatial variations. The main part of the presented procedure was applying method based on entropy and GWR method.

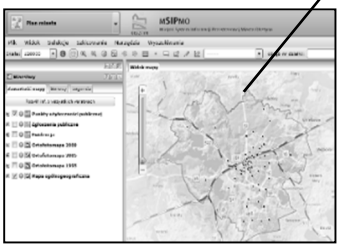
Due to the specificity of the information on the real estate markets, the measure of the entropy was used. The entropy allow to analysis the significance of the factors in the developed database and measures the uncertainty associated with a random variable, i.e. the expected value of the information in the message.

In recent years, a simple but powerful technique called geographically weighted regression (GWR) has been developed to explore the spatially varying relationships and to account for spatial autocorrelation (Fotheringham *et al*. 2002). GWR attempts to capture spatial variations by allowing regression model parameters to change over space. The local estimation of model parameters is obtained by weighting all neighboring observations using a distance decay function, assuming that the observations nearby have more influence on the regression point than the observations further away.

Data description

Within the range of this study, the database was developed on the basis of the biggest residential markets in Poland (16 markets). All the proposed markets constitute the most important space impact onto other regions and the best point of reference – representation of their region, also on account of more complete access to data. The database was developed for the 2015 with the use of geoinformation sources (Fig.1) as well statistical data from Local Bank Data.

Social categories			
	1	2	3
Białystok	44	9,58	21,30
Bydgoszcz	36,8	7,75	18,50
Gdańsk	33,9	9,61	21,10
Katowice	23,3	9,76	21,60
Kielce	40,3	7,45	18,10
Kraków	33,1	10,03	21,30
Łódź	40,3	10,21	22,40
Lublin	30,7	13,24	24,30
Olsztyn	53,5	9,40	21,50
Opole	40,3	8,27	20,40
Poznań	34,9	8,94	21,00
Rzeszów	44,5	7,11	17,80
Szczecin	21,5	8,42	20,40
Warszawa	31,3	8,92	21,60
Wrocław	53,1	10,70	22,50
Zielona Góra	40,7	9,49	21,20



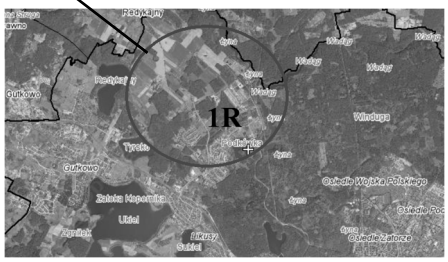


Fig. 1. Elaboration database with the use of geonformation sources
Source: Own elaboration with geoportal and Municipal Spatial Information System utilization

The data were divided into four categories of information (Table 1). The division of information take into account specific categories of data/information which are connected with the condition of urban space. Categories of information have been developed, considering the verification of the assumptions due to the substantive and practical possibilities of obtaining specific information and access to sources of information. The developed draft allows multicriterial description of information affecting and illustrating the condition of the residential real estate markets. When performing analysis of literature items, including among others: Ball and Wood (1999), D'Arcy and Keogh (1999), Kaklauskas *et al.* (2011), along with own studies of authors Renigier-Biłozor *et al.* (2015), Renigier-Biłozor *et al.* (2017) a general outline of factors and information reflecting the condition of the real property market (Table 1) was made as follow:

- Social – it describes the real estate market indirectly and shows the quality of life of residents, current and potential situation and condition of urban space.
- Economic and political – it describes not only the current economic situation of the cities but also the quality of the activities of local and national governments to increase the development and prosperity of a region that influence the residents' quality of life.
- Spatial and location – it gives information about the characteristic of an area where a given real estate is located containing also information about facilities and planning regulations.
- Residential – it describes in detail the real estate market characteristics and information about properties, transactions and offers.

Every feature was considered from the determinant or destimulant function in relation to the residential market. The determinants positively influence the features that shape the real estate market condition, while the destimulants have a negative influence on them.

Table 1. The categories of information in the database (Source: own elaboration)

No. ind.	Social type of indicator	No. ind.	Economic and political type of indicator	No. ind.	Spatial and location type of indicator	No. ind.	Residential type of indicator
1	Quality of life	20	Fuel prices per liter (€/liter)	34	Level of retail area (m2/1.000 residents)	48	Usable space in dwelling (per resident)
2	Number of deaths older than 50	21	Number of science and technology parks determinants	35	Supply of office area (m2/1.000 residents)	49	Average number of rooms in a dwelling
3	Forecasting of population number for 2020	22	Number of suspended business activities (per 1.000 residents)	36	Supply of warehouse area (m2/1.000 residents)	50	Value of new mortgage agreement (€ per resident)
4	Forecasting of population number for 2035	23	Number of new registered businesses (per 1.000 residents)	37	Per cent of green areas (per cent)	51	Total number of issued construction permits (per 10.000 residents)
5	Number of private cars	24	Number of businesses employing workers (per 10.000 residents)	38	Cycle path (per 10.000 residents)	52	The average area of room (per m2)
6	Unemployment rate	25	Local government income (€ per resident)	39	Roads with hard surface	53	Number of property transactions (per 10.000 residents)

End of Table 1

No. ind.	Social type of indicator	No. ind.	Economic and political type of indicator	No. ind.	Spatial and location type of indicator	No. ind.	Residential type of indicator
7	Unemployment rate (average from 5 last years)	26	Local government's spending (€ per resident)	40	Number of green parks in the region	54	Value of property transactions (€ per 1.000 residents)
8	Difference between regional and local unemployment rate	27	Number of businesses employing 0-9	41	Population density (per km2)	55	Number of property offers – average from the most popular websites (per 1.000 residents)
9	Population growth	28	Number of businesses employing 10–49	42	Number of buses (per 1.000 residents)	56	The average number of persons in apartment
10	Net migration rate	29	Number of businesses employing 50–249	43	Number of high schools (per 100.000. residents)	57	Availability of apartments on primary market in terms of average salary (m2)
11	Number of marriages	30	Number of businesses employing 250 and more workers	44	Number of science and technology park	58	Availability of apartments on secondary market in terms of average salary (m2)
12	Number of students	31	Number of businesses with foreign capital	45	Number of apartments	59	Offered purchasing power on the local housing market
13	Contribution of people in the productive age	32	Gross Domestic Product	46	Percent of land covered by zoning	60	Transaction purchasing power on the local housing market
14	Contribution of people in the pre-productive age group (%)	33	Difference between the national average salary and the average	47	length of bus-lane	61	Number of real estate agents on the local market (per 10.000 residents)
15	Contribution of people in the post productive age (%)					62	Number of real estate appraisers on the local market (per 10.000 residents)
16	Number of sports clubs (per 10.000 residents)					63	Average time on the secondary market (in days)
17	Number of cultural centers (per 100.000 residents					64	Average difference between the average offered and transaction price of m2 real estate on the primary and secondary market (%)
18	Number of cinemas (per 100.000 residents)					65	Changes in local property offered prices (percentage)
19	Number of hypermarkets (per 100.000 residents)					66	Changes in local property transaction prices (per cent)
						67	Average difference between changes in offered and transaction prices on the secondary and primary market (percentage)
						68	Difference between low and high standard for offered prices (€/m2)

Procedure of assessments of coherence and diversification of residential markets in the form of ranking

In the first part the procedure the unification and normalization of the data in the database were made. The aim of the normalization was to transform multidimensional space of the collected diagnosing variables into a one-dimensional space (objectively comparable). In the presented procedure, the normalization of data was made using the following formulas:

$$\text{for determinant} \quad Z_j = \frac{X_j - X_j^{\min}}{X_j^{\max} - X_j^{\min}}; \tag{1}$$

$$\text{for destimulant} \quad Z_j = \frac{X_J^{\max} - X_j}{X_j^{\max} - X_j^{\min}}, \tag{2}$$

where: Z_j – value of indicator after normalization (0,1), X_j – value of indicator before normalization, X_j^{max} ; X_j^{min} – minimum and maximum of indicator value.

The next stage of the procedure consisted in the verification of the significance and diversification of data in terms of their relevance and importance concerning the purpose of the analysis. Due to the specificity of the information on the real estate markets a measure of the diffusion and characteristic of the market information was proposed with the use of entropy. Therefore the diversity, merit and usefulness of the market information were calculated on the basis of entropy weight, that is, according to Shannon and Weaver (1963), a measure of *"disorder, chaos and randomness of certain information"* that is common characteristic of information connected with real estate markets. Furthermore this method allows data analysis without identifying a dependent variable. Entropy is perceived differently in numerous theories. In this simulation, a measure of entropy (weight vector determined by entropy weight vector determined by entropy proposed by Deng *et al.* (2000) and Ignasiak (2001) was calculated for indicators in the individual categories of rating information according to the formula:

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j}, \tag{3}$$

where: w_j – weight vector for particular criteria, d_j – degree of internal of rating variance , $d_j = 1 - E_j$, E_j – entrpy.

$$E_j = -K \sum_{i=1}^{m} n_{i,j} \ln n_{i,j}, \tag{4}$$

where: $K = 1/\ln m$; $i = 1,\ldots,m$; $j = 1,\ldots,n$, [6], m – number of states in a particular criterion.

It must be stressed that the higher entropy gets, the lower weight is generated. Table 2 presents the example of the obtained result for indicator 1.

Table 2. The weight vector for 1 indicator (Source: own elaboration)

No.ind	E_j –entropii	W_j – weight vector
1	0.9976	0.0062

In the next step the ranking of every category of condition the urban space was elaborated. The level of ranking was specified using the following formula:

$$Sr_j = \sum_{i=1}^{m} Z_j \times w_j, \tag{5}$$

where: Sr_j – level of ranking; Z_j – normalized indicator; w_j – weight vector.

The developed level of rankings for every category of information was shown in Tables 3. For instance, in the case of Bialystok in residential category, the level of ranking indicated from the calculation as follow:

social ranking for Bialystok: 0.0069 + 0.0002 + 0.0003 + 0.0361 + 0.0068 +

0.0002 + 0.0093 + 0.0298 + 0.0079 + 0.0102 + 0.0038 + 0.0153 + 0.0071 +

0.0091 + 0.0041 + 0.1024 + 0.0068 + 0.0072 + 0.0174 = 0.2811.

Table 3. Ranking for markets category of information that influenced the condition of urban space (Source: own elaboration)

City/Markets	RESIDENTIAL	SOCIAL	SPATIAL and LOCATION	ECONOMIC and POLITIC
	Ranking scale	Ranking scale	Ranking scale	Ranking scale
Bydgoszcz	0.2455	0.2836	0.1490	0.2965
Gdansk	0.5168	0.5582	0.1926	0.2695
Katowice	0.4460	0.4503	0.6026	0.1874
Kielce	0.3368	0.2831	0.1737	0.1107
Cracow	0.4264	0.6568	0.1430	0.3139
Lodz	0.3471	0.1459	0.1281	0.1331
Lublin	0.3506	0.3382	0.1360	0.1743
Olsztyn	0.3428	0.5070	0.1716	0.2651
Opole	0.3896	0.5023	0.2498	0.1968
Poznan	0.4649	0.4848	0.3137	0.3415
Rzeszow	0.4611	0.7172	0.1856	0.1732
Szczecin	0.3275	0.3080	0.1222	0.2191
Warsaw	0.5965	0.7282	0.5503	0.7476
Wroclaw	0.4414	0.6085	0.3501	0.3301
Zielona Gora	0.4897	0.6922	0.2105	0.2558

The visual presentation of the results from Table 3 would allow for more comprehensive interpretations of rankings the regions. The ranking of conditions the urban spaces was presented in the Figure 2.

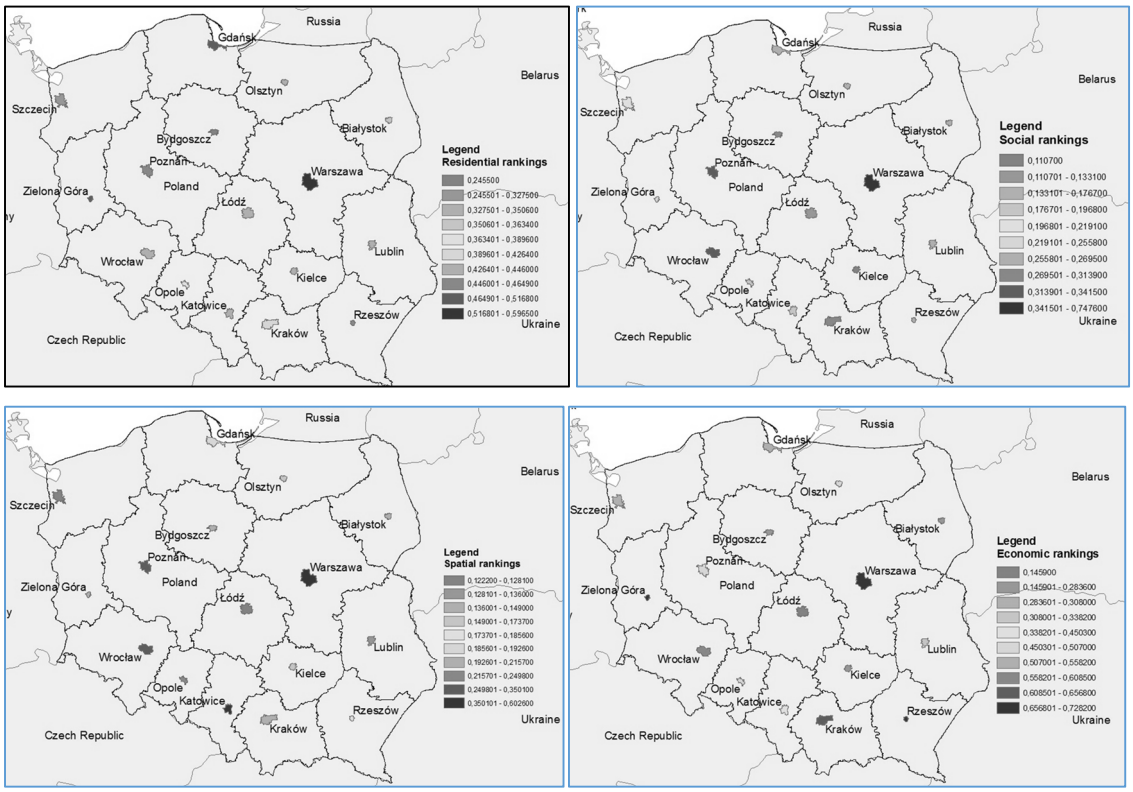


Fig. 2. Cartographic presentation of ranking the condition of urban space
Source: Own elaboration with ArcGis utilization.

From the Figure 2 indicates that we can assume some spatial variation considering state of condition the residential markets and taking into account condition of specific features of location. The variation is not very clear however we can indicate the west – south part of country with better condition and east part with worse condition (excluding Warsaw as a capital of country usually with the best condition). For further analysis and proofs the suspected results the Geographically Weighted Regression that identify the spatial patterns analysis was applied. First was analyzed linear regression and their efficiency on the basis of determination coefficient. The obtained R-squared value for linear regression was of 0.66 (p = 0.000). *The measure of goodness of fit was improved with the use of GWR model and accuracy of the model was obtained on the level of 0.73 (p = 0.000).* Therefore, GWR might serve as a useful tool to explore the spatially varying relationships between condition of residential markets and location, economic and social condition of the urban space. On the Figure 3 we can see the prediction of the ranking the residential condition of the markets on the basis of the potential condition of the urban space.

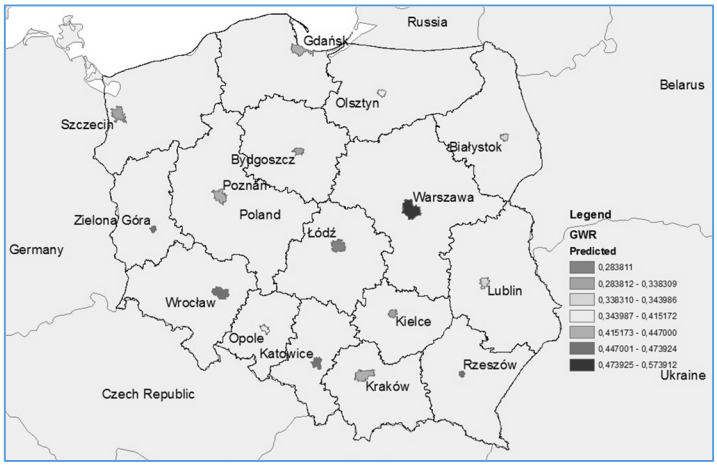


Fig. 3. Cartographic presentation of predicted the residential market ranking of urban space with the use of GWR
Source: Own elaboration with ArcGis utilization.

From this map (Fig. 3) indicates that ranking of condition the residential aspect is higher on the west and south part of country whether the satellites markets of the capital city (Warsaw) have the worse condition, probably due to the strong neighborhood. However is well known that GWR model should be used for large amount of observations. On the other hand even for the small sample of data (16) it can be seen the spatial variation of the condition the residential markets taking into account the development and amenities of the area where the market is located. This results are the signal for conducting further analysis with bigger datasets. The results will enable to develop the decision rulers on the residential markets.

Conlusions

The last Global Financial Crisis, primarily initiated by the insolvency of mortgage borrowers, underlines the importance of an objective monitoring of the real estate market as an absolute requirement to maintain balance, increase security and minimize the risk of crisis in urban spaces. One of the solutions to monitor the situation on the real estate markets is to analyze and monitor the market continuously, in the form of the comprehensive classification. Therefore, the authors proposed a ranking market classification that would provide quick, objective, reliable and updated information.

Combining the data mining methods with spatial analysis enable to conduct reliable interpretation of the results. The analysis allows establishing the residential market condition considering the social, economic, spatial aspects that represents the features of quality of life of every urban space. From the correlation analysis (Table 4) indicated that there is a significant relationship between analyzed sphere of urban areas and residential markets decisional rules. The Pearsons correlation was elaborated on the basis of rankings levels the category of information presented in Table 3.

Table 4. Correlation results for rankings condition of urban space and residential markets (Source: own elaboration)

Pearson correlation results	ECONOMIC and POLITIC	SOCIAL	SPATIAL and LOCATION
RESIDENTIAL	0.6137	0.7848	0.6045

The results indicated that there is a biggest link between social condition to the residential markets in Poland, at the same time the others features (as economic and spatial) are quite important as well. This is due to the fact that

residential housing is an important aspect of the quality of life in any community and people have many different needs related primarily to the aspects of shelter and, on the other hand, many varied needs must be fulfilled by the real estate remaining in an inseparable relation to the surrounding space and its condition.

The recent global financial crisis has highlighted the important role that real estate market plays in the global economy. The specific character of the real estate market, the availability of market information and the sudden, and unpredictable changes that often occur on that market, as well as the investments are affected by considerable risks and uncertainties. Objective monitoring of the real estate market is a requirement to maintain balance, increase security and minimize the risk of crisis in urban spaces. In the era of intensive business fluctuations, reduction of capitalization rates stops in residential resources and increases in significance of comparative analyses in property market, the following needs are increasingly perceived: quality of location of the market concerning conditions and prospects of the local economy, area growth potential, environmental conditions of space, social conditions and ideals, character of business climate in determining the value of real estate and real estate market analysis.

The methodology of the unified classification system that allows for the assessment of the residential property market condition is a requirement to maintain balance, increase security and minimize the risk of crisis in urban spaces. Consequently, the demand for reliable classification and scoring systems will continue to grow and become an essential tool in the process of investment planning and investment decisions.

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