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A RATING SYSTEM FOR THE REAL ESTATE MARKET

The authors propose rating as a new instrument providing objective comparability criteria to classify the residential market. Nowadays we face the growing popularity of various support systems, but comprehensive and effective information systems that facilitate the real estate market continue to be in short supply. The rating methodologies from the capital markets cannot be simply copied to the real estate market. The specificity of the real estate market is totally different. The main aim of this study was the development of a rating procedure for residential markets as a specific instrument to help in the making of reliable decisions within urban development. The classification was conducted on the basis of factors that can have the most important influence on property market decision-making for demand and supply relating to residential, economic and political, social, spatial and location market conditions. The crucial stage in this methodology was the establishing of the benchmark point (BB) distinguished by stimulants or destimulants of the markets. This point might represent the level of similarities (or indiscernibilities, as in rough set theory) of the features in the set. The results demonstrate that the rating of residential markets depends on the expectation of further area development and quality of life rather than the richness of a region.

Keywords: rating, real estate market, competitive markets, decision support systems
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1. INTRODUCTION

Real estate markets are becoming an increasingly important part of the global economy. As a result of the growing interest of international investors in the real estate market, the demand for reliable classification and scoring systems continues to grow. According to Zhang et al. (2018), Szulwic et al. (2015), Dawidowicz and Źróbek (2018), also Ferretti and Montibeller (2016), decision processes are processes based on choosing the best alternative among many alternatives. Along with the development of research to solve problems in multiple attribute decision-making, many theories have been used, including fuzzy sets and rough sets to increase efficiency of the analyses (Zhang et al., 2018, Bello and Verdegay, 2012, Chi et al., 2011, Renigier-Biłozor, 2011). The obtained results related to the

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classification of particular cities' positions might be of great importance when making investment decisions, especially choosing the location of an investment. The residential market is an issue that sooner or later everyone has to 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 an inseparable relation to the expectations and needs determined with respect to the space surrounding us.

On account of globalization, the implementation of IT solutions and the increasing mobility of people, making decisions in the real property market is no longer limited to the analysis of local and technical factors of real properties, i.e. so-called endogenous factors, but it is extended onto exogenous factors (e.g. labor market absorption, economic potential of the area), which influence the long-term efficiency of investments. Residential properties constitute not only a common element for securing basic existential needs and capital location, but they are also an important factor determining the conditions and development and investment potential of a given region.

Analysis of the relationship between urban areas and real estate markets is a current issue for several reasons. Firstly, the development of cities is strongly determined by the development of property markets as an important element attracting people to a given location (Renigier-Biłozor, 2017). On the other hand, a real estate market is also shaped by certain features of its environment: the immediate ones (e.g. prices, vacancies), and, more and more frequently related to macro-economic determinants, e.g. inflation, the prosperity of the area, global crisis, the condition of the banking sector, etc. (Leung, 2004; Jud and Winkler, 2002; Biłozor and Renigier-Biłozor, 2014). The attractiveness of cities is expressed in particular by their inhabitants and capital. According to Kotler (2011), nations and urban areas position themselves on their capacity to attract certain groups of human and physical capital and at the same time discourage other groups (e.g. low-income families, the homeless, or criminal types).

Moreover, housing market fluctuation may result from fluctuation in urban areas (Rossi-Hansberg, 2004; Leung, 2004). According to Renigier-Biłozor (2017), at a time of an exceptionally fast downward demographic tendency of developing and developed countries, the attractiveness of residential markets is a very important competitive attribute of cities and regions. There is a strong feedback between the housing market and the city, because the increase in the potential of residential real estate markets

depends on economic, political, social, spatial and location factors offered by the urbanized space.

On the other hand, according to Dinis (2006) and Kotler et al. (1993), urban development depends on the attractiveness of real estate markets as a result of effective territorial marketing by cities, which according to potential urban residents is an important element of the "migration decision". Furthermore, the attractiveness of the real estate market is a very important element in the process of building a city brand, which is a key factor in shaping and satisfying the residents' satisfaction (Dinnie et al., 2010).

There is a common area of connecting factors to meet the satisfaction of residents that affect the attractiveness of residential real estate markets and their potential to grow at the same time. In both cases these factors can be divided into two types, i.e. the so-called inspirers (involving causes of changes) and demonstrators (involving effects of changes), as the evidence of the most important information which affects the above-mentioned field.

The real estate market works as one of the subsystems of the economic system of a given area. This subsystem in its specificity is related to the economic, political, social, location and behavioral sphere. In this context, the division of information should take into account the macro, mezo and micro scales of the economy, along with the division into specific categories of information (data) which are connected with the analyzed market. In the context of the decision-making procedure, some of the information may be considered as exogenous, that is directly related to the real estate market, and endogenous, also related to the real estate market, but with an indirect relationship or influence, and extended in time. Making decisions is an integral element of human life, and the most frequent activity performed on a micro and macro scale. Making optimum decisions should rely on reliable data describing reality, in line with the decision-maker's preferences (Saaty, 2008). However, access to reliable data or information is difficult nowadays, not so much because of lack of access to them, but due to excessive amounts of information (the so-called information noise) and difficulties in the proper selection of the right type of data. On account of the multi-faceted nature and multiplicity of factors determining the final result of the decision-making process in the real property market, it is possible to offer assistance by working out a certain system in the form of a multi-stage classification structure which could ensure smooth and common access to reliable and precise information. Classification of the real property market's potential on the basis of the conditions and specific character of the analyzed urban space allows for its evaluation and, on the other hand, for inspiring its development

and adjustment to current and future needs. High grades in the classification system attract individual and institutional investors; increased sensitivity of local government authorities to the development of the area and stimulation of the real property market increase the efficiency of decision-making, and positively shape the image of a city, community or region.

The main problem. The complex procedures and decisions as well as the unique character of data are factors that hinder the smooth flow of information on the real estate market. A smooth flow of information is necessary to make rational investment decisions and to engage in other real estate activities. The main problem is to prepare a comprehensive classification of the real estate market relevant to the specific character of real estate market functions. The authors assumed that providing access to knowledge about the real estate market is possible thanks to developing a rating measure of real estate markets providing total and intelligible information classifying the objects of research.

The main aim. The authors propose a rating procedure for real estate markets which can provide objective comparability criteria in the established reference perspective, which was the main aim of research. The obtained results allow for a more efficient self-organization of an area leading to the identification of the economic and social processes in the spatial aspect. The obtained results support the decision-making processes regarding the location of investments in the real estate market, as well as introduce objective comparison criteria for real property markets.

Novelty. In general, ratings are performed by credit rating agencies (CRA) as well as various institutions which use ratings for their own needs, mostly banks, investment funds and insurance companies. Over the last few years we can notice that credit ratings enjoy a growing popularity as a source of information about the risk of bankruptcy, and the financial condition of the analyzed entity. Although recent years have shown the growing popularity of various support systems, there is a lack of comprehensive and effective information systems that facilitate the real estate market. The credit rating methodologies cannot be simply copied to the real estate market, in view of the specificity of the real estate market, due to:

- significant variations in the quantity of available information, subject to the type of the analyzed market (region);
- complex methods of data description (differences in the scale of attribute description);
- significant differences between realties (no two properties are identical);

- various criteria for using real estate (every property can be used and managed in a variety of ways);
- lack of comprehensive information (due to the lack of homogenous systems for gathering real estate data which results in limited and incomplete knowledge about real estate and market prices);
- inaccurate and "fuzzy" character of real estate data (caused by stochastic factors which reflect random processes that escape the generally acknowledged cause-and-effect market relationship);
- absence of homogenous functional dependencies between real estate attributes;
- decision-making strategies represented by the value, function and method of real estate management, etc., and we need the methodology especially to adjust to this domain.

Object. The object of the analysis was the residential real estate markets represented by residential apartments, taking into account the commonality of their use. The study was conducted on the basis of 16 district markets within the time period 2016-2017 constituting the most important space of impact onto other regions and the best point of reference – representation of their region, also on account of more complete access to data. The study contains 122 attributes that were used for the rating classification of real property markets (see Appendices 1 and 2).

Research method. The proposed methodology of the rating classification in the form of a multistage algorithm was developed. Due to the small number of observations (cases), there are limited possibilities of using statistical methods. Therefore, the rough set theory was applied as a method that takes into account the small number of the data. In the analytical part of the procedure to determine the rating for real estate markets the valued tolerance relation formula, existing mainly as an extension model of the classical rough set theory, was applied.

2. RELEVANT LITERATURE – THE NEED FOR PROPERTY MARKET RATING

Rating is an economic term with a variety of meanings. In the discussed context, a rating was defined as the process and the result of the evaluation and classification of a given phenomenon (Renigier-Biłozor, 2017). Generally, ratings are performed by credit rating agencies (CRA), as well as various institutions which use ratings for their own needs, mostly banks, investment funds and insurance companies. Basically, we can define credit

ratings as a system for evaluating and classifying investment risk. Over the last few years we have noticed that credit ratings enjoy a growing popularity as a source of information about the risk of bankruptcy, and the financial condition of the analyzed entity. Despite delayed and inaccurate predictions, credit ratings are a highly effective analytical tool. The independent and objective nature of CRAs has been recognized and emphasized by EU law (Regulation (EC) No. 1060/2009 of the European Parliament and of the Council of 16 September 2009 on credit rating agencies and Commission Delegated Regulation (EU) No. 447/2012 of 21 March 2012 supplementing Regulation (EC) No. 1060/2009 of the European Parliament and of the Council on credit rating agencies by laying down regulatory technical standards for the assessment of compliance of credit rating methodologies). However, the credit rating methodologies (Merrill Lynch, 2000, p. 24.) cannot simply be copied to the real estate market in view of the specificity of the real estate market. We need the methodology to adjust to this domain because of the specific nature of the real estate data and market. The methods and procedures that may be developed and implemented should account for the following defects in real estate data: significant variations in the amount of available data, absence of data, small number of transactions, significant variations in attribute coding, non-linear correlations between the analyzed data and the type of the underlying market, etc. The solutions should support market analysis at the potential (theoretical) and actual (applied) levels (Renigier-Biłozor, 2017).

The necessity of determining the structural and spatial classification of real estate markets results from various conditions. Property markets are commonly classified according to the type of real estate (residential, commercial, industrial, recreational, agricultural), type of traded estate (land plots, buildings, apartments) and geographic reach (local, supra-local, regional, national, international). D'Arcy and Keogh (1999) argued that the role of the property market in determining urban competitiveness is significant. They proved that the real estate market has a direct influence on high and sustainable urban economic growth. Moreover, the significant link between the real estate market and urban space was proved already by Torto Wheaton Research (2002). They showed that for over 300 years real estate prices in Amsterdam had displayed no trends, although they were subject to high volatility, and they indicated that there might be a high probability that some features connected with the social, political and economic conditions of the city may have an impact on this phenomenon. Moreover, Leung (2004) raised the issue that the relationship between the growth and fall of

urban area and housing markets should be indisputably and methodically established.

Taxonomy and segmentation imply a detailed classification of real estate markets, based on the preferences of specific client groups or on quality of buildings. These classifications use basic criteria, which may not be sufficient regarding current increased access to knowledge and the requirements of market participants. A more efficient market classification was presented, among others, by Goodman and Thibodeau (1998, 2003), who classified residential property based on criteria such as spatial variation, neighborhood and physical attributes. Trojanek et al. (2018) estimated models to find the impact of proximity to urban green areas on apartment prices in Warsaw. Liu et al. (2006) and Renigier-Biłozor (2011) indicated that the interaction effects and non-linear relationships between market prices and hedonic variables complicate the direct interpretation of market classification and fluctuation.

Real estate assets are heterogeneous, i.e. their characteristics vary. Researchers and practitioners have found that hundreds of factors might affect real estate markets in various situations. The link between urban amenities, soundness of the housing market and residential mobility were analyzed, among others, by: Bailey and Livingston (2007) and Lee (2014). The motivation for residential mobility has various aspects, but more or less it is connected with residential, that is with the urban, condition. Lee (2014) argued that homebuyers seem to move to neighborhoods of higher quality. The analysis by Deurloo and Dieleman (2006) indicated that homeownership rates have a significant association with residential location choices. Moreover, Dawkins (2005) and Kan (2007) proved that proximity to work places and more information about local housing markets are the determinants indicating home-buying opportunities. Humphreys et al. (2013) found that the opening of a new sports facility could increase both demand for residential housing and residential property values near a facility.

Residential housing is an important aspect of the quality of life in any community. The classification of real estate markets according to quality of life can also be one of the types of diversification of real estate markets. People experience many varied needs related primarily to aspects of shelter. On the other hand, many varied needs must be fulfilled by real estate remaining in an inseparable relation to the surrounding space and its condition. These aspects have been widely debated in the academic literature (e.g. Kaklauskas et al., 2011; Irwin et al., 1993; Jaffe and Sirmans, 1989; Bryx and Matkowski, 2001; Źróbek and Grzesik, 2013; Bełej and Kulesza, 2014).

In the eurozone, the real estate market has exhibited strong growth in many countries over the last decades. Changing housing prices have been of concern to both individuals and governments in that they influence the socio-economic conditions and have a further impact on the national economic conditions. Leung et al. (2004) argued that property prices are closely related to macroeconomic variables. Developments in the housing market have become an increasingly important element in the information set monitored by the central banks. One of the lessons of the recent global crisis was that an excessive increase in asset prices, originating in the financial and the real estate sectors, needs to be kept under constant scrutiny due to its potential disruptive impact on financial stability (Rondinelli and Veronese, 2011). Expectations of capital gains from housing investments affect house prices by increasing the demand for housing, which in turn causes high volatility in prices of housing (Selim, 2009). The housing market can be influenced by macroeconomic variables, spatial differences, characteristics of community structure, and environmental amenities (Brzezicka et al., 2018; Kim and Park, 2005; Goodhart, 2005). Cirman at al. (2015) claimed that the length of time on the market for residential property in Slovenia depends on how the initial list price was set, on property characteristics as well as the financial and general economic conditions of the markets.

Over the past three decades, considerable attention in the literature has been paid to modeling, forecasting, and explaining the long-term equilibrium of house prices and the segmentation of the real estate market (Azadeh et al., 2012; Goodhart, 2005; Goodman and Thibodeau, 2003; Haurin et al., 2013). McCue and Belsky (2007) discussed a number of factors that disturb the equilibrium between the supply and demand in housing markets. Sæther (2008) classified housing market variables into three classes: endogenous, exogenous, and excluded. Shakoorifar and Kaveh (2001) proposed housing parameters and their related effective factors as a general framework of the supply and demand system components.

An accurate prediction of the real estate market potential is essential for prospective homeowners, developers, investors, appraisers, tax assessors, and other real estate market participants, such as mortgage lenders and insurers (Dawidowicz and Źróbek, 2017; Frew and Jud, 2003; Irwin et al., 1993; Jaffe and Sirmans, 1989; Global Real Estate Transparency Index, 2014; McCue and Belsky, 2007; Renigier-Bilozor et al., 2019). Leung et al. (2004) conducted a more comprehensive analysis of the real estate markets to investigate the dynamics of property prices and their interaction with output growth.

Moreover, learning lessons from the last global financial crisis (2007-2008), primarily initiated by the insolvency of mortgage borrowers, it can be assumed that the current and objective monitoring of the real estate market is an absolute requirement to maintain equilibrium, increase security and minimize the risk of crisis in many aspects of human existence in urban space. Although recent years have witnessed the growing popularity of various support systems, there is a lack of comprehensive information systems related to the real estate market. The scarcity of relevant information and objective knowledge results from the shortcomings of market effectiveness analyses (Bieda et al., 2019; Fama, 1990; Janowski, 2018; Kaklauskas et al., 2011; Renigier-Biłozor et al., 2019).

To summarize the above review of the literature, there is an enormous need to have reliable and direct information about the classification of real estate market potential. According to TEGoVA (2003) and Kalberer (2012), Property and Market Rating is a versatile tool for evaluating the quality of property, but it should not be used for markets in general. These authors suggested the use of a developed procedure to assess individual properties' risks for securitization purposes. Anglin and Yanmin (2011) applied real estate market ratings to developing portfolio investment strategies while Berach and Skiba (2011) find real estate market ratings a useful tool for elaborating long-short portfolio strategies on housing indices for more and less risky assets characterized by low liquidity.

3. METHODOLOGY OF RESEARCH

The main objective of the analysis was the development of an analytical rating procedure. The assumed role of rating is the provision of reliable, objective and updated information, therefore the dataset must be provided via a specific knowledge platform for dedicated analyses. In view of the specific character of the real estate market, the availability of market information and the sudden and unpredictable changes that often occur in that market, the developed model of a real estate market rating score system should be flexible enough to enable frequent modifications, and provide a simplified model for the housing market in order to investigate the market more precisely. Table 1 contains a rating scale for real estate markets' classification. The developed rating is adapted to a wide range of receivers with a different level of knowledge about the analyzed real estate market.

Table 1

Rating scale for classifying real estate markets

Group	Description of market characteristics
Investment level (class A)	"High" High return on investments; positive market outlook; high market growth potential; high potential for economic and spatial growth; self-regulatory capacity, flexible response to economic changes; the situation in the real estate market fosters positive social change; satisfactory price-cost relationship; stable behavior of real estate market actors; low threats to the growth of the real estate market; the situation on real estate market fosters positive social change.
Development level (class B)	"Moderate" Moderate return on investments; moderate market outlook; certain threats to market growth potential; moderate potential for economic and spatial growth; lower self-regulatory capacity, less flexible response to economic changes; the situation on the real estate market fosters moderately positive social change; greater discrepancies between the cost and prices of real estate; less predictable behavior of real estate market actors; moderate threats to the growth of the real estate market; the situation on the real estate market fosters moderately positive social change.
Stagnant level (class C)	"Low" Low return on investments; negative market outlook; high threats to market growth potential (supply and demand on the real estate market); low potential for economic and spatial growth; low self-regulatory capacity, significantly less flexible response to economic changes; the situation on the real estate market does not foster positive social change; high discrepancies between the cost and prices of real estate; the behavior of real estate market actors is likely to be unpredictable; high threats to the growth of the real estate market; the situation on the real estate market does not foster positive social change.
Crisis level (class D)	"Lack" / "deficit" No returns on investments; the market is stagnant with no prospects for growth; no potential for economic or spatial growth; the market is undergoing reorganization. The price-cost relationship cannot be determined; the behavior of market participants cannot be predicted; very high threats to the growth of the real estate market; the situation on the real estate market drives negative social change.

Source: own study based on Renigier-Biłozor et al. (2014).

The real estate markets were scored on a 10-point rating scale and then divided into four rating level groups:

1. investment,
2. development,
3. stagnant,
4. crisis.

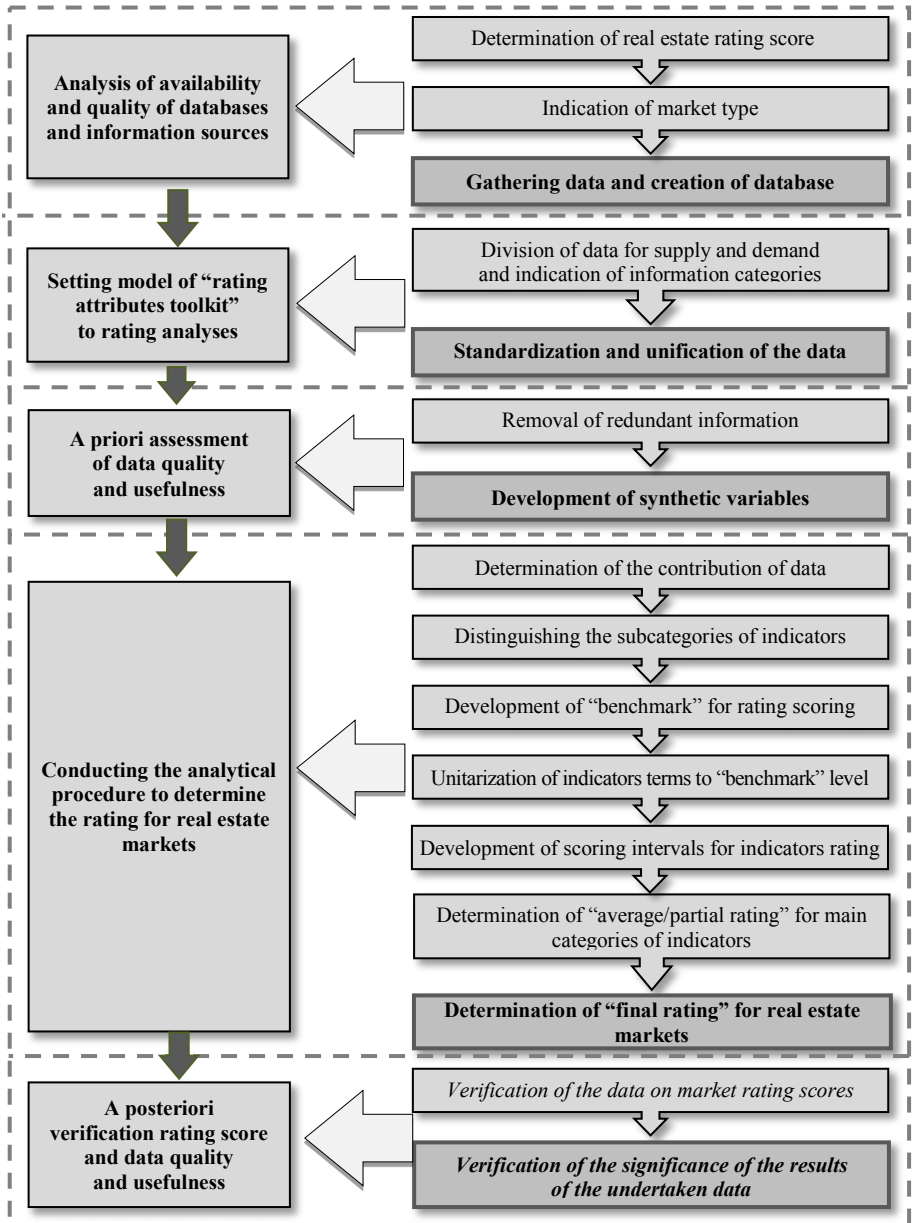

Fig. 1. Procedure of the rating score for the real estate markets

Source: own study based on Renigier-Biłozor (2017).

In each group, one of three results may appear (except for the crisis level group, which has a single score – D):

a) AAA/BBB/CCC – highest rating,
b) AA/BB/CC – medium rating,
c) A/B/C – lowest rating.

The authors' intention was the development of, and then the provision for, a significant element to support decision-making in the market. Therefore, we proposed the methodology of the rating score in the form of a multivariate procedure. Figure 1 presents the proposed procedure of the rating score for real estate markets.

One of the stages of the proposed rating procedure was related to the analysis of the availability and quality of the databases and information sources. To build a reliable rating score for the real estate market it is necessary to define the aim and the range of the study within the determination of the overall rating score. One of the stages of the proposed rating score procedure is related to the analysis of the availability and quality of the databases and information sources. To complete this task, it is necessary to define the type and the segment of the real estate market, and the utility function of the real estate. In the next step, the review and analyses of the sources of information from the available databases were made. For the next stage consisting in building the setting model of a rating attributes toolkit, a division of data should be prepared for various categories of information (social, economic, etc.) within the supply and demand aspect of indicators. In this step the unification of information was necessary. The next step in the rating assessment procedure is the analysis of the quality and suitability of data, consisting in the elimination of unnecessary data with the use of correlation analysis. In order to keep valid information, the development of synthetic variables was assumed. The analytical procedure for determining the rating for real estate markets assumes several key steps used to obtain a final rating for real estate markets. These stages lead to the separation of the subcategory, data unitarization and development of scoring results. The main platform for the analytical ranking of rating levels is benchmarking (reference point). For the analysis, the valued tolerance relation formula, existing mainly as an extension model of the classical rough set theory, was applied. The authors adopted the development of the level of benchmarking, which represents the level of similarities (or indiscernibilities) of features in the set. The development of the level of benchmarking affects the classification of further variable rating levels, which is why it is the most important step of analysis. There are some

limitations in the use of statistical methods, as they are assumed to be applied to a large number of cases compared to the data describing them. Due to the small number of observations, a rough set theory was used. A rough set theory is applied to imprecise, ambiguous and dissimilar data, and its assumptions are simple and repetitive in the following rating years without their changing.

The classical rough set theory was developed (Pawlak, 1982) to analyze the imprecise and vague data which is commonly found in the real estate market and accompanies decision-making (fuzzy decision-making) in that market. Moreover, the theory with a valued tolerance relation extension is used in many sciences, and it is often applied as the main support tool in decision-making systems (Bello and Verdegay, 2012; Chi et al., 2011; Chung and Tseng, 2012; Janowski et al., 2018; Polkowski and Semeniuk-Polkowska, 2010; Zavadskas and Turskis, 2011; Zhang, 2012; Renigier-Biłozor, 2011; Ziółkowski and Niedostatkiewicz, 2019). The rough set theory assumed the development of a decision table – the determination of the domains of different conditional attributes (real estate market attributes) and the decision attribute (rating of the market). To determine decision rules, every object $u \in U$ in the decision table $TD = \left(U, C, \{d\}, V, f\right)$ can be written in the form of a conditional segment (if.... then...), and it can be regarded as a decision rule. In decision table *TD*, the decision rule comprises functions g: $C \cup D \to V$ if $X \in U$ provides for $g = fx$. The restriction of g to *C (g|C)* and g to *D (g|D)* is referred to as the conditions and decisions of decision rule g, respectively. Degrees of indiscernibility are determined at a given level of similarity for sets in decision subgroups based on the following equation:

$$IND_{TD}\left(B,d\right) = \left\{\left(x,y\right) \in U \times U : \left(x,y\right) \in IND_{SI}\left(B\right) \vee f\left(x,d\right) = f\left(y,d\right)\right\}. \quad (1)$$

Conventional rough sets theory is based on the crucial concept of the indiscernibility relation which is a crisp equivalence relation, i.e. complete, reflexive, symmetric and transitive relation valued in {0,1}. Stefanowski and Tsoukiàs (2001, p. 2) argue that, basically, two objects, described by a set of attributes, are indiscernible if they have identical values, unless the objects may be practically indiscernible without having identical values. The concept of valued tolerance as an extension of the usual concept of indiscernibility (which is a crisp equivalence relation) in rough sets theory gives such an opportunity.

Regarding the procedure of rating score, the final stage included a posteriori assessment of rating score and data as regards the quality and

usefulness. In this case the validation of the significance of data and a final rating score in the long term with the use of a cross-method (such as rough set theory, fuzzy cognitive method, etc.) were conducted. The author applied the conducting and presentation of the final step in another analysis.

4. RESULTS – SIMULATION OF RATING PROCEDURE

The rating was performed for residential real estate markets represented by residential flats, taking into account the commonality of their use. The study was conducted on the basis of 16 provincial markets within the time period 2016-2017. All the proposed provincial cities constitute the most important space of impact onto other regions and the best point of reference – representation of their region, also on account of more complete access to data (Renigier-Biłozor, 2017). The database, called the "rating toolkit", was developed in the previous work of one author, entitled "Rating attributes toolkit for the residential property market" (Renigier-Biłozor et al., 2017). The study contains 122 attributes (see Appendices 1 and 2).

The initial stage of the procedure was based on the development of data categories' scope. Indicators for the overall evaluation of the real estate markets were developed. The authors' own observations and the solutions presented in the literature allowed to develop features that could have the most important influence on market decision-making. These features are representative for the categories of information, which are strictly related to political, economic, social, spatial and location fields. Each of these fields includes a different scope of information that affects the quality of life to a varying extent. Thus, in the long term it affects decisions concerning the buying, renting or selling of residential real estate. Appendices 1 and 2 present the classification and designation of variables in the database on supply or demand indicators. This division was proposed due to the diversity of the target group for these two market phenomena (supply and demand) and results from crucial differences in the growth potential of the analyzed real estate markets. During the data processing the initial data were unified and adjusted to the object of analyses. With this purpose in mind, the unification of "raw" data was performed, referring to a given area of a local market, by transforming it into indices expressed in the form of units per inhabitant, units of space, average pay of local inhabitants, or the average price of property.

The aim of the following stage was the removal of redundant information conducted by an a priori assessment of the quality of data in the rating

attributes toolkit. For this purpose, the following analytical procedure was applied. The first step was substantial assessment, simultaneously prepared with cross-correlation analysis. For this purpose, the Pearson correlation analysis (parametric method) and Kendall's τ (to verify the existence of the orderliness of a data set probability – non-parametric method) were applied, as well as data with a cross-correlation higher than 0.80 (on the basis of Guilford (1964), who considered such a result of correlation to be very high) and results of the test of statistical significance. The developed analyses allowed for a decision to be made on the reduction of redundant combinations of variables. Hence synthetic variables were determined with the use of the maximum likelihood estimation of factor analysis. This part was conducted in the previous study (Renigier-Biłozor et al., 2017), and the results of analyses led to removing 29 variables (from the set of 122) and adding 11 synthetic variables instead (Appendix 3).

The following stage of the developed procedure was the determination of the percentage share of indicators in each class of rating score. The contribution was developed on the basis of assuming the importance of each class in the real estate rating classification. The percentage contribution of toolkit indicators on the rating score is presented in Figure 2.

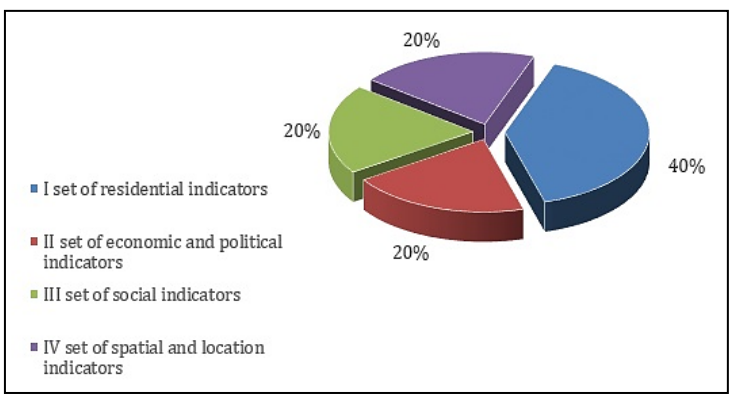

Fig. 2. Contribution of data categories in the rating score

Source: authors' elaboration.

Residential indicators constituted the most significant type of data, followed by political and economic, social, spatial and location indicators. The lower contribution of data expressed by economic, social and location indicators was assumed, due to the indirect connection with the current

situation in the real estate market. In each of the set categories the subcategories of indicators stimulating (sti.) or destimulating (des.) supply or demand were distinguished (Appendix 1). Certain indicators are "bipolar", which means they can have a significant importance both in supply and demand, e.g. the affordability of rental housing, and the contribution of individuals of post-productive age, etc.

The next issue was the determination of a reference point (basic platform) to calculate the rating level for the database. First of all, the adopted rating levels were assigned to numbers: AAA – 1, AA – 2, A – 3, BBB – 4, BB – 5, B – 6, CCC – 7, CC – 8, C – 9 and D – 10. The reference point was the BB level – a rating score was designated due to the observation that demand still outpaces supply in Poland's emerging real estate market (Renigier-Biłozor, 2017). The designation of the BB benchmark level (reference point) was established for each indicator separately with the use of an assumption of the rough set theory and value tolerance relations on the basis of the formula below:

$$R_j(x,y) = \frac{\max\left(0, \min\left(c_j(x), c_j(y)\right) + k - \max\left(c_j(x), c_j(y)\right)\right)}{k} \tag{2}$$

where: $R(x,y)$ – relationship between two sets with membership function [0,1], $c_j(x)$, $c_j(y)$ – indicator of the analyzed real estate market, k – coefficient adopted as standard deviation for a given real estate market attribute. In view of the above, the benchmark (BB) was calculated on the basis of the formula below:

$$BB_i = \max \sum_{j=1}^{n} R_j(x,y). \tag{3}$$

These benchmarks need to be realistic and objectively measurable, which is the crucial point of the assumed methodology (Renigier-Biłozor, 2017). Due to the fact that the purpose of this analysis was to obtain the objective level of the relative comparison values in a specific set of particular the variables, the benchmark level was established on the assumption of the highest value of the similarity in relation to other objects. An example of the conducted analysis is presented in Table 2. This table consists of the result of the calculation benchmark (BB) level for indicator No. 1.

Table 2

Determination of BB point (benchmark) for indicator No. 1 with the use of the value tolerance relation

Market's number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	$R_j(x,y)$															
1	1	0.00	0.07	0.53	0.69	0.00	1	0.38	0.84	0.07	0.84	0.00	0.38	0.22	0.00	0.22
2	0.00	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.07	0.00	1	0.00	0.00	0.53	0.07	0.00	0.22	1	0.00	0.38	0.69	0.00	0.84	0.84
4	0.53	0.00	0.00	1	0.84	0.00	0.53	0.84	0.38	0.00	0.69	0.00	0.00	0.69	0.00	0.00
5	0.69	0.00	0.00	0.84	1	0.00	0.69	0.69	0.53	0.00	0.84	0.00	0.07	0.53	0.00	0.00
6	0.00	0.00	0.53	0.00	0.00	1	0.00	0.00	0.00	0.53	0.00	0.84	0.22	0.00	0.69	0.38
7	1	0.00	0.07	0.53	0.69	0.00	1	0.38	0.84	0.07	0.84	0.00	0.38	0.22	0.00	0.22
8	0.38	0.00	0.00	0.84	0.69	0.00	0.38	1	0.22	0.00	0.53	0.00	0.00	0.84	0.00	0.00
9	0.84	0.00	0.22	0.38	0.53	0.00	0.84	0.22	1	0.22	0.69	0.00	0.53	0.07	0.07	0.38
10	0.07	0.00	1	0.00	0.00	0.53	0.07	0.00	0.22	1	0.00	0.38	0.69	0.00	0.84	0.84
11	0.84	0.00	0.00	0.69	0.84	0.00	0.84	0.53	0.69	0.00	1	0.00	0.22	0.38	0.00	0.07
12	0.00	0.00	0.38	0.00	0.00	0.84	0.00	0.00	0.00	0.38	0.00	1	0.07	0.00	0.53	0.22
13	0.38	0.00	0.69	0.00	0.07	0.22	0.38	0.00	0.53	0.69	0.22	0.07	1	0.00	0.53	0.84
14	0.22	0.00	0.00	0.69	0.53	0.00	0.22	0.84	0.07	0.00	0.38	0.00	0.00	1	0.00	0.00
15	0.00	0.00	0.84	0.00	0.00	0.69	0.00	0.00	0.07	0.84	0.00	0.53	0.53	0.00	1	0.69
16	0.22	0.00	0.84	0.00	0.00	0.38	0.22	0.00	0.38	0.84	0.07	0.22	0.84	0.00	0.69	1
***BB*$_i$**	4.26	0.00	3.66	4.52	4.90	3.21	4.26	3.90	5.02	3.66	**5.12**	2.43	4.64	2.97	4.21	4.73

Source: authors' calculation.

The benchmark point was established at the level of the eleventh market – BB_i was the highest (5.12). Due to this fact the benchmark point for indicator No. 1 was constituted as 49.00, which was the ranking of the quality of local government for market No. 11 (i.e. Szczecin). The benchmark point was determined for every indicator in this way.

The following step concerned the unitarization of indicators of terms to the "benchmark" level. The unitarization of indicators was established on the basis of the formula below:

$$U_i = \frac{x_i - BB_i}{\Delta x_K} \tag{4}$$

where: $\Delta x_K = x_{max} - x_{min}$.

The results of the unitarization value for the sets were sorted in ascending order. An example of the conducted analysis for indicator No. 1 is presented in Table 3.

Table 3

Determination of U_i value for indicator No. 1

Market's number	14	8	4	5	11	1	7	9	13	16	3	10	15	6	12	2
	BB_i = 49.00 and Δx_K = 25															
U_i	-0.16	-0.12	-0.08	-0.04	0	0.04	0.04	0.08	0.2	0.24	0.28	0.28	0.32	0.4	0.44	0.84

Source: authors' calculation.

The next issue was the development of scoring intervals for indicator ratings. The scoring intervals were established separately for stimulants and destimulants with the assumptions below:

- for stimulants: if BB = 0 than AAA = 1 and D = –1
- for destimulants: if BB = 0 than AAA = –1 and D = 1

To account for the above, the intervals were determined separately for stimulants and destimulants (Table 4).

Table 4

Scoring intervals for the indicator's rating

RATING LEVELS FOR STIMULANTS										
Rating class	D	C	CC	CCC	B	BB	BBB	A	AA	AAA
The range of levels	**-1.00**	**-0.8**	**-0.60**	**-0.40**	**-0.20**	**0.00**	**0.25**	**0.50**	**0.75**	**1.00**
Numerical classification	< 0.90	-0.71 to -0.90	-0.51 to -0.70	-0.31 to -0.50	-0.11 to -0.30	-0.10 to 0.12	0.13 to 0.36	0.37 to 0.62	0.63 to 0.88	> 0.88
Rating class	AAA	AA	A	BBB	BB	B	CCC	CC	C	D
The range of levels	**-1.00**	**-0.75**	**-0.50**	**-0.25**	**0.00**	**0.20**	**0.40**	**0.60**	**0.80**	**1.00**
Numerical classification	< 0.88	-0.63 to -0.87	-0.38 to -0.62	-0.13 to -0.37	-0.12 to 0.10	0.11 to 0.30	0.31 to 0.50	0.51 to 0.70	0.71 to 0.90	> 0.90

Source: authors' calculation.

Table 5 presents an example of assessments of indicators from the rating attributes toolkit.

Table 5

Results of the rating for indicator No. 1 (stimulants)

MARKET'S NUMBER																
	14	8	4	5	11	1	7	9	13	16	3	10	15	6	12	2
RATING FOR STIMULANTS																
Rating score	B	B	BB	BB	BB	BB	BB	BB	BBB	BBB	BBB	BBB	BBB	A	A	AA
U_i for indicator No. 1	-0.16	-0.12	-0.08	-0.04	0	0.04	0.04	0.08	0.20	0.24	0.28	0.28	0.32	0.40	0.44	0.84

Source: authors' calculation.

The partial rating scores were determined individually for residential, economic, social and location sub-categories within the supply and demand of sets, as the fourth step of the procedure. An arithmetic mean was calculated from indicators belonging to the given subcategory. For example, the following values were determined for Łódź in the economic and political set for supply: indicator 4 – BB (score 5); indicator 5 – BB (score 5). indicator 6 – B (score 6); indicator 7 – BBB (score 4); mean – 5 (BB). It was necessary to prepare more detailed intervals to account for variations within each rating score ("+" and "–" signs), hence every category has a different contribution in the final rating (Figure 2). The intervals were determined within the main categories to determine the final ranking scores (Table 6).

Table 6

Numerical classification of rating scores

Group		Rating scale	Numerical classification	Median rating score
Investment level	1	AAA +	below 0.75	
		AAA	0.75 to 1.25	1
		AAA -	1.26 to 1.50	1.38
	2	AA+	1.51 to 1.75	1.63
		AA	1.76 to 2.25	2
		AA-	2.26 to 2.50	2.38
	3	A+	2.51 to 2.75	2.63
		A	2.76 to 3.25	3
		A-	3.26 to 3.50	3.38
Development level	4	BBB+	3.51 to 3.75	3.63
		BBB	3.76 to 4.25	4
		BBB-	4.26 to 4.50	4.38
	5	BB+	4.51 to 4.75	4.63
		BB	4.76 to 5.25	5
		BB-	5.26 to 5.50	5.38
	6	B+	5.51 to 5.75	5.63
		B	5.76 to 6.25	6
		B-	6.26 to 6.50	6.38
Stagnant level	7	CCC+	6.51 to 6.75	6.63
		CCC	6.76 to 7.25	7
		CCC-	7.26 to 7.50	7.38
	8	CC+	7.51 to 7.75	7.63
		CC	7.76 to 8.25	8
		CC-	8.26 to 8.50	8.38
	9	C+	8.51 to 8.75	8.63
		C	8.76 to 9.25	9
		C-	9.26 to 9.50	9.38
Crisis level	10	D+	9.51 to 9.75	9.63
		D	9.76 to 10.25	10
		D-	higher than 10.25	

Source: authors' elaboration based on Renigier-Biłozor et al. (2014).

In the next step, the final rating scores were determined for the analyzed markets by calculating the mean for the partial rating scores, taking into account the percentage of each subcategory in the final result. The final rating scores were designated based on the intervals of the rating scores presented in Table 6. The results of the final rating score for the demand and supply of the analyzed markets is shown in Table 7.

Table 7

The final rating score for the residential real estate markets in 2017

RATING OF SUPPLY							
Łódź	**Warszawa**	**Kraków**	**Katowice**	**Lublin**	**Rzeszów**	**Białystok**	**Kielce**
4.81	**3.22**	4.71	3.85	6.09	5.29	6.59	**6.64**
BB	**A**	BB+	BBB	B	BB-	CCC+	**CCC+**
Zielona Góra	**Poznań**	**Szczecin**	**Wrocław**	**Opole**	**Bydgoszcz**	**Gdańsk**	**Olsztyn**
5.63	4.59	6.35	3.48	5.14	6.36	3.53	4.73
B+	BB+	B-	A-	BB	B-	BBB+	BB+
RATING OF DEMAND							
Łódź	**Warszawa**	**Kraków**	**Katowice**	**Lublin**	**Rzeszów**	**Białystok**	**Kielce**
5.58	2.59	4.28	3.42	5.02	4.87	5.84	6.52
B+	A+	BBB-	A-	BB	BB	B	CCC+
Zielona Góra	**Poznań**	**Szczecin**	**Wrocław**	**Opole**	**Bydgoszcz**	**Gdańsk**	**Olsztyn**
5.11	3.24	5.67	3.21	3.72	**6.60**	**2.48**	4.51
BB	A	B+	A	BBB+	**CCC+**	**AA-**	BB+

Source: authors' calculation.

The final rating scores were determined to minimize the impact of the potential subjective classification of various indicators (supplementing No. 1). The rating score for the analyzed markets (the main markets in Poland) in general varied from CCC+ (upper stagnant level to A+ (middle investment level), however the rating for supply and demand was not identical for particular markets. This is understandable because the equilibrium between supply and demand does not exist in real cases in the property markets. The analysis indicated that Warsaw received the highest results for supply (an area in the strongest stage of recent development and with good future expectations of urban growth), and the lowest was received by Kielce (the relatively poorest area of the country, and with uncertain future expectations for urban growth).

At the same time, the rating for demand was different for most markets. Gdańsk received the highest result (an area with a good quality of life, and in a strong stage of development, and with good future expectations for urban

growth), and Bydgoszcz received the lowest (a developing area with close strong competitors such as Toruń with higher quality of life, and with uncertain future expectations for urban growth). However, Opole received a high evaluation of demand rating: Opole (BBB), with a relatively high unemployment rate and poor living conditions, especially in comparison to the nearest main neighboring markets, but with a big potential for growth in contrast to the poor development of the urban areas closest to them.

The noticeable space trend related to the rating score was not observed. It was just noted that the best markets are mostly surrounded by lower-rated markets (e.g. Wrocław – Opole, Łódź, Zielona Góra; or Warszawa – Kielce, Bydgoszcz, Białystok). Probably the markets with the higher score work as a magnet and aggravate the condition of the main market (town) surrounding them. It can be assumed that the analyzed property markets work independently and compete with each other to increase people's interest in their strategy.

The last stage of the elaborated procedure assumed the verification rating score and data on the quality and usefulness a posteriori. This analysis will be conducted in the next study.

CONCLUSIONS

The main purpose of real estate ratings is to provide universal tools to assess the potential of the real estate market and reduce the noise of speculative information. Real estate markets play an increasingly important role in the global economy. As a result of the growing interest of international investors in the real estate market, the demand for reliable classification and scoring systems continues to grow. Thus investors are forced to identify the factors enabling ranking of the analyzed areas for different aims.

The final rating for the main Polish residential markets was established as the crucial scope of the study. The analytical algorithm based on several stages was elaborated to obtain this result. The main methods from data mining technology were used in this procedure, i.e. the methods of Boolean inference, value tolerance relations and scoring analysis. The efficiency of the presented studies depends to a significant degree on the availability and reliability of the data, and the methodology of the analysis. The developed rating provided a current, reliable, useful and comparable view of the situation of particular cities or regions (markets).

The presented analysis based on 2016-2017 data indicated that Polish markets fluctuate around maximum A and minimum CCC+ for demand, while maximum A and minimum CCC+ for supply. Rating scores below BB should be observed (monitored) carefully while rating below B- might be alarming. The classification indicated that some analyzed markets regarding the provincial capitals have alarmingly weak potentials (indicated from rating analyses for 2016-2017 – Bydgoszcz and Kielce) of residential market growth. This should be considered by buyers, sellers and investors, and also by the initiators or inspirers of urban space changes (e.g. local government, business community, etc.).

The following solutions will concern the development of fuzzy cognitive maps for rating real estate markets as a tool that can be used in a decision support subsystem in real estate markets.

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APPENDIX 1

Rating attributes toolkit for the residential property market

Group I – supply-side indicators:	
a) social set	1 – ranking of quality of life for "quality of local government" (max 100 p.) – sti.* 2 – number of deaths of those older than 50 (per 1000 residents) – sti. 3 – contribution of individuals in post-productive age (per cent) – sti .
b) economic and political set	4 – fuel prices per litre – des.* 5 – number of new registered businesses industry and construction (per 10000 residents) – sti. 6 – local government spending on public utilities and environmental protection (per resident) – sti. 7 – local government spending on investments (per resident) – sti.
c) residential set	8 – vacancy rate for office properties (per cent) – des. 9 – vacancy rate for retail properties (per cent) – des. 10 – vacancy rate for warehouse properties(per cent) – des. 11 – number of apartments (per 1000 residents) – sti. 12 – usable dwelling space(per resident) – sti. 13 – average number of rooms in a dwelling– sti. 14 – value of new mortgage agreement (per resident) – sti. 15 – total number of issued construction permits (per 10000 residents) – sti. 16 – number of issued construction permits – individual (per 10000 residents) – sti. 17 – number of apartments with started constructions (per 10000 residents) – sti. 18 – number of completed apartments (per 10000 residents) – sti. 19 – number of completed rooms (per 10000 residents) – sti. 20 – the average number of rooms in completed apartments – sti. 21 – the average area of a room (per m^2) – sti. 22 – number of developers on the local market (per 10000 residents) – sti. 23 –number of property transactions (per 10000 residents) – sti. 24 – value of property transactions (per 1000 residents) – sti. 25 – affordability of rental housing (number of square meters that can be financed from an average local salary per month) – sti. 26 –difference in the structure of (<=40) supply of usable area per transaction and offers on the primary market (per cent) – des. 27 – difference in the structure of (40; 60) supply of usable area per transaction and offers on the primary market (per cent) – des. 28 – difference in the structure of (60; 80) supply of usable area per transaction and offers on the primary market (per cent) – des. 29 – difference in the structure of (>80) supply of usable area per transaction and offers on the primary market (per cent) – des. 30 – structure of (>80) supply of usable area per transaction on the primary market (per cent) – sti. 31 – structure of (>80) usable area supply for offers/quotation on the primary market (per cent) – des.

	32 – balance of supply and demand for apartments below or equal to 50 m^2 on the primary market (per cent) – sti. 33 – balance of supply and demand for apartments over 50 m^2 on the primary market (per cent) – sti. 34 – difference in the structure of (<=40) supply of usable area per transaction and offers on the secondary market (per cent) – des. 35 – difference in the structure of (40; 60) supply of usable area per transaction and offers on the secondary market (per cent) – des. 36 – difference in the structure of (60; 80) supply of usable area per transaction and offers on the secondary market (per cent) – des. 37– difference in the structure of (>80) supply of usable area per transaction and offers on the secondary market (per cent) – des. 38 – structure of (>80) supply of usable area per transaction on the secondary market (per cent) – sti. 39 – structure of (>80) supply of usable area per transaction per offers on the secondary market (per cent) – des. 40 – local government spending on housing policy (per residents) – sti. 41 – number of property offers, average from the most popular websites in Poland (per 1000 residents) – sti.
d) spatial and location set	42 – per cent of land covered by zoning plans – sti. 43 – level of retail area (m^2/1000 residents) – sti. 44 – supply of office area (m^2/1000 residents – sti. 45 – supply of warehouse area (m^2/1000 residents) – sti.
Group II – demand-side indicators:	
a) social set	46 – forecasting of population number for 2020 (per cent in comparison with 2013) – sti. 47 – forecasting of population number for 2035 (per cent in comparison with 2013) –sti. 48 – number of private cars (per 10 residents) – sti. 49 – ranking of quality of life for health (max 100 p.) – sti. 50 - ranking of quality of life for satisfaction with life (max 100 p.) – sti. 51 - ranking of quality of life for safety (max 100 p.) – sti. 52 – unemployment rate (per cent) – des. 53 – unemployment rate (per cent average from last 5 years) – des. 54 – difference between regional and local unemployment rate (per cent) – sti. 55 – population growth (per 1000 residents) – sti. 56 – net migration rate (per 1000 residents) – sti. 57 – number of marriages (per 1000 residents) – sti. 58 – number of students (per 1000 residents) – sti. 59 – contribution of individuals in productive age (per cent) – sti. 60 – contribution of individuals in the pre-productive age group(per cent) – sti. 61 – contribution of individuals in post-productive age (per cent) – sti. 62 – number of sports clubs (per 10,000 residents) – sti. 63 – number of cultural centers (per 100,000 residents) – sti. 64 – number of cinemas (per 100,000 residents) – sti. 65 – number of hypermarkets (per 100,000 residents) – sti.

b) economic and political set	66 – average rent in a new shopping centre (affordability per average local salary-m^2) – des. 67 – average rent in the office blocks (affordability per average local salary– PLN/m^2) – des. 68 – number of science and technology parks – sti. 69 – fuel prices (per liter) – des. 70 – number of suspended business activities (per 1000 residents) – des. 71 – number of new businesses (per 1000 residents) – sti. 72 – number of self-employed individuals (per 1000 residents) – sti. 73 – number of businesses employing 0-9 workers (per 10,000 individuals in productive age) – des. 74 – number of businesses employing 10-49 workers (per 10,000 individuals in productive age) – des. 75 – number of businesses employing 50-249 workers (per 10,000 individuals in productive age) – sti. 76 – number of businesses employing 250 and more workers (per 10,000 individuals in the productive age) – sti. 77 – number of businesses with foreign capital (per 10,000 residents) – sti. 78 – Gross Domestic Product (Poland=100p.) – sti. 79 – local government income (per resident) – sti. 80 – local government spending (per resident) – sti. 81 – difference between the national average salary and the average salary on the local market (per cent) – sti.
c) residential set	82 – the average number of individuals in an apartment – sti. 83 –availability of apartments on the primary market in terms of average salary (m^2) – sti. 84 – availability of apartments on the secondary market in terms of average salary (m^2) – sti. 85 – offered purchasing power on the local housing market (average salary on the local market / average price per 1 m^2 of property in the local market) – sti. 86 – transaction purchasing power on the local housing market (average salary on the local market / average price per 1 m^2 of property in the local market) – sti. 87 – availability of mortgages in terms of m^2 (average property price / average credit rating of a family or individual) – sti. 88 – availability of mortgages on the secondary market in terms of PLN credit (m^2) – sti. 89 – availability of mortgages on the primary market in terms of PLN credit (m^2) – sti. 90 – value of new mortgages (per resident) – sti. 91 – number of real estate agents on the local market (per 10,000 residents) – sti. 92 – number of real estate appraisers on the local market (per 10,000 residents) – des. 93 – number of property transactions (per 10000 residents) – des. 94– value of property transactions (per 1000 residents) – sti.

	95 – average time on the secondary market (in days) – des. 96 – difference between the average offered and transaction price of m^2 the real estate on the primary market (PLN) – des. 97 – difference between the average offered and transaction price of m^2 the real estate on the secondary market (PLN) – des. 98 – changes in local property offered prices (per cent) – sti. 99 – changes in local property transaction prices (per cent) – sti. 100 – difference between changes in offered and transaction prices on the secondary market (per cent) – des. 101 – difference between changes in offered and transaction prices on the primary market (per cent) – des. 102 – affordability of rental housing in the secondary market (number of square meters that can be financed from an average local salary per month) – sti. 103 – difference between the minimum and maximum transaction prices in the primary market (PLN/m^2) – sti. 104 – equilibrium of supply and demand for apartments below or equal to 50m^2 (per cent) 105 – equilibrium of supply and demand for apartments of over 50m^2 (per cent) – sti. 106 – difference between the minimum and maximum transaction prices in the secondary market (PLN/m^2) – sti. 107 – difference between offered and transaction prices for low standard (PLN/m^2) – des. 108 – difference between offered and transaction prices for medium standard (PLN/m^2) – des. 109 – difference between offered and transaction prices for high standard (PLN/m^2) – des. 110 – difference between low and high standard for offered prices (PLN/m^2)– sti. 111 – difference between low and high standard for transaction prices (PLN/m^2) – sti. 112 – ratio of replacement value per 1 m^2 of property to the transaction price (per cent) – sti. 113 – ratio of replacement value per 1 m^2 of property to the offered price (per cent) – sti.
d) spatial and location set	114 – per cent of green areas (per cent) – sti. 115 – cycle path (per 10,000. residents) – sti. 116 – length of bus-lanes (km) – sti. 117 – roads with hard surface (km per 10,000 residents) – sti. 118 – roads with hard surface (km per km^2 of city) – sti. 119 – number of green parks in the region – sti. 120 – population density (per km^2)– sti. 121 – number of buses (per 1000 residents) – sti. 122 – number of high schools (per 100,000 residents) – sti.

* sti. – stimulants, des. – destimulant

Source: own study based on Renigier-Biłozor et al. (2017).

APPENDIX 2

Database of the rating attributes toolkit

		Number of indicator for 2017					
		1	2	3	4	…	122
	Markets	social	social	social	economic and political	…	spatial and location
1	Łódź	50	11.44	25.10	5.20	…	3.26
2	Warszawa	70	9.00	22.80	5.54	…	4.49
3	Kraków	56	7.99	21.60	5.39	…	2.76
4	Katowice	47	9.30	23.20	5.28	…	4.64
5	Lublin	48	7.60	21.20	5.43	…	2.63
6	Rzeszów	59	6.15	18.40	5.30	…	2.16
7	Białystok	50	6.79	18.70	5.42	…	3.38
8	Kielce	46	8.12	22.50	5.32	…	5.03
9	Zielona Góra	51	7.29	21.20	5.31	…	2.52
10	Poznań	56	8.70	22.10	5.23	…	4.58
11	Szczecin	49	8.52	21.90	5.16	…	3.44
12	Wrocław	60	8.67	22.10	5.25	…	3.94
13	Opole	54	7.69	22.10	5.21	…	3.35
14	Bydgoszcz	45	8.74	22.40	5.34	…	2.24
15	Gdańsk	57	8.65	22.00	5.23	…	2.82
16	Olsztyn	55	6.84	19.40	5.33	…	2.30

Source: own study based on the following: National Bank of Poland (reports on the residential property market); Central Statistical Office (local data bank); Polish Bank Associations: AMRON – SARFIN reports; real estate agents pages : www.otodom.pl, www.gratkadom.pl; Colliers International ”Review of polish property market”; Ober Haus property agency ”Report from real estate market”; published social rankings: “Polityka” newspaper and “Rzeczpospolita” newspaper; Real estate BNP Paribas about regional office markets: clliers.com. about commercial rents.

APPENDIX 3

Synthetic variables determined based on factor analysis

	Synthetic variables for original features combination										
No. of combination for synthetic variable	comb. 1	comb. 3	comb.4	comb.5	comb. 6	comb.8	comb.9	comb. 11	comb.12	comb.13	comb.14
No. of indicator	46	2	71	77	79	83	88	15	18	23/94	102
	47	3	73	78	80	84	89	17	19	24/95	112
			72	76		85					113
						86					
Code of synthetic variable	-0.005	0.201	0.009	-0.126	0.980	0.213	0.771	1.309	0.926	2.392	0.252
	-0.197	-1.255	-0.815	-0.632	-0.186	-0.022	-0.090	-1.251	0.314	0.964	0.663
	0.154	0.152	0.573	-0.232	-1.092	-0.464	0.299	-0.790	-0.759	-0.121	-0.214
	-1.546	0.353	-1.068	-0.509	-1.646	-0.132	-0.456	-0.907	-0.996	-0.858	0.697
	0.537	-1.478	-1.391	-0.733	-0.490	0.101	-0.908	-0.195	-0.081	-0.168	0.160
	-0.338	0.354	1.499	0.353	-0.346	0.659	-0.415	-0.189	-0.374	0.204	-0.320
	1.537	0.744	2.294	3.432	2.749	1.200	-0.107	0.537	0.595	1.502	-1.835
	-0.961	2.343	-0.777	-0.327	0.053	-0.471	-0.137	-0.933	-1.268	-1.020	1.625
	0.304	0.198	0.728	0.270	0.674	0.810	-0.494	1.488	2.075	0.999	-1.117
	-0.210	-0.513	-0.872	-0.510	0.204	0.319	-0.036	-0.503	0.608	-0.831	-0.687
	0.925	-0.106	0.453	0.227	-0.379	1.307	-0.560	2.102	1.130	-0.629	-1.378
	2.089	-1.682	-0.842	-0.437	0.191	0.320	0.163	0.686	0.848	-0.484	-0.762
	0.156	-0.461	-0.029	-0.400	-1.184	-0.720	-0.504	-0.422	0.137	-0.261	1.445
	-1.317	0.066	-0.196	-0.510	0.126	0.268	-0.767	-0.113	-0.798	-0.858	0.362
	-1.141	0.940	-0.219	0.260	0.272	-3.011	3.348	-0.465	-1.383	-0.312	1.067
	0.012	0.140	0.654	-0.122	0.072	-0.377	-0.105	-0.350	-0.973	-0.519	0.041
Test of goodness of fit – R^2.	0.95	0.93	0.97	0.95	0.98	0.94	0.94	0.85	0.98	0.91	0.89

Source: authors' calculation.