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Optimization of the Variables Selection in the Process of Real Estate Markets Rating[**]

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Abstract: *The growing significance of the real estate market prompts investors to search for factors and variables which support cohesive analyses of real estate markets, market comparisons based on diverse criteria and determination of market potential. The specificity of the real estate market is determined by the unique attributes of property. The Authors assume that developing real estate market ratings identifies the types of information and factors which affect decision-making on real estate markets. The main objective of real estate market ratings is to create a universal and standardized classification system for evaluating the real estate market.*

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One of the most important problems in this area is collecting appropriate features of real estate market and development dataset. The main problem involves the selection and application of appropriate features, which would be relevant to the specificity of information related to the real estate market and create a kind of coherent system aiding the decision-making process.

The main aim of this study is the optimization of set of variables that were used to develop the real estate market ratings. For this purpose, Hellwig's method of integral capacity of information was applied. In this particular case, the method shows what set of variables provides information most sufficiently. The results lead to obtaining the necessary set of features that constitute essential information which describes the situation on the local real estate market.

Introduction

The real estate market is one of the most rapidly developing goods markets that attract massive investments, but as an object of research it poses numerous problems.

The level of knowledge about the market and its participants is a factor that determines the efficiency of the real estate market, but is often disregarded in market analyses. Knowledge gaps may appear among active market participants, who have limited information about the system and its constituent elements. Other market participants may also have limited knowledge in this area. The knowledge manifested by entities conducting transactions on the RE market is (according to theoretical assumptions) limited or negligent. The above implies that market participants conduct transactions without mutual knowledge, which leads to asymmetry in the decision-making process. This could lower the efficiency and, consequently, the effectiveness of the entire market. Researchers analyzing the real estate market should also demonstrate a sufficient level of knowledge about the mutual relationships between the subjects and objects of market transactions (Renigier-Biłozor & Wiśniewski, 2012, pp. 95-110).

Providing access to the knowledge of the real estate market developed in the form of a simple message is the only way to solve this problem. The authors assumed that it can be achieved by developing a measure of the rating real estate markets providing general and unambiguous/clear information classifying the object of analysis and being an effective decision-making support system.

The specificity of the real estate market is determined by the unique attributes of property. For this reason, rating methodologies applied on capital markets cannot be simply copied to the real estate market.

The main objective of real estate market ratings is to create a universal and standardized classification system for evaluating the real estate market. A rating system contributes to objectivity in the decision-making process and shortens the decision-making time (Renigier-Biłozor *et al*., 2014).

Real estate market ratings serve a variety of practical purposes. They are used to develop portfolio investment strategies (Anglin & Yanmin, 2011, Collett *et al.*, 2003) and formulate long-short portfolio strategies on housing indices for more risky and less risky assets characterized by low liquidity (Berach & Skiba, 2011). The scarcity of relevant information results from the shortcomings of market effectiveness analyses (Case & Shiller, 1989; Fama, 1990, Grossman & Stiglitz, 1980; Dawidowicz *et al*., 2014). According to Case and Shiller (1989, 1990), the ineffectiveness of the analyzed market can be attributed to individual investors who do not have access to objective knowledge about the real estate market.

One of the most important reasons behind undertaking research in this area is the problem which occurs in the advanced real estate analysis, namely the collection of appropriate features of real estate market and development dataset. Market features are usually divided into macroeconomic and microeconomic factors, including socio-demographic development, overall economic development and political, legal condition and property market. The main problem involves the selection and application of appropriate features which would be relevant to the specificity of information related to the real estate market and create a kind of coherent system aiding the decision-making process.

The main aim of this study is to verify the variables that were used to develop the real estate market ratings in the author's previous work entitled: "Rating methodology for real estate markets – Poland case study" (Renigier-Biłozor *et al*., 2014). With that goal in mind, Hellwig's method of integral capacity of information was applied. This method, in this particular case, shows what store of features are providing information with the almost full source.

The results lead to obtaining the necessary set of features that constitute essential information describing the situation on the local real estate market.

Method of the Research

Although recent year have witnessed the growing popularity of various support systems, comprehensive and effective information systems that

facilitate real estate management and analyses continue to be in short supply. The above results from the specific character of real estate management operations, which involve complex procedures and decisions, as well as the unique character of real estate data. Those factors prevent smooth flow of information, which is required for the implementation of rational decisions and actions in business, investment, financial and promotional projects (Renigier-Biłozor, 2013).

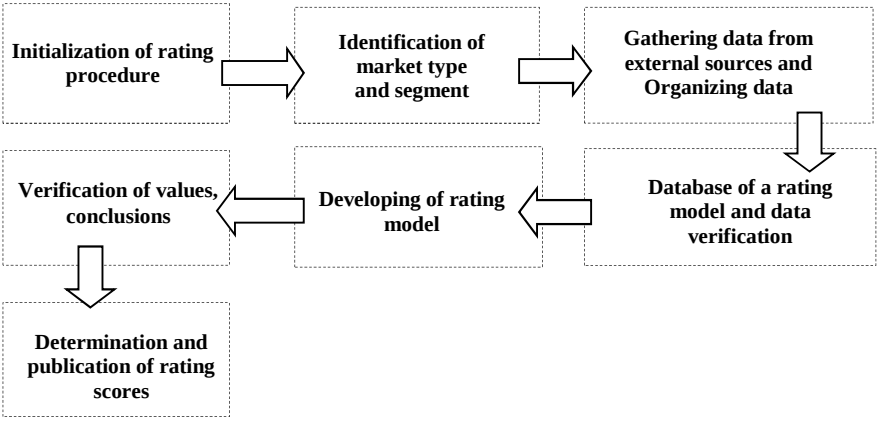
The growing significance of the real estate market prompts investors to search for factors and variables which support cohesive analyses of real estate markets, market comparisons based on diverse criteria and determination of market potential. Investors search for similarities that would enable them to develop risk minimizing strategies. Ratings are a modern tool that can be deployed in analyses and predictions of real estate market potential.

The Author's assume that developing real estate market ratings identifies the types of information and factors which affect decision-making on real estate markets. The detailed objectives of developing scoring systems for real estate markets are: to introduce objective benchmarks for comparing real estate markets, to reduce the number of variables in the decision-making process, to evaluate real estate markets' potential for economic and spatial growth, to evaluate social benefits/losses resulting from the development of a given real estate market, to provide for effective flow of information about the real estate market.

A rating methodology has to be adapted to the specific attributes of a real estate market. A general diagram of a real estate market rating procedure is shown in figure 1.

The diagram has been expanded to include detailed information about the type of the analyzed real estate market, its structure and functions. A detailed diagram can be then used to evaluate any real estate market. Rating scores are diversified for different market types and market segments at the level of rating variables, i.e. information and factors describing real estate functions. The proposed system has a modular structure to ensure greater methodological openness. A given market can be rated with the involvement of all or selected modules.

Figure 1. Diagram of a rating procedure



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

In this study, we assume that the type and the segment of the real estate market are identified, and the utility function of real estate is determined. Market type is indicative of the utility function of real estate: investment market, commercial market, industrial market, agricultural market. etc. Market segment accounts for a specific group of real estate which is identified in a given type of a market in view of its utility function. A real estate market would be very difficult to rate without prior classification. The aim of the proposed division is to introduce a certain degree of uniformity to the rating procedure. The main standardizing factor is the utility function of the market and real estate, which implies that markets will be evaluated basing on their utility rather than legal status (Renigier-Biłozor et al., 2014).

In order to collect appropriate data set of variables that diagnosed situation on the residential real estate market the many publication (Kaklauskas *et al*., 2011; Irwin *et al*., 1993; Jaffe & Sirmans, 1989; Bryx & Matkowski, 2001; Case, 2000; Źróbek & Grzesik, 2013) has been analyzed. The authors compiled the existing knowledge to propose an indicator sets for evaluating the real estate markets (table 1) that identify the types of information and factors which affect decision-making on real estate markets.

Mainly residential real estate market is selected for the analysis, due to the lack of such solutions on the market, and the universality of participation from the viewpoint of customers.

Since the main aim of a rating is to provide quick, objective, reliable and updated information, a dataset has to be developed as a platform for

quantitative and qualitative 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 on that market, the developed system for gathering market data should be flexible enough to enable frequent modifications.

From the analytical point of view, the solution to the problem requires the selection of appropriate methods for analyzing the available information rather than, as it is often observed in practice, the adaptation of the existing information to analytical methods. In the era of globalization, quick and unified solutions (procedures, algorithms) are needed to enhance the objectivity and the reliability of research results. The preferred solutions should address the problem on a global scale while accounting for the local characteristics of the analyzed markets and the relevant information.

In this case, the authors suggest the use of Hellwig's method (Hellwig, 1976) as a tool for determining an optimum set of variables to evaluate real property market rating.

The heuristic proposed by Hellwig (1969) takes into account both class feature correlation and correalation between pairs of variables. The best subset of features is selected from among all possible subsets that maximizes the so-called "integral capacity of information.

Development of an Optimal Set of Variables to Assess the Rating of Real Estate Market

Residential property (apartment) markets in capital cities of Polish regions were rated in this study. The existing knowledge was compiled to develop a set of indicators for the overall evaluation of the real estate markets. These include categories of information strictly relating to the residential, economic, social, spatial and location realms. In the study the database was determined with the use of the available sources of information from common databases i.e.: National Bank of Poland (reports on the residential property market), Central Statistical Office (local data bank), Polish Bank Associations e.g.: AMRON – SARFIN reports, real estate agents pages e.g.: www.otodom.pl; www.gratkadom.pl etc., Colliers International „Review of Polish property market", OberHausproperty agency „Report from real estate market", published social rankings e.g.: "Polityka" newspaper, "Rzeczpospolita" newspaper.

During the data processing, the initial data was unified and adjusted to the object of analyses. With this purpose in mind, unification of "raw" data was performed, referring to a given area of the local market, by transforming it into indices expressed in the form of units per inhabitants, units of space, average pay of local inhabitant or average price of real property. In the study, data for 16 province cities was taken into account of 2008-2012. The dataset for the residential property market was developed for supply and demand categories (Table 1 and 2) based on the available information.

Rating scores were determined individually for supply and demand, with the use of rough set theory and Ward's cluster analysis and statistical measures. In the mentioned study it was assumed that real estate markets are scored on a 10-point rating scale and are divided into four rating level groups: investment, development, stagnant and crisis. Except for the crisis level group which has a single score – D, there are three scores per each group: AAA/BBB/CCC, AA/BB/CC and A/B/C. Scores AAA/BBB/CCC represent the highest rating, AA/BB/CC – a medium rating, and A/B/C – the lowest rating in a given group. Plus (+) and minus (-) signs may be appended to rating symbols to indicate their relative position within each group. Numerical values were assigned to every rating score to facilitate calculations: AAA – (1), AA – (2), A – (3), BBB – (4), BB – (5), B – (6), CCC – (7), CC – (8), C – (9) and D – (10).

The result of this work was the elaboration of average rating scores that were determined for the analysed markets for demand and supply (Table 3).

The efficiency of presented studies depends, to a significant degree, on the availability of data, data reliability and uniformity. The analysed phenomenon is very complex in its nature and requires collection of a lot of varied data. This is related to significant labour outlays, as well as the necessity of incurring significant costs.

The objective of this study is to determine an optimum set of information indispensable for preparing a rating assessment. In the presented figure 1, this is a module related to the database of a rating model and data verification. In the original study (Renigier-Biłozor *et al*., 2014b), it was not possible to verify the significance of variables on account of absence of dependent variable. Therefore, assuming the result of a rating in numerical form as a dependent variable, analysis of significance of the accepted information divided into demand and supply nature of the market was adopted.

Table 1. Demand of data categories

Cities	Gdańsk	Olsztyn	Szczecin	Bydgoszcz	Białystok	Poznań	Warszawa	Łódź	Wrocław	Lublin	Kraków	Rzeszów	Zielona Góra	Kielce	Katowice	Opole
x1	0,67	0,85	0,85	0,92	0,84	0,66	0,52	0,92	0,67	0,75	0,57	0,81	1,06	0,8	0,87	0,89
x2	12677	11888	9696	10101	12389	13112	18684	10850	14915	10886	13056	11525	11627	13553	12804	12752
x3	1034	-222	96	-401	-576	472	1181	-312	-19	-58	123	-16	-670	-414	1309	-172
x4	0,75	0,47	0,52	1,07	0,48	0,65	0,85	0,44	1,02	0,32	0,2	0,46	1,13	0,54	0,55	0,22
x5	-1,68	-5,8	-3,07	-7,5	-3,6	-0,06	-5,25	-6,3	-3,57	-1,3	-1,16	-1,56	0,13	-2,1	-10,5	-4,32
x6	101,5	94,22	116,44	71,61	111,61	102,5	118,6	84,2	105,48	126,4	145,64	121,96	90,04	109,77	100,46	105,56
x7	14	3	6	4	9	11	11	3	8	3	4	10	9	4	11	6
x8	0,86	0,8	0,87	0,82	0,71	0,74	0,69	0,84	0,66	0,73	0,59	0,8	0,87	0,71	1,18	0,85
x9	-1,68	-5,8	-3,07	-7,5	-3,6	-0,06	-5,25	-6,3	-3,57	-1,3	-1,16	-1,56	0,13	-2,1	-10,5	-4,32
x10	101,5	94,22	116,44	71,61	111,61	102,5	118,6	84,2	105,48	126,4	145,64	121,96	90,04	109,77	100,46	105,56
x11	3	4	4	5	6	5	5	8	5	7	3	6	5	6	6	3
x12	186	174	200	323	80	861	2494	191	160	55	1181	64	82	41	110	156
x13	80	60	66	55	28	55	71	57	55	63	48	73	60	52	110	60
x14	4099	3000	1688	1000	2000	402	4751	634	2851	830	1380	2299	1603	817	1500	1170
x15	1744	1988	1350	2024	2890	2106	3326	2514	2162	2363	2314	1532	2017	1859	1880	1273
x16	2253	905	1951	1876	1435	2907	8217	3233	3156	1736	3732	1013	593	1037	615	225
x17	1028	442	989	955	692	1178	3566	1333	1331	648	1852	328	285	313	651	260

Table 1 continued

Cities	Gdańsk	Olsztyn	Szczecin	Bydgoszcz	Białystok	Poznań	Warszawa	Łódź	Wrocław	Lublin	Kraków	Rzeszów	Zielona Góra	Kielce	Katowice	Opole
x18	-83	-277	32	-1115	-414	-2493	7102	-1467	615	-1124	975	275	140	-699	-1160	-169
x19	91	309	-681	-308	557	443	1277	-4111	-71	208	422	557	107	64	-957	-48
x20	144003	55871	127018	109823	94169	178051	549744	212071	203364	108126	243499	56830	37680	61305	90343	38435
x21	5,9	7,8	10,5	8,2	12,7	3,8	4,1	11,3	5,2	9,6	5,4	7,8	8,5	10,3	4,9	6,8
x22	382	344	343	376	364	382	353	333	360	297	376	344	303	306	394	348
x23	38	35	42	31	34	45	46	34	41	35	42	33	39	33	34	35

x1 - average purchasing power in comparison with the national average, x2 - local government's spending per 1 resident in recent years, x3 - difference between the national average salary and the average salary on the local market, x4 - local government's spending on promotion, x5 - changes in local property prices, x6 - ratio of replacement value of 1 m2 of property and the average transaction price on the local real estate market, x7 - number of property transactions per 1000 residents, x8 - purchasing power on the local housing market, x9 - changes in local property prices, x10 - ratio of replacement value of 1 m2 of property and the average transaction price on the local real estate market, x11 - average time on the market in months, x12 - number of real estate agents on the local market, x13 - availability of mortgages in terms of m2, x14 - value of property transaction per 1 resident on the local market, x15 - population density per m2, x16 - number of marriages, x17 - number of divorces, x18 - net migration rate, x19 - population growth, x20 - age structure of potential clients (25-45 population group vs. total population in a given area), x21 - unemployment rate, x22 - quality of life, x23 - number of new registered businesses per 1000 residents.

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

Table 2. Supply of data categories

Cities	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14
Gdańsk	419	3203	279	50	123,59	22863	52,00	168,74	299,00	11190,00	24,60	2,40	9,60	64,32
Olsztyn	93	911	72	28	102,86	4926	19,00	131,46	375,00	3409,00	23,90	2,50	5,46	44,36
Szczecin	247	2704	226	39	128,04	15918	45,00	151,26	739,00	10095,00	24,80	2,50	4,41	41,44
Bydgoszcz	35	1255	139	64	76,67	22786	25,00	158,00	1017,00	7593,00	22,90	2,60	2,38	30,66
Białystok	393	1184	156	20	123,35	5879	10,00	139,27	273,00	5698,00	24,30	2,40	5,81	33,46
Poznań	340	4438	526	33	115,07	18072	45,00	143,28	1396,00	14122,00	27,90	2,30	4,54	31,39
Warszawa	379	15663	980	90,5	142,06	155703	266,00	116,17	-634,00	46458,00	28,30	2,06	5,48	28,77
Łódź	359	2562	655	20,6	93,50	15186	52,00	141,62	936,00	22823,00	25,00	2,20	2,10	5,33
Wrocław	621	8053	479	75,5	119,98	47823	100,00	107,45	13,00	16216,00	26,00	2,30	5,94	46,09
Lublin	26	2267	207	23	131,93	8043	20,00	152,43	87,00	8913,00	24,00	2,50	4,28	44,17
Kraków	221	8620	494	82,5	153,64	62393	154,00	125,43	148,00	17460,00	24,90	2,30	6,39	35,79
Rzeszów	226	1486	669	13	127,35	2301	110,00	136,75	-187,00	3406,00	24,20	2,70	8,69	11,66
Zielona Góra	613	1144	133	18	95,04	2151	10,00	129,13	686,00	2653,00	25,40	2,40	4,67	57,35
Kielce	262	1378	226	12	116,17	2502	43,00	131,67	445,00	4335,00	23,20	2,50	4,34	11,05
Katowice	694	1351	130	28	113,58	6815	30,00	181,95	1361,00	8389,00	25,90	2,30	2,14	20,55
Opole	174	270	76	21	114,94	2633	11,00	165,14	899,00	2699,00	25,20	2,50	3,35	33,13

x1 - local government's spending on housing policy in zl, x2 - total number of issued construction permits, x3 - number of issued construction permits - individual, x4 - number of property offers per 1000 residents, x5 - ratio of replacement value per 1 m2 of property to the average price quoted on the local real estate market, x6 - number of property offers, x7 - number of developers on the local market, x8 - affordability of rental housing in m2, x9 - difference between the average prices of new and second-hand property, x10 - number of deaths (older than 50), x11 - existing residential area per 1 resident, x12 - number of residents per 1 existing apartment, x13 - number of new apartments per 1000 residents, x14 - percent of land covered by zoning.

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

Table 3. Average rating scores" for the analyzed real estate markets

Markets	Rating of supply		Rating of demand	
Gdańsk	4.07	BBB	4.52	BB+
Olsztyn	6.00	B	5.42	BB-
Szczecin	4.86	BB	5.47	BB-
Bydgoszcz	6.07	B	5.61	B+
Białystok	5.50	BB-	5.71	B+
Poznań	4.64	BB+	4.80	BB
Warsaw	3.07	A	3.42	A-
Łódź	5.36	BB-	5.89	B
Wrocław	3.64	BBB+	4.76	BB+
Lublin	5.28	BB-	6.19	B
Kraków	4.00	BBB	4.67	BB+
Rzeszów	5.14	BB	5.42	BB-
Zielona Góra	5.71	B+	5.71	B+
Kielce	5.71	B+	6.27	B-
Katowice	5.43	BB-	5.33	BB-
Opole	6.36	B-	6.28	B-

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

For the purpose of finding an optimum combination of explanatory variables – combinations with greatest integral information capacity index Hellwig's method was applied. At the beginning, the Pearson's correlation coefficient was calculated for demand and supply indices (explanatory variables) with respect to the demand rating (Table 4) and supply rating (Table 5).

Table 4. Correlation scores for real estate rating of demand

Demand variables	Correlation scores with rating of demand
average purchasing power in comparison with the national average	0,75
local government's spending per 1 resident in recent years	-0,70
difference between the national average salary and the average salary on the local market	-0,69
local government's spending on promotion	-0,34
changes in local property prices	-0,01
ratio of replacement value of 1 m2 of property and the average transaction price on the local real estate market	-0,24
number of property transactions per 1000 residents	-0,57

Table 4 continued

Demand variables	Correlation scores with rating of demand
purchasing power on the local housing market	0,23
changes in local property prices	-0,01
ratio of replacement value of 1 m2 of property and the average transaction price on the local real estate market	-0,24
average time on the market in months	0,34
number of real estate agents on the local market	-0,79
availability of mortgages in terms of m2	-0,22
value of property transaction per 1 resident on the local market	-0,72
population density per m2	-0,45
number of marriages	-0,80
number of divorces	-0,83
net migration rate	-0,69
population growth	-0,37
age structure of potential clients (25-45 population group vs. total population in a given area)	-0,81
unemployment rate	0,70
quality of life	-0,53
number of new registered businesses per 1000 residents	-0,74

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

Table 5. Correlation for supply of real estate rating

Supply variables	Correlation scores with rating of supply
local government's spending on housing policy in zl	-0,34
total number of issued construction permits	-0,89
number of issued construction permits	-0,73
number of property offers per 1000 residents	-0,75
ratio of replacement value per 1 m2 of property to the average price quoted on the local real estate market	-0,65
number of property offers	-0,78
number of developers on the local market	-0,81

Table 5 continued

Supply variables	Correlation scores with rating of supply
affordability of rental housing in m2	0,45
difference between the average prices of new and second-hand property	0,55
number of deaths (older than 50)	-0,76
existing residential area per 1 resident	-0,61
number of residents per 1 existing apartment	0,62
number of new apartments per 1000 residents	-0,49
percent of land covered by zoning	-0,21

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

Subsequently, the matrix of correlation coefficients was determined among explanatory demand (Table 6) and supply (Table 7) variables.

On this basis, individual indices of information capacity were determined for each combination according to the following formula:

$$h_{kj} = \frac{r_j^2}{1+\sum_{\substack{i=1 \\ i\neq 1}}^{m} |r_{ij}|} \tag{1}$$

where:
r_j – correlation between *Y* and *Xj (*in this case - results from Table 4 and 5).
r_{ij} – correlation between X_i and X_j (in this case-results from Table 6 and7).
k – number of combinations, *k = 1, 2, …, l.*
j – variable number of combinations *j = 1, 2, …, m.*

Finally, integral information capacity indices should be determined for each combination according to the following formula:

$$H_k = \sum_{j=1}^{m} h_{kj},\ k = 1, 2, \dots, l \tag{2}$$

The optimal set of information indicates from combination of variables with the highest H_k.

Table 6. Correlation coefficients for demand

Correlation scores	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17	x18	x19	x20	x21	x22	x23
x1	1,00																						
x2	-0,68	1,00																					
x3	-0,57	0,50	1,00																				
x4	0,55	-0,33	0,34	0,06																			
x5	-0,23	-0,02	-0,27	-0,04	1,00																		
x6	-0,63	0,28	0,21	-0,56	0,45	1,00																	
x7	-0,27	0,42	0,63	0,36	0,11	0,02	1,00																
x8	0,55	-0,33	0,34	0,06	-0,57	-0,45	0,28	1,00															
x9	-0,23	-0,02	-0,27	-0,04	1,00	0,45	0,11	-0,57	1,00														
x10	-0,63	0,28	0,21	-0,56	0,45	1,00	0,02	-0,45	0,45	1,00													
x11	0,27	-0,14	-0,20	0,01	-0,20	-0,19	-0,20	0,12	-0,20	-0,19	1,00												
x12	-0,69	0,74	0,50	0,10	0,00	0,33	0,22	-0,38	0,00	0,33	-0,21	1,00											
x13	0,01	0,08	0,74	0,07	-0,42	-0,08	0,43	0,77	-0,42	-0,08	-0,01	0,01	1,00										
x14	-0,45	0,59	0,49	0,31	-0,07	0,13	0,52	-0,10	-0,07	0,13	-0,36	0,44	0,25	1,00									
x15	-0,40	0,54	0,11	0,16	-0,10	0,11	0,04	-0,43	-0,10	0,11	0,38	0,61	-0,31	0,28	1,00								
x16	-0,72	0,70	0,46	0,20	-0,01	0,26	0,18	-0,45	-0,01	0,26	0,00	0,90	-0,05	0,49	0,71	1,00							
x17	-0,71	0,69	0,52	0,18	-0,11	0,26	0,20	-0,37	-0,11	0,26	-0,08	0,92	0,02	0,50	0,69	0,99	1,00						
x18	-0,51	0,76	0,38	0,20	-0,04	0,35	0,25	-0,31	-0,04	0,35	-0,22	0,79	0,08	0,75	0,50	0,76	0,77	1,00					
x19	-0,45	0,44	0,15	0,12	0,40	0,45	0,34	-0,39	0,40	0,45	-0,48	0,35	-0,11	0,42	0,08	0,13	0,12	0,42	1,00				
x20	-0,71	0,73	0,52	0,17	-0,09	0,26	0,21	-0,37	-0,09	0,26	-0,01	0,91	0,03	0,50	0,70	0,99	0,99	0,78	0,11	1,00			
x21	0,58	-0,59	-0,70	-0,21	0,03	-0,14	-0,49	-0,03	0,03	-0,14	0,46	-0,54	-0,47	-0,35	0,00	-0,39	-0,44	-0,33	-0,38	-0,43	1,00		
x22	-0,35	0,18	0,57	0,06	-0,38	-0,06	0,48	0,21	-0,38	-0,06	-0,39	0,25	0,25	0,22	0,01	0,19	0,29	-0,01	0,08	0,22	-0,55	1,00	
x23	-0,63	0,54	0,44	0,18	0,38	0,38	0,37	-0,35	0,38	0,38	-0,38	0,70	-0,02	0,34	0,28	0,67	0,68	0,50	0,32	0,67	-0,56	0,19	1,00

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

Table 7. Correlation coefficients for supply

Correlation scores	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14
x1	1,00													
x2	0,19	1,00												
x3	0,13	0,77	1,00											
x4	0,06	0,83	0,46	1,00										
x5	0,00	0,57	0,41	0,35	1,00									
x6	0,11	0,97	0,72	0,83	0,47	1,00								
x7	0,10	0,92	0,85	0,72	0,60	0,92	1,00							
x8	-0,08	-0,57	-0,51	-0,36	-0,25	-0,48	-0,54	1,00						
x9	0,11	-0,57	-0,49	-0,39	-0,60	-0,57	-0,67	0,61	1,00					
x10	0,16	0,90	0,81	0,69	0,37	0,92	0,84	-0,39	-0,41	1,00				
x11	0,50	0,67	0,59	0,38	0,32	0,60	0,53	-0,23	-0,03	0,67	1,00			
x12	-0,53	-0,71	-0,54	-0,49	-0,25	-0,68	-0,53	0,29	0,08	-0,81	-0,76	1,00		
x13	0,04	0,22	0,26	0,17	0,52	0,15	0,33	-0,27	-0,64	0,00	-0,01	0,16	1,00	
x14	0,11	0,05	-0,37	0,26	0,08	0,02	-0,16	0,00	-0,13	-0,14	0,04	0,02	0,39	1,00

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

The authors modified the classical assumptions of this theory and conducted the sensitivity analysis in order to increase the efficiency of the analysis and to estimate the time saved. In this analysis, the influence of every variable on the result of the integral information capacity (Hi) was verified. The total integral information capacity (Ht) (with all variables) was compared with individual integral information capacity (Hi) (after deleting each variable), respectively. These deleted variables with individual indicators higher than the total indicator were removed (bold font - Table 8 and 9). The analysis indicated that the remaining variables constituted the combination of optimal set with the highest integral information capacity (Ho) (Table 8 and 9).

Table 8. Indices of integral information capacity for supply

	Sets of variables combinations	**Indicate of integral information capacity (H)**
(Ht)	C1= x1,x2,x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x13, x14	0,8365
Hi (x1)	C2 = x2,x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x13,x14	0,8191
Hi(x2)	C3 =x1,x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x13, x14	0,8307
Hi(x3)	C4 =x1,x2,x4, x5, x6, x7, x8, x9, x10, x11, x12, x 13, x14	**0,8381**
Hi(x4)	C5 =x1,x2,x3, x5, x6, x7, x8, x9, x10, x11, x12, x 13, x14	0,8142
Hi(x5)	C6 =x1,x2,x3, x4, x6, x7, x8, x9, x10, x11, x12, x13, x14	0,8113
Hi(x6)	C7 =x1,x2,x3, x4, x5, x7, x8, x9, x10, x11, x12, x13,x14	**0,8404**
Hi(x7)	C8 =x1,x2,x3, x4, x5, x6, x8, x9, x10, x11, x12, x13, x14	**0,8416**
Hi(x8)	C9 =x1,x2,x3, x4, x5, x6, x7, x9, x10, x11, x12, x 13, x14	**0,8458**
Hi(x9)	C10 =X1,X2,x3, x4, x5, x6, x7, x8, x10, x11, x12, x13, x14	**0,8452**
Hi(x10)	C11 =x1,x2,x3, x4, x5, x6, x7, x8, x9, x11, x12,x13, x14	**0,8368**
Hi(x11)	C12 =x1,x2,x3, x4, x5, x6, x7, x8, x9, x10, x12, x13, x14	0,8313
Hi(x12)	C13 =x1,x2,x3, x4, x5, x6, x7, x8, x9, x10, x11, x13, x14	**0,8415**
Hi(x13)	C14 =x1,x2,x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x14	0,809
Hi(x14)	C15 =x1,x2,x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x 13	**0,8411**
Ho	C16 =x1,x2, x4, x5, x11, x13	0,8948

Source: own study.

Table 9. Indices of integral information capacity for demand

	Sets of variables combinations	**integral information capacity (H)**
(Ht)	C1= x1,x2,x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x13, x14, x15,x16,x17,x18,x19,x20,x21,x22,x23	0,8053
Hi (x1)	C2 = x2,x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x13, x14, x15,x16,x17,x18,x19,x20,x21,x22,x23	0,8028
Hi(x2)	C3 =x1,x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x13, x14, x15,x16,x17,x18,x19,x20,x21,x22,x23	**0,8064**
Hi(x3)	C4 =x1,x2,x4, x5, x6, x7, x8, x9, x10, x11, x12, x13, x14, x15,x16,x17,x18,x19,x20,x21,x22,x23	0,7978
Hi(x4)	C5 =x1,x2,x3, x5, x6, x7, x8, x9, x10, x11, x12, x13, x14, x15,x16,x17,x18,x19,x20,x21,x22,x23	0,7981
Hi(x5)	C6 =x1,x2,x3, x4, x6, x7, x8, x9, x10, x11, x12, x13, x14, x15,x16,x17,x18,x19,x20,x21,x22,x23	**0,8197**
Hi(x6)	C7 =x1,x2,x3, x4, x5, x7, x8, x9, x10, x11, x12, x13, x14, x15,x16,x17,x18,x19,x20,x21,x22,x23	**0,8226**
Hi(x7)	C8 =x1,x2,x3, x4, x5, x6, x8, x9, x10, x11, x12, x13, x14, x15,x16,x17,x18,x19,x20,x21,x22,x23	0,7893
Hi(x8)	C9 =x1,x2,x3, x4, x5, x6, x7, x9, x10, x11, x12, x13, x14, x15,x16,x17,x18,x19,x20,x21,x22,x23	**0,8274**
Hi(x9)	C10 =x1,x2,x3, x4, x5, x6, x7, x8, x10, x11, x12, x13, x14, x15,x16,x17,x18,x19,x20,x21,x22,x23	**0,8197**
Hi(x10)	C11 =x1,x2,x3, x4, x5, x6, x7, x8, x9, x11, x12, x13, x14, x15,x16,x17,x18,x19,x20,x21,x22,x23	**0,8226**
Hi(x11)	C12 =x1,x2,x3, x4, x5, x6, x7, x8, x9, x10, x12, x13, x14, x15,x16,x17,x18,x19,x20,x21,x22,x23	0,8050
Hi(x12)	C13 =x1,x2,x3, x4, x5, x6, x7, x8, x9, x10, x11, x13, x14, x15,x16,x17,x18,x19,x20,x21,x22,x23	0,7971
Hi(x13)	C14 =x1,x2,x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x14, x15,x16,x17,x18,x19,x20,x21,x22,x23	**0,8145**
Hi(x14)	C15 =x1,x2,x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x13, x15,x16,x17,x18,x19,x20,x21,x22,x23	0,7834
Hi(x15)	C16= x1,x2,x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x13, x14,x16,x17,x18,x19,x20,x21,x22,x23	**0,8097**
Hi(x16)	C17= x1,x2,x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x13, x14, x15,,x17,x18,x19,x20,x21,x22,x23	0,7918
Hi(x17)	C18= x1,x2,x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x13, x14, x15,x16,x18,x19,x20,x21,x22,x23	0,7916
Hi(x18)	C19= x1,x2,x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x13, x14, x15,x16,x17,x19,x20,x21,x22,x23	0,8030
Hi(x19)	C20= x1,x2,x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x13, x14, x15,x16,x17,x18,x20,x21,x22,x23	**0,8123**
Hi(x20)	C21= x1,x2,x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x13, x14, x15,x16,x17,x18,x19,x21,x22,x23	0,7939
Hi(x21)	C22= x1,x2,x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x13, x14, x15,x16,x17,x18,x19,x20, x22,x23	0,7893
Hi(x22)	C23= x1,x2,x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x13, x14, x15,x16,x17,x18,x19,x20,x21,x23	0,7841
Hi(x23)	C24= x1,x2,x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x13, x14, x15,x16,x17,x18,x19,x20,x21,x22	0,7941
Ho	C25 = x1,x3, x4, x7, x11, x12, x14,x16,x17, x18, x20,x21,x22,x23	0,9359

Source: own study.

Conclusions

The authors prepared analyses of verification of variables that were used to develop the real estate market ratings. To this purpose Hellwig's method of integral capacity of information was applied. The mentioned method enables to choose the optimal combination of variables with the highest information capacity integral indicators. The results lead to obtaining the necessary set of features that constitute essential information which describes the situation on the local real estate market.

The conducted analyses indicate that the most optimal set of indicators for demand rating comprises: *average purchasing power in comparison with the national average, difference between the national average salary and the average salary on the local market, local government's spending on promotion, number of property transactions per 1000 residents, average time on the market in months, number of real estate agents on the local market, value of property transaction per 1 resident on the local market, number of marriages, number of divorces, net migration rate, age structure of potential clients (25-45 population group vs. total population in a given area), quality of life, number of new registered businesses per 1000 residents* and for supply rating: *local government's spending on housing policy in zl, total number of issued construction permits, number of property offers per 1000 residents, ratio of replacement value per 1 m2 of property to the average price quoted on the local real estate market, existing residential area per 1 resident, number of new apartments per 1000 residents.*

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