DOI: 10.5604/01.3001.0013.9130

PRZEGLĄD STATYSTYCZNY
TOM LXVI – ZESZYT 3 – 2019

Anna Gdakowicz[1]
Ewa Putek-Szeląg[2]
Wojciech Kuźmiński[3]

Examination of the effects of non-measurable explanatory variables on the value of real estate in the process of mass valuation of land[4]

Abstract. The paper proposes a solution to the problem of how to introduce non-measurable features (attributes) of a property that significantly affect its value to the process of its valuation. The authors adopt two measures enabling them to study the influence of order features on the value of property, the Spearman rank coefficients and standardized β_k coefficients, and proceed to check their efficiency, applying an algorithm of mass property valuation (SAMWN) to the sample of 567 plots of land in Szczecin designated for housing purposes. The results thus obtained are then compared with the valuations of these plots of land performed by property appraisers. The study demonstrates that lower valuation errors are obtained when using standardized β_k coefficients than the Spearman rank coefficients.

Keywords: method of statistical market analysis, mass valuation of real estate, non-measurable attributes, Spearman rank coefficient, standardized β_k coefficient

JEL: C35, R31

1. INTRODUCTION

According to the Real Estate Management Act[5], it is possible to estimate the market, the replacement and the cadastral values in the process of real estate valuation. The market value is defined as the most likely price that could be obtained for a given property at the date of valuation, under the following conditions: both parties to the transaction have to be independent of each other, have to be determined to enter into the deal, have to act of their free will and have to

---

[1] University of Szczecin, Institute of Economics and Finance, ul. Mickiewicza 64, 71–101 Szczecin, ORCID: https://orcid.org/0000-0002-4360-3755, corresponding author – e-mail: anna.gdakowicz@usz.edu.pl.

[2] University of Szczecin, Institute of Economics and Finance, ul. Mickiewicza 64, 71–101 Szczecin, ORCID: https://orcid.org/0000-0002-9302-2115.

[3] University of Szczecin, Institute of Economics and Finance, ul. Mickiewicza 64, 71–101 Szczecin, ORCID: https://orcid.org/0000-0003-3256-9093.

[4] Article financed under the project of the National Science Centre, registration no. 2017/25/B/HS4/01813.

[5] Act of 21 August 1997 on Real Estate Management, Journal of Laws of 1997, No 115, Item 741, as amended.

have the same knowledge about the property. Additionally, the property has to be exposed to the market for a sufficient period of time. The market value can only be determined for properties that are tradable. Replacement value is determined as the estimated amount consisting of the cost of the acquisition of land (its market value) and the cost of the production of property components, taking into account the degree of wear and tear and assuming that production costs were incurred at the date of valuation. Unlike the market value, the replacement value applies to properties which are not tradable (due to the type of property, its current use or purpose). The cadastral value is determined during the general taxation, however, there are no legal acts which would specify in a detailed way the manner and methodology for determining this value.

The person authorised to determine the value of real estate in Poland is a property appraiser. Such person is responsible for choosing an optimal way of estimating the value of a particular property. This value may be estimated using the comparative, income-based, mixed or cost-based approach (Tabl. 1), depending on the type of real estate, the type of value to be determined, the purpose of the valuation and the availability of data.

TABLE 1. LIST OF APPROACHES, METHODS AND TECHNIQUES OF PROPERTY VALUATION AND THE TYPE OF THE PROPERTY VALUE ASSESSED

Approach	Method	Technique	Type of property value to be assessed
Comparison	pair sales comparison	–	market value
	mean price correction		
	market statistical analysis		
Income	investment	simple capitalisation	
		discounting flows income	
	profit	simple capitalisation	
		discounting flows income	
Mixed	residual	–	
	liquidation costs	detailed	
		index	
	land estimate indexes	–	
Cost	replacement costs	detailed	replacement value
		joined elements	
		index	
	substitution costs	detailed	
		joined elements	
		index	

S o u r c e: own compilation on the basis of the Regulation of the Council of Ministers of 21 September 2004 on the valuation of real estate and preparation of a valuation report (Journal of Laws of 2004, No 207, Item 2109).

Almost all valuation methods and techniques are described and explained in detail in the Real Estate Valuation Regulation[6] and in the national valuation standards of the Polish Federation of Valuers' Associations[7]. There is one exception, however, namely the method of the statistical analysis of the market, which has not been described in detail by any legal act. The current legislation refers[8] to the idea of a comparative approach, which involves comparing the property under valuation with similar properties traded on the market. The method of the statistical analysis of the market necessitates not only using a suitable set of transaction prices of similar properties as a reference, but also, in order to achieve more precise results, obtaining information about the terms of these transactions and on the characteristics of these properties that affect their prices. It is therefore necessary to build a database of properties similar to the property under valuation and to define a set of attributes for each of them. The attributes may vary depending on the type of property and on the type of the market. The Polish legislator and valuers' associations have left the choice of further calculation procedures to the person carrying out the valuation. There are no guidelines as to the appropriate algorithm, pattern of conduct or conditions enabling the adoption of suitable statistical-econometric methods

At the turn of the 20th and 21st century, many attempts were made to apply an econometric model (most often in the form of linear regression models) to estimations of the price or value of real estate (Czaja and Żak, 1993; Sawiłow, 1995; Cellmer, 1999; Źróbek and Bełej, 2000; Dacko, 2000a; Dacko, 2000b; Cellmer, 2000; Lipieta, 2000; Pawlukowicz, 2001; Zadumińska and Sztaudynger, 2001; Hopfer et al., 2001; Źróbek, 2002; Lis, 2008; Renigier-Biłozor, 2008; Zbyrowski, 2010; Walkowiak and Zydroń, 2012; Doszyń and Gnat, 2016; Kubus, 2016; Gdakowicz and Putek-Szeląg, 2018)[9]. In those models, properties were described by various features, for example: their purpose determined by local zoning plans, available utilities, accessibility, size, shape of the plot, type of buildings, year of construction and quality of the land or landscape. The number of the variables was limited only by the availability of data. With the expansion of databases and the general improvement of computer skills among property valuers and real estate analysts, the matching parameters of estimated econometric models have improved. Those models were not subject to a reliable statistical verification; most likely, it was only the validity of their structural parameters and the degree to which they fitted which were checked.

---

[6] The Regulation of the Council of Ministers of 21 September 2004 on the valuation of real estate and preparation of a valuation report (Journal of Laws of 2004, No 207, Item 2109).

[7] *National Valuation Standards of the Polish Federation of Valuers' Associations*, https://pfsrm.pl/aktualnosci/item/14-standardy-do-pobrania, (accessed 20.08.2018).

[8] The Regulation of the Council of Ministers of 21 September 2004, op. cit.

[9] In the article, the authors refer to articles written by Polish authors, because the proposed models take into consideration the Polish legal status. In other countries, the problem of mass valuation using econometric and statistical methods was also discussed, e.g. Kauko and D'Amato (2008); Yasnitsky and Yasnitsky (2016); Arribas et al. (2016); Ciuna et al. (2017).

The method of statistical market analysis is likely to gain additional significance in the context of the increasing demand for mass valuation of real estates. Mass valuation applies when (Hozer et al., 1999; Kuryj, 2007; Telega et al., 2002):

- the subject of the valuation is a large number of properties of one type,
- the valuation is carried out by means of a uniform, objective approach which yields consistent results,
- all properties subject to the valuation are assessed simultaneously, i.e. on the basis of data (the state of the property and the level of prices) collected on the same day for all the valued properties.

Due to the scale of the process, classical and non-classical multidimensional methods of statistical analysis tend to be applied while searching for practical solutions – for example, in general taxation (Benjamin et al., 2004; Kauko and D'Amato, 2008). However, when using these methods, it is not possible to fully utilize non-measurable explanatory variables (which influence the value of properties – the so-called real estate attributes) in the analysis. So far, the impact of individual attributes (often encoded as features measured on ordinal scales) on the value of estate property has been measured using the Pearson correlation coefficient (Czaja and Dąbrowski, 2008; Czaja and Ligas, 2010), Spearman rank correlation coefficient (Gaca and Sawiłow 2014; Babatunde, 2018; Gaca, 2018) or conjoint analysis (Pawlukowicz and Bartłomowicz, 2005; Głuszak, 2011).

The question arises whether it is possible to measure the influence of variables on the value of a property when it is not possible to measure their quantitative condition, as for example in the case of the current market trend concerning location. An immediate answer to this question would be negative, because if we do not observe a variable, we cannot measure its effect, and if we do not measure the effect, we cannot measure its impact. However, the empirical study presented in this paper demonstrates the opposite – indeed, it is possible to measure the effects of such variables. The aim of the paper, therefore, is twofold: to assess the influence of non-measurable features (attributes) on the value of real estate with the use of Spearman rank coefficients and the standardized β_k coefficients, as well as utilizing these features in the process of real estate valuation, conducted according to the Szczecin algorithm of mass real estate valuation (SAMWN).

2. HOW TO MEASURE THE NON-MEASURABLE?

The analysis of the real estate market demonstrates that the location of a property is one of the attributes which strongly influence its value. A residential property located in an attractive, fashionable district will be valued higher than a similar property located in an unattractive area, far from the city centre. Location is a qualitative feature. Experts try to quantify this attribute by describing it as desirable, average or undesirable. But even this kind of definition is very subjective – the assessment of the attractiveness of a location depends, at least to some extent, on the emotions and the potential associations the person describing the property might have with a given location. So, how to measure the effect of this qualitative variable on the value of a property? Guzik (2008) proposed an approach where the attractiveness coefficient for particular locations, i.e. the location rent, is incorporated into the econometric model.

In the econometric analysis, when examining the relationship:

$$X_{1t} = f(X_{2t}, X_{3t}, \dots, X_{kt}, U_t) \tag{1}$$

we can use, e.g.:

1. levels of variables X_{it},
2. changes $\Delta X_{it} = X_{it} - X_{it-1}$,
3. effects of variables $X_{2t}, X_{3t}, \dots, X_{kt}$ on X_{1t} (structural parameters),
4. outcome of effects of variables X_{it}, i.e. $X_{1t}(X_{it}); i = 2, 3, \dots, k$.

It appears that even when it is not possible to examine the levels and relations listed in points 1 to 3, we can still examine the effects of non-measurable explanatory variables (attributes) on the explanatory variable (Hozer, 2003). In order to be able to examine the effects referred to in point 4, it is necessary to conduct a special procedure based on the non-classical model of relationships described in point 2.

3. METHODOLOGY

In the first phase of the study, variables that significantly affect the value of a property were specified, out of which these attributes were selected that both had the strongest effect on the value of a property and at the same time were collectable, e.g.: size, transport accessibility, neighbourhood, development, utilities, land and water conditions. It is often impossible to meet both of these conditions simultaneously. The Szczecin land property mass valuation algorithm (SAMWN) presented below, however, takes into account both the deliberate human activity and non-measurable factors in the form of the market value coefficients (WWR_j):

$$\widehat{W}_{ji} = WWR_j \cdot pow_i \cdot W_{baz} \cdot \prod_{k=1}^{K} (1 + A_k), \tag{2}$$

where:

$\widehat{W}_{ji}$ – market (cadastral) value of the i-th property in the j-th elementary area,
WWR_j – market value coefficient in the j-th elementary area ($j = 1, 2, \dots, J$),
J – number of elementary areas,
pow_i – size of the i-th property,
W_{baz} – price of 1 m^2 of the cheapest land in the valuated area,
A_k – effect of the k-th attribute ($k = 1, 2, \dots, K$),
K – number of attributes.

Coefficients WWR_j are computed for individual elementary areas[10] as an arithmetical mean of the WWR_i (formula 3) calculated for individual properties-representatives of each of the elementary areas. These, in turn, are the quotients of the market value of the property (formula 4) determined by the property valuer[11] in the process of individual valuation and the hypothetical value of the property determined on the basis of formula 5:

$$WWR_j = \frac{\sum_{i=1}^{l} WWR_i}{l}, \tag{3}$$

$$WWR_i = \frac{WR_{ri}}{\widehat{W}_{hi}}, \tag{4}$$

$$\widehat{W}_{hi} = pow_i \cdot W_{baz} \cdot \prod_{k=1}^{K} (1 + A_k), \tag{5}$$

where:

WWR_i – ratio of the market value to the hypothetical value of the i-th property,
l – number of properties-representatives in the j-th elementary area,
WR_{ri} – market value of the i-th property, determined by a property valuer,
$\widehat{W}_{hi}$ – hypothetical value of the property calculated on the basis of the model.

In the SAMWN algorithm (formula 2), it is problematic to determine the A_k coefficients whose function is to measure to what extent particular attributes (features) affect the value of a property. Since the attributes are presented on an ordinal scale, the following two methods have been used to determine the effects of particular characteristics on the value of properties: the Spearman coefficients (R_{xy}) and standardised β_k coefficients. The latter are calculated according to the following formula:

[10] The elementary area is defined as an area in which a certain number of valued properties are located that are characterised by the same effect of the location attribute on their value.
[11] Property valuers who estimated the value of given properties used location as one of attributes describing the property.

$$\hat{\beta}_k = \frac{S_{A_k}}{S_{WR_r}} \cdot \frac{(WR_{ri} - \overline{WR}_r)}{(A_k - \bar{A}_k)}, \tag{6}$$

where:

$\hat{\beta}_k$ – standardised beta coefficient of the k-th attribute,
S_{WR_r} – standard deviation of the value of 1 m^2 of land determined by a property valuer
$\overline{WR}_r$ – average value of 1 m^2 of land calculated on the basis of values determined by a property valuer,
S_{A_k} – standard deviation of the effect of the k-th attribute,
$\bar{A}_k$ – average value of the effect of the k-th attribute

The calibration of the attributes of land properties is carried out on the basis of correction coefficients $(1 + A_k)$, which are determined according to the method of distance from extreme values (Lis, 2008):

$$\begin{aligned} 1 + A_k &= \left(1 - \frac{1}{2}\rho\right) + \left[\left(1 + \frac{1}{2}\rho\right) - \left(1 - \frac{1}{2}\rho\right)\right] \cdot \frac{l_{kp}}{k_p - 1} \\ &= \left(1 - \frac{1}{2}\rho\right) + \rho \frac{l_{kp}}{k_p - 1}, \end{aligned} \tag{7}$$

where:

l_{kp} – the p-th category of the k-th attribute,
k_{p} – number of categories of the k-th attribute,
ρ – standardised coefficients of the k-th attribute, depending on the method adopted: Spearman coefficient R_{xy} or beta coefficient $\hat{\beta}_k$.

In order to fully explain the value of the property (in 100%), the estimates of the relevant Spearman coefficients and standardised beta coefficients are adjusted, so that the sum of their absolute values equals one.

At the next stage of the study, the results of property valuations carried out by individual valuers are juxtaposed with the results obtained through SAMWN, using the adjusted Spearman and beta coefficients.

The results thus obtained are compared using a relative valuation error:

$$\partial = \sum_{i=1}^{n} \frac{|W_{ji} - WR_{ri}|}{W_{ji}} \cdot 100\% \tag{8}$$

and the following two variation measures:

$$Se = \sqrt{\frac{\sum_{i=1}^{n}\left(WR_{ri} - WR_{ji}\right)^2}{n}}, \tag{9}$$

$$Vs = \frac{Se}{\overline{\overline{WR_{r\iota}}}} \cdot 100\%, \tag{10}$$

where:
Se – standard deviation of the value of 1 m^2 land,
Vs – variation coefficient of the value of 1 m^2 of land.

4. EMPIRICAL EXAMPLE

The study used the data on 567 plots of land in Szczecin designated for housing purposes, which were the subject of individual valuation in 2005. The plots were located in 5 elementary areas (Tabl. 2).

TABLE 2. NUMBER OF INDIVIDUAL ELEMENTARY AREAS COVERED BY THE STUDY

Elementary area	Number
3	187
4	37
5	178
6	62
7	103
Total	567

S o u r c e: own compilation.

The plots were described by the following attributes:
y – value of 1 m^2 (in PLN), a dependent variable,
x_1 – physical traits (0 – undesirable, 1 – average, 2 – desirable),
x_2 – development (0 – no, 1 – yes),
x_3 – utilities (0 – no, 1 – partial, 2 – full),
x_4 – neighbourhood (0 – undesirable, 1 – desirable),
x_5 – accessibility (0 – poor, 1 – average, 2 – good),
x_6 – location (0 – undesirable, 1 – average, 2 – desirable),
x_7 – size (0 – large, 1 – medium, 2 – small),
x_8 – ground and water conditions (0 – bad, 1 – undesirable, 2 – average, 3 – desirable).

Since the main purpose of the paper is to present the method of calculating the effect of non-measurable variables on the value of real estate, the location attribute was omitted in the subsequent calculations. The value of this attribute was determined on the basis of the opinion of a property valuer, who while deciding about it, took into account the popularity of the given area. The estimates of the Spearman correlation coefficients and $\hat{\beta}_k$ coefficients between the value of 1 m^2 of a land property in Szczecin and individual attributes are presented in Tabl. 3

TABLE 3. ESTIMATES OF THE SPEARMAN CORRELATION COEFFICIENT AND $\widehat{\beta}_k$ COEFFICIENTS OF 1 M² AND INDIVIDUAL ATTRIBUTES OF LAND PROPERTIES IN SZCZECIN IN 2005

Coefficient	x_1	x_2	x_3	x_4	x_5	x_7	x_8
R_{xy}	–0.063	**0.282**	**0.343**	–0.074	**0.175**	–0.081	**0.187**
Adjusted R_{yx}		**0.286**	**0.347**		**0.177**		**0.190**
$\hat{\beta}_k$	0.039	**0.106**	**0.158**	–0.049	**0.092**	**–0.155**	**0.389**
Adjusted $\hat{\beta}_k$		**0.118**	**0.176**		**0.102**	**–0.172**	**0.433**

x_1 – physical traits, x_2 – development, x_3 – utilities, x_4 – neighbourhood, x_5 – accessibility, x_7 – size, x_8 – water and ground conditions.

Figures in bold – significant at 5%.

S o u r c e: own calculation.

They indicate that when determining the impact of attributes using the adjusted Spearman coefficients, the physical traits, neighbourhood and size variables turned out to be insignificant; whereas when using the standardised beta coefficients, only physical traits and neighbourhood were insignificant.

According to the Spearman coefficients, the value of properties was influenced by utilities to the largest extent. In the case of beta coefficients, the highest correlation was observed for the land and water conditions. All the coefficients had low magnitudes.

Adjusted coefficients were calculated by adjusting the significant values of the coefficients of individual attributes, so that their sum equalled one. Only the attributes significantly affecting the value of the property were taken into account.

Tabl. 4 shows the calculation of the effect of each attribute on the value of the property.

TABLE 4. CALCULATION OF VALUES OF LAND PROPERTY ATTRIBUTES

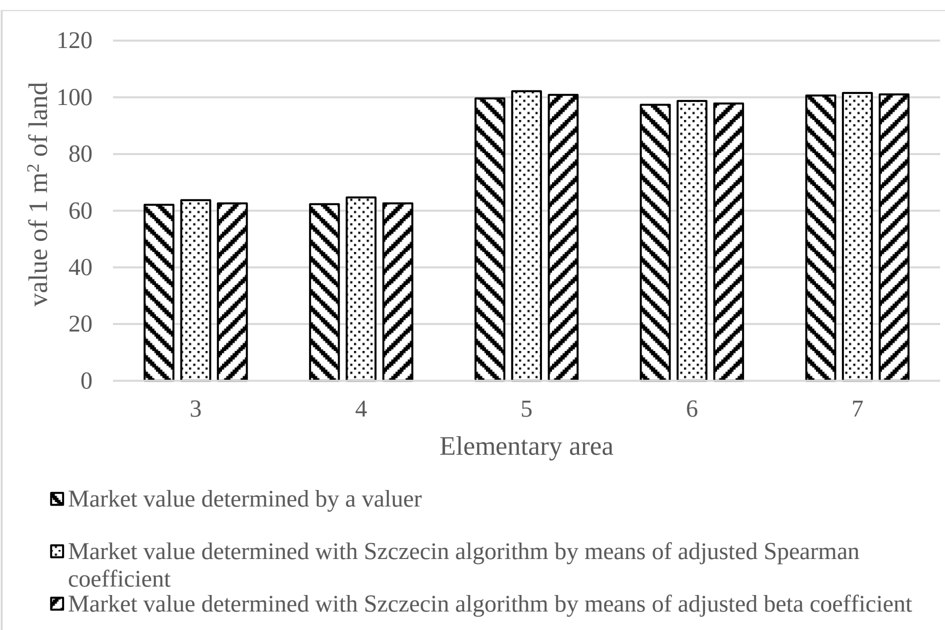
Attribute	Attribute alternative	Adjusted R_{xy}	$1 + A_k$	A_k %	Adjusted $\hat{\beta}_k$	$1 + A_k$	A_k %
Development	0	0.286	0.857	–14.29	0.118	0.941	–5.9
	1		1.143	14.29		1.000	0
Utilities	0	0.347	0.827	–17.35	0.176	0.912	–8.79
	1		1.000	0		1.000	0
	2		1.174	17.35		1.088	8.79
Accessibility	0	0.177	0.911	–8.86	0.102	0.949	–5.08
	1		1.000	0		1.000	0
	2		1.089	8.86		1.051	5.08
Size	0	–	–	–	–0.172	1.086	8.6
	1		–	–		1.000	0
	2		–	–		0.914	–8.6
Ground and water conditions	0	0.190	0.905	–9.49	0.433	0.784	–21.63
	1		0.968	–3.16		0.928	–7.21
	2		1.032	3.16		1.072	7.21
	3		1.095	9.49		1.216	21.63

S o u r c e: own calculations.

The power of the effect of the attributes on the value of a property varies depending on the applied coefficient. When we use the adjusted Spearman coefficient, it is utilities that affect the value of 1 m^2 of land to the largest extent. Plots equipped with all the required utilities are on average 34.7% more expensive than non-equipped plots. The second most influential feature is development. The attributes which relatively have the smallest effect on the value of the property are ground and water conditions and accessibility.

On the other hand, when applying the adjusted $\hat{\beta}_k$coefficient, ground and water conditions turned out to be a variable shaping the value of a property to the largest extent. A plot of land with favourable ground and water conditions was on average 43.3% more expensive than a plot with poor such conditions. All attributes affected the value of the property, including size, however, what is questionable here, is the sign of the correlation – the smaller the plot, the lower the value of 1 m^2 (1 m^2 of a small plot was worth 17.2% less than 1 m^2 of a large plot). Interestingly, the observation of the real estate market shows something opposite, namely positive rather than negative correlation, i.e. the smaller the plot, the higher the value (price) of 1 m^2 (Foryś and Gdakowicz, 2004). This inconsistency might result from the fact that small plots of land belonged to natural persons (and the value of the plots was lower), while large plots were owned by institutionalised entities, and the value of these properties was higher.

Figure 1. Summary of the average value of 1 m^2 of land estimated by property valuers and calculated using SAMWN with the application of adjusted Spearman coefficients and standardised beta coefficients in individual elementary areas



S o u r c e: own calculations.

The estimations of the average value of 1 m^2 of land carried out both by property valuers and using the Szczecin mass valuation algorithm (with the use of both approaches) yielded similar results, in each of the elementary areas (Fig-ure 1). According to property valuers, popular and attractive plots (i.e. worth more) were located in elementary areas No 5, 6 and 7, where the value of 1 m^2 of the plot reached about 100 PLN. The application of the Szczecin algorithm of mass valuation of real estate confirmed the above results – plots located in areas 5, 6 and 7 were valued higher than plots located in areas 3 and 4. The application of the SAMWN calculation algorithm and the estimation of WWR_j values for particular elementary areas enabled the inclusion of the effect of the plot location (fashion) in the calculation, although that variable was not one of the *a priori* attributes.

Tabl. 5 presents values of market coefficients (WWR_j) estimated for particular elementary areas using SAMWN. The results obtained through the application of the algorithm (in two variants: using the adjusted Spearman and beta coefficients) are compared with the values estimated by property valuers. The consecutive columns present measures of agreement between the obtained results, such as the residual deviation, coefficient of variation and relative valuation error.

TABLE 5. COEFFICIENTS OF MARKET VALUES FOR PARTICULAR ELEMENTARY AREAS AND MEASURES OF AGREEMENT BETWEEN SAMWN RESULTS AND VALUERS' APPRAISALS

Elementary area	Adjusted R_{xy}				Adjusted $\hat{\beta}_k$			
	WWR_j	Se	Vs	∂	WWR_j	Se	Vs	∂
3	0.978	8.377	13.50	13.03	0.983	4.643	7.48	6.05
4	0.987	10.525	16.89	16.96	0.973	3.507	5.63	4.54
5	1.546	13.736	13.79	13.13	1.575	9.226	9.26	6.73
6	1.537	9.641	9.91	7.73	1.431	5.978	6.15	4.33
7	1.449	7.663	7.61	6.12	1.546	5.432	5.40	4.45

S o u r c e: own calculations.

The coefficient of the market value in No 5 elementary area (for the Spearman coefficients) is 1.546, which means that the value of land in this area, as calculated with the use of SAMWN, was on average 54.6% higher than the value of land located in a less attractive elementary area. The same coefficient in the same elementary area for the $\hat{\beta}_k$ coefficients, however, totals 1.575, which means that the value of land in this area, also calculated via SAMWN, is on average 57.5% higher than the value of land located in a less fashionable area.

When the SAMWN with the adjusted Spearman coefficient was applied, the value of a plot of land in No 3 elementary area differed from the value estimated by the property valuer on average by +/– 8.38 PLN per 1 m^2, which constituted 13.5% of the average value of land determined by the valuer. When having applied the adjusted $\hat{\beta}_k$ coefficient for the same elementary area, however, the value of 1 m^2 of land differed on average by +/– 4.64 PLN per 1 m^2 from the value estimated by the valuer, which equals 7.48% of the average value of land determined by the valuer.

The analysis of the results of the relative valuation error shows a smaller discrepancy between the results of the valuation carried out by valuers and the results obtained with SAMWNs using the adjusted beta coefficients than when using the adjusted Spearman coefficients. In all the elementary areas the results thus obtained showed lower values of stochastic structure parameters.

5. CONCLUSION

Taking account of the impact of non-measurable variables on the dependent variable proves particularly useful for real estate market analysts. Many attributes that influence the value and price of a property are non-measurable, for example fashion, attractiveness or popularity. The article proposes a procedure for estimating the value of a property in the form of mass valuation, in which the attributes related to location and fashion are not included *a priori*.

The values of properties estimated using the SAMWN and those obtained on the basis of individual valuers' appraisals turned out to be similar. The construction of the algorithm makes it possible, through the estimation of the WWR_j, to take the degree of impact non-measurable attributes have on the value of the property into account while performing the calculation. Among the two proposed methods of determining the influence of attributes on the value of a property, better results were obtained when adjusted beta coefficients were applied.

The proposed method for estimating the value of a property has assumed particular importance in the context of increasing demand for mass valuation of real estate and the method of statistical market analysis. The legislator has not defined a detailed procedure for any of these approaches, thus leaving many decisions to the discretion of property valuers. This study may therefore be an important voice in the debate on the use of econometric and statistical methods in the process of real estate valuation.

REFERENCES

Arribas I., Garcia F., Guijarro F., Oliver J., Tamosiuniene R., (2016), Mass Appraisal of Residential Real Estate Using Multilevel Modelling, *International Journal of Strategic Property Management*, 20(1), 77–87, DOI: 10.3846/1648715X.205.1134702.

Babatunde I. O., (2018), Examining Heuristics for Building – Work-In-Progress Valuations in Niger State Nigeria, *Real Estate Management and Valuation*, 26(2), 92–103, DOI: 10.2478/remav-2018-0019.

Benjamin J. D., Randall S., Guttery R. S., Sirmans C. F., (2004), Mass Appraisal: An Introduction to Multiple Regression Analysis for Real Estate Valuation, *Journal of Real Estate Practice and Education*, 7(1), 65–77.

Cellmer R., (1999), *Zasady i metody analizy elementów składowych rynku nieruchomości*, Wyd. Educaterra, Olsztyn.

Cellmer R., (2000), Metody analizy rynku nieruchomości – przykłady, *Wycena*, 2(49), 6–10.

Ciuna M., Milazzo L., Salvo F., (2017), A Mass Appraisal Model Based on Market Segment Parameters, *Buildings*, 7, 34, DOI: 10.3390/buildings7020034.

Czaja J., Dąbrowski J., (2008), Special Algorithms for Assesing Market Value of Real Estates, *Geomatics and Environmental Enginering*, 2(2), 21–31.

Czaja J, Ligas M., (2010), Zaawansowane metody analizy statystycznej rynku, *Studia i Materiały Towarzystwa Naukowego Nieruchomości*, 18(1), 7–19.

Czaja J., Żak M., (1993), *Systemy przetwarzania danych przy szacowaniu nieruchomości metodami rynkowymi*, Acta Acad. Agricult. Tech. Olst., 451, Geod. Ruris Regulat., 24: 7–19.

Dacko M., (2000a), Solver – zastosowanie w modelowaniu ekonometrycznym na potrzeby analiz rynku nieruchomości, *Wycena*, 4, 41–45.

Dacko M., (2000b), Zastosowanie regresji wielokrotnej w szacowaniu nieruchomości w arkuszu kalkulacyjnym Microsoft Excell 2000, *Wycena*, 2, 50–56,

Doszyń M., Gnat S., (2016), Taksonomiczno-ekonometryczna procedura wyceny nieruchomości dla różnych miar porządkowania, *Prace Naukowe Uniwersytetu ekonomicznego we Wrocławiu nr 427. Taksonomia 27 Klasyfikacja i analiza danych – teoria i zastosowania*, 84–93.

Foryś I., Gdakowicz, (2004), Wykorzystanie metod ilościowych do badania rynku nieruchomości, *Studia i materiały Towarzystwa Naukowego Nieruchomości*, 12(1), 41–49.

Gaca R., Sawiłow E., (2014), Zastosowanie współczynnika korelacji rang Spearmana do ustalenia wag cech rynkowych nieruchomości, *Rzeczoznawca majątkowy*, 82, 24–30.

Gaca R., (2018), Parametric and Non-Parametric Statistical Methods in the Assessment of the Effect of Property Attributes on Prices, *Real Estate Management and Valuation*, 26(2), 83–91, DOI: 10.2478/remav-2018-0018.

Gdakowicz A., Putek-Szeląg E., (2018), Ekonometryczno-statystyczne metody masowej wyceny nieruchomości w Polsce – studium przypadków, W: Nieruchomość w Przestrzeni 4, Wydawnictwa Uczelniane Uniwersytetu Technologiczno-Przyrodniczego w Bydgoszczy, Bydgoszcz, 141–154.

Głuszak M., (2011), Eksperyment conjoint jako metoda wyznaczania współczynników wagowych atrybutów w wycenie nieruchomości, *Zeszyty Naukowe Uniwersytetu Ekonomicznego w Krakowie*, (850), 49–64.

Guzik B., (2008), Statystyczne metody szacowania atrakcyjności lokalizacji mieszkań Statistical Methods for Estimating the Attractiveness of Apartments Location, *Roczniki Ekonomiczne Kujawsko-Pomorskiej Szkoły Wyższej w Bydgoszczy*, (1), 233–250.

Hopfer A., Jędrzejewski H., Żróbek R., Żróbek S., (2001), *Podstawy wyceny nieruchomości*. Twiger, Warszawa.

Hozer J., (2003), *Tempus locus homo casus et fortuna regit factum. Zbiór esejów ekonomicznych*, Oficyna "in Plus", Szczecin.

Hozer J., Foryś I., Zwolankowska M., Kokot S., Kuźmiński W., (1999), *Ekonometryczny algorytm masowej wyceny nieruchomości gruntowych*, Stowarzyszenie Pomoc i Rozwój, Szczecin.

Kauko T., D'Amato M., ed., (2008), *Mass Appraisal Methods: An International Perspective for Property Valuers,* Blackwell Publishing Ltd.

Kubus M., (2016), Locally Regularized Linear Regression in the Valuation of Real Estate, *Statistics in Transition new series*, 17(3), 515–524

Kuryj J., (2007), Metodyka wyceny masowej nieruchomości na bazie aktualnych przepisów prawnych, *Wycena*, 4(81), 50-58.

Lipieta A., (2000), Model ekonometryczny ze zmiennymi jakościowymi opisujący ceny mieszkań, *Wiadomości Statystyczne*, 8, 10–20.

Lis Ch., (2008), Wykorzystanie metod ilościowych w procesie powszechnej taksacji nieruchomości w Polsce, *Prace Naukowe Akademii Ekonomicznej w Katowicach, Modelowanie matematyczne i ekonometryczne na polskim rynku finansowym*, 191–204.

National Valuation Standards of the Polish Federation of Valuers' Associations, Standardy – do pobrania, https://pfsrm.pl/aktualnosci/item/14-standardy-do-pobrania, (accessed: 20.08.2018).

Pawlukowicz R., (2001), Przegląd propozycji określania wartości rynkowej nieruchomości z wykorzystaniem modeli ekonometrycznych, *Zeszyty Naukowe Uniwersytetu Szczecińskiego nr 320, Prace naukowe Katedry Ekonometrii i Statystyki Szczecin*, 317–324.

Pawlukowicz R., Bartłomowicz T., (2005), Conjoint analysis jako sposób wyznaczania wag cech rynkowych w wycenie rynkowej nieruchomości za pomocą podejścia porównawczego, *Prace Naukowe Akademii Ekonomicznej we Wrocławiu, nr 1096, Ekonometria, 15*, 128–139.

Renigier-Biłozor M., (2008), Zastosowanie teorii zbiorów przybliżonych do masowej wyceny nieruchomości na małych rynkach, *Acta Scientiarum Polonorum, Administratio Locorum*, 7(3), 35–51.

Sawiłow E., (1995), *Próba matematycznego modelowania wartości gruntów na terenach zurbanizowanych*, Wyd. Stowarzyszenie Rzeczoznawców Majątkowych we Wrocławiu i Polska Federacja Stowarzyszeń Rzeczoznawców Majątkowych, Wrocław, Warszawa.

Telega T., Bojar Z., Adamczewski Z., (2002), Wytyczne przeprowadzeni powszechnej taksacji nieruchomości, *Przegląd Geodezyjny*, 6, 6–11.

Walkowiak R., Zydroń A., (2012), Zastosowanie regresji krokowej do określenia atrybutów wpływających na wartość nieruchomości rolnych na przykładzie gminy Mosina, *Acta Scientiarum Polonorum Administratio Locorum*, 11(3), 239–253.

Yasnitsky L. N., Yasnitsky V. L., (2016). Technique of Design for Intergrated Economic and Mathematical Model for Mass Appraisal of Real Estate Property. Study Case of Yekaterinburg Housing Market, *Journal of Applied Economic Sciences*, 11(46), 1519–1531.

Zadumińska M., Sztaudynger J., (2001), Wykorzystanie modelu ekonometrycznego do wyceny nieruchomości, *Wiadomości Statystyczne*, 1, 6–13.

Zbyrowski R., (2010), Szacowanie wartości nieruchomości na podstawie modeli ekonometrycznych, *Equilibrium*, 1(4), 241–252.

Źróbek S., (2002), *Określenie wartości rynkowej nieruchomości*, Wydawnictwo Uniwersytetu Warmińsko-Mazurskiego, Olsztyn.

Źróbek S., Bełej M., (2000), *Podejście porównawcze w szacowaniu nieruchomości*, Wyd. Educaterra, Olsztyn.