Different methods for assessing the similarity of real estate in two-stage estimation algorithm based on multiplicative functions[1]

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Key words: multi-dimensional modelling of the real estate market, similarity criteria, multiplicative functions

SUMMARY

This paper proposes using different methods to establish similarity criteria of real estate. The problem of assessing the similarity is a key issue in the comparative approach to real estate appraisal in which the appraiser selects properties most similar to the appraised one from a collected database.

Algorithms for establishing the degree of similarity may be based on estimating absolute differences between qualitative characteristics, for example using one of the following methods:

- relative similarity analysis,
- property ranking analysis,
- selection of similar properties on the basis of a determined number of identical attributes.

Similarity can also be assessed only on the basis of a determined number of selected attributes considered to be the most significant characteristics of a given type of real estate and estimated type of model. In the case of homogenous markets, the most significant attributes can be selected using so-called beta weights determined from regression coefficients.

This paper presents examples of using various methods of property similarity assessment and evaluates their impact on the final result of the appraisal, made using a defined two-stage algorithm.

Another aspect of this work consists in analysing the influence of different forms of multiplicative functional models on the effect of the real estate market value estimation in a two-stage appraisal algorithm. The following models in multiplicative form were analysed:

- exponential model

$$c = a_0 \cdot a_1^{x_1} \cdot a_2^{x_2} \cdot \dots \cdot a_m^{x_m}$$

- power model

$$c = a_0 \cdot x_1^{a_1} \cdot x_2^{a_2} \cdot \dots \cdot x_m^{a_m}$$

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Różne metody ustalania podobieństwa nieruchomości w dwuetapowym algorytmie wyceny opartym na funkcjach multiplikatywnych

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Słowa kluczowe: wielowymiarowe modelowanie rynku nieruchomości, kryteria podobieństwa, funkcje multiplikatywne

STRESZCZENIE

W artykule zaproponowano zastosowanie różnych metod ustalenia kryteriów podobieństwa nieruchomości. Problem ustalania podobieństwa jest kluczowym zagadnieniem podejścia porównawczego wyceny nieruchomości, w którym rzeczoznawca ze zgromadzonej bazy danych wybiera nieruchomości najbardziej podobne do wycenianej.

Algorytmy ustalania stopnia podobieństwa mogą być oparte na określaniu absolutnych różnic między cechami jakościowymi, na przykład poprzez zastosowanie następujących metod:
- analiza porównania względnego,
- analiza szeregowania nieruchomości,
- wybór podobnych na podstawie określonej liczby identycznych atrybutów.

Podobieństwo może być również ustalone wyłącznie na bazie ustalonej liczby wybranych atrybutów, uznanych za cechy najbardziej znaczące dla danego typu nieruchomości i najbardziej cenotwórcze w wyestymowanym modelu funkcyjnym. W przypadku jednorodnych rynków nieruchomości, najbardziej znaczące atrybuty mogą być wybrane na podstawie tak zwanych wag-beta, wyznaczonych ze współczynników regresji.

Niniejszy artykuł prezentuje przykłady zastosowania różnych metod oceny podobieństwa między nieruchomościami i ocenia ich wpływ na końcowy efekt wyceny, przy wykorzystaniu określonego dwuetapowego algorytmu wyceny.

Drugi aspekt badawczy niniejszej pracy, to analiza wpływu różnych postaci multiplikatywnych modeli funkcyjnych na efekt szacowania rynkowej wartości nieruchomości, w dwuetapowym algorytmie wyceny. Analizowano następujące modele w formie multiplikatywnej:

- model wykładniczy

$$c = a_0 \cdot a_1^{x_1} \cdot a_2^{x_2} \cdot \cdots \cdot a_m^{x_m}$$

- model potęgowy

$$c = a_0 \cdot x_1^{a_1} \cdot x_2^{a_2} \cdot \cdots \cdot x_m^{a_m}$$

Different methods for assessing the similarity of real estate in two-stage model based on multiplicative functions[2]

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1. WPROWADZENIE

The assessment of the similarity between a real estate to be appraised and these, which are to serve as the basis for this appraisal, is the first and essential stage of the comparative approach in the estimation of a real estate value. A skilful expert, having knowledge of a local market, can choose, without any algorithms, among many parcels being subject of transaction, the ones that are close to the subject of appraisal in consideration of the significant features. However, considering the importance of selecting the objects similar to the appraised one – they are the basis for the whole further appraisal process in a comparative approach – it is worth examining the effect of the similarity assessment method on the final appraisal result, i.e. on the real estate value as well as on the accuracy of its determination. By the method I mean the application of a real mathematical algorithm.

The analysis of the effect of applying different methods for assessing the similarities between parcels on their value prediction was made by the example of using for the assessment multidimensional functional models of a multiplicative character. The application of these models is based on the assumption that the features of a real estate creating its price are interrelated, so it is difficult to isolate their individual effect. Two types of multiplicative models were used in the work: exponential and power model.

2. TWO-STAGE ALGORITHM OF REAL ESTATE APPRAISAL

The starting point for the analyses carried out on a local market of parcels of an established type, is a numerous market database on the transactions concluded within the time not very far away the appraisal date. On the basis of these data, the appraisal model parameters are estimated, in form of a multidimensional function, verified in view of the quality of fitting to the market data and in view of its parameters stability, and, in consequence, of the reliability of the prediction determined on its grounds. The assessment of a real estate value on the basis of an estimated multidimensional model is done with a full accuracy analysis.

[2] The task within own research in Department of Geomatics,
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The basis for a model value prediction done in such a way, is the whole gathered database, which, in the case of multidimensional functional models, must be numerous enough, being often by this strongly diversified. Hence, at the second stage of prediction, the value, got directly from the model, is corrected. The correction is calculated on the basis of a small group of parcels most similar to the appraised one, selected of the input database. The detailed description of the two-stage algorithm leading to the final market value of a real estate can be found in [6.] and [8].

3. FIRST STAGE OF THE REAL ESTATE ASSESSMENT – multidimensional modeling

3.1. Forms of estimated assessment models

The models, which parameters were estimated at the first assessment stage, were:

- exponential multiplicative model

$$c = a_0 \cdot a_1^{x_1} \cdot a_2^{x_2} \cdot \cdots \cdot a_m^{x_m} \qquad (1)$$

where:

c – real estate unit price,
x_i – value of attribute i,
m – number of considered attributes,
a_i – model parameters.

- power multiplicative model

$$c = a_0 \cdot x_1^{a_1} \cdot x_2^{a_2} \cdot \cdots \cdot x_m^{a_m} \qquad (2)$$

with the notation as in the exponential model.

The estimation of these model parameters is done according to the least squares method LSM, after a linearization process of the model. Finding the logarithms of the expression both sides (1) and (2), we get respectively:

$$\ln c = \ln a_0 + x_1 \cdot \ln a_1 + x_2 \cdot \ln a_2 + \cdots + x_m \cdot \ln a_m \qquad (1a)$$
$$\ln c = \ln a_0 + a_1 \cdot \ln x_1 + a_2 \cdot \ln x_2 + \cdots + a_m \cdot \ln x_m \qquad (2a)$$

As a result of applying LSM to the linearized model forms (1a) and (2a), we get a random component in form $[\ln[\delta]]$, assuming that $[\delta]$ is the random component in the model (1) or (2). Deviations $[\ln[\delta]]$ will be used to determine a random correction of the model value at the stage II.

The verification of the estimated model is done accordingly to the algorithm described in details in the work [5]. The basic parameter indicating the quality of matching the model up to the empirical data is the coefficient of determination R^2, determining the share of the variance of the part explained by the model, in a total dispersion of the dependent variable (real estate price) around its mean value. In order to increase the value R^2, the cases standing out (parcels with standing out prices) were removed, and in order to improve the stability of parameters, some insignificant explaining variables were eliminated. The basis for further calculation was the models well matched to the market data and statistically verified.

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4. METODY WYBORU NIERUCHOMOŚCI PODOBNYCH

All methods of similarity assessment, described in 4.1 – 4.3, we apply to these real estate features that showed to be essential at the stage of modeling a real estate local market of a given type. In the similarity assessment algorithm, it is essential then to select among the features describing the parcels in the database – the ones that are the most significant in creating their prices by the estimated model. In the example discussed below, among 18 real estate features with which the market data had been primarily described – there was 11 significant features in the exponential model, and in the power model – 10.

To select such features, a parametric significance test was used, on the 0.05 significance level, in relation to the model parameter standing close to the analyzed variable (real estate attribute). Here, the test function is the expression:

$$T = \frac{\hat{a}_i}{\sigma(\hat{a}_i)} \tag{3}$$

where:

$\hat{a}_i$ – estimator of model parameter a_i,

$\sigma(\hat{a}_i)$ – estimator standard deviation.

Using the test above, the zero hypothesis H_0: $a_i = 0$ was verified
against the alternative hypothesis H_1: $a_i \neq 0$.

To select price-creating attributes among all real estate features, we may use also the Pearson correlation coefficient, in relation to the transformed model variables, achieved by linearization. As is well known, Pearson correlation coefficient examines only the degree of linear correlation between random variables. Therefore, in the case of nonlinear models it will not be suitable for original values of random variables, because it is very sensitive to the standing out cases.

In this work, three different methods (criteria) have been used to assess the similarity between parcels:
- relative comparison analysis,
- real estate ranking analysis,
- selection of similar parcels on the basis of at least half identical attributes among the most price-creating attributes.

The methods above take all attributes of the parcel as its equivalent features creating prices. They consider however only these attributes, which passed successfully, in a separate selection, a significance verification test in view of their significant influence on the price variability of parcels of a given type, using an actual form of the functional model. Two first methods are based on algorithms described in the works [4] and [10]. The last one reduces the similarity to the identity of an established number among all the selected features.

4.1. Relative comparison analysis

The analysis of a relative comparison is based on the qualitative comparison of the similar parcel attributes with the attributes of the appraised parcel, aiming only to find out the differences, without investigating their importance. For each feature of the compared parcel, a correction +1 or -1 is established, depending on that if it is better or worse than the corresponding feature of the appraised parcel. The sum of corrections gives a global correction positive or negative, meaning that the appraised real estate has in sum correspondingly "worse" or "better" attributes. As the most similar parcels to the appraised one we recognize these with a global correction equal to zero and, possibly, two others directly close to them, i.e. the cheapest of "better" and the most expensive of "worse".

4.2. Real estate ranking analysis

In the analysis of ranking, the essential is determining the rank (position) for each compared parcel and for a parcel appraised within the whole database, in relation to a theoretical parcel, to which we assign the smallest (or the greatest) values of all attributes. The ranks come from the global number of corrections for individual attributes. Besides, contrary to the relative comparison analysis, assigning a correction in consideration of a given attribute, we take into account of how much degrees on its scale it differs from the extreme value considered as a reference point. In this way, the corrections take the values of integers with the same signs, e.g. 0, -1, -2 and so on, when the reference point is "the worst" parcel, or 0, +1, +2 and so on, when the reference point is "the best" parcel.

Parcels with ranks, assigned in such a way, are arranged in a determined order. As the most similar to the appraised parcel are recognized these, which are on the same position and, possibly, two parcels close to them, i.e. the cheapest one among "better" of one rank and the most expensive among "worse" of one rank.

4.3. Selecting similar parcels on the basis of half identical attributes

This method of assessing similarity is the simplest of all presented methods, since it assumes that the most similar to the appraised object are the parcels having at the minimum half significant features of identical values as the appraised one. In the presented example, it will be at the minimum 5-6 attributes of identical values as their equivalents in the appraised parcel.

5. SECOND STAGE OF APPRAISING A PARCEL – correction of the model value

Estimated parameters of a linearized appraisal model allow determining the systematic component of the model for unitary prices of parcels in the database used for estimation. They are prediction values of logarithms of parcel prices achieved from the model, i.e. model values. To each systematic component of the linearized model [ln$W$] a collection of model random deviations $[\ln[\delta]]$ corresponds:

$$[\ln \delta] = [\ln C] - [\ln W] = [\ln C] - [X] \cdot [X]^{+} [\ln C] = [I - X \cdot X^{+}] \cdot [\ln C] \tag{4}$$

having an inaccuracy characteristic within its covariance matrix:

$$Cov[\ln \delta] = \hat{\sigma}_0^2 \cdot [I - X \cdot (X^T \cdot X)^{-1} \cdot X^T] \tag{5}$$

where:

[ln$W$] – vector of dependent variable model value in a linearized model,

[ln$C$] – vector of logarithms of parcel actual prices in a database,

$[\ln[\delta]]$ – random deviations of a linearized appraisal model,

X – parameter matrix [of matrix notation] of the equation system after linearization,

X^{+} – matrix X pseudoinverse,

σ_0^2 – estimator of linearized model remainder variance.

From the systematic model, taking into account the values of the attributes of the appraised parcel, we calculate its model market value ln(w_M), and, applying growing variance law, we determine its standard deviation, i.e. the accuracy of the appraisal σ(ln(w_M)).

From the vector of linearized model random component $[\ln[\delta]]$, we isolate deviations $\ln \delta_{i_W}$, which correspond to k of selected parcels, the most similar to the appraised one. From the covariance matrix of random deviations we choose the submatrix $Cov(\ln \delta_w)$, with $(k \times k)$ dimension, containing the elements corresponding to the selected deviations.

From the random model we appraise the market value of the random correction $\ln w_L$ to the model value $\ln w_M$ for the appraised parcel and its standard deviation $\sigma(\ln w_L)$:

$$\ln w_L = \left[\underline{1} \cdot P \cdot \underline{1}^T\right]^{-1} \cdot \left[\underline{1} \cdot P\right] \cdot [\ln \delta_W] \tag{6}$$

$$\sigma^2(\ln w_L) = \sigma_{0_W}^2 \cdot \left[\underline{1} \cdot P \cdot \underline{1}^T\right]^{-1} \tag{7}$$

where:

$\underline{1} = \begin{bmatrix} 1 & 1 & \dots & 1 \end{bmatrix}$ – vector composed of ones of $(1 \times k)$ dimension,

$P = Cov^{-1}(\ln \delta_W)$ – weight matrix being the inverse of covariance matrix,

$\sigma_{0_w}^2$ – remainder variance, determined for the group k of selected parcels.

The prediction of the parcel final value logarithm $\ln w_R$ is the sum of model value $\ln w_M$ and the determined random correction $\ln w_L$. From this, we get easily the final prediction of the appraised parcel market value as $w_R = \exp(\ln w_R)$ or as $w_R = w_M \cdot w_L$, where

$w_M = \exp(\ln w_M)$ and $w_L = \exp(\ln w_L)$. We determine the accuracy of the final prediction w_R using the variance transfer law.

6. SUBJECT OF ANALYSIS

The analysis concerned the market information on the plots of land in one of the South Poland communes. The commune area was treated as a local real estate market. It was information about transactions concluded during almost two years (23 months). The transactions concerned the building plots. The gathered database contains information on 117 parcels. The appraisal concerned one of the parcels from the database, so its transaction price was known. To predict the model value of the parcel, we used the models, which, on the analyzed local market, showed a satisfactory matching to the market data and passed successfully the process of statistical verification, described in details in [5].

7. ESTIMATION OF THE MODEL AND PREDICTION OF THE MODEL VALUE

On the basis of the gathered database, an approach was made to estimating parameters of multiplicative models: exponential (1) and power (2), after linearizating them with a logarithmic transformation to the form (1a) and (2a) respectively.

7.1. Exponential model

In the case of the form (1a) of exponential model, in estimation process, from the gathered data on 117 parcels, 9 of them were recognized as standing out cases and eliminated from the database. Plots of land were described with 18 attributes, 7 of which showed to be insignificant in modeling the parcel prices. Thus, final estimators of model parameters were determined on the basis of 108 parcels, described with 11 market features. They were: date of transaction, communication access, destination in a local plan, type of access road, site topography, territorial infrastructure, parcel shape, attractiveness of the location, type of land, level of risk in the case of flood, area.

Punctual estimation of the parameters in linearized model (1a) is presented in table 1. Table 1 contains also the results of the significance parametric tests performed for every determined estimator. They all showed to be statistically significant on the significance level 0.05 ($p<0.05$).

Table 1. Parameters of a linearized exponential model

Estimators		$\sigma(ln(\hat{a}_i))$	T	p-value
$ln(\hat{a}_0)$	1.827	0.351	5.203	0.000
$ln(\hat{a}_1)$	0.013	0.005	2.841	0.005
$ln(\hat{a}_2)$	-0.062	0.021	-2.947	0.004
$ln(\hat{a}_3)$	0.148	0.039	3.806	0.000
$ln(\hat{a}_4)$	-0.137	0.040	-3.403	0.001

$ln(\hat{\alpha}_5)$	0.068	0.030	2.273	0.025
$ln(\hat{\alpha}_6)$	0.132	0.032	4.098	0.000
$ln(\hat{\alpha}_7)$	8.841	3.759	2.352	0.021
$ln(\hat{\alpha}_8)$	0.255	0.022	11.706	0.000
$ln(\hat{\alpha}_9)$	0.139	0.035	4.010	0.000
$ln(\hat{\alpha}_{10})$	0.219	0.050	4.408	0.000
$ln(\hat{\alpha}_{11})$	0.000	0.000	-2.451	0.016

On the basis of the calculated coefficient of multiple correlation *R*, we can state that the linearized exponential model, with parameters presented in table 1, explains 73.0% of land price variability on the analyzed market.

7.2. Power model

For a power model linearized to the form (2a), analogical estimation process of its parameters was done giving the estimators presented in table 2. Two last columns in the table contain the results of the statistical significance examination of the obtained estimators.

The results below are obtained after taking away 21 standing out cases and 8 insignificant parameters. Then, the estimation of final values of model parameters was carried out for 96 parcels, described with 10 attributes: date of transaction, urban area (zone of a town), type of access road, territorial infrastructure, location (surroundings), parcel shape, building density, attractiveness of the location, type of arable land, area.

Table 2. Parameters of a linearized power model

Estimators		$\sigma(ln(\hat{\alpha}_i))$	T	p-value
$ln(\hat{\alpha}_0)$	3.460	0.463	7.470	0.000
$\hat{\alpha}_1$	0.137	0.031	4.425	0.000
$\hat{\alpha}_2$	0.526	0.109	4.820	0.000
$\hat{\alpha}_3$	-0.092	0.032	-2.839	0.006
$\hat{\alpha}_4$	0.099	0.023	4.248	0.000
$\hat{\alpha}_5$	0.202	0.053	3.818	0.000
$\hat{\alpha}_6$	0.652	0.074	8.771	0.000
$\hat{\alpha}_7$	0.305	0.061	5.024	0.000
$\hat{\alpha}_8$	0.059	0.028	2.093	0.039
$\hat{\alpha}_9$	0.350	0.189	1.856	0.067
$\hat{\alpha}_{10}$	0.207	0.062	3.361	0.001

P-value for the parameter α_9 exceeded the value 0.05 equal to the assumed significance level. It was decided however, that this parameter with the random variable standing close to him, would be left in the model, regarding a slight exceeding of the limit value.

In the case of this model, the square of a multiple correlation coefficient was R^2=0.764 and this means that the linearized power model, with the parameters presented in table 2, explains 76.4% of the variability of the land prices on the analyzed market.

7.3. Model value

Obtained parameters estimators for both models allowed doing a punctual estimation of the appraised parcel model value. Its actual unit market price was 44 [zł/m^2]. The results of the model value estimation are presented in table 3.

Table 3. Model values of the appraised parcel

Exponential model		Power model	
R^2=0.730		R^2=0.764	
w_M	σ(⊟ EMBED Equation.DSMT4 ⊟⊟	w_M	σ(⊟ EMBED Equation.DSMT4 ⊟⊟
43.64	4.08	48.31	3.40

Model values are very close to the market value confirming thus the reliability of the estimated models.

8. SELECTION OF SIMILAR PARCELS

In parcel databases used to estimate models parameters (n=108 for the exponential model and n=96 for the power model), a selection of parcels most similar to the appraised one was done using three methods, described in p. 4. The selection results are presented in table 4.

Table 4. Numbers of the most similar real estates

Model	Exponential model			Power model		
	Method of selecting similar			Method of selecting similar		
Method notation	4.1	4.2	4.3	4.1	4.2	4.3
Numbers of selected parcels	10, 25, 26, 35, 72, 83, 85, 87, 93, 94, 102, 103	76, 80, 84, 91, 92, 93, 94, 95, 97, 99, 100, 101, 103, 104, 105, 106, 107	17, 36, 40, 54, 63, 69, 75, 87, 106	20, 36, 46, 49, 55, 64, 68, 72, 73, 74, 75, 78, 79, 83, 99, 103	80, 81, 91, 93, 97, 101, 106	6, 10, 17, 26, 48, 54, 63, 69, 71, 75, 85, 98
k	12	17	9	16	7	12

The results in table 4 show that the methods of assessing the similarity between parcels give quite different data set of parcels recognized as the most similar to the appraised one. No one of the appointed parcels appears in all three methods at the same time, within a given model. Moreover, the number *k* of selected parcels in every method is different. It proves that the methods greatly differ. Next, we will examine how a given method influences the final prediction of the parcel value in a two-stage algorithm of the appraisal.

9. FINAL PREDICTION OF THE REAL ESTATE VALUE

According to the two-stage appraisal algorithm, on the base of selected parcels the most similar, the random corrections were determined from the model random deviations corresponding to the selected parcels. Table 5 contains the results of calculating corrections with their standard deviations. Two last table lines present the results of the punctual estimation of the final prediction of a parcel unit value, for three different methods of assessing similarity between parcels, in two different multiplicative models.

To evaluate the effect of the method, applied for assessing the similarity between parcels, on the final assessment result, the parametric significance tests were done. Using these tests, the final market value predictions and their accuracy have been compared, for different selection methods but within the same model. In this way, the influence of the function model form on the value prediction was eliminated.

To compare market values w_R, the form of test function was used:

$$Z = \frac{w_{R_I} - w_{R_{II}}}{\sqrt{\sigma^2\left(w_{R_I}\right) + \sigma^2\left(w_{R_{II}}\right)}} \tag{8}$$

With this function, the zero hypothesis H_0: $w_{R_I} = w_{R_{II}}$ was verified against the alternative hypothesis H_1: $w_{R_I} \neq w_{R_{II}}$.

To compare the prediction accuracy $\sigma(w_R)$, the statistics was applied:

$$F = \frac{\sigma^2\left(w_{R_I}\right)}{\sigma^2\left(w_{R_{II}}\right)} \tag{9}$$

verifying the following zero hypothesis H_0: $\sigma^2\left(w_{R_I}\right) = \sigma^2\left(w_{R_{II}}\right)$
against the alternative hypothesis H_1: $\sigma^2\left(w_{R_I}\right) > \sigma^2\left(w_{R_{II}}\right)$.

Table 5. Results of punctual estimation of random corrections and final value prediction

Model	Exponential model			Power model		
	Method of selecting similar			Method of selecting similar		
Notation of similarity selection method	4.1	4.2	4.3	4.1	4.2	4.3
w_L	0,918	0,987	1,102	1,036	1,068	0,838
$\sigma(w_L)$	0,041	0,037	0,033	0,048	0,121	0,049
unit	[PLN/m^2]					
w_R	40,06	43,07	48,07	50,07	51,62	40,47
$\sigma(w_R)$	4,16	4,35	5,84	4,23	6,90	3,71

Table 6 contains results of performed tests. The test function values showing statistical significance are marked in bold. In these cases, the calculated statistical value (8) Z_{cal} or (9) F_{cal} exceeds the critical test value Z_{tab} or F_{tab} respectively, read out on statistical tables for the significance level 0.05

Table 6. Analysis of the effect of similarity assessment method on the prediction of a parcel market value

Model	Model wykładniczy			Model potęgowy		
	Compared pair of selection methods			Compared pair of selection methods		
Notation of similarity selection methods	4.1 i 4.2	4.1 i 4.3	4.2 i 4.3	4.1 i 4.2	4.1 i 4.3	4.2 i 4.3
Z_{cal}	0,50	1,12	0,69	0,19	1,71	1,42
Z_{tab}	1,96					
F_{cal}	1,09	**1,97**	**1,81**	**2,66**	1,30	**3,46**
F_{tab}	1,40			1,44		

The results presented in table 6 demonstrate that in none of the models, the method of similarity assessment influences the height of the final prediction of the parcel market value, on an analyzed local market, in a two-stage appraisal algorithm. However, it can be seen that it influences the accuracy of this prediction. It is difficult to formulate universal conclusions, because in both models different methods of selecting similar parcels were recognized as the least accurate: in the exponential model it is the third of discussed methods (selection on the basis of at least half identical parameters), while in the power model it is the analysis of real estate ranking.

In addition, the tests were done comparing value predictions and their accuracy for different models, but using the same parcel similarity selection method. The results of these tests are presented in table 7. Statistics applied here are analogical to functions (8) and (9).

Table 7. Analysis of the effect of model form on the prediction of parcel market value

Notation of similarity selection method	Z_{cal}	Z_{tab}	F_{cal}	F_{tab}
4.1	1,69	1,96	1,03	1,41
4.2	1,05		**2,52**	1,41
4.3	1,10		**2,48**	1,43

Likewise, in the case of examining the effect of model form on the final prediction of market value, there was no evidence of statistical significance of any analyzed differences. However, the accuracy of evaluation in the case of two similarity assessment methods, showed to be, in fact, different for two different function models. As in the previous test series, also here it was difficult to formulate general conclusions, because every time it was another model. In the real estate ranking analysis – the exponential model was found, in fact, more accurate, while, in the method of selecting similar on the basis of, at least, half identical attributes, the power model gave really better accuracy of the final value prediction.

10. PODSUMOWANIE

In the study, was presented theoretical and practical discussion on the effect of applying different methods of assessing similarity between parcels on a parcel final value, obtained with a two-stage algorithm of evaluating a real estate, based on multidimensional multiplicative function models. Performed parametric significance tests did not show any significant differences between final predictions of the parcel values, both for different methods of selecting similar parcels within the same model and for different models within the same method of similarity assessment. However, an effect of both the selection method and the actual model form on the final prediction accuracy, was noticed. Yet, the results in this field do not allow, because of their irregularity, to formulate global conclusions on the subject – which of the methods or of the models leads to better or worse accuracy of real estate appraisal.

REFERENCES

[1] Adamczewski Z.: "Elementy modelowania matematycznego w wycenie nieruchomości Podejście porównawcze", Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa, 2006

[2] Barańska A.: 2004 "Criteria of database quality appraisement and choice stochastic models in prediction of real estate market value", FIG Working Week 2004 and 27th General Assembly in Athens, Greece, 22 – 27 May 2004

[3] Barańska A.: 2006 „Estimation of parameters of multiplicative exponential function model for real estate market value prediction", XXIII FIG Congress "Shaping the Change", Munich, Germany, 8-13 October 2006

[4] Barańska A.: "Quality and quantity methods for estimating real estates", XX Jesienna Szkoła Geodezji im. Jacka Rejmana, Polanica Zdrój, Poland, 16-17 September 2007

[5] Barańska A. Czaja J.: 2007 "Statistical verification of real estate estimation models", FIG Working Week 2007 "Strategic Integration of Surveying Services", Hong Kong SAR, China, 13-17 May 2007

[6] Barańska A.: "Two-stage model for estimating real estate", The Polish Real Estate Scientific Society press, v. 15, no. 3-4, Olsztyn, 2007

[7] Barańska A., Łuczak A.: "Comparing the results of function model estimation for the prediction of real estate market values in additive and multiplicative form", AGH University of science and technology press, Geomatics and Environmental Engineering, v.1, no.3, Cracow 2007

[8] Barańska A.: "Verification of a two-stage valuation model for different types of real estates in local markets", FIG Working Week 2008 "Integrating Generations", Stockholm, Sweden, 14-19 June 2008

[9] Czaja J.: „Metody szacowania wartości rynkowej i katastralnej nieruchomości", Kraków, 2001

[10] Czaja J., Parzych P.: „Szacowanie rynkowej wartości nieruchomości w aspekcie międzynarodowych standardów wyceny", Stowarzyszenie Naukowe im. Stanisława Staszica, Kraków 2007

[11] Radhakrishna Rao C.: "Modele liniowe statystyki matematycznej", PWN, Warszawa, 1982

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