DEVELOPMENT OF REAL ESTATE MASS VALUATION MODEL FOR CONDOMINIUMS IN SKOPJE

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Real estate mass valuation models of a market value have a tendency to generate real estate property values as close as to the real market values. The success of the mass valuation model is determined based on the differences in the appraised market value and the price a certain property has reached on the open market. In order to establish a model with satisfactory quality, the right factors that determined property value need to be considered in creating mathematical relations between property value and selected factors. Property valuation theory, as one of the primary factors influencing property value, considers location. The paper is striving toward establishing a mass valuation real estate property model considering the implementation of spatial data as a significant factor in determining the market value of condominiums in Skopje.

Keywords: Real estate valuation, mass valuation, Spatial data, GIS.

1. INTRODUCTION

The great importance of real estate, both in economic as well as in social life creates a need for trustworthy data about its own value, which will be helpful in making decisions during its management and usage.

The value, in the publication Uniform standards of professional appraisal practice by the Appraisal Foundation, is defined as “*the monetary relationship between properties and those who buy, sell, or use those properties*”. Value expresses an economic concept. As such, it is never a fact, that is, it is always an opinion about the value of the property at a given time in accordance with a certain definition of value. Real estate appraisal or property valuation is *"the act or process of developing an opinion of value of the property"* (USPAP, 2017).

According to international standards, more types of real estate value can be defined, depending on the situation and the needs for which the assessment is performed. The most common type of value that is estimated is the market value of real estate. The market value by the International Valuation Standards Council in their publication International Valuation Standards is defined as *"the estimated amount for which an asset or liability should exchange on the valuation date between a willing buyer and a willing seller in an arm's length transaction, after proper marketing and where the parties had each acted knowledgeably, prudently and without compulsion"* (IVS, 2017).

It is important to distinguish the term market value from the term market price, which is the amount for which real estate is sold on a certain date. In addition to the market, investment, liquidation value, value according to the principle of continuity and many other types of real estate value can be also estimated.

Regarding the method of valuation, i.e., the number of real estates that are apprised, there is an individual and mass valuation. The individual valuation is an estimate of the value specifically intended for individual real estate, taking into account its specific characteristics and referring to a specific date. Unlike individual valuation, mass valuation is a process of valuing a group of real estate, on a given date, using common data, applying standardized methods and conducting statistical tests to ensure unity and equality in valuation. When assessing a large number of real estates, it is difficult to emphasize each of their qualities, so special attention is paid to defining what is common to all real estate that is valued, i.e., significant factors for their value. The mass valuation, by the Appraisal Foundation in their publication Uniform Standards of Professional Appraisal Practices, is defined as a *"process of valuing a universe of properties as of a given date using standard methodology, employing common data and allowing for statistical testing"* (USPAP, 2017).

1.1 DEVELOPMENT OF A MASS VALUATION MODEL

Mass valuation is based on the same basic principles as individual valuation. However, mass valuation includes many real estates for a certain date, which is why mass valuation techniques include equations, tables, and plans, collectively called models.

Mass valuation models attempt to represent the market for a certain type of real estate in a particular area. The structure of such models can be seen as a two-step process:

- Model specification and
- Model calibration.

The model specification provides a framework for simulating supply forces and real estate market demand. This step involves selecting the variables of supply and demand, that need to be considered and defining their correlation towards the value as well as their own correlation. Model calibration is the process of adjusting the mathematical model for mass valuation, the tables, and the estimates for the current market. The structure of the model can be valid for several years, but it is usually calibrated or updated each year. For longer periods, a complete market analysis is required (Eckert et al., 1990). The purpose of the mass valuation is to reflect the current conditions in the local market.

When specifying the mass valuation model, firstly the variables are identified (supply and demand) that can impact the value of the real estate and then they are defined as mathematical conversions such as logarithms, which are often used to transform nonlinear data. At the same time, the mathematical form of the model is defined. It can be used in linear (additive) and nonlinear (including multiplier) forms. Next, the model is calibrated, i.e., the data are analyzed so we can determine the adjustments or the coefficients that represent the contribution to the value of the real estate of the selected variables.

The construction of the models requires a good theoretical foundation, data analysis, and research methods. The best valuation models are expected to be accurate, rational, and explainable. Regression analysis is one of the most used methods in statistics, it is used for understanding, modelling, predicting, and explaining complex phenomena. In regression analysis, the predicted variable is called a dependent variable, and the variables used for prediction are called independent variables. Regression analysis allows the creation of a model for predicting the values of a dependent variable, based on the values of other independent variables or only one independent variable.

Building a regression model is an iterative process that involves finding effective independent variables to explain the dependent variable we are trying to model or understand. By repeating the regression procedure, we determine which variables are effective predictors, and then we constantly subtract and/or add variables until we find the best possible regression model. The process of building a model is a research process. It is necessary to identify explanatory variables in consultation with theory, experts in the field, and based on common sense. We need to be able to state and justify the expected relationship between each explanatory variable and the dependent variable before the analysis, and we need to question the models where these relationships do not match.

Input data in the mass valuation models discussed in this paper are transactions that have occurred in the past, for real estate for what the model is built for, at locations within the area subject to processing, purified for transactions that bounce off the standard values and characteristics of the real estate subject to assessment.

For a long time now, the Republic of Northern Macedonia has been creating a basis for establishing a mass valuation system where the central institution that organizes and manages the system is the Agency for Real Estate Cadastre, which has established this mandate with the 2013 Real Estate Cadastre Act. (Official Gazette No. 55 from 16.04.2013). The infrastructure that is being built and on which the mass valuation system is based in the Register of Leases and Real Estate Prices, which was established on March 18, 2015, where for the first time the registration of real estate transactions by the Real Estate Cadastre Agency was created, the analysis and mass valuation models that result from this data are intended to be applied by researchers and professionals who need this data. The records that this database registers contain data on the characteristics of the real estate and the price for which the transaction or lease was conducted. All this explains the basis for establishing a sustainable system that will provide continuity in the assessment, increased uniformity and easy access to real estate transactions, and of course the value of the real estate.

2. OBJECTIVE / AIM OF THE RESEARCH

Based on the established infrastructure related to the mass valuation of real estate, the goal set before this research paper is defined as the first attempt to establish a model for mass valuation of real estate for parts of the city of Skopje, while explicitly incorporating the spatial factor. The research also focuses on the application of data that the Agency of Cadastre, registers as real estate transactions that take place within the state, and which are the only official and relevant data source. Considering that in the value of the real estate, and consequently in the assessment of the value, the location has a great impact, the intention is to base the research on GeoInformation systems with which the spatial factor will be easily implemented in the model as well as the control of this component will be more extensive.

3. RESEARCH METHODOLOGY

For the needs of this research, the selected reference unit is the residential property in collective buildings, because this type of property has homogeneous characteristics compared to other types of property (for example, houses, retail properties), which means that characteristics that influence the value of the residential property can be better determined. Also, the market with residential properties (apartments) is quite active and a sufficient number of transactions can be provided, which allows the application of statistical models for mass valuation. In order to establish a model for mass assessment of real estate by applying GeoIS as a system that in the valuation itself explicitly carries the spatial component, an excerpt from the Register of Leases and Prices will be applied in order to test the power of the data, but also the power of the model that can be built on this data.

The empirical research was conducted on the basis of transactions for the purchase of apartments in five municipalities in Skopje, in the period from 2016 to 2017.

The research area covers a surface of about 30km^2. As the capital city of the country, Skopje has a dynamic real estate market, and the living market is particularly active. Urban areas are considered more dynamic real estate markets compared to rural areas, so the value of the property is determined by the forces of supply and demand. According to the annual reports of the Department of Mass Real Estate Valuation at the Real Estate Cadastre Agency, most of the purchase of apartments in the city of Skopje is in the municipalities of Centar, Aerodrom, and Karposh. In addition, the research includes the municipalities of Kisela Voda and Chair to make a more complete representation of the condominium market in the city of Skopje.

The regression model that will be used in the research is built on a spatially weighted regression (Geographically weighted regression, GWR) because the value of a real estate can vary considerably depending on its location, so the model needs to have the characteristic of a local model that incorporates the variables obtained on the basis of regression in the valuation of specific real estate where the unknown values before the variables are obtained on the basis of real estate transactions that occurred near the real estate subject to valuation, not taking into account the transactions that took place in other parts of the city and which are at a greater distance than what is considered to be a limit of influence.

The data obtained from the *Register of Leases and Real Estate Prices* in one part will be used for calibration of the model i.e., determining the values before the variables while other part will be used to determine the quality of the developed model, i.e., it will be used as control transactions that will control how close the value of the real estate obtained from the valuation model and the prices of the real transactions are.

4. REGRESSION MODELS

4.1 LOCAL REGRESSION MODELS

In this particular research focused on creating a model for mass valuation of residential units in buildings for collective housing, taking into account the number of transactions with this type of real estate as well as the characteristics of this real estate market, a local regression model was chosen. Local models have been developed to capture spatial heterogeneity. If the nature of spatial relations is different in different places in the study area, these models allow the determination of coefficients, and thus predictions at the local level, so that the established relationships are limited to well-defined neighbourhoods, called windows. The window of local models can be in different shapes and sizes. Most suitable for real estate price modelling, however, are windows with an irregular shape with different sizes depending on the distribution of adjacent real estate that will be included in the window.

4.2 GEOGRAPHICALLY WEIGHTED REGRESSION

The often-applied regression model for real estate valuation is geographically weighted regression. Geographically Weighted Regression - GWR is a type of spatial analysis for the research of spatial non-stationary or spatial heterogeneous processes. The basic idea of GWR is that the parameters can be estimated anywhere in the field of study of a given dependent variable and a set of one or more independent variables that have been measured in places whose location is known (Fotheringham, et al., 2002). The GWR expands the linear regression model by taking into account the spatial component and creates a separate model and local parameters for each data location, based on a local data set using a different weight scheme. Geographically weighted regression is the most popular local model. In each regression window, only a subgroup of observations that are closest to the point of regression is included in the regression. Nearby regression occurs with higher weights while observations beyond the regression point gain less weight. Due to the unequal valuation of the observations, it is used evaluation with WLS (Weighted Least Squares), instead of the method of OLS (Ordinary Least Squares). As a result of the application of GWR, a number of areas with the estimated parameters are obtained. The diversity of values of these parameters indicates the impact of local variations in the dependent variables of the explanatory variables, and thus the spatial heterogeneity of the considered phenomenon. It can be said that GWR is similar to a "spatial microscope" in terms of the ability to measure and visualize variations in relationships that are not seen in non-spatial, global models (Yang, et al., 2016).

The GWR expands the global regression model

$$y_i = \beta_0 + \sum_k \beta_k x_{ik} + \varepsilon_i \quad (1)$$

allowing local parameters to be assessed instead of global ones, so the model can be written as:

$$y_i = \beta_0(u_i v_i) + \sum_k \beta_k(u_i v_i) x_{ik} + \varepsilon_i \quad (2)$$

where $(u_i v_i)$ denotes the coordinates of the "i" point in space, and $\beta_k(u_i v_i)$ is the realization of the continuous function $\beta_k(uv)$ in point "i".

This means that there is a continuous surface of values of the parameters, and the measurements on this surface are taken at a certain point to indicate the spatial variability of the surface.

A very important part of GWR is its calibration. It is necessary to calibrate the GWR function for each independent variable x and in each geographical location i. The procedure for calculating GWR is as follows:

1) Drawing a circle with a given bandwidth, *h* around a certain location i (in the centre).

2) Calculate the weight for each measurement/observation according to the distance between the neighbour and the centre.

3) Calculate the coefficients using regression with weighted smallest squares (Weighted Least Squares - WLS) so that

$$\hat{\beta_i} = (X^T W_i X)^{-1} X^T W_i Y \quad (3)$$

where W_i is a spatially weighted matrix for centre i, so $Wi = f(d_i, h)$, where $f()$ is a function of a spatial kernel, d_i is a vector at a distance between centre *i* and all neighbours, and *h* is a bandwidth or a drop parameter.

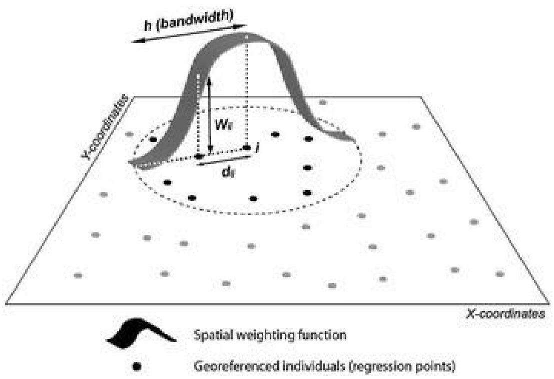

Figure 1. Spatial kernel, source: Fotheringham, et al., 2002

In the core of GWR, there are two kernel functions to achieve calibration, a fixed spatial kernel, and an adaptive spatial kernel. In general, in the calibration of the spatially weighted regression, regions described around the regression points i are used and all points in these regions are used to calibrate the model.

Each data point is weighted according to its distance relative to the regression point, i.e., the data points that are closer get more weight than the data points that are further away. For example, for a given data point, maximum weight is given when it shares the same location as the regression point. This weight decreases as the distance between the two points increases. The complete regression model is calibrated locally by moving the regression point across the region. For each location the calibration is different.

5. ANALYSIS OF THE RESULTS / OUTCOMES

According to the theoretical settings, experience, available research and data made available from the *Register of Leases and Real Estate Prices*, a set of proposed explanatory variables has been identified that are considered to determine the market value of the real estate. Despite the good reasons for including any available real estate data as variables in the model, it was found that some of the explanatory variables were statistically significant and some were statistically insignificant. For this reason, statistical tests have been conducted to make a number of possible combinations of proposed input explanatory variables, requiring models that best explain the dependent variable and thus perform the model specification. The analysis of the proposed explanatory variables gave the results shown in the table below. Also, through the statistical analysis, multicollinearity is calculated between the explanatory variables, i.e., VIF value. In which the value taken as a limit is the value 7.5, i.e., if the VIF value is less than 7.5 there is no multicollinearity between the explanatory variables.

The following table shows the result for significance and multicollinearity based on the analysis of the explanatory variables.

Table 1. Result of the analysis of variables

Summary of variable significance				Multicollinearity
Variable	**Significant**	**Negative**	**Positive**	**VIF**
Area	100	0	100	1.69
Garage (area)	100	0	100	1.19
Distance to closet mall	100	100	0	4.17
Age	98.07	100	0	1.67
Elevator	87.67	0	100	1.64
Distance to closest university	85.09	99.14	0.86	2.97
Distance to school	79.93	0	100	1.33
Balcon area	74.53	0.02	99.98	1.19
Floor number	73.79	0	100	1.21
High quality interior	69.43	0	100	1.03
Distance to closest park	65.00	62.99	37.01	3.71
Rooms	60.68	18.84	81.16	1.47
Own heating system	60.21	8.77	91.23	1.93
Distance to closest hospital	54.98	16.58	83.42	1.90
Distance to closest kinder garden	44.19	42.45	57.55	1.38
Distance to city centre	43.51	48.20	51.80	2.56
Basement area	39.99	77.79	22.21	1.30
Communal heating system	33.04	24.30	75.70	2.32
Distance to closest bus station	22.33	72.18	27.82	1.33

The results obtained from the analysis of the explanatory variables show that there is a high significance of certain structural, but also spatial characteristics for the real estate that is subject to transaction. It can also be noted that we do not have a redundant explanatory variable, i.e., there is no multicollinearity between the explanatory variables. In the process of defining an appropriate model, it is necessary to experiment with different variables to explain the value of the real estate. It is important to be aware that the coefficients of the explanatory variables (and their statistical importance) may change radically depending on the combination of variables we include in the model.

5.1 GEOGRAPHICALLY WEIGHTED REGRESSION

For the purposes of the research, two models were created with GWR, while for assessing the quality of the created models, the statistical parameters R^2, adjusted $R^2$and Akanke's Information Criterion (AICc) were used. R^2 and adjusted R^2 are statistically derived from the regression equation to quantify model performance. The value of R^2 ranges from 0 to 1. If the model explains the dependent variable perfectly R^2 is 1.0. As an example, if you get a value of R^2 of 0.49, it can be interpreted with the words: "the model explains 49 percent of the variations in the dependent variable". Adjusted R^2 is always slightly lower than the value for R^2, as it reflects the complexity of the model (number of variables). Consequently, the adjusted R^2 is a more accurate measure of model performance. The Akaike information criterion (AIC) is an estimator of prediction error and thereby the relative quality of statistical models for a given set of data. AIC estimates the relative amount of information lost by a given model: the less information a model loses, the higher the quality of that model.

Model 1 – GWR

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Model 1 – GWR

Model 1 created with GWR is specified only with structural features of residential property. As explanatory variables for which statistical tests showed the greatest signification are as follows: Area, Garage (area), Balcony area and Age. Using these explanatory variables, the first model for which the following statistical indicators are obtained is formed in the table below, through which we can see the success of the model.

Table 2. Results of the analysis – Geographically Weighted Regression for Model 1

OID	VARNAME	VARIABLE	DEFINITION
0	Bandwidth	2137.860192	
1	ResidualSquares	54169319433	
2	EffectiveNumber	21.807198	
3	Sigma	8063.135068	
4	AICc	17821.981138	
5	R2	0.794736	
6	R2Adjusted	0.78961	
7	Dependent Field	0	PRICE_EU
8	Explanatory Field	1	AREA
9	Explanatory Field	2	AREA_BALCO
10	Explanatory Field	3	AREA_GARAG
11	Explanatory Field	4	AGE

The correlation analysis between the appraised market value of the residential property that has been sold, obtained with model 1 and the actual purchase price performed in transactions for the control group of transactions, calculated with Pearson the correlation coefficient in the SPSS software for this model is 0.899, i.e., 89.9 %.

Table 3. Result of determining the correlation coefficient between the projected prices by Model 1 and the actual purchase prices for the control group points

Correlations

		price_eu	Predicted
price_eu	Pearson Correlation	1	,899**
	Sig. (2-tailed)		,000
	N	95	95
Predicted	Pearson Correlation	,899**	1
	Sig. (2-tailed)	,000	
	N	95	95

**. Correlation is significant at the 0.01 level (2-tailed).

Model 2 – GWR

Model 2 created with GWR uses the same structural and explanatory variables as Model 1 and supplemented by three spatial explanatory variables that the analysis showed were statistically significant: Distance to the closest mall, Distance to the closest hospital and Distance to the closest university. By applying all these explanatory variables, the following statistical indicators shown in the following table are obtained:

Table 4. Results of the analysis – Geographically Weighted Regression for Model 2

OID	VARNAME	VARIABLE	DEFINITION
0	Bandwidth	2137.860192	
1	ResidualSquares	47401929637.900002	
2	EffectiveNumber	31.111344	
3	Sigma	7585.142586	
4	AICc	17724.392795	
5	R2	0.82038	
6	R2Adjusted	0.813815	
7	Dependent Field	0	PRICE_EU
8	Explanatory Field	1	AREA
9	Explanatory Field	2	AREA_BALCO
10	Explanatory Field	3	AREA_GARAG
11	Explanatory Field	4	AGE
12	Explanatory Field	5	DIST_MAL
13	Explanatory Field	6	DIST_HOS
14	Explanatory Field	7	DIST_UNI

The correlation analysis between the appraised market value of the residential property that has been sold, obtained with model 2, and the actual purchase price performed in the transactions for the control group points, calculated with Pearson correlation coefficient in the SPSS software for this model is 0.906, i.e., 90.6%.

Table 5. Result of determining the correlation coefficient between the projected prices by Model 2 and the actual purchase prices for the control group points

Correlations

		price_eu	Predicted
price_eu	Pearson Correlation	1	,908**
	Sig. (2-tailed)		,000
	N	95	95
Predicted	Pearson Correlation	,908**	1
	Sig. (2-tailed)	,000	
	N	95	95

**. Correlation is significant at the 0.01 level (2-tailed).

When calibrating mass valuation models where spatial regression models are used, they have a variable value that varies depending on the location. In order to register this variation, spatial data in raster data format is used. Hence, a significant advantage in using the GWR model and applying GeoIS is the ability to create a series of raster layers of variable coefficients. This allows the identification of spatial variations within the research area, which can help in effective decision making. Such records can provide an excellent insight into the key parameters that affect the value of the property in a particular area. For example, the age of the property can have a significant negative impact on the value of the property in newly developed areas where most of the properties are completely new, and on the other hand it can have a positive impact in an old part of the city where older buildings have architectural features and historical significance. In order to emphasize the importance of these models, the results of the age factor of the building will be presented. As expected, the age of the building is inversely proportional to the value of the property, i.e., the older construction reduces the value of the property due to obsolescence, deterioration and depreciation. The analysis of the raster data model of the coefficient for the age of the building showed that the impact of this factor varies through the field of research and less impact (lower coefficients) this factor is observed in the central area of the city, while the impact of the age of the building increases as we move away from the central urban area, to the settlements of Karposh, Aerodrom, where new buildings are being built and the demand for new buildings is higher.

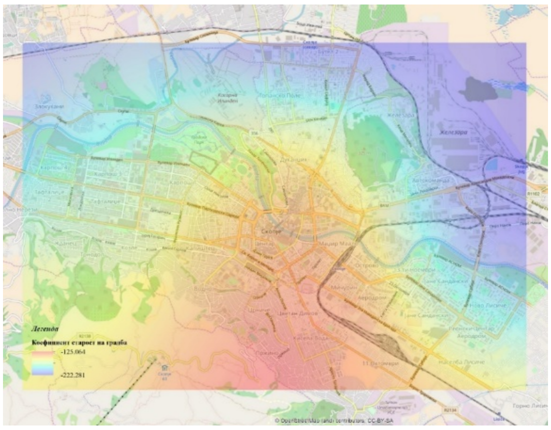

Figure 2. Value of the coefficient before the variable age

The analysis of the raster data model of the coefficient for the impact of the garage surface showed that this impact is greater in the municipalities of Centar and Karposh, while in the municipalities of Aerodrom and Chair, that impact is less, as expected, due to the existence of more and larger parking spaces.

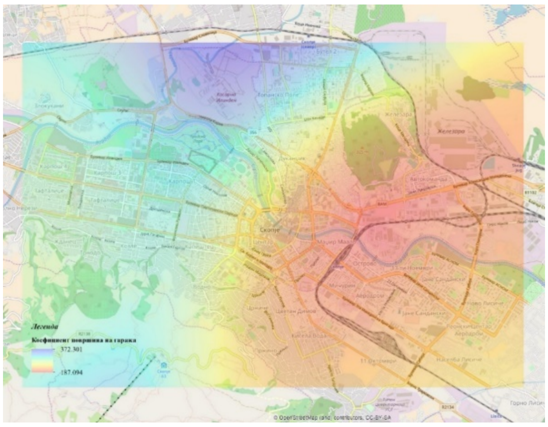

Figure 3. Values of the coefficient in front of the variable area of the garage

6. CONCLUSION

Based on the results obtained from quality control of the established models for mass valuation we can conclude that both models meet the statistical checks and have a satisfactory accuracy of market value prediction. However, although they have satisfactory accuracy, it is necessary to emphasize the difference between the number and type of explanatory variables that these models incorporate and how they affect the end result.

Table 6. Comparison of mass valuation models performance

	Model 1 - GWR	*Model 2 - GWR*
Coefficient of determination – R^2	79.5%	82.0%
Akaike Information Criterion – AICc	17822	17724
Pearson correl.	89.9%	90.8%
Input data	Non-spatial	Spatial
Number of explanatory variables	4	7

Model 2 has higher R^2 coefficient, which means that the created model fits much better in the data. A higher percentage shows that the dependent variable (the value of the residential property) is better explained by the selected independent variables, while this percentage is lower in Model 1. Also, the AICc value of the first model is lower than the one of Model 2.

As for the accuracy of the prediction, which is calculated as the correlation coefficient between the projected prices of the control transactions that were omitted from the creation of the models and the actual prices of their purchase, Model 2 has a higher Pearson correlation factor than Model 1.

The results show that the use of Geographically weighted regression (GWR) in predicting market real estate values is a great basis for developing mass valuation models. In doing so, the incorporation of spatial explanatory variables can have a positive impact on real estate mass valuation models.

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