QUANTITATIVE METHODS IN ECONOMICS
Volume XIX, No. 1, 2018, pp. 28 – 37
Received: 01.09.2017
Accepted: 05.04.2018

SPATIAL ANALYSIS OF LOCAL HOUSING REAL ESTATE PRICE CHANGES (USING OLSZTYN AS AN EXAMPLE)

Radosław Cellmer (ORCID: 0000-0002-1096-8352)
Faculty of Geodesy, Spatial Engineering and Construction
University of Warmia and Mazury in Olsztyn, Poland
e-mail: rcellmer@uwm.edu.pl
Marcelina Zapotoczna (ORCID: 0000-0003-2542-7644)
Faculty of Economic Sciences
University of Warmia and Mazury in Olsztyn, Poland
e-mail: imz@uwm.edu.pl

Abstract: This paper analyses the spatial dynamism of price changes in the housing market in Olsztyn. A geographically-weighted regression was used to examine the relationship between price changes in time and features of properties that describe specific technical and functional parameters. Data from 2007-2015 obtained from RCiWN were used to construct one exponential GWR model as well as separate models for each year under analysis. The results are presented in background maps.

Keywords: housing market, spatial analysis, geographically-weighted regression

JEL classification: C21, R31

INTRODUCTION

The specific nature of the housing market has been noted by a number of researchers [e.g. Łaszek 2006, Belniak 2008, Kucharska-Stasiak 2016] who associated this market with the features of real estate which, on the one hand, distinguish it from other economic goods, but which restrict market operations, on the other. Such specific features include: the function that it plays in the life of each person, heterogeneity, durability, absence of substitutes and immobility. The latter feature makes location one of the key factors affecting the price of a property, because a buyer buys both an apartment and the place where it is situated. The

DOI: 10.22630/MIBE.2018.19.1.3

position itself can have various dimensions, e.g. it can concern the immediate neighbourhood of a property, (i.e. the building type, nature of the street, neighbours), but it can also describe, for example, the quality of other houses in the neighbourhood, the proximity of commercial and service facilities, transport connections with the place of one's work or natural and aesthetic value, or it can cover a broader area, e.g. a city, (i.e. economic activity and the attractiveness of labour markets or the prestige of the city). Therefore, a neighbourhood can have both positive and negative effects. The price is the key factor considered when making an apartment purchase decision. Therefore, since a property occupies a permanent place in space, prices are affected by variables that describe closer and more distant surroundings of a property, i.e. variables that are beyond the control of potential buyers. The effect of location on prices in the housing market has been dealt with, for example, by Rosen [1974], Li and Brown [1980], Clapp and Wang [2006], Kiel and Zabel [2008]. Models of hedonic regression are usually employed to describe the issue. On the other hand, according to Kulczycki and Ligas [2007], classic regression models do not include potential interactions which may occur between observation units (real-estate) and assume "stability" of the process related to price formation in the geographic space. Further, according to Cellmer [2013], the application of a geographically-weighted regression to a real-estate market analysis allows the effect of the particular attributes of a real-estate on its price to be determined depending on its location. Moreover, Cellmer [2010] further claims that this correlation is reinforced by the occurrence of submarkets within local markets. To determine the borders of submarkets which may form districts, Clapp and Wang [2006] used classification and regression trees (C&RT methods). The authors demonstrated that certain assessment parameters of a property location have a greater effect within sub-market borders. Lack of data describing a location (which was necessary for a detailed analysis) was an important issue faced by researchers. Appropriate methods of spatial analysis are still being sought to identify a pattern on local housing markets describing the relationship between the price and the location which takes into account the spatial dimension of the surroundings of a real estate property.

RESEARCH METHODOLOGY

This study analysed the spatial dynamism of price changes in the housing market in Olsztyn with the use of Geographically Weighted Regression (GWR). The analyses were based on transaction data for the sale of residential establishments in 2007 - 2015, obtained from the Real Estate Price and Value Register (Rejestr Cen i Wartości Nieruchomości – RCiWN). Transactions were selected for the study which contain information on: transaction date, location (address, geodesic precinct), transaction price, form of trade, floor area, position on a storey and year of construction. A total of 10,192 transactions were analysed.

The period taken for analysis was not a random one. The year 2007, recorded in the Polish economy as the last year of prosperity on the housing market, was the starting point. The next year, 2008, saw the beginning of an economic slowdown, which affected the housing market. Furthermore, a steady increase in the number of residential facilities entering the market was recorded, beginning with 2010, which translated into the number of flats put to use in the following years. A slow recovery was observed after 2011, which resulted from decreasing interest rates, unsatisfied housing demand and a growing supply of flats that met the conditions for a preferential credit[1]. Changes in the level of interest in flat purchases during the analysed period resulted in fluctuations of transaction prices both on the primary and secondary markets. Therefore, one of the important variables in constructing statistical models of transaction prices is the time specified as the transaction date expressed on the interval scale.

By estimation of parameters of multiple regression classic models, one can determine, for example, the effect of time on transaction prices, but those will be global parameters, not taking into account the spatial heterogeneity.

One of the methods by which the spatial structure can be taken into account in regression models is to assign weights to observations, which – due to their position in space – can have a theoretically greater effect on the issue than others. These weights are taken into account in GWR models. The equation of a typical GWR model will have the following form of results [Charlton, Fotheringham 2009]:

$$Y = \beta_0 (x_i, y_i) + \sum_{i=1}^{k} \beta_j (x_i, y_i) \cdot X_i + \varepsilon_i \tag{1}$$

where Y denotes an explaining variable, β_0 model constant, β_j model parameters, X_j explaining variables, x_i and y_i coordinates of the point in which model parameters are estimated, whereas ε_i is a random element (residue) of a model. Detailed discussion of the principles of construction and evaluation on GWR model fitness GWR have been extensively presented in the literature [among others, Brunsdon et al. 2000; Charlton, Fotheringham 2009].

Parameters of a linear model with a dependent variable as a transaction price are interpreted as an amount per unit of change in an independent variable. Considering the fact that a number of market phenomena are not linear, and in view of the multiplicative nature of the effect of explaining variables on prices, it was assumed that the effect can be regarded as a multiplier (per cent). This allows for easier interpretation, especially with high spatial diversification of average prices. Therefore, a GWR exponential model in the following form was used to determine the relationship:

$$Y = \delta_0 (x_i, y_i) \cdot \prod_{j=1}^{k} \left(\delta_j (x_i, y_i)\right)^{X_j} \cdot \xi_i \tag{2}$$

[1] Credits taken in government programmes: RnS and MdM, which are government subsidies.

where δ_0 is a model constant, δ_j model parameters interpreted as multipliers. Random element ξ can also, in this case, be treated as a multiplier. The remaining elements of the formula are the same as in formula (1)
If it is assumed that:

$$\delta_j(x_i, y_i) = r_j(x_i, y_i) + 1 \text{, and } r_j(x_i, y_i) = \delta_j(x_i, y_i) - 1 \qquad (3)$$

then r_j can be regarded as a direct relative effect of an attribute on transaction prices, at the point of known coordinates (x_i, y_i), expressed as a multiplier effect (compound interest).
When the model is brought to an additive form, estimation of the parameters can be performed by the least squares method, taking into account the location-dependent weights of observations [Charlton, Fotheringham 2009].
The direct percentage effect of the explained variable is then calculated as:

$$r_j = e^{\delta_j^{'}(x_i, y_i)} - 1 \text{, where } \delta_j^{'}(x_i, y_i) = \ln(\delta_j(x_i, y_i)) \qquad (4)$$

When the transaction date is regarded as one of explaining variables, determined with the resolution down to one month, information is obtained on the annual relative (expressed as percent) change of prices:

$$r_j \;/\; year = (1 + r_j \;/\; month)^{12} - 1 \qquad (5)$$

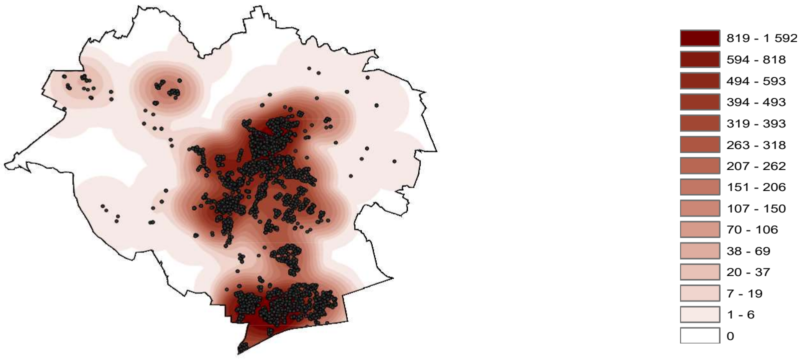
The average index of price changes for each geodesic precinct (as well as its error) was calculated as the arithmetic average of the values of raster cells (from interpolation) within its borders. This provided a distribution map of the average price change index for each year of the analysis. This helps to identify areas in which price changes can result not only from global, but mainly from local conditions. The calculations and visualisations were prepared with Statistica v. 12 and ArcGIS v. 10.2 software.

RESULTS AND DISCUSSION

The spatial activity of the housing market is naturally dependent on spatial distribution of existing housing resources and new investments. New investments are located on the outskirts of cities as well as in the middle and central zone, where the supply of land for housing investments is decreasing. Characteristic features of Olsztyn include natural spatial barriers such as a forest (in the north of the city) and numerous lakes in the city. Due to the presence of these barriers, the urban areas have mainly expanded to the south, where - according to the land use plan – the area of land for housing investment is the greatest.

The spatial diversity of the housing market in Olsztyn and the spatial distribution of transactions is shown in Figure 1.

Figure 1. The number of transactions per 1 km^2 on the housing market in Olsztyn in 2007 - 2015



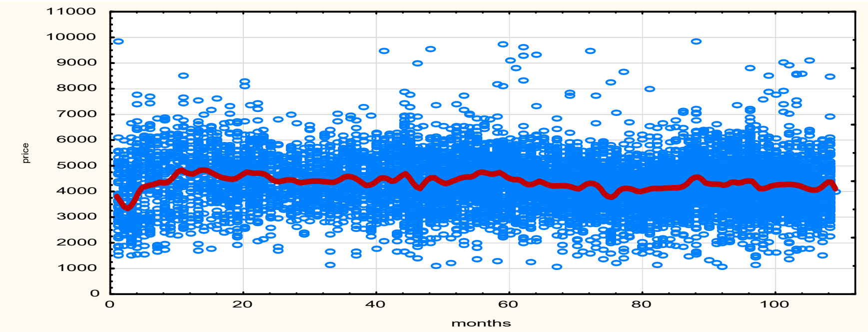
Source: the authors' research

The quartic kernel density estimation provided information on the average number of transactions per 1 km/m^2 [cf. Silverman 1986, Porta et al. 2009].

More than 100 transactions/km^2 annually were recorded in the city central area and in some of its residential quarters. The transactions in the centre and in the residential area (Zatorze) were usually conducted on the secondary market, which was the most active in the first two years of the analysis. Moreover, an increase in the supply on the primary market of flats that met the criteria for preferential loans attracted the interest of flat purchasers in this market segment. In effect, since 2010, the number of transactions increased in the south-eastern part of the city, i.e. in the area bordering on the communes of Purda and Stawiguda (areas where mainly multi-family residential buildings were constructed). This area is referred to in the land use plan as the reserve area for development of multi-family housing, on condition of conservation of the natural value of the land.

The difference between the supply and demand produced a slight increase in the flat prices in 2007-2008. A decrease in the amount of loans granted caused by an increase in the interest rate, and consecutive government programs (RnS and MdM), reversed the trend. Thus, the period of transaction price growth was followed by stabilisation at a medium level of ca. 4,500 PLN/m^2. Figure 2 presents the changes in transaction unit prices for residential premises (trend after inverse exponential smoothing).These fluctuations were not systematic and resulted from behavioural and random factors rather than from market conditions.

Figure 2. Trend of the changes in prices for the territory of the city of Olsztyn in 2007-2015



Source: the authors' research

Considering the fact that the greatest price change was observed in 2007 (38.5%), which considerably deviated from the other years of the analysis, data from this period were left out from the remaining part of the analysis and taken only for illustrative purposes. A detailed data analysis resulted in constructing an exponential GWR model for all of the 2008-2015 data and – independently – for the data from each of the years under analysis. The general results of GWR modelling are shown in Table 1.

Table 1. General GWR modelling results for 2008-2015 data

Model properties	Min	Max	Average
Observedvalue (log price)	6.967	9.194	8.349
Local R^2	0.031	0.880	0.226
Predictedvalue (log price)	7.147	8.663	8.349
Interceptδ_0	8.239	8.514	8.371
Std. error of δ_0	0.011	0.226	0.015
δ_1 (influence of time)	-0.004	0.003	-0.001
Std. error of δ_1	0.000	0.005	0.000
δ_2 (influence of flat area)	0.000	0.007	0.002
Std. error of δ_2	0.000	0.003	0.000
δ_3 (influence of floor)	-0.092	0.205	0.009
Std. error of δ_3	0.007	0.105	0.009
δ_4 (influence of year of building)	-0.009	0.010	0.002
Std. error of δ_4	0.000	0.004	0.001
Residual (ξ)	-1.301	1.346	0.000
Std. error of model	0.027	0.191	0.190
Prices dynamic [%/year]	-4.304	4.100	-1.760

Source: the author's calculations

Model parameters were estimated for each of the locations, where a transaction occurred. Thus, the min, max and average values refer to over 10,000 models. These values reflect the scale of spatial diversity of the parameters of the particular models.

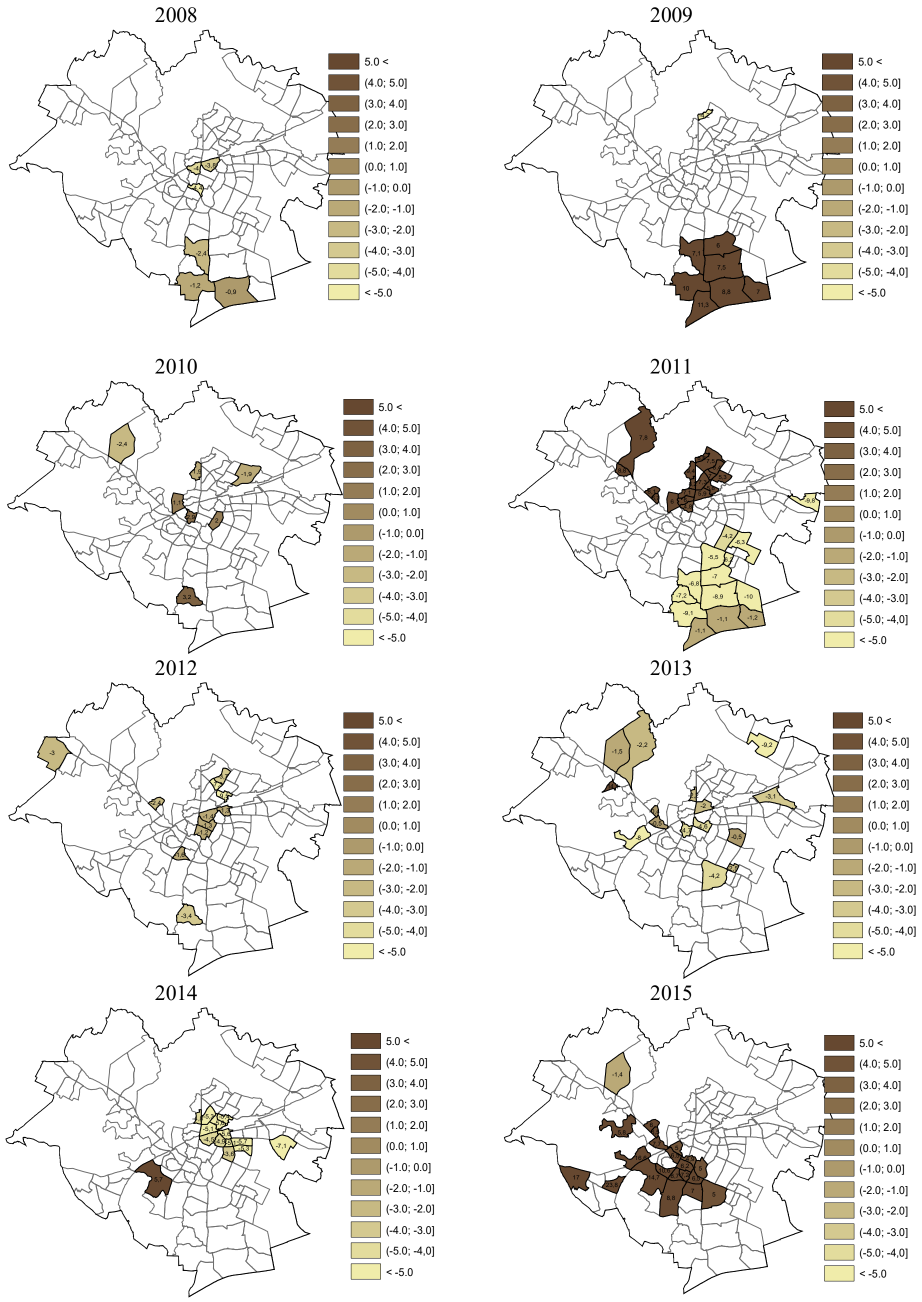
The trend parameters ranged from -0.004 to 0.003, which, according to formula (13), gives -4.3% to 4.1% for a year. The mean parameter for the impact of the area was 0.002 (which means that the 1 m^2 price decreased by 0.2%). The average impact of position on a storey was approx. 0.9% (per unit on the scale adopted). The mean parameter which shows an effect of the building age on the price indicates that each year affects the price by approx. 0.2%. The averaged relative error of the model was approx. 20%. It must be emphasised that these are averaged values; a detailed and precise analysis is possible independently for each of over 10,000 models created and they are not presented here to retain the paper's conciseness and clarity.

A great majority of the models indicate a negative trend, with nearly 1/4 of the observations ranging from -3% to -2.5% annually. The values of the local determination coefficient were mainly within the interval from 0.2 to 0.25 (for nearly 1/3 of cases). For a large majority of the points at which the GWR model was created, all the explaining variables (including the price change trend) proved to be significant at a level of significance not lower than 0.01. Considering the averaged results for the entire period, the unit prices decreased at 1.7% per year. In areas with the highest market activity, the price decrease was relatively small – usually approx. 1% annually. The smallest estimation errors were calculated for the city centre, whereas the highest (as expected) were calculated for the areas with relatively small numbers of transactions. No significant relationship was observed between the transaction density function and the annual price change index.

In the next stage of the study, GWR modelling was performed independently for each year of the analysis (beginning with 2008). For easier interpretation, a register precinct was taken as a reference unit. The average annual price change trend index was estimated independently for each precinct as an arithmetic average of the raster obtained by interpolation by the ordinary kriging method. Precincts with no housing were left out of the analysis. Fig. 3 shows the annual price change indexes in various city suburbs. Only precincts were taken into account in which the annual price change trend was statistically significant at the level of significance of $p < 0.05$.

No steady price change trends in various precincts of the city of Olsztyn were observed in the period under study. The price decrease observed was not permanent.

Figure 3. The spatial distribution of price change indices (%) in the city of Olsztyn in 2008-2015



Source: prepared by the authors

In 2009, the southern and south-eastern part of the city became the most attractive to flat buyers, which resulted in the price increase. This area of the city has become the most attractive to market participants due to an increase in the supply of land for construction caused by changes in the spatial structure, resulting from the transformation of agricultural land into land for residential building construction, and improvement of the living conditions by raising the technical and architectural value of existing buildings (the average yearly price increase coefficient was estimated at 4-5%).
In 2011, prices of housing property increased in the northern and north-western part of the city. The price increase in the north-western part resulted from the growing demand for detached and semi-detached single-family houses in a naturally attractive part of the city – Redykajny, which is surrounded by lakes, in the Łyna river valley and near the Municipal Forest complex. This trend reversed in 2013 due to the transport connection difficulties caused by a population increase in this part of city (an average estimated price decrease by 1-3%). Furthermore, a number of flats were put to use in the northern part in three completed multi-family buildings. The attractiveness of the location consisted in complementing the existing buildings or expansion or modernisation of the existing buildings while preserving the historic urban arrangement. On the other hand, the secondary market and scarce new investment projects were the most active in the eastern and south-eastern part of the city, whose location was perceived by flat purchasers as less attractive, which translated into decreasing transaction prices (the average annual price decrease index was estimated at 1-3%).
The greatest price increase in the last year, i.e. 2015, was recorded in the residential area of Podgrodzie, i.e. a suburb situated near the university campus.
The price change indexes were stable in the majority of precincts. Only in years 2009, 2011 and 2015 were the prices seen to increase (the average annual price increase index was estimated to be 4-5%), while a slight price decrease was observed in 2011, 2013 and 2014 (the average annual price decrease index was estimated at 1-3%).

SUMMARY

The spatial analysis of price changes employing geographically-weighted regression conducted for the housing market in Olsztyn, showed the trends and areas where the greatest price increases and decreases occurred during the analysed period. No steady trends in price changes were recorded in the years 2008-2015 in various parts of the city of Olsztyn, which may be a consequence of small fluctuations of the average transaction prices on the market under analysis. Extreme changes occurred in the south-western part of the city, where the greatest increases were observed in 2009, which were followed by the greatest decreases in 2011. Considering the increase (4-5%) and decrease index (1-3%), as well as the absence of changes in subsequent years, one should conclude that the prices stabilised at the average transaction price level for Olsztyn.

An analysis of prices on the housing market is a constant element of the market activity evaluation. The geographically weighted regression allowed for a detailed analysis of spatial prices diversity, which may be of particular use to market participants, especially entities making housing investments, institutions which provide market financing, real estate agents and urban planners.

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