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THE IMPACT OF MACRO FACTORS ON APARTMENT PRICES IN POLISH COUNTIES: A TWO-STAGE QUANTILE SPATIAL REGRESSION APPROACH[1]

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Abstract

The aim of this study is to identify the economic, demographic, environmental and spatial determinants of residential property prices in Polish counties. Two-stage quantile spatial regression (2SQSR) is the main method of analysis. Additionally, two-stage least squares regression (2SLS) is used.

The estimation results indicate that there are several significant determinants of residential property prices with observable quantile effects. In particular, the findings reveal a very interesting U-shaped pattern among quantile regression coefficients for variables describing unemployment rate, the standard of properties and county area. For the spatially lagged dependent variable, a linear pattern is observable.

Generally, the findings of this study have notable implications for developing housing policies, both at the national and local levels.

Key words: *spatial quantile regression, Polish counties, apartment prices, housing market in Poland.*

JEL Classification: *R21, R31, R32.*

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1. Introduction

In order to increase the efficiency of the housing market, it is necessary to fill the information gap concerning the factors affecting the prices of residential properties (RENIGIER-BIŁOZOR, WIŚNIEWSKI 2012). Knowledge of the determinants of residential property prices can improve decision-making on an individual level, as well as the functioning of the housing market at a macro level. A better understanding of the price setting mechanisms of the housing market can also contribute to more effective alignment of housing policies on both the state and local levels.

Factors affecting residential property prices in Poland have been explored in numerous studies. The main objective of these studies, however, was to investigate micro factors, i.e. factors relating to property attributes. In order to better understand the functioning of the housing market as a whole, further research on a macro level is needed. Previous empirical research on the housing market in Poland has not dealt with macroeconomic, demographic and environmental factors, with the exception of studies with a very narrowly defined field of investigation (BEŁEJ, CELLMER 2014; BEŁEJ, KULESZA 2012; LESZCZYŃSKI, OLSZEWSKI 2016; KOKOT 2018) or studies referring to Poland as part of

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a wider international context (RENIGIER-BIŁOZOR, WIŚNIEWSKI 2012; GRUM, GOVEKAR 2016). Thus, it can be said that there is a research gap in this field. Studies on other European countries cannot fill this gap, because, as HON-CHUNG (2009) claims, the results of individual studies cannot be generalized to other countries, since each has its own specific issues. Against this background, the main aim of this study is to identify the economic, demographic, environmental and spatial macro factors which have a significant impact on the average prices of apartments in Polish counties.

This study covers the period from 2015 to 2017, and is based on data obtained from the Local Data Bank of Statistics Poland. This specific period of time was chosen based on the availability of data on residential property prices. The study includes most counties in Poland, with the exception of some in the case of which no data was available at the time. Two-stage quantile spatial regression (2SQSR) is the main method of analysis, and the average price of apartments per square meter in a county in a given year is the dependent variable.

2. Literature review

2.1. Micro and macro determinants of residential property prices

The literature on the identification of factors affecting residential property prices can be separated into two main lines of research:

- the hedonic model that investigates the relationship between prices of individual properties and the characteristics of these properties, as well as characteristics of the environment and localization,
- an approach that is concerned with the relationship between prices of residential properties and factors describing a particular territory (e.g. state, voivodeship, county or municipality area).

According to the hedonic model, prices of marketable goods can be explained by their characteristics. For the housing market, this should be interpreted as both physical characteristics of the property and the characteristics of the local environment, where the property is located (GASPARENIENE et al. 2016). The hedonic model can be used for identifying factors affecting residential property prices, and can be applied to an individual transaction analysis. In business practice, it is often used by developers, public institutions and, in particular, certified appraisers. Generally, empirical studies use four types of the hedonic model: linear, logarithmic, linear-logarithmic and semi-logarithmic. The latter model is very often used due to the fact that the converted coefficients obtained from it can be interpreted as the percentage impact on the price. Overall, the factors identified by the hedonic approach can be referred to as micro factors, since they only relate to a very narrow scope of reality and describe the characteristics of the particular property (e.g. area, number of rooms, standard of finishing) and its localization (noise levels around a property, distance to a park or a bus stop). The correct identification of these factors is significant to local housing markets, as they are fundamental to the estimation of the real value of a property.

In turn, macro factors may be defined as determinants describing a certain territory with regard to economic, demographic, environmental and spatial aspects. These factors affect housing demand and supply as well as determining the prices. It is worth noting that macro factors can successfully explain housing price volatility, as well as the volatility of the average price level in a certain territory. When studying macro factors, two aspects should be taken into account. Firstly, these factors may relate to different territories, e.g. countries, regions or counties. Depending on the research area, these factors can be referred to differently. Namely, when analyzing countries, one should talk about macro factors. Conversely, when analyzing smaller areas, one should talk about meso factors. In this article, it was decided to adopt a uniform nomenclature and to name all examined determinants of apartment prices as macro factors because they do not have a micro character. Secondly, it is questionable whether the spatial aspect should be treated as a price determinant or only as a form of price autocorrelation. In this article, the spatial aspect will be treated as a price determinant. This assumption will allow consistency to be maintained in this section (literature review) and in section 4 (empirical results).

2.2. Macro determinants of prices – economic aspect

Economic factors are the most frequently analyzed determinants of residential property prices at a macro level. The most important variables in this aspect are GDP per capita, household income, level of interest rates, inflation, unemployment rate and availability of financing.

GDP is the fundamental factor determining prices on the housing market. An increase in this variable indicates a good shape of the economy, which leads to higher demand and also higher prices,

including residential property prices. Previous studies have noted the positive impact of GDP on the prices of residential properties (KASPAROVA, WHITE 2001; EGERT, MIHALJEK 2007; VALADEZ 2010; LIN et al. 2014; BEŁEJ, CELLMER 2014).

Household income is the second economic factor affecting the prices of residential properties. In this case, an increase in income leads to an increase in customer purchasing power, which contributes to higher demand, thus driving up prices. A number of studies have demonstrated the positive impact of income on residential property prices (LIN et al. 2014; LEE 2009; CIARLONE 2015; REICHERT 1990; AKBARI, AYDEDE 2012; NISTOR, REIANU 2018; KHOLODILIN et al. 2010; POTEPAN 1996; HORTON, THOMAS 1998; LEWIN-EPSTEIN et al. 1997).

A similar interpretation is applied to the impact of the unemployment rate on the prices of residential properties. In regions with a low unemployment rate, the population has higher purchasing power, which subsequently increases the prices. A significant negative relationship between unemployment rate and the prices of residential properties had been demonstrated in numerous studies (LIN et al. 2014; LEE 2009; CIARLONE 2015; BEŁEJ, CELLMER 2014; EGERT, MIHALJEK 2007; GRUM, GOVEKAR 2016; AKBARI, AYDEDE 2012; NISTOR, REIANU 2018). Several studies have also investigated the impact of employment rate on the prices of residential properties (APERGIS 2003; REICHERT 1990).

Inflation, which implies an increase in the prices of goods and services, including the prices of residential properties, is also considered to be an influential economic factor. A positive relationship between the prices of residential properties and inflation has been shown in several empirical analyses (LEE 2009; APERGIS 2003; GASPARENIENE et al. 2016).

Existing research often investigates interest rates as one of the determinants of residential property prices. An increase of this determinant leads to higher financial costs for housing purchases, which may discourage potential buyers and decrease the liquidity of the housing market. A negative relationship between interest rates and the prices of residential properties has been confirmed in numerous studies (LIN et al. 2014; CIARLONE 2015; APERGIS 2003; EGERT, MIHALJEK 2007; REICHERT 1990; NISTOR, REIANU 2018; KHOLODILIN et al. 2010).

The availability of financing is also considered to be an important factor affecting residential property prices. This is due to the fact that numerous transactions on the housing market are financed by a bank mortgage. A greater availability of financing increases the liquidity of the housing market and, subsequently, increases the prices. Previous empirical studies have reported the positive impact of the availability of financing on the prices of residential properties (CIARLONE 2015; EGERT, MIHALJEK 2007; GASPARENIENE et al. 2016).

2.3. Macro determinants of prices – demographic aspect

The second group of determinants which significantly affect the prices of residential properties includes demographic factors. In this case, variables describing population, population density and net migration rate in a given area are the most important demographic macro factors. The basic demographic determinant is population. A growing number of inhabitants within a given area increases demand on the local housing market, which leads to higher prices. Previous research has indicated a positive correlation between population and the prices of residential properties (LIN et al. 2014; LEE 2009; EGERT, MIHALJEK 2007; REICHERT 1990; AKBARI, AYDEDE 2012; KHOLODILIN et al. 2010; POTEPAN 1996).

In the same way, the analysis of other demographic factors shows that an increase in these factors positively affects demand on the housing market and leads to an increase in prices. Previous empirical research has indicated that various demographic factors, such as population density or the number of migrants, have a positive impact on residential property prices (AKBARI, AYDEDE 2012; NISTOR, REIANU 2018; HAZAM, FELSENSTEIN 2007).

2.4. Macro determinants of prices – environmental aspect

As noted by JIM and CHEN (2006), green areas such as forests and parks, but also water bodies and other environmental components, have a substantial impact on the quality of life. Therefore, environmental factors determine the prices of residential properties in a given area. Literature on the housing market shows that the presence of a forest or green areas is often investigated as a factor affecting the prices of residential properties.

Specifically, TYRVAINEN (1997) proves that a higher proportion of green areas in a residential district has a positive impact on the prices of residential properties. At a micro level, LI et al. (2018) and TROJANEK (2016) report that the prices of residential properties increase as distance to a park becomes smaller. Similarly, KIM and JOHNSON (2002) show the same relationship between price and distance to a forest.

Research to date has also focused on the impact of water bodies on residential property prices. For example, WEN et al. (2014a) indicate that the prices of residential properties decrease as distance to a lake becomes greater.

2.5. Macro determinants of prices – spatial aspect

In recent years, researchers investigating the determinants of residential property prices have shown an increased interest in factors describing the spatial dependence of prices. Studies focusing on a micro level assume that house or apartment prices are determined not only by localization attributes and the physical characteristics of a property, but also by prices of other properties in close proximity. For example, LI et al. (2018) indicate that there is a significant spatial dependence of residential property prices at a micro level.

On a macro level, spatial dependence should be considered as a correlation between average prices in given regions. Research can investigate, for example, the average prices of residential properties in countries, administrative units or, on a smaller scale, in housing communities. Several researchers have identified the spatial dependence of residential property prices on a macro level, e.g. HAZAM, FELSENSTEIN (2007) – for defined statistical units in Israel; WEN et al. (2014a) – on the housing community level; GOFFETTE-NAGOT et al. (2011) – on a municipality level (the study investigated residential land prices).

2.6. Macro determinants of prices – other aspects

The aforementioned macro determinants of residential property prices do not cover the full spectrum of factors affecting prices on the housing market. Empirical research has also concentrated on factors relating to the standard of residential properties, the housing market supply and the safety of residential areas in particular.

In the context of housing supply, CIARLONE (2015) shows a positive relationship between the number of construction permits and residential property prices at the state level. In a similar analysis, AKBARI and AYDEDE (2012) indicate that the highest number of available and new residential properties can be found in areas with higher average prices. A possible explanation for this relationship may be the fact that a higher housing supply is present in actively developing local housing markets.

The general standard of existing housing resources is also a very important factor determining the average price of residential properties in a given area. A number of studies have examined this determinant (EGERT, MIHALJEK 2007; REICHERT 1990; HAZAM, FELSENSTEIN 2007) concluding that the higher standard of residential properties contributes to higher prices in a given area.

Studies on the determinants of residential property prices also focus on the factors describing the technical and social infrastructure in a given area. It should be expected that the prices of residential properties are higher in regions with a better infrastructure. For example, in their research, WEN et al. (2014b) noted that a higher number of kindergartens and sports facilities contributes to higher prices of residential properties in housing communities. This study also shows that the presence of a University within a distance of 1 km from the housing community has a positive impact on the prices of residential properties.

The matter of safety in residential areas has also been investigated. It can be concluded that the prices of residential properties are higher in regions where, for example, crime rates are lower. Such a relationship had been previously indicated in studies conducted by HAZAM and FELSENSTEIN (2007), and THALER (1978).

3. Data and methods

3.1. Study area

The purpose of this paper was to investigate determinants of apartment prices in Polish counties. A county is one of the basic administrative units in Poland. Generally, one county includes several municipalities. Poland currently has 314 counties and 66 cities with county rights. The latter are quite

specific units. From a formal point of view, they are municipalities but, under Polish law, they perform tasks which are assigned to the county government. Therefore, in this study, both "normal counties" and cities with county rights are referred to as counties. Average prices of apartments in Polish counties in the period of 2015-2017 vary immensely (see Figure 1). The highest average prices per square meter during the considered period were noted in Sopot – 9,056 PLN and in Tatra County – 8,810 PLN. It should be noted that these regions are typical tourist counties. Access to the Baltic Sea is the main advantage of Sopot, while most of the Tatra County is located in the Tatras, the highest mountain range of the Carpathian Mountains. By contrast, the lowest average prices were noted in Głubczyce and Kalisz counties, 1,450 (PLN/sq. meter) and 1,470 (PLN/sq. meter) respectively.

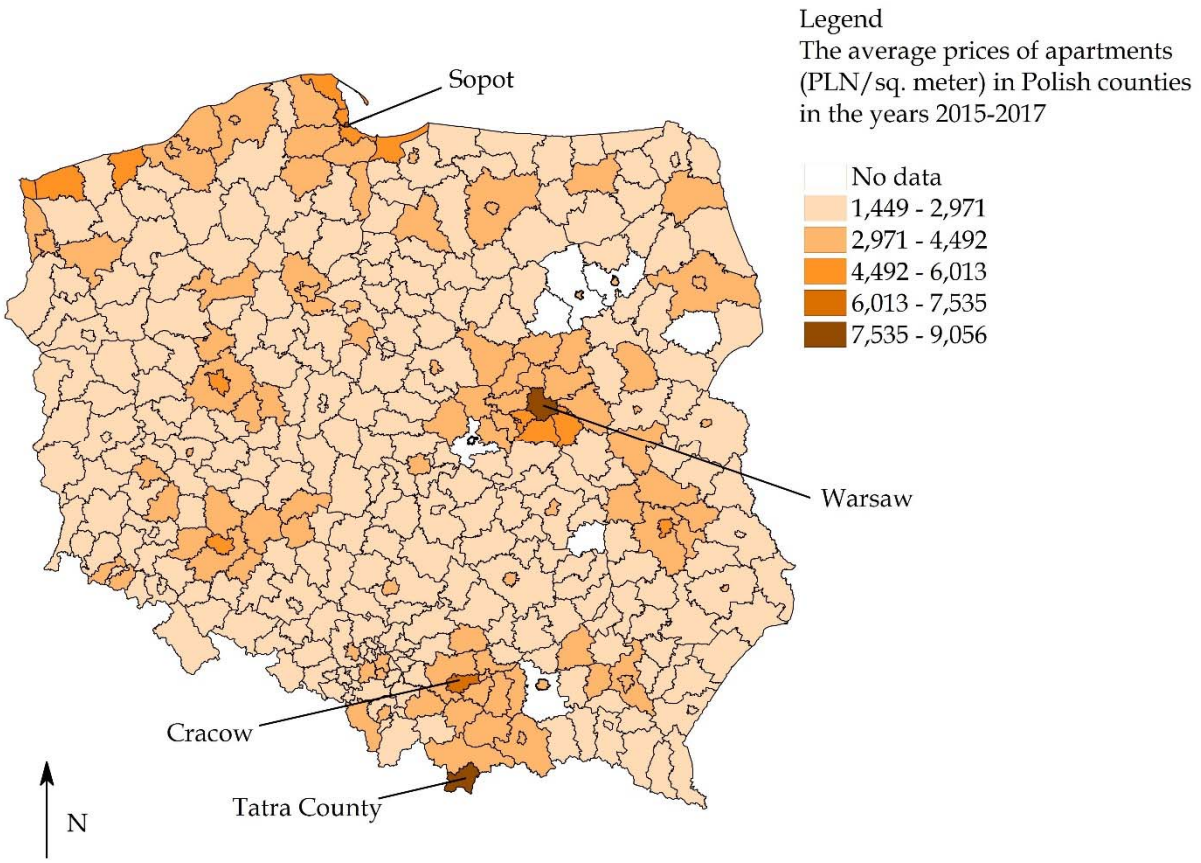

Fig. 1. The average prices of apartments (PLN/sq. meter) in Polish counties in the years 2015-2017. *Source:* own study.

On the basis of the above figure, one can see a spatial autocorrelation of prices, especially around large urban centers.

3.2. Data Description

The data for this study were collected from two sources: the Local Data Bank of Statistics Poland and the author's own calculations. Information on the average prices of apartments in Polish counties was gathered from LDB SP. At the moment of data collection, only data for the period of 2015–2017 were available. It should be noted that there is no other countrywide database on residential property prices.

This study investigated 369 counties. Seven units were excluded due to the lack of adequate available data. A further four units were excluded because that they share borders with only the counties for which no adequate data is available, which could distort the results of the spatial analysis. A detailed description of potential determinants of apartment prices in Polish counties is presented in Table 1 and Table 2.

Table 1

Description of the dependent and independent variables used in the analysis

Variable	Description	Data Source
Price (PLN)	The average price of apartments in a county per square meter in a given year.	LDB SP
Year 2016	Dummy variable. 1 if year = 2016, 0 otherwise.	LDB SP
Year 2017	Dummy variable. 1 if year = 2017, 0 otherwise.	LDB SP
Spatial Price (PLN)	The spatially lagged average price of apartments per square meter in a given year.	own calculations
Population (units)	County population in a given year.	LDB SP
Rate of Natural Increase (units)	Difference between number of births and deaths per 1,000 residents of a county in a given year.	LDB SP
Population Change (units)	Change in population per 1,000 residents in a county in a given year.	LDB SP
GDP (PLN)	GDP per capita in 2017 prices in a county in a given year. GDP is determined on the basis of the tax method outlined by CIOŁEK (2017).	own calculations
Income (PLN)	Average gross income per month in 2017 prices in a county in a given year.	LDB SP
Unemployment (%)	County unemployment rate in a given year.	LDB SP
Hospital Beds (units)	Number of beds in public hospitals per 1,000 residents in a county in a given year.	LDB SP
Roads (km)	Length of municipal and county hard-surfaced roads per 100 km^2 in a county in a given year.	LDB SP
Green Areas (100*%)	The proportion of parks, public gardens and green areas in the total county area in a given year.	LDB SP
Forests (%)	The proportion of forests (private and public) in the total county area in a given year.	LDB SP
Standard of Apartments (units)	Standard of apartments in a county in a given year. Standard is determined on the basis of housing equipment, i.e. water-line, flush toilet, bathroom, central heating, and network gas. Values of this variable are determined by constructed synthetic measures.	own calculations
Number of Apartments (units)	Number of apartments per 1,000 residents in a county in a given year.	LDB SP
New Apartments (units)	Number of completed apartments per 1,000 residents in a county in a given year.	LDB SP
Apartments Under Construction (units)	Number of apartments under construction, started in a county in a given year .	LDB SP
Area (ha)	County area in a given year.	LDB SP

Source: Local Data Bank of Statistics Poland.

Table 2

Descriptive statistics for the dependent and independent variables

Variable	Min	Max	Mean	Standard deviation
Price	1,281.56	10,246.00	2,835.76	974.38
Year 2016	0	1	Not applicable	Not applicable
Year 2017	0	1	Not applicable	Not applicable

Spatial Price	1,503.92	6,460.84	2,708.03	609.09
Population	20,270.00	1,764,615.00	102,019.36	119,439.46
Rate of Natural Increase	-9.47	10.58	-0.59	2.47
Population Change	-207.70	166.40	-1.06	12.02
GDP	19,779.94	138,963.47	40,002.70	13,878.86
Income	2,530.13	7,515.99	3,664.80	528.75
Unemployment	0.01	0.31	0.10	0.05
Hospital Beds	0.00	16.38	4.23	2.80
Roads	21.49	501.13	115.63	87.80
Green Areas	0.00	21.45	0.73	1.81
Forests	0.00	0.28	0.05	0.05
Standard of Apartments	0.02	0.97	0.63	0.20
Number of Apartments	248.88	539.88	348.44	48.26
New Apartments	0.28	17.47	3.24	2.20
Apartments Under Construction	0.19	18.98	3.48	2.58
Area	1,331.00	297,644.00	82,304.47	51,519.21

Source: own study.

3.3. Regression model

The oordinary least squares method (OLS) assumes homoscedasticity of residuals. This assumption, however, is often violated in practice, which may cause biased standard errors of the coefficients. Moreover, the ordinary least squares method can lead to the modelling of the conditional mean function of a dependent variable only. Therefore, complete information on the relationship between the dependent variable and the independent variables at various points of conditional distribution is not available.

Additionally, studies to date show that prices in the housing market are spatially correlated. Therefore, the use of the least squares method will not meet the condition of no autocorrelation of residuals. The presence of this autocorrelation causes the inefficiency of the estimators of the parameters and bias of the standard errors of the coefficients.

Under the conditions mentioned above, the least squares model is inappropriate for the identification of factors affecting residential property prices. Hence, for the purposes of this study, the two-stage quantile spatial regression model (2SQSR) is adopted, with estimation for quantiles: 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9. Unlike the least squares method, quantile regression estimates the relationship in the full conditional distribution of a dependent variable (MATHUR 2019). Thus, quantile regression fully describes the relationship between a dependent variable and the independent variables. Additionally, the distribution of residuals is not assumed in the quantile regression model (WIDŁAK, NEHREBECKA 2011). Moreover, quantile regression reduces the possibility of the non-constant variance of the errors and has a better capability of handling outliers (LIAO, WANG 2012).

In order to eliminate the spatial correlation of residuals, the quantile regression model should be extended by spatial econometric techniques. There are two basic approaches to incorporating spatial dependence into the model. The first approach is based on a spatially lagged dependent variable, and the second one focuses on a spatial error model. Quantile regression, however, is not yet applicable to the estimation of a spatial error model (LIAO, WANG 2012). Therefore, this research adopts quantile regression to estimate a spatial lag model. The final model adopted in this study has the following formula (MATHUR 2019; LIAO, WANG 2012)[2]:

$$p = \rho_\tau W p + X\beta_\tau + \varepsilon_\tau \quad (1)$$

[2] In the study I use panel data; hence, the final model is a pooled regression with time-fixed effects only. In my opinion, there is far too little time data available in relation to the number of counties to use a regression with county-fixed effects.

where p is a vector of ln-transformed average prices of apartments per square meter, τ - corresponding quantile, ρ_τ – a spatial parameter, W is a spatial weight matrix, Wp – a vector of spatially lagged ln-transformed average prices of apartments per square meter, X – a matrix of independent variables described in Table 1, β_τ – a vector of the parameters, and ε_τ –a vector of errors. Additionally, with the issue of endogeneity of the spatially lagged variable, an instrumental variable method is implemented in the estimation. In this paper, the instrumental procedure outlined by KIM and MULLER (2004) is used. The above-mentioned procedure consists of the following steps:

1) The calculation of predicted values of the spatially lagged dependent variable from the formula:

$$\widehat{Wp} = X\hat{\beta}_\tau^* + WX\hat{\gamma}_\tau^* \quad (2)$$

where: $\widehat{Wp}$ – the vector of predicted values of the spatially lagged dependent variable from the above equation, WX – a matrix of all spatially lagged independent variables, X and WX – the set of instruments, $\hat{\beta}_\tau^*, \hat{\gamma}_\tau^*$ - the vectors of parameters,

2) The estimation of the final model with the predicted values from Eq.(2):

$$p = \rho_\tau \widehat{Wp} + X\beta_\tau + \varepsilon_\tau \quad (3)$$

In the above model, the spatial weight matrix, W, is one of the most important elements. This matrix shows how the prices of residential properties are spatially correlated. The elements of this matrix have two values: 1 – when there is a common border between two counties; 0 – when there is no common border. Additionally, the matrix is row-standardized to one, which means that the average price of apartments in the county depends on the weighted average price of apartments in the neighboring counties. More specifically, this research uses the spatial multiplier matrix, which has three identical spatial weight matrices on the main diagonal (due to the fact that, in the period 2015-2017, there were no changes in the boundaries of the Polish counties).

Moreover, for the purpose of comparing the quantile regression results, the two-stage least squares method (2SLS) is implemented to examine the determinants of residential property prices.

4. Empirical results

Table 3 summarizes the estimation results of the 2SLS and 2SQSR models with time-fixed effects only. Additionally, in order to identify quantile effects, Figure 2 shows the regression coefficients.

The adjusted R^2 of the 2SLS model is above 0.6, which indicates that the selected set of determinants can explain the volatility of the average prices of apartments by approximately 60%. The spatially lagged dependent variable is significant and the value of its estimated coefficient is approximately 0.50. This indicates that the increase of the average apartment price in a given county is also determined by the increase of the apartment prices in neighboring counties. More specifically, an increase of prices in neighboring counties by 1% leads to the increase of prices in a given county by 0.50%. Generally, there are 11 significant determinants in the 2SLS model. The first of these significant variables is the rate of natural increase. A rise in the rate of natural increase by 1 person per 1,000 residents determines the increase of the average price in a county by 1.20%. This results from the fact that counties with a higher rate of natural increase are more attractive to developers who tend to invest there, due to higher demand on the housing market. In this case, demand is generated by families with small children actively looking for a new place to live. Interestingly, the GDP per capita variable was found to be insignificant. This can result from the substantial correlation between GDP and incomes (the Pearson correlation coefficient for the above-mentioned variables is equal to 0.68). The increase of the latter by 1,000 PLN contributes to the increase of apartment prices by $(e^{1{,}000*2.59E-05} - 1) * 100\% = 2.63\%$. This result is natural due to the fact that higher incomes determine the higher purchasing power of the population. A similar conclusion can be drawn for the variable describing unemployment rate. A decrease in this variable of 1 percentage point contributes to the increase of the dependent variable in the obtained model by 0.61%. The next significant determinant relates to the number of hospital beds per 1,000 residents of a county. As expected, this determinant positively affects the prices of apartments. In particular, each subsequent hospital bed increases the average price by 1.03%. This follows from the fact that people tend to pay more money for a residential property in a region with better healthcare infrastructure. This is particularly clear in Poland, where there are enormous problems with the availability of medical services, and especially specialized healthcare. The 2SLS model also indicates that higher prices of apartments are reported in counties with the highest level of afforestation. Currently, it can be observed that a lot of people look

for residential properties in locations with a good quality of natural environment. Therefore, the estimated impact of forests on apartment prices is undeniable. In the analyzed model, the increase of the forest variable by 1 percentage point causes an increase in prices by 0.85%. The variables related to the standard of apartments and their number in a county also have a positive impact on prices. The positive impact of the first of the above-mentioned variables on the price is natural, because a better standard of apartments leads to an increase in their value. In turn, the positive impact of the higher number of apartments in a county on price may be explained by the fact that higher prices can be observed in rapidly growing local housing markets, in particular in big cities and their surroundings. In these locations, despite the growing supply of apartments, a significant shortage of residential properties is still observable. The determinant related to a total area of a given county is the last significant variable analyzed in the 2SLS model. It could be expected that a higher supply of land would decrease the prices of apartments. The estimation results, however, show an inverse relationship. In particular, each subsequent 1 km² of area contributes to an increase in the average price of 0.0038% (1 km²=100 ha, so $(e^{100*3.78E-07} - 1) * 100\% = 0.0038\%$). This may follow from the fact that a higher amount of available land increases the number of investments, which subsequently improves the economic situation of the local housing market. In this case, due to the significant shortage of residential properties in Poland, the prices of apartments may rise.

Table 3

2SLS and 2SQSR estimates of the spatial lag model with time-fixed effects only

	2SLS	2SQSR				
		0.1	0.3	0.5	0.7	0.9
Spatial Price	5.03E-01***	2.12E-01***	3.68E-01***	4.42E-01***	4.79E-01***	5.75E-01***
Population	4.90E-08	1.67E-07**	8.68E-08	1.11E-07*	9.67E-08	–6.78E-09
Rate of Natural Increase	1.19E-02***	2.56E-02***	1.60E-02***	1.05E-02**	9.90E-03**	–7.75E-04
Population Change	–3.89E-04	–4.73E-04	–2.51E-04	2.00E-04	8.78E-04	–8.86E-04**
GDP	–6.58E-07	1.94E-06**	2.04E-07	–6.20E-07	–8.15E-07	–1.51E-06**
Income	2.59E-05*	–2.20E-05	3.45E-05**	3.33E-05**	2.45E-05	3.39E-05***
Unemployment	–6.12E-01***	–4.48E-01***	–8.10E-01***	–1.0E+00***	–6.50E-01***	–8.04E-01***
Hospital Beds	1.02E-02***	1.15E-02***	8.19E-03***	1.01E-02***	1.20E-02***	9.88E-04
Roads	1.12E-04	1.92E-04	6.66E-05	3.13E-05	2.87E-04**	2.00E-04*
Green Areas	–1.39E-03	6.52E-03	–1.36E-03	–1.74E-03	–4.07E-03	–9.53E-03**
Forests	8.48E-01***	9.74E-01***	7.41E-01***	8.05E-01***	8.32E-01***	9.50E-01***
Standard of Apartments	2.13E-01***	3.30E-01***	1.16E-01**	1.22E-01**	1.84E-01***	2.73E-01***
Number of Apartments	1.42E-03***	1.37E-03***	1.41E-03***	1.08E-03***	1.06E-03***	1.74E-03***
New Apartments	3.70E-02***	2.89E-02***	4.03E-02***	4.09E-02***	3.67E-02***	3.23E-02***
Apartments Under Construction	1.08E-03	2.89E-03	–4.15E-03	–3.85E-03	–7.10E-04	7.66E-03**
Area	3.78E-07**	7.90E-07***	2.62E-07	2.62E-07	3.97E-07**	6.35E-07***

Notes: The dependent variable is the ln-transformed average price of apartments. The sample size is 1,107. *** One percent level of significance. ** Five percent level of significance. * Ten percent level of significance. Calculated VIF values rejected the possibility of multicollinearity in the models. *Source:* own study.

The analysis of the estimation results in the 2SQSR model indicates that they are similar to those obtained in the 2SLS model. For some of the price determinants, however, quantile effects are observable. Generally, there are 10 variables in the 2SQSR model, which are significant for more than half of estimated quantiles. The first is a variable that relates to the spatial dependence of prices. From the data in Figure 2, it can be said that the coefficient obtained in the 2SLS model describes the impact of this variable on the prices of apartments to a very limited extent. The quantile regression estimation indicates that the spatial coefficient has the characteristics of an increasing linear function. In particular, prices in neighboring counties have the biggest impact on counties with the highest average prices of apartments. The main reason for this is that high prices of apartments appear mainly in big cities and neighboring counties. Such regions create hermetic areas with strong connections also affecting the housing market. It is interesting to note that there are strong suburbanization processes underway in Poland. In particular, an increasing number of people working in a city that functions as a regional center are buying residential properties in neighboring counties. Individual earnings in big cities are higher and this subsequently creates the opportunity to buy more expensive residential properties. For this reason, residential property prices in metropolitan areas are becoming increasingly similar. Conversely, there are counties with low average prices of apartments. In this case, the quantile regression results show that the spatial dependence is substantially lower. This refers to counties, which do not have as strong relationships with other administrative units, as is observed in "expensive" metropolitan areas. There are much fewer housing investments in such counties, and barriers between counties are more evident. Therefore, the prices of residential properties also do not depend so much on each other.

Quantile effects are also observable for the variable describing the rate of natural increase. The rise of the rate of natural increase by 1 person per 1,000 residents increases the average price in a county by 2.56% for the 1st decile. For the 8th decile, the average price increases only by 0.65%. A possible explanation for this weak impact of the rate of natural increase in expensive counties may be the fact that these regions have a high population or high population density. Simultaneously, the rate of natural increase value is usually low in such regions; therefore, this variable does not impact the housing market deeply. It should also be noted that regression coefficients for the 8th and 9th deciles are insignificant; hence, conclusions should be interpreted with caution.

The average income is the next variable that significantly determines apartment prices in Polish counties. Interestingly, for the 1st and 2nd deciles, the decrease of income contributes to the increase of apartment prices. This result may be explained by the fact that residents of counties with lower incomes try to compensate for this with incomes from sources other than work. In this case, residents try to maximize their income from the sale of residential properties. It should be noted that the amount of developer investments in counties with lower prices is small, and the majority of available apartments is in the hands of private owners. Quantile regression coefficients for the 1st and 2nd deciles are, however, insignificant, and the results should therefore be interpreted carefully.

For the variable describing the county unemployment rate, the partially U-shaped quantile regression coefficient is identified. Specifically, the strongest impact of unemployment rate on the prices of apartments is observable for the 5th and 6th deciles. It should be noted that these deciles refer to counties with average prices of apartments in relation to other administrative units. It may be assumed that residents with an average income and small savings (on a national scale) are the main property buyers in this type of counties. For many of these residents, high prices of properties make purchases with personal savings impossible; therefore, they are forced to turn to mortgage loans. In this regard, a labor market downturn can have a bigger impact on residential property prices due to the subsequent weaker purchasing power of the population. Conversely, the impact of the unemployment rate in counties with low and high prices of apartments is moderately similar. For the 1st decile counties, low prices of properties and a small amount of properties being traded is observable. The purchase of residential property is very often the effect of long-term plans and savings. Therefore, labor market changes may affect residential property prices to a limited extent. An analysis of the counties with the highest prices shows two factors which explain the weaker impact of

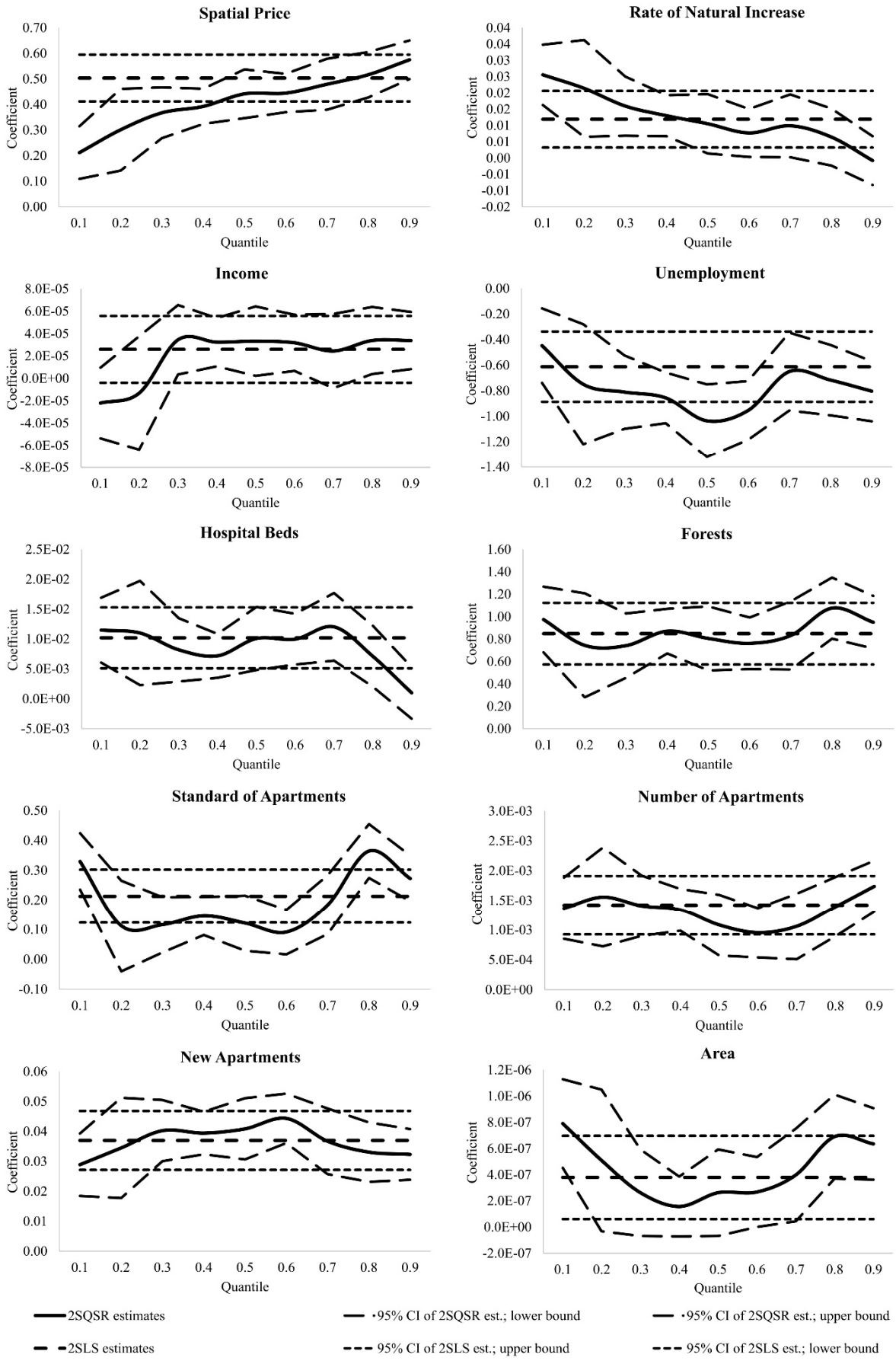

Fig. 2. The coefficients of the 2SQSR model with only time fixed effects. *Source:* own study.

the unemployment rate in these counties compared to counties with average prices. First, residential properties in these locations are often bought for investment or living purposes by individuals or legal entities from outside the given county. Second, there are significantly higher incomes in counties with higher prices, as well as the general conviction that it is much easier to find a new job there than in other counties.

The number of hospital beds per 1,000 residents is the next variable with observable quantile effects. Generally, from the 1st to the 8th decile, the impact of this variable on apartment prices is similar. Specifically, each additional hospital bed increases the average price of apartments by approximately 1%. The 9th decile has the lowest value. This may be explained by the fact that residents of counties with the highest average prices of residential properties decide to use private healthcare more often. Moreover, in bigger cities, companies often offer access to private healthcare for their employees. Therefore, a smaller demand for public healthcare services can be observed in such counties. The coefficient for the 9th decile, however, is insignificant, and these findings should be interpreted with caution.

For a variable describing the standard of apartments, quantile effects are also observable. The U-shaped pattern among regression coefficients is similar to that observed for the unemployment rate. It can be noted that the standard of apartments is more important in counties with the lowest and highest prices than in counties with average prices. This situation appears to be normal. For less developed counties with lower incomes, purchasers do not tend to pay an additional amount of money for renovation. Conversely, in counties with the highest prices, it can be concluded that purchasers who pay considerable amounts of money expect that the purchased property is well equipped.

The last variable for which one can observe quantile effects among the regression coefficients describes the area of the county. A U-shaped pattern can also be seen for this variable. In particular, the area of the county has the strongest influence on the prices of apartments from the first and last quantiles. For the most expensive counties in terms of housing prices, this influence can be explained by the fact that there is a very high turnover of residential real estate in these self-government units, and each additional area makes it possible to carry out new housing investments. This type of situation is particularly noticeable in cities with county rights, such as Cracow or Warsaw, where a large increase in land prices has been observed in recent years. Moreover, as had already been mentioned, there is a huge shortage of apartments in Poland, which means that an increase in the supply of land or apartments may also cause an increase in the prices of residential properties. To the contrary, the impact of the above-mentioned variable on prices from the first quantiles is difficult to explain. This can be caused, however, by single transactions that overstate the average price in the county. It should be noted that, in counties with low average prices, there are very few new investments and the housing stock is dominated by old and poorly maintained apartments. Therefore, in this type of counties, the larger the area of the local government unit is, the higher the probability of new development investments, which significantly affects the average transaction price of apartments in a given area.

Quantile effects are not observable for the rest of the significant variables in the 2SQSR model. Therefore, the interpretation of these variables in the quantile regression model is consistent with the interpretation discussed for the 2SLS model.

5. Discussion and conclusions

This research has found several determinants affecting the average prices of residential properties in Polish counties. In particular, the most important factors are economic, demographic, environmental and spatial in character. Additionally, the variables describing the state of infrastructure and the characteristics of the housing market in a given area also affect the average prices of apartments. The analysis was conducted with the 2SLS model and the two-staged quantile spatial regression model (2SQSR). The adopted research method indicated that there are significant quantile effects among the independent variables. For the spatially lagged dependent variable, a linearly increasing pattern among quantiles is observable, and this relationship shows that there are some hermetic areas on the housing market in Poland, where prices are very similar. This is especially the case in the most expensive counties. The existence of such areas indicates that the Polish counties are unevenly developed. There is, therefore, a definite need for the implementation of relevant policies in the housing market in Poland, both at national and local levels. Additionally, the study has shown

interesting quantile effects for the variables describing the unemployment rate, the standard of apartments and the county area. For these variables, a U-shaped pattern was observed among quantile regression coefficients. The above-mentioned finding requires further research, in particular regarding the presence of such a characteristic pattern among quantiles.

As the obtained results show, local administration units, at the level of a municipality or county, may significantly shape the housing market with an appropriate range of action. In particular, the activation of the unemployed and the provision of public healthcare are two of the statutory tasks of the county government. Conversely, the municipal government has the instruments to shape demographic and environmental factors. This can be achieved by higher availability of nurseries and kindergartens, as well as forests and green areas. Effective implementation of all above-mentioned tasks can directly affect the prosperity of the housing market.

Furthermore, to the author's knowledge, no previous study has investigated the prices of apartments in Polish counties with the 2SQSR model, and this study has attempted to fill this research gap. For future research, it is recommended to extend the time frame of the analysis. Finally, the presence of a spatial price relationship among the analyzed counties requires more detailed research on the existence of house price convergence in the housing market in Poland.

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