Technical Note

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TRAFFIC NOISE AS A FACTOR DRIVING APARTMENT PRICES – A CASE STUDY OF A LARGE EUROPEAN URBAN AGGLOMERATION

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This paper presents an analysis of the correlations between apartment prices and road traffic noise levels in Olsztyn, the capital city of the Region of Warmia and Mazury in north-eastern Poland. The results of this study presented in graphic and analytical form indicate that noise pollution is an important determinant of the prices of residential property.

INTRODUCTION

Noise is a growing concern around the world, and this problem has been addressed by the European Union in Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise [1]. The main objective of the directive is to prevent and control traffic noise through the achievement of a high level of health and environmental protection across the European Union. The Directive places Member States under obligation to monitor the observance of allowable noise limits and to develop acoustic maps.

Annoyance caused by excessive noise levels is reflected in the prices of real estate. Neighborhood quality is an important factor that influences buyers' decision to purchase property. The objective of this study was to evaluate the correlations between traffic noise levels and prices on the local apartment market in Olsztyn, the capital city of the Region of Warmia and Mazury in north-eastern Poland.

TRAFFIC NOISE AND PROPERTY PRICES

Urban traffic noise has adverse economic consequences by driving down the prices of real estate [2]. The economic effects of noise pollution which are discussed in this paper are directly linked with social aspects. This problem is most visible in residential real estate. Noise pollution considerably influences the value of property because it lowers the quality of the living environment and compromises safety. A review of published sources clearly indicates that traffic noise has a detrimental impact on the value of residential property [3, 4, 5, 6, 7, 8, 9, 10, 11, 12]. The Noise Depreciation Sensitivity Index (NDSI) is one of the most popular indicators for describing the impact of road traffic noise on real estate prices. NDSI determines the percentage change in house prices per dB increase in noise levels [4]. In studies of road traffic noise, NDSI was determined in the range of 0.08% to 2.22%. In a different approach, the effect of noise is determined by estimating the direct decrease in the monetary value of property.

Most studies investigating the effects of traffic noise concern highly industrialized countries in North America and Europe that are characterized by high levels of awareness about the market value of real estate and the impact of various factors, including noise, on the prices of residential property. This study analyzes a city in Central Europe where the transition from centrally-planned to free-market economies began only in 1990. For this reason, Central European countries have much lower levels of awareness about the correlations between environmental quality and real estate value.

RESEARCH OBJECT

The effects of road traffic noise on the prices of residential property have been studied in selected districts of Olsztyn, a city in Central Europe. Olsztyn is the capital city of the Region of Warmia and Mazury in northern Poland (Figure 1). It is a city of supra-regional importance with a population of 200,000. Its suburban region comprises mostly single-family houses, and it stretches within a 20 km radius from the city's administrative boundaries. The suburban region has an estimated population of 120,000, and its inhabitants generate additional traffic by commuting to work, school and retail outlets on a daily basis.

The Olsztyn urban agglomeration is one of the main transport hubs leading to destinations in eastern and north-eastern parts of Europe. The entire urban agglomeration is characterized by low levels of road infrastructure development. Population density is 1998 persons per km^2 [13].

This study focuses on the neighboring districts of Jaroty and Pieczewo. Jaroty is the most populous unit of local administration in Olsztyn. Jaroty and Pieczewo constitute a compact functional area with an estimated population of 50,000 which is homogeneous in terms of infrastructure and architecture. This part of the city features mostly multifamily residential buildings with enclaves of single-family houses and a well-developed network of retail outlets. The road network comprises two municipal transit corridors that provide access to downtown Olsztyn. Those corridors serve local inhabitants who commute to work, public transport vehicles, heavy transport vehicles that supply large housing districts (7 large supermarkets and 4 hypermarkets) and vehicles transiting to suburban areas south of Olsztyn that are inhabited by around 35,000 people. The local transport network also includes main access corridors, estate roads and car parks. In view of the availability of data (transaction prices) and the homogeneity of analytical samples (similar parameters), the research object comprises one municipal transit corridor (Krasickiego street) and one main access corridor (Wilczyńskiego street).

Figure 1. Location of the research object

ACOUSTIC MAP

Upon its accession to the European Union, Poland became subject to the provisions of the Environmental Noise Directive 2002/49/EC of 25 June 2002 [1]. Point 10 of the Resolution stipulates that strategic noise mapping should be imposed in certain areas of interest for capturing the data needed to provide a representation of noise levels perceived within that area. The national regulations of EU Member States place local authorities under the obligation to develop acoustic maps. In Poland, the applicable legal act is the Environmental Protection Law [14].

The cited directive defines environmental noise as unwanted or harmful outdoor sound created by human activities, including noise emitted by means of transport (road traffic, rail traffic, air traffic) and noise from sites of industrial activity. Excessive noise levels contribute to health problems. The following indicators are used to describe levels of environmental noise in an acoustic map:

1. L_{den} – (day-evening-night noise indicator) the noise indicator for overall annoyance.
2. L_{night} – (night-time noise indicator) the noise indicator for sleep disturbance.

All noise indicators are A-weighted long-term average sound levels as defined in ISO 1996-2: 1987, determined over all day and night periods of a year. In line with the provisions of the cited directive, the day is 12 hours, the evening – four hours, and the night – eight hours. The Member States may shorten the evening period by one or two hours and lengthen the day and/or the night period, provided that this choice is identical for all the sources. The beginning of the day and, consequently, the beginning of the evening and the night is chosen by the Member State, and that choice has to be the same for noise originating from all sources. In the directive, the default hours are 07.00 to 19.00, 19.00 to 23.00 and 23.00 to 07.00 local time.

Noise assessment points (L_{den}) for strategic noise mapping inside and near buildings have to be located 4.0 ± 0.2 m above the ground and on the most exposed facade. Other heights may be chosen, but they should not be less than 1.5 above the ground, and the results should be adjusted to the equivalent height of 4 m. The most exposed facade is defined as the external wall facing and nearest to the noise source.

METHODOLOGY, RESULTS AND DISCUSSION

The study was carried out on the assumption that the quality of the acoustic environment in the vicinity of a residential building (noise levels determined by the building's location relative to roads) influences prospective buyers' decision to purchase property. A total of 132 property transactions concluded between January 2012 and December 2013 in residential districts of Jaroty and Pieczewo were analysed. The evaluated real estate was apartments in multifamily residential buildings. To consolidate experimental samples and eliminate other price-shaping factors, the analysed data was sorted to produce transactions relating to apartments with the same legal status, apartments in buildings erected based on the same construction technology and in similar condition, apartments with similar area, situated in distinct housing estates. The main differentiating factor was location relative to a road. Significant variations in real estate prices resulting from changes in market demand or time were not observed in the analysed period. Unit prices per square meter were expressed in the principal currency of the European Union, the Euro (EUR), based on the average EUR/PLN exchange rate quoted by the National Bank of Poland.

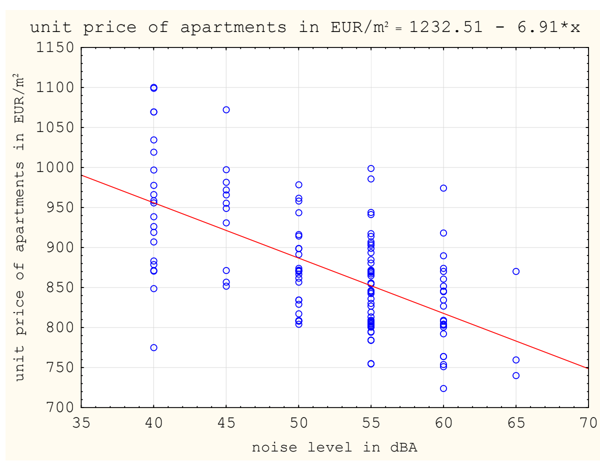

Figure 2. Distribution of apartment price vs noise level.

Table 1. Linear correlations between unit prices of apartments and noise levels.

Variable	Correlations (unit prices of apartments in EUR/m^2 - noise level in dBA) ; N = 132 Correlation coefficients are significant at p < .05000			
	Average	SD	unit price in EUR/m^2	noise level in dBA
unit price in EUR/m^2	873.22	77.79	1.00	- 0.61
noise level in dBA	51.97	6.82	- 0.61	1.00

The study was carried out in four principal stages:

1. Traffic noise levels were determined based on the acoustic map [15] which is prepared using CadnaA (Computer Aided Noise Abatement) - noise prediction software. The analysis of noise levels is based on the L_{den}.
2. The distribution of unit prices of apartments was mapped relative to noise levels. The distribution of prices for the entire analysed area is presented in Figure 2. An increase in noise levels by 1 dB was accompanied by a drop in the unit price of apartments by EUR 6.91/m^2.
3. Linear correlations between unit prices of apartments and noise levels were analysed. A statistical correlation between a dependent variable (unit price of an apartment) and an independent variable (noise level) was determined by Pearson's linear correlation analysis. The correlation coefficient for the analysed districts was determined at -0.61 (Table 1), which points to a significant relationship between the evaluated parameters. A negative value of the correlation coefficient indicates that unit prices of apartments decrease with an increase in noise levels.
4. The distribution of unit prices of apartments was mapped by ordinary kriging. Isoline interpolation tools available in ArcGIS 10 software were used. Kriging is a geostatistical estimation method that accurately estimates the values of the analysed variables. Kriging estimates are assumed to be a weighted, linear combination of random regionalized variables. Kriging methods and their applicability in various areas of science and technology are widely discussed in literature. The use of kriging in analyses of the spatial distribution of property prices expands our knowledge of those methods' capabilities and applicability [16, 17, 18, 19]. The following value is a kriging estimator (1) represented by a random function $Z(s_i)$ [16]:

$$Z^*(s_0) = \sum_{i=1}^{n} w_i Z(s_i) \qquad (1)$$

where:

$Z^*(s_0)$ – estimated value in location s_0,
$Z(s_i)$ – observed value of the analysed variable in location s_i,
w_i – kriging weights (calculated on the assumption of minimum error variance; the sum of weights has to be equal to 1).

The acoustic map of the analysed area illustrating the exposure to road traffic noise is presented in Figure 3. The highest noise levels (65–70 dBA) were noted along the municipal transport corridor (Krasickiego street) and the main access corridor (Wilczyńskiego street). Noise levels were somewhat lower along estate roads (55–65 dBA), and they reached the lowest values (below 45 dBA) in enclaves surrounded by buildings in the proximity of transit corridors. High noise levels in the analysed districts are confirmed by the distribution of unit prices of apartments (Figure 2) and linear correlations between unit prices (Table 1).

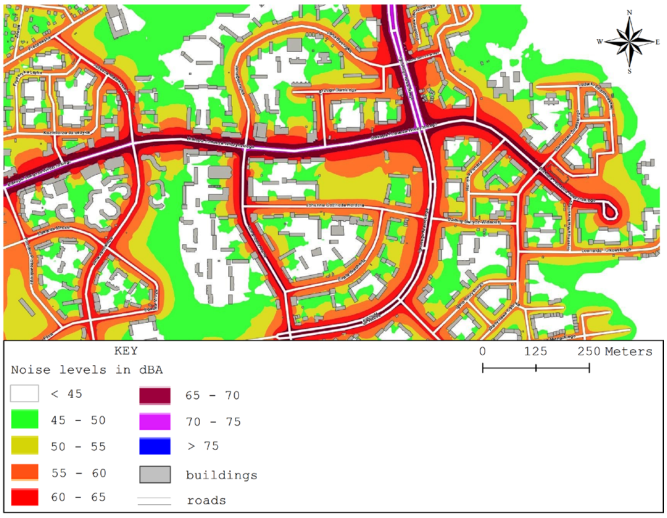

Figure 3. Acoustic map of Olsztyn – districts of Jaroty and Pieczewo.

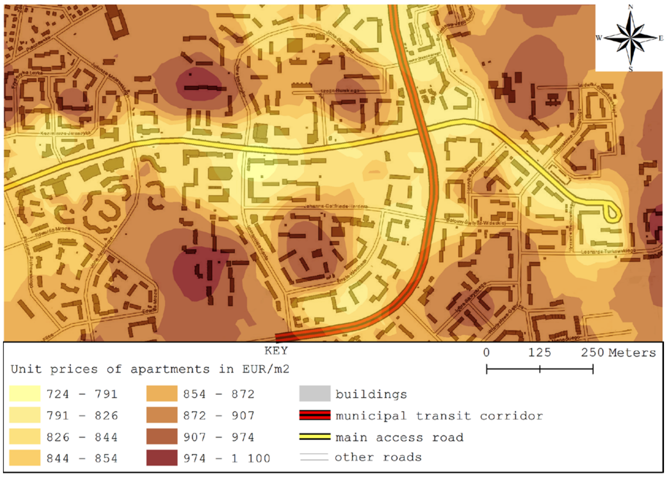

Figure 4. Distribution of unit prices of apartments in districts of Jaroty and Pieczewo.

The distribution of unit prices of apartments in the districts examined is presented in Figure 4. The lowest prices were reported for apartments situated along the municipal transit corridor and the main access corridor. Higher prices were quoted for apartments away from transit and access corridors where noise levels are considerably lower. The average price was EUR 873/m^2, and the maximum difference between the analysed transaction prices was EUR 376/m^2. The high difference between the minimum (EUR 724/m^2) and the maximum (EUR 1100/m^2) price and the spatial distribution of prices clearly indicate that road traffic noise considerably influences apartment prices in the evaluated districts in Olsztyn.

CONCLUSIONS

Acoustic maps developed for large cities in the European Union are an abundant source of analytical data concerning the spatial distribution of traffic noise sources. Maps indicating road traffic noise levels can be used to identify the correlations between road traffic noise and prices on the local real estate market. The results of this study, presented in graphic and analytical form, indicate that noise pollution is an important determinant of the prices of residential property.

Isoline maps developed with the use of GIS tools are a rich source of information about the spatial distribution of property prices. Isoline maps and acoustic maps are useful tools in the process of planning new residential property and road networks. The resulting information supports the implementation of planning measures to prevent the devaluation of real estate and the deterioration of the living environment.

The results of our study indicate that road traffic noise is one of the key factors driving the prices of residential property. Noise traffic levels, in particular the highest local noise values, considerably determine the prices of apartments in large cities.

REFERENCES

[1] Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise, Brussels, 2002

[2] J. Papi and B. Halleman, Road Traffic Noise The Road Sector's Perspective. The European Union Road Federation, (2004)

[3] J. Benoit and P. Lanoie, "The effect of noise barriers on the market value of adjacent residential properties", *International Real Estate Review* **10**(2), 113-130 (2007)

[4] "The State-Of-The-Art on Economic Valuation of Noise, Final Report to European Commission DG Environment, April 14th 2002", Ståle Navrud, Department of Economics and Social Sciences Agricultural University of Norway (2002)

[5] N. Karanikolas, D. Vagiona and A. Xifilidou, "Real estate values and environment: A case study on the effect of the environment on residential real estate values", *International Journal of Academic Research* **3**(1), 861-868 (2011)

[6] K.S. Kim, S.J. Park and Y.J. Kweon, "Highway traffic noise effects on land price in an urban area", *Transportation Research Part D: Transport and Environment*, **12**(4), 275-280 (2007)

[7] J.P. Nelson J.P, "Hedonic property value studies of transportation. noise: aircraft and road traffic", A. Baranzini (ed.) Hedonic Methods in Housing Market Economics, Springer, 57-82 (2008)

[8] M. Wilhelmsson, "The impact of traffic noise on the values of single-family houses", *Journal of Environmental Planning and Management*, **43**(6), 799–815 (2000)

[9] M.A. Theebe, "Planes, trains, and automobiles: the impact of traffic noise on house prices". *The Journal of Real Estate Finance and Economics*, **28**(2-3), 209-234 (2004)

[10] W.T. Hughes, C.F., Sirmans, "Traffic externalities and single-family house prices". *Journal of Regional Science*, **32**(4), 487-500 (1992)

[11] S.M. Taylor, B.E. Breston, F.L. Hall, "The effect of road traffic noise on house prices". *Journal of sound and vibration*, **80**(4), 523-541 (1982)

[12] H. Andersson, L. Jonsson, M. Ögren, "Property prices and exposure to multiple noise sources: Hedonic regression with road and railway noise". *Environmental and resource economics*, **45**(1), 73-89 (2010)

[13] Central Statistical Office. http://www.stat.gov.pl/gus. Retrieved on: 18.02.2014

[14] Environmental Protection Law of 27 April 2001 (Journal of Laws of 2008, No. 25, item 150)

[15] Serwis of acoustics map of Olsztyn http://213.184.21.79/geoportal/dotnetviewerolsztyn/ajaxviewerolsztyn.aspx. Retrieved on: 20.02.2014)

[16] S.C. Bourassa, E. Cantoni, M. Hoesli, "Spatial Dependence, Housing Submarkets, and House Price Prediction". *Journal of Real Estate Finance and Economics, Springer Science*, **35**, 143–160 (2007)

[17] A. Páez, "Recent research in spatial real estate hedonic analysis. *Journal of Geographical Systems*, **11**(4), 311 – 316 (2009)

[18] D.D. Sarma, "Geostatistics with Applications in Earth Sciences", Springer, (2009)

[19] R. Cellmer, "The Use of Selected Spatial Interpolation Methods for Analyzing the Worth of Land Zoned for Housing Development". *Geomatics and Environmental Engineering*, **4**(3), 19-33 (2010)