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The Restricted Use Zones around the Airports and the Property Value**

1. Introduction

The disadvantageous impact of air ports activities on such a sensitive economic category as property value is not questioned. However, capturing total quantitative impact brings a great deal of difficulties.

The first researches concerning determining the quantitative impact (decline in property values) as a result of air ports activities dates back to seventies of XX century (mainly United States).

This problem is new for Polish government and has been present since enforcing the new policy of regulating the restricted use zones around airports. The best example of the above issue of environmental and legal restrictions is restricted use zone set around Poznan-Krzesiny Air Force Airport (F-16 fighter aircraft import). The analogical problems occur at present at commercial airports along with increasing activity of commercial airlines due to Polish joining the European Union in 2004 and occurrence of "cheap" commercial airlines.

Increased activity of commercial airlines was proven by the studies performed by Krakow-Balice International Airport and is presented in (Tab. 1). In 2000, there were 15,288 departures and arrivals with 517,015 passengers. The airport serviced two flights per one hour. While in 2004, there were 26,171 departures and arrivals with 841,123 passengers. The airport serviced three flights per one hour. On the other hand in 2006, there were 39,322 departures and arrivals with 2,367,257 passengers. The airport serviced five flights per one hour. In 2010, experts predict 9,000,000 passengers serviced by the airport (analysis includes extension of the airport) and so, we may expect around 120,000 departures and arrivals with relation

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to the structure of commercial airlines (service provided by various size commercial planes). The airport would service fourteen flights per one hour (average time of a departure or a arrival would be four minutes).

All the data above exclude Polish Military Air Force activity at the Krakow-Balice Airport.

Table 1. The activity of Krakow-Balice International Airport

Year	1999	2000	2001	2002	2003	2004	2005	2006	2010
Number of departures and arrivals	13 089	15 288	16 674	15 290	17 029	26 171	34 313	39 322	Approximately 9 000 000 passengers serviced by the airport
Number of sreviced passengers	419 487	517 015	549 298	500 852	593 214	841 123	1 586 130	2 367 257	
Transit	18 493	22 327	15 579	14 616	26 739	27 662	17 292	3930	
The amount of cargo (tons)	2059	2856	2204	2104	2969	3289	3255	3438	

On the basis of *Raport o stanie miasta* original source: Krakow-Balice International Airport

The unpleasant consequences of transportation activities of air-ports can be divided into two groups: the first is connected with servicing the airport – surface traffic, the second is connected with the allocated air corridors having the direct impact on real estates (the excessive level of noise,the increased level of air pollution, the disadvantageous influence on human health and the visual effect).

But, in this place it is worth noting that, the positive aspect of airport functioning cannot be forgotten: additional employment opportunities connected with airport servicing both aerial and terrestrial (transportation to the place of destination), infrastructure development around the airports.

The positive and negative influence of airports' activities should be considered jointly in the purpose of obtaining the most objective mechanism of generating the decline in real property values.

The implementation of restricted use zones hampers the use of real estate in a very significant way or even precludes it, what causes decline in property value or forces changes in use of existing buildings. Decline in property value of real estates situated within restricted use zones is estimated by appraisers on approximately 10–30% of the value.

2. Regulations

The implementation of restricted use zones, through the *Act from april 27th 2001 year Prawo ochrony środowiska* (Journal of Laws of 2001 No. 62, item 627 with changes.) [1] through the appropriate organs simultaneously creates legal and real consequences. This increases of the bundle of rights with limits the free usage of the property and the property is indeed affected by pollution factor.

In accordance to the previously mentioned regulation the pollution is defined as the following: "emission which can be harmful to the health of people or the environment, can cause side effects to the common wealth, can degrade the esthetic advantages of the environment or possibly interfere with other defined ways of environmental use". As is evident from the previously defined, activity of airports brings all the side effects mentioned above.

It would be useful here to cite the definition of environment derived from article 3, point 39 above mentioned Act: "the environment – is understood through various elements of nature, including those reshaped through human activity, in particular the surface of earth, deposits, waters, air, landscape, climate as well as the remaining elements of biological diversity, as well as the relations between these elements" as well as article 135, paragraph 1. "In case of assessment of the influence on the environment through the post – implementation analysis or from ecological review suggest that despite of the application of available technical solution, technological and organizational cannot maintain the standard of quality of the environment beyond the area of the plant or other object, for the waste, water, treatment plant, dump yards, communication routes, air ports, electro energetic stations, as well as the installation of radio communication, radio navigation, and radio location in effect creates a restricted use zone".

As is seen in the previous article it limits the fulfillment of article 4, paragraph 1 above mentioned Act: "The common use of the environment applies to everyone through regulation and includes the use of the environment, without the use of any installation, in the aim of fulfilling personal and household needs, including relaxation and sports, in the range of...".

Along with the implementation of the resolution concerning the forming of restricted use zones surrounding the air port legalized becomes the above average emission of pollution within the environment. From this moment on, the owner of the property which is situated within the limits of the restricted use zone has the right on the basis of article 136, paragraph 1 ("in the case of the limitation of the use of the environment in the result of the established use zones in controversial issues concerning the amount of the compensation or the repurchase of the property, responsible are the common courts") to demand the compensation or the

repurchase of property from the subject which is referred to in article 136, paragraph 1: "Obliged to compensation payment or the repurchase of property is the one whose activity caused to implement limitations in connection with the establishment of the restricted use zone".

The amount of the compensation or the price of repurchase of property which is refferred to in article 136, paragraph 1 of the act *Prawo ochrony środowiska* [1] are defined in accordance to article 133 of the above mentioned regulation which states: "the determination of the amount of compensation and price of repurchase follows the opinion of the appraiser, determining the value of the property in accordance to the principles and mode specified in the regulations *Ustawa o gospodarce nieruchomościami* [6].

The role of the appraiser is, in this moment, determining, on the basis of their knowledge as well as available market information, the quantitative decline in real estate value caused by the established restricted use zones. Within this process the appraisers act according to the regulations *Ustawa o gospodarce nieruchomościami z dnia 21 sierpnia 1997 r.* (Journal of Laws of 2004 No. 261, item 2603 with changes) [6], *Rozporządzenie Rady Ministrów z dnia 21 września 2004 r. w sprawie wyceny nieruchomości i sporządzania operatu szacunkowego* (Journal of Laws of 2004 No. 207, item 2109 with changes) [19] and *Standardy Zawodowe Rzeczoznawców Majątkowych* [3].

Table 2. Permissible level of noise

No.	Category of the area	The permissible level of noise	
		Take off and landings as well as the flights by	
		L_{aeqD} reference time interval equal to 16 hours	L_{aeqN} reference time interval equal to 8 hours
1	a) Spa's protected zone „A" b) Areas of hospitals and rest – homes c) Built-up area connected with permanent or temporary stay of children and youth	55	45
2	a) One and multi-family residential areas as well as farms and collective housing b) Recreational and servicing area c) Housing and servicing area d) Areas in downtown zones of cities with number of citizens above 100 000	60	50

Source: [2]

The permissible level of noise in the environment caused by flying operations, it means, take off and landings as well as the flights by expressed by L_{aeqD} (during the day) and L_{aeqN} (during the night) ratings are presented in *Rozporządzenie Ministra Środowiska z dnia 14 czerwca 2007 r. w sprawie dopuszczalnych poziomów hałasu w środowisku* [2] (Tab. 2).

The values of the permissible levels of noise are worth comparing with the table of acoustical comfort (Tab. 3) and it is necessary to remember that the airport influence is not limited to the noise only, but also the visual effect (aircrafts flights by), fumes emission and secondary things like disease caused by long lasting staying within non – comfort acoustic climate.

Table 3. Acoustical comfort and noise threat

Description of conditions	Level of noise L_{AeqD} [dB]	Level of noise L_{AeqN} [dB]
Full acoustical comfort	< 50	< 40
Average acoustical conditions	50–60	40–50
Average noise threat	60–70	50–60
High noise threat	> 70	> 60

Source: http://www.zielonewrota.pl/

3. Statistical Methods of Appraisal

In the author's opinion, the appraisal (and also decline in property value) of properties situated within limits of the restricted use zones around air ports may by carried out in model approach with using modern methods of statistics and econometrics therein methods of spatial statistics and spatial econometrics.

The Profession of econometricians has been employing the methods called Hedonic Regression (Hedonic Price Models) in valuation (the most likely price) of heterogeneous goods described by the bundle of attributes (characteristics) for tens years. The word "hedonic" may bring into memory the philosophical doctrine telling that the pleasure is the highest good of human being, however in this case, this word "hedonic" has the connection with a utility value of particular characteristics which form a compound good – real estate. According to this theory, the value (price) of composite good, the real estate, is spanned into individual influence of particular characteristics in total price (value) creation. This approach assumes the existence of hypothetical markets for particular characteristics of real estate. In accordance with this mentioned above each property may be described by means of the specific set of attributes. The standard categories of explanatory

variables usually used in studies of the property prices are the structural features of the properties, location characteristics, and attributes of the social and natural environment. In case of the determination the decline in property value caused through the implementation of restricted use zones the interest is focused on the latter – natural environment. The only one directly measurable quantity is the level of noise, which can be obtained through the noise contour maps (acoustical maps) for the surroundings of the airports. The price of the property is the dependent variable of the constructed model. The functional relation between the price and the explanatory variables (features of the property) can be written as follows

$$y = f(x). \tag{1}$$

This functional relation may take the linear or different non-linear forms. The functions describing relation between the price and the characteristics of the property met the most often in the literature are:

- linear: $y_i = \beta_o + \sum x_{ik} \cdot \beta_k$,
- power: $y_i = \beta_o \cdot \prod x_{ik}^{\beta_k}$,
- logarithmic: $y_i = \beta_o + \sum \ln x_{ik} \cdot \beta_k$,
- exponential $y_i = \beta_o \cdot \prod e^{x_{ik} \cdot \beta_k}$,

where:

y_i – price of *i*-th property,
x_{ik} – value of *k*-th attribute of *i*-th property,
β_0, β_k – estimated model parameters.

In the aim of estimating the values of model parameters describing the dependence of property price from its characteristics, many of estimation methods may be applied, among which the most common are: Least Squares, Maximum Likelihood, Method of Moments.

The estimated model parameters give the basis for the assessment of the influence of particular property characteristics (implicit prices, hedonic prices) in forming the total property value. The implicit prices are defined as partial derivatives of the function (1), what can be written as follows

$$\frac{\partial y}{\partial x_k} = \frac{\partial f(\mathbf{x})}{\partial x_k}.$$

This partial derivatives of the property price with respect to the particular explanatory variable provide information on the marginal willingness to pay (MWTP) for the additional unit of this explanatory variable. Nelson [10] states that early studies on housing prices in relation to airport noise found the property

value reduction within the range 0.4–1.1% per unit of additional noise. In later studies, Nelson [11] found a smaller range from 0.5 to 0.64 for the reduction in property values per decibel of additional noise

The method described above assumes the independence of the observations in the geographical space, however such assumption is unlikely to occur because of the fact that nearby properties share almost the same localization and what follows almost the same accessibility, neighborhood and environmental characteristics. The remedy for this suffering of classical hedonic models is the application of spatial hedonic price models which are the generalization of classical models in relation to spatial problems, and no doubt, real estate valuation belongs to them. The Spatial models give the opportunity of taking into consideration of spatial autocorrelation both in the properties' prices and in the error term of appraisal models.

Generally, spatial autoregressive models can be described by means of the following equations:

– type A:

$$y_i = f(y_i) + X_i \cdot \beta + \varepsilon_i,$$

– type B:

$$y_i = X_i \cdot \beta + u_i,$$

$$u_i = f(u_i) + \varepsilon_i.$$

These models require relevant methods of estimation because employing standard method of estimation like Least Squares causes unwanted properties of obtained estimators. Below, there is presented short characteristic of spatial models.

As an example of model of type A, we have **Spatial Autoregressive Model** (spatially lagged dependent variable)

$$\mathbf{y} = \rho\mathbf{W}\mathbf{y} + \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon},$$

where:

$\mathbf{y}$ – the vector of dependent variable (prices),
$\mathbf{W}$ – the matrix of spatial structure (describes the neighborhood),
$\mathbf{X}$ – the matrix of independent variables (property's characteristics),
$\boldsymbol{\varepsilon}$ – the residual vector $\boldsymbol{\varepsilon} \sim N(0, \sigma^2 \mathbf{I})$,
$\boldsymbol{\beta}$ – the vector of regression coefficients,
ρ – the autoregressive parameter.

As an example of model of type B, we have **Spatial Error Model** (error term with a spatial structure):

$$\mathbf{y} = \mathbf{X\beta} + \mathbf{u}$$

$$\mathbf{u} = \lambda\mathbf{Wu} + \boldsymbol{\varepsilon}$$

where:

$\mathbf{y}$ – the vector of dependent variable (prices),
$\mathbf{W}$ – the matrix of spatial structure (describes the neighborhood),
$\mathbf{X}$ – the matrix of independent variables (property's characteristics),
$\mathbf{u}$ – the vector of error term with a spatial structure $\mathbf{u} \sim (0, \sigma^2\Omega)$,
$\boldsymbol{\varepsilon}$ – the pure residual vector $\boldsymbol{\varepsilon} \sim N(0, \sigma^2\mathbf{I})$,
$\boldsymbol{\beta}$ – the vector of regression coefficients,
λ – the autocorrelation coefficient.

Below, there are mentioned some reasons of autocorrelation of error term (based on [20]):

- the nature of some social, economic processes;
- psychology of decision making process, the actions from the close surroundings have its influence;
- incorrect analytical form of the model;
- faulty dynamic structure of the model, lack of lagged variables;
- omission of important independent variable in the model specification.

The reasons of autocorrelation of error term mentioned above were presented for the case of time series, using the analogy, otherwise making the paraphrase of Welfe words – exchanging time into surrounding space we get the same set of reasons in application to spatial case.

Combining the models of type A and type B we obtain the **Spatial General Model** of the following form:

$$\mathbf{y} = \rho\mathbf{Wy} + \mathbf{X\beta} + \mathbf{u},$$

$$\mathbf{u} = \lambda\mathbf{Wu} + \boldsymbol{\varepsilon},$$

where:

$\mathbf{y}$ – the vector of dependent variable (prices),
$\mathbf{W}$ – the matrix of spatial structure (describes the neighborhood),
$\mathbf{X}$ – the matrix of independent variables (property's characteristics),
$\mathbf{u}$ – the vector of error term with a spatial structure,

$\boldsymbol{\varepsilon}$ – the pure residual vector,
$\boldsymbol{\beta}$ – the vector of regression coefficients,
λ – the autocorrelation coefficient,
ρ – the autoregressive parameter.

The application of spatial models has a significant meaning in case of presence unmeasurable factors which have an influence on a quantity being estimated. In case of appraisal, these factors are for certain environmental factors which are market's features of the particular property. Spatial models with error term with spatial structure allow to obtain additional information being held within this error term and having influence on total value of the property without pinpointing these unmeasurable factors. On the basis of spatial models Cohen and Coughlin [7] in their studies on airport related noise near Atlanta's Hartsfield-Jackson International Airport found that houses located in an area in which noise disrupts normal activities (defined by a day-night sound level of 70–75 decibels) sell for 20.8% less than houses located where noise does not disrupt normal activities (defined by a day-night sound level below 65 decibels).

4. Conclusions

The implementation of restricted use zones constitutes a real threat for people having the legal title to the property thus the methods of appraisal in such cases should not be casual only but should be the fixed tool of the appraisers. In case of constantly collected market data (special database system) the model approach on average seems to be a very useful and justifiable tool. It gives the opportunity of appraising all the property within the given area (the restricted use zones) in the real time. Such a properly constructed model has the ability of recalculating every time when additional data come into the system. This gives the constant insight in mechanism of declining property values caused through the implementation of the restricted use zones and could be a useful tool for policy-makers and people having the legal title to the property. It is worth mentioning that spatial statistics possesses also other methods than spatial autoregressive models like Kriging and GWR (Geographically Weighted Regression) which gives the opportunity of mapping the results of estimation what seems to be particularly relevant (unfortunately the author could not collect enough reliable data especially those concerning the precise location in geographical space thus it was impossible to present the spatial distribution of declining in property value).

Concluding, the decline in property value is estimated in the range from 10 to 30 percent of the value but the market verifies those numbers and very often those numbers for particular properties are much higher.

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