A NON-CLASSICAL MODEL OF MASS VALUATION OF AGRICULTURAL PROPERTY

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Abstract

Mass valuation of real estate requires meeting a combination of several demands, such as estimating a large number of real estate properties in a short time, and above all carrying out calculations using the same tools. Econometric models ensuring that the above requirements are met are widely used throughout the world. Their application is subject to the fulfillment of assumptions, which, in practice, turns out to be difficult, especially in a market with low information efficiency, which the real estate market is an example of. Hence, apart from classical models, including multiple regression, there are proposals of non-classical models. Additionally, researchers usually analyze the market of apartments or land in urbanized areas, whereas the research area in the article is non-urbanized areas. The non-classical model of mass valuation of agricultural property tested in the Szczecin center for ad valorem property tax purposes can be treated as an alternative to classical models. The article discusses the methodology of mass valuation of undeveloped agricultural properties in non-urbanized areas, with a proposal of features significantly affecting the value of these properties. A comparative analysis of the advantages and disadvantages of classic and non-classical models used in the mass valuation of real estate was also carried out. The issues addressed are important given the different concepts of introducing cadastral value in Poland, but also the concepts of mass valuation in developing countries where there is not enough developed methodology of real estate estimation by authorized entities.

Keywords: *property valuation, econometric model of valuation, agricultural property*.

JEL Classification: *C38, R31*.

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1. Introduction

The ad valorem property tax is applicable in well-established market economies, and thus mass valuation methods of real estate are accepted and applied (BARAŃSKA 2013). In developing countries as well as those that have undergone an economic transformation in recent decades, the process of mass property valuation is hampered by the high cost of this operation upon its first application. Traditionally conducted valuations are time-consuming and require the involvement of large teams of appraisers or other competent individuals predisposing them to advanced real estate market analyses.

Technical progress and the development of IT tools facilitate the use of dispersed database resources for mass valuation using econometric methods as well as the widespread application of already used methods (*Standard on Mass Appraisal…, 2016*), especially for fiscal purposes (DORNFEST et al., 2010).

Despite this, the mass valuation of real estate in Poland continues to arouse numerous discussions, which have been going on since the mid-1990s. A scientific discussion has emerged in conjunction with the concept of building a cadaster of real estate and method of determining the cadastral value, which is the basis for calculating *ad valorem* tax instead of the existing real estate tax. The environmentally-oriented discussion of property appraisers primarily concerns the role of these persons in the valuation process and mass valuation methods which are not in line with the classical methods applied in the case of individual property valuations.

Mass valuation, taking into account the objectives it is intended to serve (often fiscal or other objectives related to state intervention in social life), is a valuation that involves so many properties that a single valuation of each property would not be economically justifiable. As a result, it is necessary to search for unified methods, using information distributed in the "cloud", as well as IT and econometric tools, to carry out this process in an optimal period of time and with minimal influence of deliberate human action. Guaranteeing valuation in a short time is socially justified, due to dynamic changes taking place on the real estate market in ever shorter market cycles. They concern not only the dynamics of real estate prices but also the preferences of trading participants as to the essential features of real estate determining its price.

An indirect statutory delegation is provided by the Ordinance of the Council of Ministers on the general valuation of real estate, indicating that the correction factors for differences between the features of representative real estate and those of other real estate in a given valuation zone are determined using statistical analysis methods, i.e. one of the methods of the comparative approach to estimating the market value of real estate. However, attributing the method of market statistical analysis to the comparative approach is not tantamount to delegating this method to exclusive use in the process of universal valuation, that is to say mass valuation. There are also no professional standards indicating specific tools (techniques) recommended in the method of statistical analysis, which, by name, corresponds to a rich body of descriptive and mathematical statistics, as well as related fields such as econometrics.

The aim of the study is to demonstrate the usefulness of non-classical econometric mass valuation models for estimating the value of real estate in non-urbanized areas against the requirements of classical models, including multiple regression, and to discuss the existing formal and legal regulations in terms of mass valuation.

2. Mass valuation in theoretical terms

2.1. Formal and legal grounds for the mass valuation of real estate in Poland

The process of property valuation is correlated with the purpose of valuation and the scope and subject matter of estimation. Appropriate to these elements and in accordance with legal and professional standards as well as on the basis of the theory of economics, a concept of real estate value has been developed, and a methodology for determining this value therewith.

In the Polish legal system (*Ustawa o gospodarce nieruchomościami…*), there are three basic real estate values: market, restoration and cadastral. Market value, after the amendment of the Real Estate Management Act from 1 September 2017, means the estimated amount that can be obtained on the valuation date for real estate in a sale transaction concluded on market terms between the buyer and the seller. It is assumed that the two parties have a firm intention to conclude an agreement, that they act with discernment, that they act prudently, and that they are not in a forced position. The reproduction value is in turn equal to the replacement costs less the wear and tear.

Against the background of two economic concepts of value, the cadastral value is not included in any of them, as the legislator points out by adding it as a separate value in relation to the market and restoration value. The delegated legislation to the market value refers only to the statement that cadastral values, established in the process of common property valuation, should take into account the differences that occur between individual properties and approximate to the market value that can be obtained by applying the rules adopted for mass valuation. Here another problem arises with regard to mass valuation principles. What is mass valuation and what are the principles of the mass valuation of properties? Are these the principles of econometric modeling; are restrictive assumptions of the particular classes of models adhered to?

Another trap in the definition appears on the occasion of creating maps and valuation tables which are drawn up on the basis of an estimate of representative properties made by property appraisers. Therefore, does mass valuation mean generalization of conclusions from structural parameter estimates of econometric models built on objects selected for the model according to the representative method, and is the selection of such representative objects (real estate) random?

Additionally, the values determined on the principles of mass valuation may be updated at the request of the owner or perpetual usufructuary and another person who is subject to the tax obligation, as well as ex officio, on the basis of an individual assessment of the real estate value. In this case, individual estimation becomes a verification of mass methods (e.g. accuracy of econometric models).

In the ordinance on the general valuation of real estate (*Ordinance of the Council of Ministers....*), the features of real estate which, according to the legislator, affect the cadastral value, are listed. For example, for land developed or intended for development and land designated for non-agricultural or forestry purposes, these are: the location, use determined in a local spatial development plan and, if there is no such plan, the use of the land, the condition of technical infrastructure facilities, development status and soil valuation class of the land, if specified in the property cadaster. In the case of agricultural and forestry land, these are: the location, type of land use, condition of technical infrastructure facilities for agricultural or forestry production, and soil valuation class. Notwithstanding the fact that other features may also be accepted if they are characteristic of a particular valuation zone, it may be considered whether, in each mass valuation model (econometric model), the features indicated prove justified in view of the assessment of the statistical significance of the model's structural parameters. This may lead to the exclusion of many classical econometric models from mass valuation or to a change in their analytical form with changes in the market and the impact of particular features on the purchase price of a property. Most of the proposed mass valuation models refer to linear models or models brought to a linear form because of their interpretative usefulness (PAWLUKOWICZ 2001).

An unfortunate definition of cadastral value is also visible in the legal acts in which value has been defined through the activities leading to its determination, i.e. it is a value determined in the process of common property transfer and through the purpose it is supposed to serve. It is assumed that it will be used to determine the basis of property tax taxation (in other legal systems, the cadastral value), as well as, in special cases, when determining the value of real estate owned by the State Treasury or a competent local government unit, or when performing official activities for the performance of which it is necessary to determine the value of real estate (i.e. the market value?). Does the legislator mean the market value of real estate here, which would lead directly to the conclusion that, in special cases, the cadastral value is identified with the market value?

In addition to the definition dilemmas and the permeation of cadastral values with market values, a more serious problem is the mass valuation method itself, and consequently, finding the adequate tools.

2.2. Econometric property valuation models

In the absence of a clearly defined procedure for the method of statistical market analysis in the comparative approach and mass valuation, researchers use both classical and non-classical econometric models and numerous functional forms to model property prices.

Multiple regression models, which are linear in nature, are most commonly used, although most of the phenomena observed in the economy over a longer period of time are non-linear. Linear models in the form of structural parameters quantify the force of the direct actions of the exogenous variable on the endogenous variable. Their universality is caused by the ease of interpretation of structural parameters and, in many cases, by the weakness of economic theory in determining the formal form of relationships.

The use of linear models requires a number of assumptions to be made (PAWŁOWSKI 1978):

– exogenous variables are non-random quantities between which there is no collinearity (no linear relationship between two or more variables),
– the random component has the mathematical expectation of zero and constant variance of a finite value,
– observations are independent, so that the sequence of random components is a sequence of independent random variables,

– the random component has a distribution that is independent of exogenous variables.

The occurrence of collinearity between exogenous variables leads to a decrease in the accuracy of the estimated structural parameters of the model, which is reflected in an increase in standard errors of parameter assessments and may lead to the removal of a variable significantly affecting the endogenous variable from the model. The occurrence of collinearity influences the quality of the model, and may also cause algebraic signs of estimated model parameters to change, although the substantive analysis shows that signs should be different. The collinearity may lead to an artificially high degree of matching of the model to empirical data.

A prerequisite for the good selection of exogenous variables is a reasonable interpretation of model parameter estimators (BOROWIECKI et al. 1986). This means that the sign of a parameter evaluation value for a given exogenous variable should be consistent with the correlation coefficient sign of this variable with the endogenous variable (coincidence). Catalysis is equally important for the quality of the model. It causes the coefficient of determination to reach very high values – close to unity, as a result of not only a strongly correlated endogenous variable with the exogenous variables, but also of strong mutual correlation of exogenous variables. As a result, indetermination and determination coefficients lose their usefulness and the quality of the model is overestimated. In this case, the actual variable relationships are distorted.

Estimation of the model's structural parameters using the classical least-squares method gives estimators that are unbiased, consistent, and efficient in the class of linear estimators, and have the smallest generalized variance in the class of linear estimators. To sum up, the least squares method is based on meeting the following assumptions:

– maximization of the degree of accuracy with which the econometric model describes the development of the phenomenon under investigation in the past, which is determined on the basis of the coefficient of determination,
– relevance of parameters and the accuracy of model structural assessments,
– coincidence of the model,
– absence of collinear or almost collinear variables,
– no or minimal catalyst effect,
– the exogenous variable should be characterized by high volatility (e.g. coefficient of variation >10%),
– in the case of a time trial, there should be no autocorrelation of the random component and no correlation between the random component and exogenous variables in the model, i.e. values of exogenous variables are not random, while the rest of the model should be random,
– distribution of the random component should be stable, i.e. it should be normal and have a constant finite variance of $N(0,\sigma^2)$,
– the structural parameter estimators of the model should be compatible, unbiased and efficient.

The inclusion of the random component in the model is related to the quality of the empirical material on the basis of which the estimated model is based, as well as the assumed analytical form of the model (GAJDA 1988) or the occurrence of randomness, i.e. purely random factor.

Non-fulfillment of the assumption that the random component is independent and has a mathematical expectation of zero and constant variance (heteroscedasticity) signifies that the estimators obtained by the least squares method are consistent and unbiased, but they are not the most effective (ENGLE, GRANGER 1987). In this case, the Aitken's generalized least squares method (i.e. the least squares weighted method) should be used. On the other hand, in a situation where there is an autocorrelation of a random component in the model which also leads to a decrease in the efficiency of estimators, it is proposed to estimate the model using the exact differential or Cochran-Orcutt method. However, if exogenous variables are not correlated with the random component, the estimators are asymptotically unbiased, which allows the use of the least squares method. Otherwise, the method of least squares does not even give compatible estimators. In such a case, the method of instrumental variables should be used to estimate the model parameters.

An equally important aspect of econometric modeling is the selection of an appropriate set of exogenous variables. The methods of selecting variables (PAWŁOWSKI 1978; GRABIŃSKI et al. 1982; BOROWIECKI et al. 1986; PLUTA 1986; FORYŚ, GACA 2017), which are also important in the valuation process due to the specificity of the real estate market (MARK, GOLDBERG 1988), are widely described in literature. In the field of property valuation, these methods are also commonly used by Polish real estate researchers and practitioners (LIS 2003; FORYŚ 2011; CZAJA, LIGAS 2011; BARAŃSKA 2013; BATÓG, FORYŚ 2013; FORYŚ, GACA 2016).

In the case of non-linear models, a good theory which justifies the model's functional form and a set of independent variables accepted to describe the studied phenomenon, especially in the case of models that cannot be reduced to a linear form, are necessary. One should mention here the general division in which non-linear models can be divided, i.e., generally speaking, into two groups. The first of them includes those which, after appropriate transformations, can be reduced to linear models. The second group of models are non-linear models in the strict sense, i.e. those for which there are no methods of transformation into linear models. Spatial models (BASS, THIBODEAU 1998; CELMER 2013; CELMER 2014), or increasingly complex methods of analyzing transactional prices derived from related sciences (GNAT 2010; BEŁEJ, KULESZA 2013) are becoming increasingly popular among asset appraisers. These are the methods used, among others, in physics, econometrics, operational research and marketing research

2.3. Non-classical model of property mass valuation

Since, in economic practice, the phenomena are usually not linear, they are also not constant in time, hence the proposal to use a non-classical (nonlinear) mass valuation model which bypasses most of the above-mentioned strong assumptions of linear models. The concept of the model was conceived in the Department of Econometrics and Statistics of the University of Szczecin as a response to the problem of estimating the economic impact of changes in the local land development plan, which are the basis for determining the planning fees in the case of showing an increase in the value of real estate as a result of a change in the plan. The model, constructed in 1999 using the existing data resources in computer databases, proved to be user-friendly and, above all, proposed a uniform methodology for estimating large collections of real estate in a short time. In the next step, the model was tested in the process of land property revaluation for perpetual usufruct. Subsequent verification of the model led to the improvement of information acquisition procedures, selection of features influencing the value of a property and calibration of these features.

The mathematical formula of the algorithm of the mass valuation of land property is presented below in the following Formulas 1-3 (HOZER et al. 1999), while the influence of particular features on the value of a property in Formulas 4-5 according to the formula proposed by Chlo. Lis (LIS 2005).

$$WR_{li} = \widehat{WWR}_l \cdot P_{li} \cdot WB \cdot \prod_{j=1}^{k}(1 + A_{ij}) \tag{1}$$

$$\widehat{WWR}_l = \frac{\sum_{i=1}^{l} WWR_i}{m} \tag{2}$$

$$WWR_i = \frac{WWR_{ri}}{\widehat{W_{hi}}} \tag{3}$$

$$\widehat{W_{hi}} = P_{li} \cdot WB \cdot \prod_{j=1}^{k}(1 + A_{ij}) \tag{4}$$

where:

WWR_l – the average market value coefficient determined for the *l*-th homogeneous spatial unit,

P_{li} – the usable area of the *i*-th land property,

WB – the base value constituting the median of the unit transaction price calculated on the basis of a database on transactions of similar real estate properties,

A_{ij} – the value of the *j*-th feature for the *i*-th land property,

m – the number of representative real estate in particular spatial units,

k – the number of features of a land property taken into account in the valuation,

i, l – identifiers of the spatial variable respectively for representatives of the *l*-th spatial unit,

W_{hi} – the hypothetical value of the *i*-th land property.

The influence of particular features on the estimated value of the land property is determined by using standardized beta factors according to the following formula (Lis 2005):

$$\hat{\beta}_j = \frac{S_{A_j}}{S_y} \cdot \frac{(Y_i - \overline{Y})}{(A_{ij} - \overline{A}_j)}, \tag{5}$$

$$1 + A_{ij} = \left(1 - \frac{1}{2}\hat{\beta}_j\right) + \left[\left(1 + \frac{1}{2}\hat{\beta}_j\right) - \left(1 - \frac{1}{2}\hat{\beta}_j\right)\right] \cdot \frac{l_{ij}}{k_j} = \left(1 - \frac{1}{2}\hat{\beta}_j\right) + \hat{\beta}_j \cdot \frac{l_{ij}}{k_j} \tag{6}$$

where:

$\hat{\beta}_j$ – standardized beta factors of the *j*-th feature,

S_y - standard deviation of the unit price of land property,

$\overline{Y}$ - the average unit price of land property,

S_{A_j} - standard deviation of the *j*-th feature,

Y_i – unit price of land of the *i*-th land property,

$\overline{A_J}$ – the average value of the *j*-th feature.

l_{ij} – the ordinal number of the category of the *j*-th feature and *i*-th land property,

$k_j = n_j$ -1 – the number of degrees of freedom,

n_j – the number of classes (categories) of the *j*-th feature.

The model has been tested several times on, among others, large collections of land properties and premises (HOZER et al. 1999; HOZER, LIS 2001; PUTEK-SZELĄG 2004; GNAT 2010) with a good match between theoretical results and empirical data.

Land valuation models analyzed in literature often narrow the area of variability of the market value. From a practical point of view, this property of models should be considered as an advantage rather than a disadvantage. Real estate characterized by land unit price that is very different from those generally observed means that these transactions were concluded under special conditions and the values of particular features do not significantly affect the value of the property. It should be stressed that the real estate market is characterized by the asymmetry of information, hence the transaction price does not always best reflect rational decisions of the parties to the transaction. In the proposed model, both conscious actions of man and non-measurable factors are taken into account in the form of market value coefficients. It is calculated based on Equation 6. This solution allows consistent distribution of market values with transaction price distribution to be obtained, while achieving a relatively low level of valuation errors.

3. Practical application of the model on the example of agricultural real estate

3.1. Research data and research assumptions

The algorithm was used to value a large collection of agricultural real estate (undeveloped land plots). In accordance with the purpose of the study, in the first step, each of the 190 properties sold was described with value-enhancing features resulting from the principles of common valuations contained in the ordinance on general real estate valuation, i.e. taking into account:

- location (6 surveying districts),
- type of agricultural area,
- condition of technical infrastructure facilities for agricultural or forestry production,
- soil valuation class.

In addition, using survey resources and practical knowledge of research centers, information on the following (consecutive variables X1-X18) has been included:

- general location,
- area of the real estate (ha),
- real estate area in conversion hectares (ha)
- site index,

– share of arable land in the area of the real estate (%),
– share of grassland in the area of the real estate (%),
– share of wasteland in the area of the real estate (%),
– access to the property,
– distance from the nearest city (km),
– distance to the nearest provincial capital (km),
– distance to the nearest district capital (km),
– detailed location,
– shape of the property,
– the lie of the land,
– soil structure,
– index of agricultural production space valorization in the commune,
– average area of an agricultural holding in the commune,
– agricultural acreage in the commune.

General location means the commune where the property under study is located.

The interdependence study was based on non-parametric tests (ANOVA Kruskal-Wallis and the median test) due to the small number of variables (e.g. general location) or qualitative variables (general location, access to the property, detailed location, shape of the property, the lie of the land, soil structure). The results of the Kruskal-Wallis test confirm the significant variation of real estate prices in communes which correspond to the overall variable location. The lie of the land was assessed according to the concept of the vertical configuration of agricultural land, with a ten-point scale adapted to a one hundred-point scale of soil evaluation, with level/flat configuration being the most valued (WITEK 1974). The index of agricultural production space valorization was calculated as the sum of evaluation points, using the IUNG method as the sum of parameters: soil quality, terrain relief, water conditions and agroclimate. The shape turned out to be an important feature affecting the unit price of the following variants: trapezoidal, rectangular (square), triangle and irregular shape. Pyrzyce was adopted as a district capital (all surveying districts were located in this district), with the city of Szczecin being the capital of the province.

The analysis used transactions from January 2001 to June 2004 due to a stable trend of average unit prices of undeveloped agricultural real estate in the area under analysis, which did not necessitate price valorization due to the passage of time (PUTEK-SZELĄG 2004). Data were analyzed in quarterly periods (eight quarters).

In the research period, the average price of 1 ha of agricultural land was PLN 5.7 thousand, while the median price was PLN 5.5 thousand/ha; prices in the PLN 4-6 thousand/ha range dominated. The average differentiation of unit prices in relation to the average price amounted to PLN 2.44 thousand/ha, which constituted 43% of the average value and is a sign of great diversity. The distribution of the unit price is right-sided asymmetrical, as evidenced by the value of the asymmetry coefficient (0.78).

For the studied variables and analyzed objects (real estate), the relationship between variables was checked, leaving variables strongly correlated with the unit price, but poorly correlated between exogenous variables.

3.2. Calibration of features accepted for the model

The median of the price, which for the analyzed period of time was at the level of PLN 5,444, was assumed base value of the price of 1 ha of agricultural land a median was taken which for the analyzed period was at the level of PLN 5,444. This solution makes it possible to adjust the value of a property both downwards and upwards, depending on whether the property being valued is superior or inferior to the base property.

The first stage of modeling is the selection of features affecting the value of land property. From the set of variables describing each transaction, only those that are significantly correlated with the real estate price were chosen. Ultimately, the following variables were used to construct the model:

- date of transaction,
- real estate area (ha),
- soil quality coefficient,
- share of arable land in the real estate area (%),

– shape of the property,
– the lie of the land.

The influence of individual variables on the value of a property was determined using standardized beta factors (Formula 4). The features of agricultural land were then calibrated using Formula (5). The results are presented in Table 1 below.

Table 1

Values of components of the agricultural property mass valuation model

Feature	β_j	k	Variants	l_{ij}	$1+A_{ij}$	A_{ij} (%)
t	0.200	7	Q1	0	0.9002	-9.98
			Q2	1	0.9287	-7.13
			Q3	2	0.9572	-4.28
			Q4	3	0.9857	-1.43
			Q5	4	1.0143	1.43
			Q6	5	1.0428	4.28
			Q7	6	1.0713	7.13
			Q8	7	1.0998	9.98
X_{2i}	-0.024	3	less than 5.64 ha	0	1.0118	1.18
			5.64 - 10.78 ha	1	1.0039	0.39
			10.78 - 25.25 ha	2	0.9961	-0.39
			more than 25.25 ha	3	0.9882	-1.18
X_{4i}	0.236	3	below 1.11	0	0.8818	-11.82
			1.11 - 1.39	1	0.9606	-3.94
			1.39 - 1.57	2	1.0394	3.94
			more than 1.57	3	1.1182	11.82
X_{5i}	0.108	3	below 84.62	0	0.9461	-5.39
			84.62 - 97.54	1	0.9820	-1.80
			97.54 - 99.98	2	1.0180	1.80
			more than 99.98	3	1.0539	5.39
X_{13i}	0.152	3	irregular	0	0.9242	-7.58
			triangle	1	0.9747	-2.53
			rectangle	2	1.0253	2.53
			trapezoid	3	1.0758	7.58
X_{14i}	0.105	2	undulating	0	0.9473	-5.27
			flat	1	1.0527	5.27

Source: own calculations.

Land properties were classified for the variable X5i based on the calculated quartiles. A set of properties was divided into four groups, including the following ranges of X5i:

$X_{5min}X_{5i} \leq X_{5Q1.4}$ - for the first group of land properties (I) -0

$X_{5Q1.4}X_{5i} \leq X_{5Q2.4}$ - for the second group of land properties (II) -1

$X_{5Q2.4}X_{5i} \leq X_{5Q3.4}$ - for the third group of land properties (III) -2

$X_{5Q3.4}X_{5i} \leq X_{5max}$ – for the fourth group of land properties (IV) -3.

The resulting beta factors do not only reflect the pure influence of individual independent variables. For example, the value (-0.024) means that a change in the property area of one standard deviation will result in a decrease in the price of 1 ha of land price by (-0.024) of the standard deviation of the price. In turn, the sum of absolute values of the standardized beta factors is 0.825. This results from the fact that, in economic phenomena, which are stochastic in their nature, there are no functional dependencies and some of the phenomena is unexplained by selected exogenous variables.

The value assigned to a given property depends on the beta factor value, the order number of the category of the *j*-th feature of the *i*-th land property, and the number of variants that a given property can accept. In the case of continuous variables (e.g. real estate area, land quality ratio or percentage of arable land in the whole property), ranges have been established. In the case of quasi-quantitative features, appropriate rankings have been given, taking into account the results of the Kruskal-Wallis test.

In the next step, market value coefficients were determined in homogeneous spatial units - surveying districts. The market value coefficients (Table 2) were calculated for the individual districts in which real estate purchase and sale transactions were carried out, calculated as the ratio of the actual value determined in the process of individual valuation by a property appraiser to the hypothetical value determined on the basis of Formula (3).

Table 2

Market value coefficients in individual districts

District	Market value coefficient	
	min	max
Bielice	0.405	0.940
Kozielice	0.690	2.250
Lipiany	0.436	1.596
Przelewice	0.658	2.015
Pyrzyce	0.724	1.546
Warnice	0.971	

Source: own calculations.

The values presented in the table are the ratios of results from individual valuations and values obtained from the model. The value of the ratio above unity means that it was estimated on average (WWR - 1)*100% more or less than would be the result of the features of the agricultural land itself. Only within Bielice were all land properties sold below the value resulting from the property's features. In the remaining districts, there were both kinds of properties, those where real estate was valued at a higher as well as lower price than would have resulted from the features of the market values. The authors considered a municipality as the elementary area. These are relatively large areas, and this can explain the large spread of the obtained results.

3.3. Results of land property value estimation

The obtained results allow us to estimate, using a non-classical model of market value, the value of 190 land properties (agricultural, undeveloped). The diagram below shows the distribution of actual and theoretical unit market values of agricultural land obtained from the model (Fig. 1).

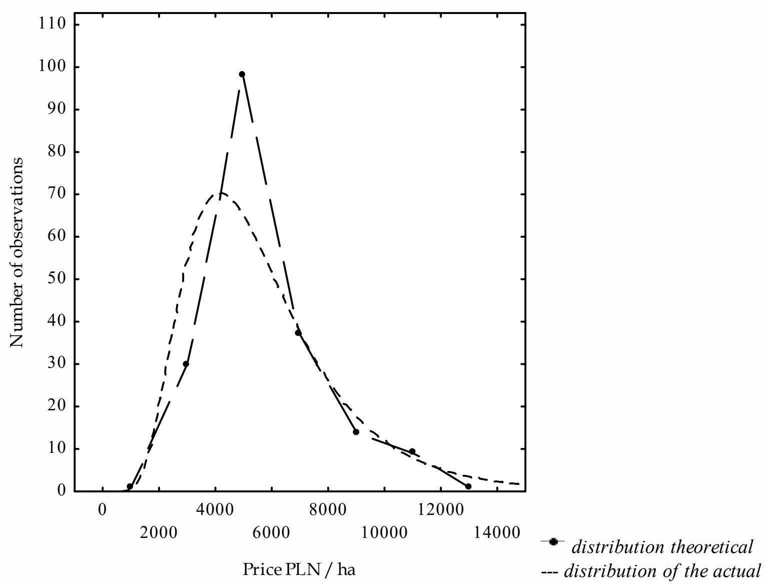

Fig. 1. Distribution of the actual (solid line) and theoretical (bars) agricultural land unit values obtained on the basis of a non-classical valuation model (PLN/ha). *Source*: own calculations.

The resulting distribution is characterized by moderate right-hand asymmetry. The market value of particular properties differs from the average value by +/- PLN 1,474 on average, which constituted 25% of the average price. The range between the minimum and maximum price was 10,379 and is only 8% narrower than the range calculated for transaction prices. Half of the real estate obtained a unit price not exceeding PLN 5.4 thousand per ha, i.e. PLN 100 less than in the case of transaction prices. Most often, 1 ha of land cost PLN 5,054, and was thus PLN 184 more expensive than in reality. The distribution of theoretical prices is characterized by a stronger right-side asymmetry. The distribution of market values can be considered as consistent with the distribution of transaction prices (at a significance level of 0.05.). Using the model, 40 properties were wrongly valued, which represented 21% of all the estimated properties (Table 3).

Table 3

Parameters assessing the correctness of property valuation using a non-classical valuation model

No.	Parameters	Statistics
1	λ - Kolmogorov	0.821
2	Mean squared valuation error (PLN/ha)	1,474
3	Coefficient of variation	25%
4	Percentage of incorrect valuations	21%

Source: own calculations.

Figure 2 shows the actual unit price and the difference between the real property prices and the market value derived from the model with a 30% tolerance band for all estimated properties. In 31 cases (16.1% of the total valuated properties) market values were higher than transaction prices by more than 30%, and only in 9 cases were they lower (4.7% of the total of valuated properties), which gives satisfactory results compared to the results obtained using classical models.

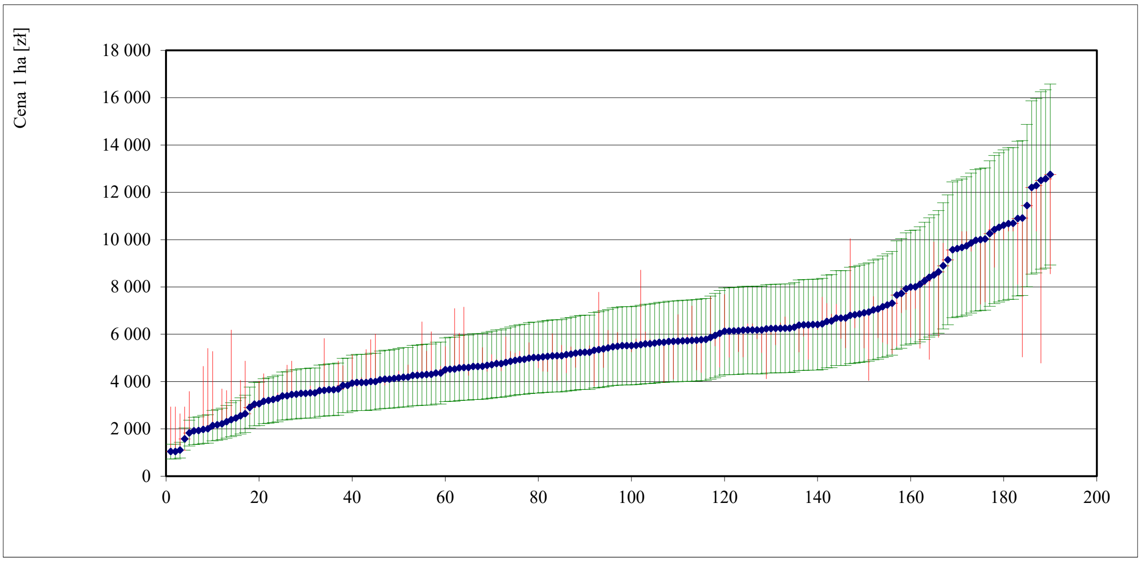

Fig. 2. Distribution of actual real estate prices with a 30% tolerance band and the difference between real property prices and market value derived from the model. *Source*: own calculations.

5. Summary and conclusions

The performed analysis is a contribution to further detailed research concerning the use of econometric models in the process of mass property valuation. In particular cases, the mass valuation model may be used to determine the market value of real estate on the basis of which the cadastral value of the property will be determined. A graphical element of the cadaster are cadastral maps created for cadastral units. The mass valuation model can be used to obtain a land value representative of the cadastral unit which can be used as a basis for determining the cadastral value of the remaining land in the area.

The results obtained and the accuracy of the estimation using a non-classical model in relation to actual transaction prices are at a satisfactory level. Compared to classical econometric models, the advantage of the model used is the possibility to use variables showing strong co-linearity in valuation so long as they constitute an important source of information. The assumptions of classical econometric models need not be checked. In addition, it can be used to separately valuate properties for each surveying area with a relatively inactive market in which few transactions are traded. Classical models cannot be used because, in many situations, the number of objects may be lower than the number of exogenous variables.

The land valuation model verified in the article meets the requirements of mass valuation due to the possibility of the quick valuation of a large number of real estate properties in a uniform manner, and is possible to adopt on every local market (uniform methodology). In addition, it is universal, because it can be used for purposes other than common valuations, takes into account the individual features of the property, and allows for the possibility of applying software to the valuation process.

The next research step will be the estimation of values of representative unit prices for cadastral units and the proposal to build maps and valuation tables using a non-classical model and classical models used in literature.

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