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The Assessment of the Influence of Average Errors of Parcels' Surface Areas on the Final Result of Land Properties' Valuation Process**

1. Introduction

Basic rules of estimation of a market value of real properties are described in the Act of 21 August 1997 on Real Estate Management [7] hereinafter referred to as UGN (the Polish acronym of *Ustawa o gospodarce nieruchomościami*) together with the Regulation of the Council of Ministers on the 21th of September, 2004 on the valuation of real properties and the development of the Valuation Report [8]. Until recently, the issue of methodology of valuation of real properties could be also appealed to *Powszechne krajowe zasady wyceny* (Common National Valuation Rules) issued by The Polish Federation of Valuers' Associations. Unfortunately, in none of these legal texts such an important issue as average errors of parcel's surface areas, buildings' or premises' areas of the valued objects is considered.

Despite the actions aimed at modernization of the register of land and buildings, in many cases we still have to face low accuracy and credibility of the data in question. This statement applies mainly to superior spatial attribute of cadastral parcels, that is their borders [1, 3, 5]. Unfortunately, it is revealed that the boundary points' location errors have a significant influence on the precise determination of surface areas [1, 2], which according to applicable regulations [6] are calculated with the usage of the analytical method. Considering the fact that the effect of the appraisal of the real properties' market value is most often a unit value, which is finally multiplied by a real property's surface area [4], it is worth to consider the influence of average errors of parcel surface areas on final valuation result of land properties.

In the article generated examples of objects and data obtained from geodetic and cartographic documentation centres were used to conduct the research. Such actions let to estimate both the scale and scope of the impact in question and to

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compare the result of the analysis with the reality. To obtain information about the transaction prices of land properties on selected areas, the studies published by Central Statistical Office were used.

2. Market Value of Real Properties – Considering the Influence of Average Errors of Surface Areas

In accordance with the binding rules of law in Poland, the market value of a real property is established by using one of the three approaches:

- 1) comparative approach,
- 2) income approach,
- 3) mixed approach.

Definitely, the most popular approach is the comparative one, which is most often used by property valuers. In accordance with article 153 of UGN, it is based on establishing a real estate value, assuming that this value matches the ascribed prices of similar real properties traded on the market. The prices should be corrected due to differentiating features between real properties. Moreover, the changes of prices which take place in time are taken into account.

The comparative approach includes three methods:

- comparisons of pairs method,
- correcting the average price method,
- market statistical analysis method.

It should be highlighted that regardless which of the previously mentioned method is used, it is the unit value which is always the obtained result. To compute the final market value of a real estate, the obtained result is then multiplied by the surface area of a property as a valued object:

$$WR = W \cdot P,$$

where:

- WR – market value of a real estate,
- W – market unit value of a real estate,
- P – surface area of a property.

Even at this stage it can be estimated that the final result of the valuation process of land properties is going to be burdened with the influence of average errors of parcel surface areas. A similar situation will take place if the investment method of income approach is used, also in case of the residual method of mixed approach (grounds of height growth potential with no record in transaction on local markets of similar properties). The scale and scope of this impact should be, therefore, checked.

On the basis of the rule of transferring average errors, the general formula for average error of a market value was introduced, which includes accuracy of analytical determining of parcels', buildings' or premises' areas depending on the object being valued:

$$m_{WR}^2 = P^2 \cdot m_W^2 + W^2 \cdot m_P^2$$

where:

- m_{WR} – average error of a market value of a real estate,
- P – surface area of a real estate,
- m_W – mean error of the appraisal of a real estate unit value,
- W – market unit value of a real estate,
- m_P – mean error of analytical determining of surface area.

The formula above (2) is going to be the basis of the realisation of further research. The influence of the analytical determining accuracy of the average error of parcel surface area on a market value will be greater together with bigger market unit value of a real estate. It was estimated, therefore, that the scope of analysis should mainly consider land properties on both urbanized areas and in the suburbs.

At this point it should be highlighted that the conducted research considers grounds with no buildings. In case of the appraisal of a market value of land properties with buildings with the aid of comparative approach methods, the usable floor area of the building is a conversion value, instead of parcel area.

3. Evaluation of the Scale and Scope of the Influence of Average Errors of Parcel Surface Areas on the Final Result of Land Property Valuation

Under the current Regulation of the Minister of Regional Development and Construction Disposition of 29 March, 2001 on the register of land and buildings [6], hereinafter referred to as Regulation 2001, the accuracy of establishing a cadastral parcel boundary points location is demonstrated with the attribute called "point location error" (the Polish acronym: BPP). The upper limits of the values ranges corresponding to the previously mentioned attribute formed the basis to estimate average errors of the surface areas in the article. This issue has already been a subject of broad analysis [1–3] on the basis of which, *inter alia*, it was demonstrated that the accuracy of the surface areas stated by the analytical method, apart from boundary points' location errors, influences also the number and placing of these points, which is basically the geometry of a parcel.

To evaluate the scope and scale of the impact of average errors of the surface areas on a market value of land properties, data fulfilling imposed criteria were

generated in the first place. As it was estimated, the proper object to conduct the analysis would be a rectangle of the surface area equals 2000 m² of 40 × 50 m, which shape was defined by four boundary bend points. It is a very popular example of the parcels' geometry, particularly on urbanized areas and in the suburbs.

Furthermore, depending on the value of BPP, the accuracy of the analytical evaluation of the area was established. Finally, with the aid of stated unit values "W" which could be equated with the prices of investment lands of various location attractiveness, average errors of market values of real properties were computed. Formula (2) was used. The results of the calculations are presented in (Tab. 1).

Table 1. Average errors of a market value of a real estate (m_{WR}) with reference to the influence of accuracy of surface area determination

Boundary points' location errors [m]	Average error of surface area [m ²]	W = 250 [PLN/m ²]	W = 1000 [PLN/m ²]	W = 5000 [PLN/m ²]	Relative error of a market value of a real estate [%]
		average error of a market value of a real estate [PLN]	average error of a market value of a real estate [PLN]	average error of a market value of a real estate [PLN]	
0.10	4.53	1131.92	4527.69	22638.46	0.23
0.30	13.58	3395.77	13583.08	67915.39	0.68
0.60	27.17	6791.54	27166.16	135830.78	1.36
1.50	67.92	16978.85	67915.39	339576.94	3.40
3.00	135.83	33957.69	135830.78	679153.89	6.79

The obtained average errors of market values of a real estate were established on the basis of the appraisal of unit value inerrancy. Therefore, they are the result of the impact of average errors of the surface areas. In such situations, both relative errors of a market value of real properties and the surface areas are identical, regardless of the unit value. It is rather obvious and yet significant property, thanks to which it is easy to verify whether the accuracy of the determination of the surface area has an influential effect on the final valuation result. If the surface area is characterised by a more significant relative error than the estimated unit value, then its impact on the market value of a real estate will be more significant.

On the other hand, analysing the average errors of the market value of real properties, it should be noticed that they grow proportionately to the average errors of parcel surface areas. Higher unit value means a higher influence of accurate analytical evaluation of the area on the final valuation result.

Analogical considerations were carried, assuming that the relative errors of a unit value were on the level of 5% (own analysis), which in the case of the considered issues led to mean errors at the level of: 12.50 PLN/m², 50.00 PLN/m² and 250.00 PLN/m². Such actions allow for determining of the total influence of appraisal accuracy and average errors of parcel surface areas on a market value of real properties.

Table 2. Average errors of a market value of a real estate (m_{WR}) with reference to the influence of accuracy of surface area and unit value estimation

Boundary points' location errors [m]	Average error of surface area [m ²]	W = 250 [PLN/m ²]	W = 1000 [PLN/m ²]	W = 5000 [PLN/m ²]	Relative error of a market value of a real estate [%]
		average error of a market value of a real estate [PLN]	average error of a market value of a real estate [PLN]	average error of a market value of a real estate [PLN]	
0.10	4.53	25025.61	100102.45	500512.24	5.01
0.30	13.58	25229.57	100918.28	504591.42	5.05
0.60	27.17	25906.08	103624.32	518121.61	5.18
1.50	67.92	30220.54	120882.17	604410.87	6.04
3.00	135.83	42167.82	168671.28	843356.39	8.43

The comparison of Table 1 and Table 2 is a confirmation of the previously made conclusions. In case of a relative error of an area being smaller than a relative error of a unit value, then the final valuation result is mainly based on the appraisal accuracy. It also results from the rule that errors sum up in squares.

Considering inerrancy of surface areas determination, average errors of a market value of real properties in question would amount to: 25,000 PLN, 100,000 PLN, 500,000 PLN. It means that in this case, the influence of the accuracy of analytical evaluation of the surface area would be more significant than the accuracy of a unit value estimation only if the errors of the boundary points location amounts to 3.00 m, which corresponds to the BPP equal to 5 and 6. However, it should be noted that the average error of the surface area depends also on the geometry of the parcel [1, 2]. The analysis of the influence of surface area determination accuracy in the process of valuation of land properties and taking it into account would be well founded, also if the value of BPP attributes equals 3 or 4. It should be reminded that the case is about boundary points which do not fulfill accuracy requirements set out in § 61 section 1 of the Regulation 2001. Then, it may be expected that average errors of the surface areas would influence significantly the final valuation result.

To illustrate the results more specifically, graphic presentation was prepared on the basis of which further interesting conclusions can be drawn (Fig. 1).

The graph could be interpreted in two ways. The first one is the analysis of the point of intersection of the straight line illustrating the influence of appraisal accuracy (red colour) with the straight line corresponding to surface area errors (blue colour). In the point of intersection factor change occurs, which has a primary influence on the accuracy of a market value of a real estate. In the examined case the situation occurs when the errors of the boundary points location are on the level of ~2.20 m, which corresponds to the average error of the surface area of the specified figure

which equals 100 m². It is possible to consider the opposite problem such as establishing the accuracy of the boundary points' location, so as the impact of their errors would not have a significant influence on the final valuation result of a specific object.

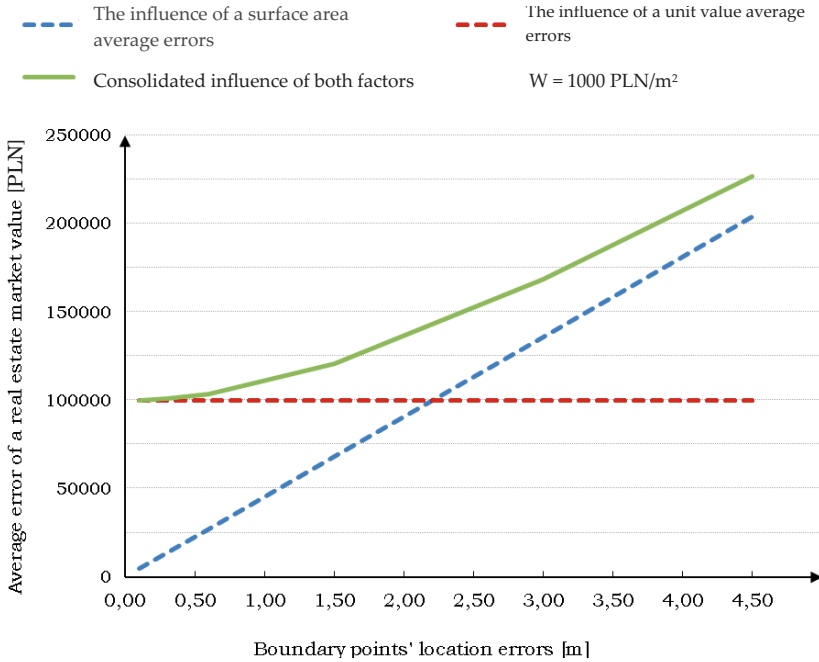


Fig. 1. Average errors of a real estate market value with reference to the influence of particular factors

The second way of interpreting the graph (Fig. 1) concerns the influence of both factors combined. It is easy to spot that with greater boundary points' location errors of a parcel, the deviation of the green curve from the red straight line corresponding only to errors of appraisal is more pronounced. In the examined case the boundary points' location errors up to ~0.60 m, the deviation mentioned above is slight. Only when the values of BPP attributes equal 4, the beginning of gradual, yet significant degradation of both accuracy and credibility of the whole valuation process is observed. If there was an analysis of a real estate which unit value would be estimated with a smaller relative error, for example 1%, then the influence of the errors of the surface areas would be probably more significant, even with the accuracy of the boundary points location equalling to ~0.30 m. It is worth to remind that this type of consideration is linked with an important role of the geometry of an object, which may differentiate significantly average errors of the surface area [1, 2]. It can be assumed, therefore, that striving for appraisal of a real estate unit value with the highest possible accuracy makes sense only when it is realisable to obtain the exact

surface area of a valued object. As it was mentioned before, if a relative error of surface area is bigger than a relative error of an estimated unit value, then the surface area would be a decisive factor.

In spite of the simplicity of the formula (2), which forms the basis for further calculations, the obtained results is an interesting study material which may provide valuable information depending on the demands. The proposed analysis may also be used during the process of the general valuation of real properties, which final result would be an introduction of cadastral tax. However, presently it is important to be conscious of the fact that the surface areas taken from the register of land and buildings are not, in fact, error-free values. It means that the influence of their determination accuracy, depending on the circumstances and with more or less significance, may disrupt the final result of the valuation process of unbuilt land properties. This problem may be extended to built-up land properties, as well as to buildings and premises. Definitely, usable floor area also is not an error-free value.

4. Market Value of Land Properties with Reference to the Average Errors of Their Surface Areas

After carrying out the analysis based on the generated theoretical example, it is necessary to confront the obtained results and conclusions with reality. With regard to the topic of the study, the full valuation process was finally rejected.

To establish an approximate market value of land properties in specified poviats, the following assumptions were applied:

- undeveloped parcels were treated as independent agricultural properties and estimated unit values were based on the agricultural areas' average transaction prices (all arable lands) in the first quarter of 2016 for Małopolska and Śląsk voivodeships provided by Central Statistical Office,
- developed parcels were treated as independent undeveloped land properties for residential development and estimated unit values were based on the developed land average transaction prices in 2014 for Małopolska and Śląsk voivodeships provided by Central Statistical Office.

It should be noticed that these are most actual data published by Central Statistical Office (second quarter of 2016). Of course, after analysing specific transaction prices on local markets of real properties, it can be assumed that they differ from unit values presented in (Tab. 3). Taking into account the aim of the study, it should not influence significantly the final results.

On the basis of the data obtained from geodetic and cartographic documentation centres, the accuracy of the analytical evaluation of the parcel surface areas was estimated. The basis for these calculations, just like in previous analysis, were the upper limits of the ranges corresponding to particular values of the BPP attribute.

Table 3. Market unit values of a real properties being the object of the analysis

Voivodeship	Agricultural lands [PLN/ha]	Lands for development [PLN/m ²]
Małopolska voivodeship	29 484	126.98
Śląsk voivodeship	33 451	117.41

Source: <http://stat.gov.pl/>

Then, the establishment of average errors of market values of land properties located in the following cadastral units were assign:

- Michałowice (Małopolska voivodeship, Kraków powiat),
- Potępa (Śląsk voivodeship, Tarnowskie Góry powiat).

The calculations were made on the assumption of the inerrancy of the unit value (0). Formula (2) was used. The results are shown in the Tables 4 and 5.

Table 4. Estimation of the market values of specific real properties together with assessment of accuracy (Cadastral unit: Michałowice)

No.	Average BPP [m]	Surface area [m ²]	Average error [m ²]	Market value [PLN]	Average error [PLN]	Relative error [%]	Range of WR [PLN] (p = 95%)	
Agricultural lands								
1	2.26	14239	277.5	41983	818.27	1.9	40346	43619
2	3.00	7636	255.7	22513	753.87	3.3	21006	24021
3	3.00	7682	350.6	22650	1033.72	4.6	20583	24718
4	1.91	17063	313.3	50309	923.72	1.8	48462	52157
5	2.38	21137	299.1	62321	881.78	1.4	60557	64085
6	1.84	10891	275.1	32111	811.07	2.5	30489	33733
7	0.97	26655	325.9	78591	960.85	1.2	76669	80513
8	1.19	20014	769.0	59011	2267.35	3.8	54476	63545
9	1.14	12141	190.9	35797	562.82	1.6	34671	36922
10	1.61	4567	89.1	13465	262.76	2.0	12940	13991
Lands for residential development								
11	1.15	6358	183.0	807396	23238.97	2.9	760918	853874
12	1.26	1347	61.2	171025	7769.99	4.5	155485	186565
13	1.26	4307	154.3	546862	19592.83	3.6	507676	586048
14	1.95	1796	74.3	228032	9432.28	4.1	209167	246896
15	2.52	1030	100.6	130760	12778.52	9.8	105203	156317
16	2.10	7700	200.7	977767	25479.55	2.6	926808	1028726
17	2.52	1640	113.1	208207	14367.14	6.9	179473	236941
18	1.76	2806	109.1	356352	13856.87	3.9	328639	384066
19	2.24	1261	137.9	160119	17515.36	10.9	125088	195150
20	3.00	3628	152.0	460687	19301.43	4.2	422084	499290

Table 5. Estimation of the market values of specific real properties together with assessment of accuracy (Cadastral unit: Potępa)

No.	Average BPP [m]	Surface area [m ²]	Average error [m ²]	Market value [PLN]	Average error [PLN]	Relative error [%]	Range of WR [PLN] (<i>p</i> = 95%)	
Agricultural lands								
1	0.60	13991	88.6	46802	296.23	0.6	46210	47395
2	0.56	14463	61.1	48379	204.33	0.4	47971	48788
3	0.58	5328	34.0	17824	113.72	0.6	17597	18052
4	0.60	5666	37.3	18953	124.84	0.7	18703	19203
5	0.50	6669	40.4	22309	135.27	0.6	22038	22579
6	0.60	10937	62.5	36587	209.11	0.6	36168	37005
7	0.60	6214	43.2	20786	144.43	0.7	20497	21075
8	0.39	2121	29.2	7094	97.66	1.4	6899	7289
9	0.60	6689	54.5	22377	182.38	0.8	22012	22742
10	0.60	2577	61.9	8620	206.99	2.4	8206	9034
Lands for residential development								
11	0.30	904	10.8	106144	1264.00	1.2	103616	108672
12	0.30	1251	13.8	146930	1622.96	1.1	143685	150176
13	0.34	749	9.0	87991	1058.85	1.2	85873	90108
14	0.33	2527	27.3	296696	3205.30	1.1	290285	303106
15	0.40	698	11.2	81907	1309.58	1.6	79288	84526
16	0.47	1734	22.8	203613	2681.71	1.3	198250	208977
17	0.60	984	20.2	115530	2376.58	2.1	110777	120283
18	0.30	2945	27.7	345734	3251.70	0.9	339230	352237
19	0.51	1758	21.8	206429	2564.45	1.2	201300	211558
20	0.60	1059	22.5	124289	2643.77	2.1	119001	129576

On the basis of the obtained results, it was stated that the accuracy of the analytical evaluation of the surface area does not influence significantly the market value of agricultural properties. The main reason for this state is low unit values of agricultural areas, or at least significantly lower than, for example, of investment lands. Of course, such situation may occur when the average error of surface area is big enough therefore its impact is more significant. However, as it can be seen in the analysis, such situations are very rare. While investigating the same problem from the aspect of lands designed for development, it was stated that average errors reach a higher level which is mostly connected to a bigger unit value. It is worth mentioning that the data concerning the boundaries of parcels on urbanized areas are most often characterised with higher accuracy.

In most of the cases in question, we have data of high enough quality to be used for the purposes of estimation of land property market value. This is the effect of

systematic actualisation and modernisation of the register of land and building data bases. However, much time and money are needed to make National Surveying and Cartographic Resource data possible to be considered as equally accurate. This conclusion is confirmed by the examples from Michałowice cadastral unit (Tab, 4, no. 15, 17 and 19). The ranges in which established market value with 95 probabilities is placed, indicate the scope of the influence of spatial data accuracy on the land property valuation process.

Finally, attention should be drawn to the fact that the problem of the influence of average errors of parcel surface areas on final land property valuation results may be examined simultaneously in two ways – scientific and practical. At this point, it is worth to remind that presently, for the aims of real property valuation, the areas which are revealed in the register of land and buildings are considered to be inerrant.

From the scientific perspective, each case in which the impact of surface area average errors on final result of valuation will be bigger than the one of the influence of unit value appraisal accuracy should be considered to be important. The final average error is of secondary importance here. The most important is the fact that the factor which is not included in the calculation process causes deterioration of accuracy of the obtained results.

Yet, from the a practical perspective, the value of the average error of final valuation result is the most important. However, this claim is a kind of abuse, because in practice only a market value of a real estate is important, whereas the accuracy of its establishment is rarely verified. Therefore, conducting simple calculations, which include the influence of the average errors of surface areas, and revealing them in the valuation report may contribute to higher credibility of the valuation process.

5. Summary

Valuation of real property is a very important issue which is strictly connected with the notion of real estate management. Unfortunately, the methodology of conducting this process has not been changed for many years. The final market value is most often calculated as a product of estimated unit value and the area of lands, buildings or premises which are the valued object.

It is clear that systematic actualisation and modernisation of the register of land and buildings brings very positive effects. The obtained results confirm this. However, it is still impossible to talk about fulfilling the postulate about equal accuracy of the data shown in National Surveying and Cartographic Resource. This statement mainly concerns cadastral parcels which boundaries, as a primary spatial attribute, often do not fulfill technical requirements specified in the binding rules of law. Particularly in such cases, when uncritical usage of surface areas in valuation process in spite of their wrongness occurs, it should not be admitted.

The conducted reasoning is the basis for the following conclusion: Average errors of surface areas influence the final market value of unbuilt land properties. Their impact gets bigger together with the unit value. It means that in case of appraisal of attractively located investment grounds, it would be reasonable to supplement the valuation reports with accuracy assessment, which would include the influence of average errors of surface areas. The data about the value of these errors should be given to property valuer by an appropriate local authority which keeps Cadastre. In this case it would be a good solution to introduce an additional attribute of a cadastral parcel which would present the value of average error or relative error of the surface area. This information would be an undisputed base for the verification of the valuation result made by a property valuer.

It should be remembered that the accuracy of an appraisal is also connected with the revenues for local government authorities and the Treasury which results from, *inter alia*, fees paid for perpetual use, a betterment levy, pension planning and in the future an *ad valorem* tax. If it would transpire that the available spatial data are not accurate enough to realize tasks connected to real properties valuation, then the appraisal process, in justified cases, should be preceded by the actualization procedure of the register of land and buildings conducted by an authorised surveyor. Such actions would contribute to a significant increase of credibility of the final valuation result which, taking the importance of the issue of establishing the value of the rights assigned to real estate into account, will surely bring very positive results.

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