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STUDY OF METHOD OF CALCULATION OF MARKET VALUE OF THE ASSESSMENT OBJECT AS THE FUNCTIONS OF THE PRICE OF THE SALES OF OBJECTS OF COMPARISON AND THE WEIGHTS OF THE POSSIBILITY OF THEIR APPROXIMATION

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Formulation of the problem

Comparison - a method of empirical research, during which phenomena or objects being valued are compared with known, previously studied, to identify common or different between them [1,2]. The valuation is based on observing and analyzing data on numerous sales and leasehold transactions. Despite some commonality of the features of these deals and objects, each transaction for each object has its qualitative and quantitative characteristics, which greatly complicates the research task. Therefore, its solution is impossible without comparison. The comparison is at the heart of any judgmental judgments aimed at obtaining objective and substantiated results. It is regarded as a condition of subjective measurement processes, empirical generalizations, categorization and identification of objects and phenomena, which allows, on the one hand, to avoid voluntarism and on the other, to check and adjust assumptions, which formed a conclusion about the cost [3].

Analysis of research and unresolved parts of the general problem

When evaluating market value, the subject of comparative analysis is data that adequately reflects the situation on the market where the estimated item is presented. These data relate to similar things, that is, those that can and can compete with the estimated thing in the same market, and are sensitive to changes in the characteristics that are selected as elements of comparison. As a method of cognition, the comparison is based on two principles of formal logic: the principle of similarity - for comparison of any objects it is necessary to show that they have common features; the principle of difference - for comparison, such objects should have signs that they can be distinguished [4].

In order for the comparison to be fruitful, it must satisfy two basic requirements: only those objects with which there is a certain objective community can be compared; the comparison of such objects should take place on the most important, essential features. The comparison can be made both quantitatively and qualitatively, of transactions and objects in respect of which they are concluded [5]. Qualitative signs are data that characterize some property or state of the unit of observation, as well as the presence or absence of this property in this unit. They are based on discrete and predefined categories and allow you to distinguish between units of observation among themselves, to allocate units of a certain type. For example, real estate is divided by the main purpose of residential, commercial, industrial; for circulation in the market - for non-specialized and specialized [4, 5]. Quantitative attributes are data whose individual values allow the numerical measure of the manifestation of one or another property (for example, area, building volume, prices, etc.) and to arrange the units of observation to such extent and, thus, to further differentiate this property [5].

Setting objectives

The comparison allows you to establish similarity and difference in units of observation. As a result of the comparison, establish the general that is characteristic of units of observation, and the special that distinguishes them, and thus solve the problem of similarity of objects. This is especially important in view of the fact that each object is characterized by numerous and varied features. The comparison can be carried out on qualitative and quantitative features, which collectively form a representative space of observation units. Qualitative signs are expressed in the form of concepts, definitions that characterize their essence, state or quality. Quantitative signs express the individual values of qualitative signs in a numerical expression [6].

Therefore, we set ourselves the task of calculating the market value of the object of evaluation, as a function of the selling price of comparative objects and the degree of their similarity, for example, in a commercial object in Busk, Lviv district.

Presentation of the main research material

Qualitative and quantitative characteristics are closely interrelated with each other. Typically, a study begins with identifying qualitative characteristics, according to which transactions and properties for which these agreements are concluded, can be attributed to a particular market, that is, to name the object of observation. Such qualitative signs are considered nominal. Then, the objects of observation are compared on the quantitative features, which allows for each object to establish its numerical parameters (metric signs), on the basis of which objects can be divided into certain classes, that is, to obtain new qualitative characteristics.

The comparison is based on the general idea of the possibility of quantitative measurement of signs of objects of observation. The degree of similarity of

objects is determined by the degree of their proximity to certain features.

Objects are considered to be completely analogous if their features completely coincide, that is, in the case of the equation [7-9]:

$$S_1 = \sqrt{\sum_{k=1}^{m}\left(1-\frac{a_{ik}}{a_{jk}}\right)^2} = 0, \qquad (1)$$

or

$$S_2 = \frac{a_{i1}}{a_{j1}} \times \frac{a_{i2}}{a_{j2}} \times ... \times \frac{a_{ik}}{a_{jk}} = 1, \qquad (2)$$

where a_{ik} – the value k of the factor-specific i object; a_{jk} – the value k of the factor-specific j object.

Therefore, for comparison, select those objects for which S_1 the minimum value or value S_2 is maximally approximated to one. By degree of similarity, units of observation can be grouped into groups (strata), which allows to structure the totality of these units by characteristics (characteristics) of transactions and / or objects of real estate and to identify the relationship between them and their features.

Stratification - is the division of the whole set of units of observation into several groups (subgroups) by their characteristics (characteristics).

Typically, there are three types of groupings:

• structural grouping, which gives an idea of the structure of aggregates of homogeneous units of observation on certain grounds (for example, single-family farmsteads according to their location, the area of the household plot for the total area of the house, etc.);

• typological grouping, which allows, based on the simultaneous combination of several features, to distinguish in a heterogeneous set of homogeneous groups (for example, to classify residential buildings of the city depending on the number of floors, the material of the walls and the time of construction);

• analytical grouping by which the relationship is studied by features (for example, between the characteristics of the transaction or the object of the property and the price of its sale or lease).

Theoretically, stratification can be carried out on any basis, but it is important that objects on these grounds were able to compete in one market. Otherwise, you can get a distorted idea of the power of supply and demand.

In practice, the degree of similarity of objects is evaluated using different metrics.

Metric is a way of measuring the distance between any objects on a certain basis.

Different metrics in different ways formalize the space of signs and give different interpretations of the proximity-distance of objects. However, under all conditions, the general requirements are for the numerical function d_{ij}, which is the given distance [8, 9]:

1. The distance function must be an integral value:

$$d_{ij} \geq 0, \qquad (3)$$

which is equal to zero only when the objects i and j are similar. That is, the maximum likeness of an object has itself:

$$d_{ij} = min\, d_{ij}. \qquad (4)$$

2. The distance function must be symmetric:

$$d_{ij} = d_{ji}. \qquad (5)$$

3. The function of the distance between two points must be less than or equal to the sum of distances from each of these points to any third point:

$$d_{ij} \leq d_{in} + d_{nj}. \qquad (6)$$

That is, for each sign, the "object-object" relation can be represented by a square symmetric matrix D whose diagonal elements must be zero

$$D = \begin{pmatrix} d_{11} & d_{12} & ... & d_{1n} \\ d_{21} & d_{22} & ... & d_{2n} \\ ... & ... & ... & ... \\ d_{n1} & d_{n2} & ... & d_{nn} \end{pmatrix}. \qquad (7)$$

In fact, the matrix D reflects the structure of the relationship between objects that can be interpreted as some geometric configuration of points in a multidimensional feature space.

Depending on the nature of the signs, the distance can be measured as the difference in the date of sale of real estate, in the place where they are located, in metric characteristics, etc.

Of the possible ways of measuring the distance between objects i and j the k second sign most often use the Euclidean metric [8].

$$d_{ij}^{(E)} = \sqrt{\sum_{k=1}^{p}\left(a_{ik} - a_{jk}\right)^2}. \qquad (8)$$

The Euclidean metric well approximates the distances between objects described by quantitative, qualitative and dichotomous attributes that are relatively equivalent and equivalent and none of them is dominant.

In case of necessity to quantify the weight of factor marks or to align the scale of heterogeneous signs it is expedient to weigh the distances defined by the Euclidean metric:

$$d_{ij}^{(wE)} = \sqrt{\sum_{k=1}^{p} w_k \cdot \left(a_{ik} - a_{jk}\right)^2}, \qquad (9)$$

where w_k - weighted coefficients for k character with the condition that their sum is equal to one.

The theoretical generalization of the Euclidean metric is the metric of Minkowski:

$$d_{ij}^{(MI)} = \sqrt[m]{\sum_{k=1}^{p} w_k \cdot \left(a_{ik} - a_{jk}\right)^m}, \qquad (10)$$

where a_{ik}, a_{jk} – k - is the coordinate i and j objects; m - the constant of Minkowski [9].

Obviously, when $m = 2$ we have an Euclidean metric, in which straight rectilinear distances are measured. However, in assessing real estate, it is often necessary to take into account the absolute values of the proximity-distance of objects according to factor characteristics. This is achieved provided that the Minkowski constant is equal to ($m = 1$). Such a metric is called the metric of "urban quarters" or the Manhattan metric, since in this case the distance between objects is determined similarly to the distance along mutually perpendicular streets of urban quarters [7]:

$$d_{ij}^{(MI)} = \sum_{k=1}^{p} \left|a_{ik} - a_{jk}\right|. \qquad (11)$$

The Manhattan metric was used by Hamming to determine the differences between the objects given by the dichotomous traits. In this case, the distance between the objects is interpreted as the number of discrepancies in the values of attributes in objects i and j. Just as for an Euclidean distance, we can use the weighted distance of Minkowski or Hamming:

$$D = \frac{d_{ij}^{(MI)}}{K}, \qquad (12)$$

where D - standardized distance; K - number of signs
Another application of the metrics of Minkowski in the assessment of real estate is the measurement of proximity-distance objects for the most significant (dominant) sign, that is, when the Minkowski constant $m \to \infty$. Such a metric is also called the dominant metric [8]:

$$d_{ij}^{(MI)} = \sqrt[\infty]{\sum_{k=1}^{p} w_k \cdot \left(a_{ik} - a_{jk}\right)^{\infty}}, \qquad (13)$$

or

$$d_{ij}^{(MI)} = max\left(a_{ik} - a_{jk}\right). \qquad (14)$$

Each of the above types of metrics can be used to determine the degree of similarity of objects of observation, since the smaller the value of distance d_{ij}, the object i is chosen by the features closer to the j object. That is, the degree of similarity i and j objects will be the value s_{ij} that is the inverse of the value of the distance between these objects:

$$s_{ij} = \frac{1}{d_{ij}}. \qquad (15)$$

The degree of similarity is an important indicator in the evaluation of real estate. It is based on one of the main principles of evaluation - the principle of replacement - by which the object of evaluation is more likely to be sold or rented for the price of similar objects.

If, for comparison, objects are selected, some of which according to the factor characteristics will exceed the object of evaluation, accepted for the center of coordinates, and part - to give it, then the value of the object of evaluation can be determined by the formula [6, 9]:

$$V_0 = \sum_{i=1}^{n} w_{0i} \times P_i, \qquad (16)$$

where V_0 - the market value of the object of evaluation; P_i - selling price of the i object of comparison; w_{0i} - weighted coefficient, which reflects the probability that the value of the object of evaluation will be the same as the sale price of the i object of comparison:

$$w_i = \frac{s_{0i}}{\sum_{i=1}^{n} s_{0i}}. \qquad (17)$$

So, we need to determine the cost of a land area of 605 m^2 with a building on it with a non-residential premises of poor technical condition with a total area of 133.8 m^2, which is most appropriate to use at the store. Entrance to the building facade from the street. Not convenient transportation accessibility. There are no parking spaces. Output data for calculations is presented in the table. 1.

Solution to the task

1. We formalize qualitative signs, denoting:

• organization of the entrance to the store - "from the street" as 1, "from the court" - 0;

• technical condition - "good" as 3, "satisfactory" - 2, "bad" as 1;

• transport accessibility - "good" as 3, "satisfactory" - 2, "bad" as 1;

• parking - "exists" as 1, "no" - 0.

Transform table 1 and write the results in table 2.

2. Convert table 2 to the comparison table, subtracting from the value of each element of comparison that characterizes the object of evaluation, the value of the same element, which characterizes the object of comparison, and the results are presented in table 3.

3. Given that the elements of the comparison had different and incomparable units of measurement (date, square meters, etc.), we will perform the normalization of the elements of comparison. To do this, we first calculate the length of each vector column, which characterizes the difference between objects of comparison from an object, which is evaluated by the j factor ($j = \overline{1;7}$) as a square root of the sum of squares of all elements of the corresponding column. The results of the calculations are presented in Table 4. We transform the comparison table 3, taking into account the results obtained in Table 4 of the normalized comparison elements, and the results of calculations are presented in Table 5.

4. Calculate the distance of objects of comparison from the object of evaluation in the seven-dimensional (by the number of elements of comparison) Euclidean space, preliminary raising the normalized values of the elements of comparison in a square, and the results of calculations are presented in table 6.

5. Calculate the value of the object of evaluation as a function of the sale price of objects of comparison and the degree of their similarity to the object of evaluation and the result of calculations are presented in table 7.

Conclusions

Consequently, the research carried out implies observing a certain sequence:

• first, it is necessary to outline the market, which includes deals and real estate objects in respect of which these agreements were concluded, that is, to allocate the object of observation;

• then establish individual qualitative and quantitative characteristics of the units of observation, which unites or distinguishes them from the rest of the market;

• systematize units of observation for significant qualitative and quantitative features, that is, to stratify transactions and / or real estate objects and to identify the relationship between these features.

A compulsory condition for conducting a study is the comparability of data, which implies:

• the unity of volumetric, costly, qualitative, structural indicators;

• the unity of the time periods for which the comparison is made;

• uniformity of market conditions;

• uniformity of measurement method (metrics) of indicators.

The degree of similarity of transactions and / or objects of real estate is measured using various measurement scales: nominal, ordinal, intervals, relationships, differences and absolute. The first two scales apply to the measurement of qualitative characteristics, the rest of the scales - to measure quantitative characteristics.

At the same time, the Euclidean metric and metric of Minkowski (metric of urban neighborhoods or the Manhattan metric) are used most often in the assessment as a way of measuring the distance between any units of observation on a certain basis.

According to the results of the measurement units of observation can be grouped into groups (strata) on one basis (structural grouping), on several grounds (typological grouping), which allows to identify the relationship between units of observation and their features (analytical grouping).

For formed groups, measures of the central trend (arithmetic or average distributions) and dispersions (dispersion coefficient or standard deviation) can be calculated, which allows to form an idea of the typical level of prices in a certain segment of the market and its dynamics, and thus realize two aspects of comparison :

• static, used to determine the level of prices prevailing in the market at a certain point in time;

• dynamic, used to study price dynamics over a certain period of time.

In this case, the dynamic comparison can be synchronous when it tracks price changes within one stage or cycle of market development, and asynchronous when comparing prices that are inherent to similar stages, but in different market cycles.

In our opinion, the prospects for further research in this direction are the improvement of methods for assessing the market value of real estate objects, which will avoid the subjectivity of appraisers and mistrust of controlling authorities.

Consequently, the market value of non-residential premises for commercial use calculated by this method is 104844 hr., which per 1 m^2 of land - 173.30 hr. it is fully consistent with the current market situation.

Table 1

Output data for calculations

Objects	Selling price	Elements of comparison						
		Date of sale until the valuation date, months	Total area of the land plot, m^2	Total area, non-residential rooms, m^2	Technical condition	Arriving at the store	Transport accessibility	Parking
Object of evaluation	-	0	605	133,8	bad	from the street	bad	no
Object 1	110	1	650	155,2	good	from the street	good	yes
Object 2	107	1	640	148,6	satisfactory	from the yard	good	yes
Object 3	105	0	615	140,4	satisfactory	from the yard	satisfactory	yes
Object 4	98	2	550	121,2	bad	from the yard	bad	no
Object 5	95	2	530	125,8	bad	from the yard	bad	no
Object 6	100	0	600	132,7	satisfactory	from the street	satisfactory	no
Object 7	115	1	700	168,9	good	from the street	good	yes
Object 8	102	0	610	135,5	bad	from the street	satisfactory	yes
Object 9	120	1	720	170,1	good	from the street	good	yes
Object 10	117	1	705	165,2	good	from the yard	good	yes

Table 2

Digitized output

Objects	Elements of comparison						
	Date of sale until the valuation date, months	Total area of the land plot, m^2	Total area, non-residential rooms, m^2	Technical condition	Arriving at the store	Transport accessibility	Parking
Object of evaluation	0	605	133,8	1	1	1	0
Object 1	1	650	155,2	3	1	3	1
Object 2	1	640	148,6	2	0	3	1
Object 3	0	615	140,4	2	0	2	1
Object 4	2	550	121,2	1	0	1	0
Object 5	2	530	125,8	1	0	1	0
Object 6	0	600	132,7	2	1	2	0
Object 7	1	700	168,9	3	1	3	1
Object 8	0	610	135,5	1	1	2	1
Object 9	1	720	170,1	3	1	3	1
Object 10	1	705	165,2	3	0	3	1

Table 3

Comparison table

Objects	Elements of comparison						
	Date of sale until the valuation date, months	Total area of the land plot, m^2	Total area, non-residential rooms, m^2	Technical condition	Arriving at the store	Transport accessibility	Parking
Object 1	-1	-45	21,4	-2	0	-2	-1
Object 2	-1	-35	-14,8	-1	1	-2	-1
Object 3	0	-10	-6,6	-1	1	-1	-1
Object 4	-2	55	12,6	0	1	0	0
Object 5	-2	75	8,0	0	1	0	0
Object 6	0	5	1,1	-1	0	-1	0
Object 7	-1	-95	-35,1	-2	0	-2	-1
Object 8	0	-5	-1,7	0	0	-1	-1
Object 9	-1	-115	-36,3	-2	0	-2	-1
Object 10	-1	-100	-31,4	-2	1	-2	-1

Table 4

Calculation of the base of the valuation of the comparison elements

Objects	Elements of comparison						
	Date of sale until the valuation date, months	Total area of the land plot, m^2	Total area, non-residential rooms, m^2	Technical condition	Arriving at the store	Transport accessibility	Parking
Object 1	-1	-45	21,4	-2	0	-2	-1
Object 2	-1	-35	-14,8	-1	1	-2	-1
Object 3	0	-10	-6,6	-1	1	-1	-1
Object 4	-2	55	12,6	0	1	0	0
Object 5	-2	75	8,0	0	1	0	0
Object 6	0	5	1,1	-1	0	-1	0
Object 7	-1	-95	-35,1	-2	0	-2	-1
Object 8	0	-5	-1,7	0	0	-1	-1
Object 9	-1	-115	-36,3	-2	0	-2	-1
Object 10	-1	-100	-31,4	-2	1	-2	-1
$\sum_{i=1}^{n}\left(\Delta a_{ij}\right)^2$	**13**	**44300**	**4483,08**	**19**	**5**	**23**	**7**
$\sqrt{\sum_{i=1}^{n}\left(\Delta a_{ij}\right)^2}$	**3,6056**	**210,4756**	**66,9558**	**4,3589**	**2,2361**	**4,7958**	**2,6457**

Table 5

Transformed comparison table, taking into account the standardization of comparison elements

Objects	Elements of comparison						
	Date of sale until the valuation date, months	Total area of the land plot, m^2	Total area, non-residential rooms, m^2	Technical condition	Arriving at the store	Transport accessibility	Parking
Object 1	-0,277	-0,214	0,320	-0,459	0	-0,417	-0,378
Object 2	-0,277	-0,166	-0,221	-0,229	0,447	-0,417	-0,378
Object 3	0	-0,048	-0,098	-0,229	0,447	-0,208	-0,378
Object 4	-0,555	0,261	0,188	0	0,447	0	0
Object 5	-0,555	0,356	0,119	0	0,447	0	0
Object 6	0	0,024	0,016	-0,229	0	-0,208	0
Object 7	-0,277	-0,451	-0,524	-0,459	0	-0,417	-0,378
Object 8	0	-0,024	-0,025	0	0	-0,208	-0,378
Object 9	-0,277	-0,546	-0,542	-0,459	0	-0,417	-0,378
Object 10	-0,277	-0,475	-0,469	-0,459	0,447	-0,417	-0,378

Table 6

Distance of object of comparison from the object of evaluation

Elements of comparison	Objects									
	1	2	3	4	5	6	7	8	9	10
Date of sale	-0,277	-0,277	0	-0,555	-0,555	0	-0,277	0	-0,277	-0,277
Land area	-0,214	-0,166	-0,048	0,261	0,356	0,024	-0,451	-0,024	-0,546	-0,475
The area of the rooms	0,320	-0,221	-0,098	0,188	0,119	0,016	-0,524	-0,025	-0,542	-0,469
Technical condition	-0,459	-0,229	-0,229	0	0	-0,229	-0,459	0	-0,459	-0,459
Arriving at the store	0	0,447	0,447	0,447	0,447	0	0	0	0	0,447
Transport accessibility	-0,417	-0,417	-0,208	0	0	-0,208	-0,417	-0,208	-0,417	-0,417
Parking	-0,378	-0,378	-0,378	0	0	0	-0,378	-0,378	-0,378	-0,378
$\sum_{j=1}^{m}\left(\Delta a^{*}_{ij}\right)^{2}$	**0,752**	**0,722**	**0,450**	**0,611**	**0,649**	**0,097**	**1,082**	**0,187**	**1,196**	**1,250**
$d_{0i}=\sqrt{\sum_{j=1}^{m}\left(\Delta a^{*}_{ij}\right)^{2}}$	**0,867**	**0,850**	**0,671**	**0,782**	**0,806**	**0,311**	**1,040**	**0,432**	**1,094**	**1,118**

Table 7

Estimate table for determining the value of the object of evaluation

Objects	Distance d_{0i}	Degree of similarity $s_{0j} = \frac{1}{d_{0j}}$	Weight of degree of similarity $w_i = \frac{s_{0i}}{\sum_{i=1}^{n} s_{0i}}$	P_i	$w_i \times P_i$
Object 1	0,867	1,153	0,079	110	8,690
Object 2	0,850	1,176	0,08	107	8,560
Object 3	0,671	1,490	0,102	105	10,710
Object 4	0,782	1,279	0,087	98	8,526
Object 5	0,806	1,241	0,085	95	8,075
Object 6	0,311	3,215	0,22	100	22,000
Object 7	1,040	0,962	0,066	115	7,590
Object 8	0,432	2,315	0,158	102	16,116
Object 9	1,094	0,914	0,062	120	7,440
Object 10	1,118	0,894	0,061	117	7,137
	$\sum_{i=1}^{n} s_{0i}$	**14,639**	**1,00**	V_0**, grn.**	**104 844 grn.**

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The study of the method of calculating the market value of the valuation object, as a function of the sale price of objects of comparison and the weight of their degree of similarity

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The study of the formation of the market value of a commercial real estate object by comparison with the calculation of the weight of the degree of similarity of comparison objects is performed. The assessment is based on the observation and analysis of data on numerous sales transactions and on the rental of real estate.