

## METHODOLOGICAL FEATURES OF CALCULATION OF THE LEASE VALUE OF AGRICULTURAL LANDS

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### Abstract

*We have proposed to use the inverse matrix method when calculating the value of the lease right of an agricultural land plot in the context of a methodological approach based on comparing the sale prices of such rights at land auctions for similar land plots. The reflection its use for the determination of rental rights when comparing their sales prices at land auctions using the system of linear algebraic equations provides the application of the quantitative and qualitative analyses to measure differences between comparison elements. The proposed method allows taking into account the qualitative characteristics of the objects of comparison, such as the land plot shape or the presence of restrictions and burdens on its use.*

*Key words:* value of the lease right, expert evaluation, regulatory evaluation, inverse matrix method, land plot

### INTRODUCTION

The moratorium on the agricultural lands sale in Ukraine has created the conditions for the market principles implementation due to the lease of land, which is calculated on the basis of the normative monetary valuation – capitalized rental income, determined by established and approved standards [8]. According to the calculation algorithm proposed in it, the value of lands has decreased. This fact has had a negative effect on the lease relations.

Leading scientists, in particular, O. Hutorov [5], A. Martyn [6], M. Stupen [10; 11], A. Tretyak [12] and others made a significant contribution to the development of theoretical and methodological foundations of regulatory monetary valuation of agricultural lands. An analysis of their research indicates that there are gaps in regulatory evaluation methods. One should mention the authors investigating the use of mathematical modeling methods in estimating the value of land plots, mainly Yu. Dekhtiarenko, Yu. Mantsevych, Yu. Palekha [2], O. Drapikovskiy [3], I. Ivanova [4].

We have a task of calculating the value of agricultural land plot using expert evaluation

with mathematical modeling, comparing it with the value determined in accordance with the regulatory monetary valuation methodology to select the most practical and reliable valuation method.

### MATERIALS AND METHODS

In the research one has used the inverse matrix method to calculate the value of the leasehold right using expert judgment [7], which is based on the comparison of prices for the sale of such rights for similar land lots at land auctions.

The method of sales prices comparison allows using the mathematical apparatus of matrix algebra.

To apply this method, the comparison objects ( $a_{i1}, a_{i2}, \dots, a_{im}$ ) must be as similar as possible to the object of evaluation ( $(a_{01}, a_{02}, \dots, a_{0m})$ ).

To represent the basic information as a state matrix  $A$ , its first line must correspond to the elements of the comparison of the object of evaluation, and the following ones – to the objects which have been selected for comparison:

$$\begin{pmatrix} a_{01} & a_{02} & \dots & a_{0m} \\ a_{11} & a_{12} & \dots & a_{1m} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nm} \end{pmatrix} = A$$

$$\begin{pmatrix} \Delta a_{11}V_1 & \Delta a_{12}V_2 & \dots & \Delta a_{1m}V_m \\ \Delta a_{21}V_1 & \Delta a_{22}V_2 & \dots & \Delta a_{2m}V_m \\ \dots & \dots & \dots & \dots \\ \Delta a_{n1}V_1 & \Delta a_{n2}V_2 & \dots & \Delta a_{nm}V_m \end{pmatrix} = \Delta A$$

The  $\Delta A$  comparison matrix has the form  $n \times m$  and shows the difference between the object and the comparison analogues as  $\Delta a = a_{0j} - a_{ij}$ , where  $i=1, n; j=1, m$ .

$$\begin{pmatrix} \Delta a_{11} & \Delta a_{12} & \dots & \Delta a_{1m} \\ \Delta a_{21} & \Delta a_{22} & \dots & \Delta a_{2m} \\ \dots & \dots & \dots & \dots \\ \Delta a_{n1} & \Delta a_{n2} & \dots & \Delta a_{nm} \end{pmatrix} = \Delta A$$

The difference between a comparison object and evaluation not only has a natural value, but also a value that reflects  $\Delta V_{ij}$  - a monetary adjustment for the difference between the  $i^{th}$  comparison object and the evaluation object by the  $j^{th}$  comparison element:

$$\begin{pmatrix} \Delta V_{11} & \Delta V_{12} & \dots & \Delta V_{1m} \\ \Delta V_{21} & \Delta V_{22} & \dots & \Delta V_{2m} \\ \dots & \dots & \dots & \dots \\ \Delta V_{n1} & \Delta V_{n2} & \dots & \Delta V_{nm} \end{pmatrix} = \Delta A$$

Since the monetary amendment  $\Delta V_{ij}$  reflects the difference in the  $j^{th}$  element of comparison between the object of evaluation and the  $i^{th}$  object of comparison in natural  $\Delta a_{ij}$  indicators, it will look like:

$$\Delta V_{ij} = (a_{0j} - a_{ij}) \times V_j = \Delta a_{ij} V_j$$

where:

$a_{ij}$  is the natural indicator of the  $j^{th}$  element of comparison for the  $i^{th}$  object of comparison;  
 $a_{0j}$  - the natural indicator of the  $j^{th}$  element of comparison for the  $i^{th}$  object of evaluation;  
 $V_j$  is the value of the  $j^{th}$  element of comparison, according to which the matrix of comparison  $\Delta A$  will be:

where:

$\Delta a_{ij}V_j$  - the product a single indicator of the characteristic of the  $j^{th}$  element of comparison by the difference in the values of that indicator between the  $i^{th}$  object of comparison and the object of evaluation.

The size of the  $\Delta a_{ij}V_j$  amendments adjusts the sale price for each object to minimize the difference in the  $j^{th}$  element of comparison with the evaluation object, taking into account differences in their characteristics according to the formula:

$$\Delta V_i^a = P_i + \sum_{j=1}^m \Delta a_{ij} V_j$$

where:

$V_i^a$  is the adjusted sales price;

$P_i$  is the sales price;

$\Delta a_{ij}V_j$  - sales price amendment.

## RESULTS AND DISCUSSIONS

Previous studies have based their criteria for selection on the methodological approach of comparing sales prices (market approach to evaluation) [9] as the most objective concerning the end result is the methodological approach of comparing sales prices (market approach to valuation), because it is based not on the appraiser's subjective assumptions, but objective information. A methodical approach of comparison of sales prices (market approach to valuation) is the most objective one concerning the end result, since it is based not on the subjective assumptions of the appraiser, but on information about the sale of land leases of agricultural land plots of state ownership of land auctions (8 % of regulatory monetary valuation) [1]. We have collected information on the sale value of the right to lease at land auctions to apply the methodological approach of comparing selling prices, as the most reliable method, which causes the

comparison of the estimation object with analogues by the selected elements of comparison in Table 1.

She below illustrates source data on the sale of the lease on land auctions and the characteristics of such objects by comparison elements, which has been collected in order to determine the lease rate for agricultural land plots of 1 ha for object of evaluation.

It can be seen from the source data that object of the evaluation of lease right and comparison objects have a similar location. The implementation of the offer objects is not

compulsory, the exposure time limit has not been revealed, since the information on all the comparison objects is reliable and proposed as of 2019. Closer inspection of the table shows the object of evaluation and the comparison objects have the same functional use – agricultural purpose for maintenance of commodity agricultural production. The selected land plots are free of development but have different characteristics in terms of land form, existence of restrictions or burdens on its use and the term of the lease agreement.

Table 1. Source data for the value calculation of the lease right of the valuation object, 2019.

Location of object of evaluation (comparison)	Lease payment, UAH/ha/year	Comparison objects				
		size, ha	location (distance from Lviv (Ukraine), km)	physical characteristics (land plot shape)	existence of restrictions or burdens on its use	the term of the lease agreement
Object of evaluation (the village of Nadychi, Zhovkva district, Lviv region (Ukraine))		6.0	19	Regular	no	10
Object of comparison 1	2,078	4.5	17	Irregular	yes	7
Object of comparison 2	6,948	11.0	22	Regular	no	7
Object of comparison 3	8,377	19.54	39	Irregular	no	10
Object of comparison 4	2,244	6.0	35	Regular	yes	7
Object of comparison 5	3,780	17.2	32	Irregular	no	7

Source: it is done by the author on the basis of data [1].

A methodical approach to comparing the sale prices of the right to lease in land auctions with the help of the matrix apparatus of construction of a system of linear algebraic equations involves the use of both quantitative and qualitative analysis for measuring the differences between the elements of comparison.

Explicitly, a crucial element in the methodological approach of price comparison is to outline the elements of comparison and the magnitude of the amendments [4]. When assessing the value of the right to lease, we formalize the qualitative features, marking the regular form of the land as 1, and the irregular one – 0, and existence of restrictions or burdens on its use: if there are not ones – 1, if there are ones – 0. Thus, we present the source data for the value determination of the lease right of the valuation object as matrix A, where the first line corresponds to the comparison elements for the valuation object, and the following lines – to the analogues selected for comparison:

$$\begin{bmatrix} 6.0 & 19 & 1 & 1 & 10 \\ 4.5 & 17 & 0 & 0 & 7 \\ 11.0 & 22 & 1 & 1 & 7 \\ 19.54 & 39 & 0 & 1 & 10 \\ 6.0 & 35 & 1 & 0 & 7 \\ 17.2 & 32 & 0 & 1 & 7 \end{bmatrix} := A$$

We subtract the corresponding elements of all subsequent lines from the value of the first line of the matrix in order to reflect the differences between each comparison object and the evaluation object. Consequently, we get a comparison matrix:

$$\begin{bmatrix} 1.5 & 2 & 1 & 1 & 3 \\ -5 & -3 & 0 & 0 & 3 \\ -13.54 & -20 & 1 & 0 & 0 \\ 0 & -16 & 0 & 1 & 3 \\ -11.2 & -13 & 1 & 0 & 3 \end{bmatrix}$$

Next, we do the calculation matrix:

$$\begin{bmatrix} -1.5 & -2 & -1 & -1 & -3 \\ 5 & 3 & 0 & 0 & -3 \\ 13.54 & 20 & -1 & 0 & 0 \\ 0 & 16 & 0 & -1 & -3 \\ 11.2 & 13 & -1 & 0 & -3 \end{bmatrix}$$

Then we construct a coefficient matrix for the variables  $\Delta A$ . According to it, in matrix form  $\Delta A \times V = P$ , where  $V$  is a vector of variables,  $P$  is a vector of free terms.

$$\begin{bmatrix} -1.5 & -2 & -1 & -1 & -3 \\ 5 & 3 & 0 & 0 & -3 \\ 13.54 & 20 & -1 & 0 & 0 \\ 0 & 16 & 0 & -1 & -3 \\ 11.2 & 13 & -1 & 0 & -3 \end{bmatrix} := \Delta A, \begin{bmatrix} 2,078 \\ 6,948 \\ 8,377 \\ 2,244 \\ 3,780 \end{bmatrix} := \Delta P$$

We calculate the matrix inverted to the matrix  $\Delta A$  using the methods of matrix algebra with the help of MS Excel functions, which greatly simplifies the procedure of their calculation:

$$\begin{bmatrix} 0.0778 & 0.2957 & 0.2179 & -0.0778 & -0.2957 \\ -0.0571 & -0.1170 & -0.0599 & 0.0571 & 0.1170 \\ -0.0887 & 1.6629 & 0.7516 & 0.0887 & -1.6629 \\ -1.1315 & -1.9997 & -1.8682 & 0.1315 & 2.9997 \\ 0.0726 & 0.0424 & 0.3032 & -0.0726 & -0.3758 \end{bmatrix} := \Delta A^{-1}$$

We can find the solution  $V = \Delta A^{-1} \times P$ , where  $\Delta A^{-1}$  – is a matrix inverted to the matrix  $\Delta A$ .

$$\begin{bmatrix} 2,749 \\ -863 \\ 1,1578 \\ -20,260 \\ 1,402 \end{bmatrix} := V$$

Thus, having solved the inverse matrix system, we calculated the value of the lease right for the evaluation object in the villag of Nadychi of Zhovkva district of Lviv region (Ukraine), amounting to 2,749 UAH per 1 hectare per year in 2,019 (99 euros), or 10.7 % of the average normative monetary evaluation of arable lands in Zhovkva district as of September 01, 2019 (25,637 UAH or 923 euros).

## CONCLUSIONS

Based on the obtained results, it is advisable to calculate the rent as to our proposed algorithm of calculation. So, the provided method allows you to quickly obtain a result due to the analysis and processing of information on the starting amount of the annual fee for the land plot use for sale at land auctions, and to form a justified conclusion about the market value of the lease right. The reason for this is that the current practice of determining the rent in the amount of 3-12 %

of the regulatory monetary valuation in Ukraine does not reflect its fair value and is lower in terms of market relations.

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