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A combined muilticriteria procedure for agriculture real estate valuation

Abstract. Let us consider a problem of valuation of agricultural real estate. It is important to properly indentify their market value, which is determined by many factors. A detailed set of data on the properties that were the subject of the transaction is needed to accomplish this task. It is quite confusing in the case of agricultural land because the number of transactions in the local market is often not sufficient. The purpose of this paper is to present some method for multicriteria valuation of agriculture real estate. This technique is specifically created for situation in which limited information are available. It is a combination in valuation field of the Analytic Hierarchy Process (AHP) and Goal Programming (GP).

Key words: agricultural real estate, value of the agricultural real estate, Analytic Hierarchy Process (AHP), Goal Programming (GP), multicriteria agricultural valuation (MAVAM)

Introduction

Let us consider a problem of valuation of agricultural real estate. Suppose further definitions of valuation and the market value of the real estate taken in Poland are based on recommendations of The International Valuation Standards, European Valuation Standards and EU directives [Trojanek 2010]. The valuation is defined as the process of estimating value. The market value is defined as the price most likely to be concluded by buyers and sellers of a property that is available for purchase [Aznar et al. 2011]. Valuation of property (including agricultural property) is made within the local market and on the basis of information and transactions on the market. Therefore characteristics also have a local nature. Unfortunately, there are not always sufficient number of transactions that can be used for this purpose. This problem does not occur, of course, exclusively on the Polish agricultural real estate market. Appraisers in Spain are dealing with the same. It means, that on the agricultural real estate market in Spain there is also not always sufficient number of transactions that can be used for example for the valuation of property or for an analysis of prices on this market.

The purpose of this paper is to present method of valuation of agricultural land based on a combination of two multicriteria decision-making methods (i.e. the Analytic Hierarchy Process – AHP and Goal Programming – GP). This solution was created by J. Aznar, F. Guijarro, J.M. Moreno-Jimenez during the research projects of the Spanish Ministry of Education and Science. Proposed by them mixed AHP and GP procedure for multicriteria agriculture valuation has been designed especially for valuation in situation in which information are limited. The main objective of this technique is to extract the knowledge underlying the valuation process from specific characteristics. It could be used with intangible and scarce information. Authors illustrate proposed methodology by its

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applications to a valuation of a peach plantation in the La Riberta district in Valencia in Spain. They have only five comparable plantations which have been involved in recent transactions. It means, that it was not possible to use the comparative methods as they require quantitative information that was not available in this situation. Proposed methodology allowed them to work with tangible and intangible factors to determine the value of the subject peach plantation.

In the paper, the Spanish experience will be used for the valuation of an agricultural real estate located on Masovian voivodeship.

The Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process is the heuristic method which was developed by T. L. Saaty. It combines elements of decision theory and mathematics in its structure. This method is used to determine the weights of criteria and characteristics and to make optimal choices in multicriteria decision problems. It reduces complex decision problems to a series of pairwise comparisons. Those comparisons are made by experts to determine a numerical measure of the validity of the analyzed variants. It is important that these criteria and features may be in the form of both metric and non-metric (ordinal). AHP algorithm can be divided into six stages:

1. definition of the problem,
2. construction the hierarchical model,
3. pairwise comparison of the validity of decision elements at each level of the hierarchy,
4. construction of vector of priorities for analyzed decision elements,
5. verification of the consistency of comparisons at each level of the hierarchy,
6. analysis of the results.

The first stage includes a general definition of the problem, i.e. a determination of a main goal and determination of a main criteria and a partial criteria. It also lays out what variants of these criteria will be analyzed. The main goal in the analysis of real estate is to prioritize aspects of the property, which affect its market value. The main criteria are properties that were traded on the local market with their prices. The sub-criteria are characteristics of properties and their values [Kozioł – Kaczorek et al. 2011, Kozioł – Kaczorek 2012].

The second stage includes construction of a multicriteria hierarchical tree structure. Main criterion is always at the top of the hierarchy. It consists of at least two but not more than seven sub-criteria. This principle is based on the fact that a man can compare with no mistakes, no more than 7 ± 2 objects [Kozioł – Kaczorek et al. 2011, Kozioł – Kaczorek 2012, Wysocki 2010].

In the third stage, following Saaty's fundamental scale (Table 1) the expert incorporates their judgments through pairwise comparison of decision elements. A positive, reciprocal pairwise matrix is provided for each node of the hierarchy.

The fourth stage includes construction of a vector of priorities for analyzed decision elements.

The two last stages include the verification of the consistency of comparisons at each level of the hierarchy and the result analysis [Aznar et al. 2011, Kozioł – Kaczorek et al. 2011, Kozioł – Kaczorek 2012].

Table 1. Saaty's fundamental scale

Numerical scale	Verbal scale
1	Same importance
3	One item moderately more import ant than another
5	One item significantly more import ant than another
7	One item moderately much more import ant than another
9	One item moderately very much more import ant than another
2, 4, 6, 8	Intermediate situations

Source: own study based on literature [Kozioł – Kaczorek et al. 2011, Kozioł – Kaczorek 2012].

AHP enable to incorporate the tangible aspect with the intangible by means of using paired comparisons in an agricultural valuation procedure [Aznar et al. 2011].

Goal programming (GP)

The Goal Programming (GP) is an extension of linear programming. It is mathematical nonlinear programming which can be easy linearized. It focuses on the idea of achieving a number of goals at the same time. Decision-maker formulates its objectives by specifying the desired values of the analyzed criteria. The main task of goal programming is to find a best solution. The ideal solution is a solution in which all the conditions are satisfied. A lot of variants of GP exist in literature. In this paper two of them are applied: Weighted Goal Programming and MinMax.

The form of the basic model for WGP is:

$$\begin{aligned} &\underset{x}{Min} \quad z_{[i1]} = \sum_{j=1}^{r} \lambda_j \left(d_j^- + d_j^+ \right) \\ &z_j(x) + d_j^- - d_j^+ = \hat{z}_{j,} \quad j = 1,\ldots,r \\ &g_i(x) \le 0, \quad i = 1,\ldots,m \\ &x \ge 0, \quad d_j^- \ge 0, \quad d_j^+ \ge 0, \end{aligned} \tag{1}$$

where d_j^- and d_j^+ denotes, respectively, the negative and positive deviations with respect to the j-th goal ($\hat{z}_j$). Let λ_j be a normalisation factor. The model includes m strong constrains that determine feasible region i.e. $g_i(x), i = 1, \ldots, m$ and r weak constrains for the goals considered ($\hat{z}_j, j = 1, \ldots, r$). The valuation of real estate adopted $\hat{z} = (\hat{z}_1, \ldots, \hat{z}_r)$ as the goal vector with the price observed for each of agricultural estate comparable to the subject one. The form of the valuation function is:

$$z(x^j) = a_0 + \sum_{l=1}^{n} a_l x_l^j, \quad j = 1,\ldots,r, \tag{2}$$

where x_l^j denotes the relative value in the l-th criterion of the j-th agricultural real estate, and a_l denotes estimated parameters of the model. The contribution of each criterion is in additive form. Note that, since the values are already normalised in the distribution mode, there is no need for normalisation factor, so $\lambda_j = 1$ is taken [Aznar et al. 2011].

The basic model for MinMax uses L_∞ - metric to obtain the best solution. The form of this model (symbols are the same as in WGP) is:

$$\begin{aligned} &\underset{x}{Min} \quad z_{[\infty 1]} = d_{\max} = \max_j \left(d_j^- + d_j^+ \right) \\ &z_j(x) + d_j^- - d_j^+ = \hat{z}_{j,} \quad j = 1,\ldots,r \\ &d_j^- + d_j^+ \le d_{\max}, \quad j = 1,\ldots,r \\ &g_i(x) \le 0, \quad i = 1,\ldots,m \\ &x \ge 0, \quad d_j^- \ge 0, \quad d_j^+ \ge 0. \end{aligned} \tag{3}$$

GP enable to include both the scarce information available (objective) and the individual appraiser's attitude with regards to the valuation process (subjective) [Aznar et al. 2011].

Multicriteria agricultural valuation method (MAVAM)

The multicriteria agricultural valuation method (MAVAM) is a combination if the AHP's hierarchical modelling and Goal Programming (GP). It is their combination in the valuation field, particularly, in the estimation of the linear regression model used to obtain the monetary values of agricultural real estate. MAVAM algorithm can be divided into three stages [Aznar et al. 2011].

The first stage involves the use of AHP to quantify the subjective information about the elements being compared. The appraiser defines the set of factors that determine the value of agricultural real estate in the local market. The main goal is to prioritize this factors. Using pairwise comparison matrices and Saaty's fundamental scale [Aznar et al. 2011, Kozioł – Kaczorek at al. 2011, Kozioł – Kaczorek 2012], the expert measure the importance of the explicative variables in the set of comparative assets.

The second stage involves the use of a relative regression model (2) to obtain the market value of agricultural real estate. This relativity of the models derived from relative values assigned by AHP for the explicative variables. The GP is used to estimate the regression parameters in two different cases. First one is a L_1 norm, which is the Manhattan norm. This norm incorporates the scarce information available into the model. The second one is a L_∞ norm, which is the Tchebychef norm. This norm captures the subjective attitude with respect to the valuation process. That is, the greater the distance between the compared elements contribute to the greater subjectivity of the assessment. Furthermore, they "allows consideration of the proximity of the subject asset to one of the comparable sets of assets that does not follow common or majority behaviour". These norms are used to determine the objective function to be optimised [Aznar et al. 2011].

The last stage involves the final valuation of the agricultural real estate. The market value is as a result of a convex combination of two values obtained in stages two and three for the L_1 and L_∞ norms [Aznar et al. 2011]. The formula of the market value is:

$$MAVAM(X) = (1-\alpha)V_1(X) + \alpha V_\infty(X), \quad \alpha \in [0,1] \tag{4}$$

where $V_1(X)$ and $V_\infty(X)$ are the L_1 and L_∞ values. The choice of level of α depends on the expert. If α = 1, it means that the valuated property is very similar to the properties of a fixed set of comparable properties. On the other hand, if α = 0, this means that the valuated properties is significant different from the properties of a fixed set of comparable properties [Aznar et al. 2011].

Valuation of agricultural real estate

The above described methodology was applied to the valuation of agricultural real estate from Masovian voivodeship. This property is located in the rural part of the municipality of Ostrow Mazowiecka and it is undeveloped farmland. The date used in previous analysis were obtained from local real estate market on the municipality of Ostrow Mazowiecka and they related of property that were the object of market transaction. The set of data contained information about transaction price, area, localization, the position as regards the habitat parcels, the shape of the plot, the bonitation and production capacity, the variety of types of soil area and the quality of the access road. Analysis carried out is described below.

The first stage of valuation process was application of AHP to determine the weights of characteristics of property. A detailed description of the analysis presented in the publication Kozioł – Kaczorek et al. 2011. The main aim of this paper was hierarchisation of characteristics of the property.The main criteria were properties that were traded on the local market with their prices. The set of real estate on this market, which were comparable with valuated one (X), included four objects: a real estate with a minimum price (A), a real estate with a price somewhat below average (B), a real estate with a price somewhat above average (C), a real estate with a maximum price (D). All of them were undeveloped agricultural land with the similar area. The sub – criteria were characteristics of property and their values. The set of features relevant to the value of the property there were included: the position as regards the habitat parcels, the shape of the plot, the bonitation and production capacity, the variety of types of soil area, the quality of the access road. It was established by analysis of the local market and the appraiser knowledge. Weights obtained as a result of the analysis are presented in the Table 2. (for the details of the analysis see Kozioł – Kaczorek et al. 2011.

Table 2. Weights of characteristics of property

Characterisctics	A	B	C	D	X
the position as regards the habitat parcels	0,305	0,290	0,295	0,296	0,297
the shape of the plot	0,160	0,155	0,157	0,153	0,156
the bonitation and production capacity	0,276	0,280	0,278	0,278	0,278

the variety of types of soil area	0,116	0,124	0,122	0,124	0,121
the quality of the access road	0,143	0,151	0,148	0,148	0,147

Source: Kozioł – Kaczorek et al. 2011

The next stage contains WGP and MinMax applications for estimating the regression (2) parameter. In the current analysis, the form of the regression model is:

$$z(x^j) = a_0 + a_1 x_1^j + a_2 x_2^j + a_3 x_3^j + a_4 x_4^j + a_5 x_5^j \quad j = 1,2,3,4 \tag{5}$$

where x^j denotes weight of l-th characteristics of j-th agricultural real estate and $z(x^j)$ denotes their prices. Obtained parameters are used to calculate the values of assessed property by:

- WGP: V[1](X) = 11 526,18 PLN Ha^{-1},
- MinMax: $V_{[\infty]}$(X) = 10 602,48 PLN Ha^{-1}.

This means that, the value of the valuated agricultural real estate (X) is within the range (10 502,48; 11 526,18) PLN Ha^{-1} defined by the expression (4). The obtained value is similar to the average value of 1 Ha on the considered local agricultural real estate market.

Conclusions

Some result of valuation of agricultural real estate, located on Masovian voivodeship, is presented in the paper. Because of the problem with insufficient number of transactions on this local agricultural real estate market it was not possible to use usual valuation method. Therefore, described above method (MAVAM) was used in the process of valuation. It is the appropriate solution for situations with a lack of information and a limited number of transactions. This technique is a mixed method that combines two multicriteria methodologies i.e. Analytic Hierarchy Process (AHP) and Goal Programming (GP). The AHP enables to quantify qualitative variables and include the weight of the importance of preferences. The GP captures the information from the limited information and the attitude of the appraiser in the valuation process. The comparable data have been quantified in the mixed valuation method itself and in such a way that the value obtained is a function of all the data used and it is also a function of their importance or weighting. The calculated value range enables the expert to define the final value. It is depending on whether the comparable data of valuated properties are the average of the reference values or are closer to the distant asset. Aznar et al. [2011] proposed it for Spanish agricultural real estate market, but this procedure suits also for Polish real estate market. The obtained value of the valuated agricultural real estate (X) is within the range (10 502,48; 11 526,18) PLN Ha^{-1}. The market value is close to the average value from considered local market.

References

Aznar J., Guijaro F., Moreno-Jiménes J.M. [2011]: Mixed valuation methods: a combined AHP-GP procedure for individual and group multicriteria agricultural valuation. Annals of Operations Research, 190.01, 221–238;

Kozioł–Kaczorek D., Parlińska M. [2011]: Zmienne decydujące o wartości rynkowej nieruchomości rolnej z zastosowaniem AHP. Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu, 13.2, 236-239;

Kozioł–Kaczorek D. [2012]: Hierarchizacja cech nieruchomości z zastosowaniem Analitycznego Procesu Hierarchicznego. Journal Of The Polish Real Estate Scientific Society, 20.1, 165–174;

Trojanek M. [2010]: Methodic of estate valuation In Poland – actual status. Economics and sociology, 3.1, 66–75;

Wysocki F. [2010]: Metody taksonomiczne w rozpoznawaniu typów ekonomicznych rolnictwa i obszarów wiejskich. Uniwersytet Przyrodniczy w Poznaniu, Poznań.