OPERATIONS RESEARCH AND DECISIONS

No. 4 2015

DOI: 10.5277/ord150404

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THE IMPACT OF WEIGHTS ON THE QUALITY OF AGRICULTURAL PRODUCERS' MULTICRITERIA DECISION MODELS

Decisions regarding agricultural production involve multiple goals. A multicriteria approach allows decision makers to consider more aspects of the decision scenario, although it also leads to other problems, such as difficulties with the selection of goals or criteria, as well as assigning them appropriate weights. It is argued that not only do goals vary depending on the decision-makers' socioeconomic features, but their relative importance changes as well. A simulation study has been conducted based on the Farm Accountancy Data Network (FADN) database. We use the distance-to-the-negative-solution maximization model. Seven sets of criteria and different sets of weights are considered. The main purpose of the study is to determine the impact of weights on the quality of the model. Quality is assessed by comparing the optimal and observed values of the decision variables. The results lead to the conclusion that the differences between the quality of various models are small.

Keywords: *Farm Accountancy Data Network (FADN), agricultural producers, weighting methods, multiple criteria*

1. Introduction

It is underlined in the literature that a single-criterion approach is not sufficient for the empirical analysis of producers' decisions. There are numerous studies that focus on the multiplicity of agricultural producers' goals, motives, criteria and their relative importance for different groups of farmers. Apart from [8] examples include [1, 7, 9, 10, 14, 19, 21, 24]. An extensive review of agricultural producers' goals can be found in [11]. The analytic hierarchy process (AHP) method [17, 18] is often used to elicit

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rankings of goals, criteria or preferences [5, 23], although other approaches are employed as well [4, 11].

Among Polish authors, this topic was discussed by Ziętara [25], Majewski and Ziętara [15] and Bańkowska [2]. Both economic and non-economic goals/motives were considered. These researchers also took into account the relative importance of these goals and differences between various groups of agricultural producers. These studies were based on the data collected from questionnaires carried out among farmers.

On the other hand, Sielska [20] used a quantitative approach and simulation in a study which focused on decisions relating to the allocation of the factors of production. The two main purposes of that research were to identify the decision criteria used by Polish agricultural producers and to explore the relationship between them and the socioeconomic characteristics of decision-makers and farms. 21 forms of optimization models were proposed. Various optimization problems were solved for each agricultural producer individually and the optimal values of the decision variables were compared with the observed ones, in order to assess how well a given model fits the data. The approaches which perform best in describing decisions were chosen based on an analysis of the results of simulations obtained for several thousand Polish agricultural producers and an assessment of the optimal and observed values of the decision variables. This paper is a direct continuation of that study.

Although a multicriteria approach allows one to represent a decision scenario in a more realistic way and therefore improve the goodness of fit, it also involves some additional difficulties. One of these problems is to choose appropriate goals and criteria, and further, to elicit their respective weights, in order to describe their relative importance. The importance of criteria can significantly affect the final results, especially if a lexicographic approach is employed. Although this can be considered the most evident case, it is by far not the only one. Even when only one objective function is to be optimized, while the values of other objective functions need only satisfy conditions given by the decision-maker, it is necessary to establish one major goal, which de facto implies some ordering of the goals, even if weights are not directly assigned. However, the literature reports that the rankings of criteria or goal depend on decision-makers' socioeconomic characteristics.

Numerous factors are considered to influence agricultural producers' decisions. The most obvious of these are the characteristics of the decision-maker herself. These factors are of particular importance in the case of group decision making (for example, on family farms), or when decisions are delegated. It is reported that even if decisions are made by a single decision-maker, they are made under the influence of other people's (often called significant others) opinions [22]. Ziętara [25] took into account the goals of both farmers and their spouses, while Bańkowska [2] discussed the variation of goals and motives in relation to a decision maker's gender. Other studies provide further factors which may influence an agricultural producers' decision making, such as a decision maker's level of education [7, 15, 19, 21, 25], her experience [10, 14] and age [10, 14, 15, 19, 21, 25]. The literature also reports differences between the hierarchies of goals established by the experts and those established by the farmers themselves [6].

All these observations lead to the conclusion that eliciting an appropriate hierarchy of goals or criteria is a crucial step in modelling agricultural producers' decisions.

This study aims to analyze the impact of weights on the quality of multicriteria models. We used the approach from [20]. The quality of a model is assessed on the basis of comparing the values of the decision variables in the optimal solution to those used in reality.

The paper is organized as follows. In Section 2, optimization models are discussed and the source of the data is presented. The 3rd section contains a description of the three methods of weight elicitation employed in the study. In the 4th part we present and discuss the results of a simulation study, which can be considered as the next step of the analysis provided in [20]. Figures and computations have beem performed in the GNU R [16] and calculation spreadsheet.

2. Optimization problem

2.1. Distance-to-the-negative-solution maximization models

The optimization models used in this study are taken from [20], where it was assumed that the decision criteria are of equal importance. We chose distance-to-the-negative-solution maximization models, because in [20], based on Polish agricultural producers, they performed best. For the year 2009, this approach proved best in representing the real allocation of the factors of production for 36.86% of farms. In comparison, other multicriteria models based on the minimization of the distance to the positive solution, minimization of the relative distance to both the positive and negative solutions, and the single-criterion model of income maximization, which performed best for 23.48%, 23.96% and 15.7% of farms, respectively.

All the models used in the study are based on the nested constant elasticity of substitution (CES) production function [12, 13]:

$$
\begin{aligned}
&F\left(L_{O_i}, L_{P_i}, C_{O_i}, C_{R_i}, A_{O_i}, A_{R_i}\right) \\
&= \gamma\left(\delta\left(\delta_1\left(L_{O_i}+L_{P_i}\right)^{-\rho_1}+\left(1-\delta_1\right)\left(C_{O_i}+C_{R_i}\right)^{-\rho_1}\right)^{\rho/\rho_1}+(1-\delta)\left(A_{O_i}+A_{R_i}\right)^{-\rho}\right)^{\upsilon/\rho}
\end{aligned}
\tag{1}
$$

where: L_{O_i} – own labor, L_{P_i} – paid labor, C_{O_i} – own capital, C_{R_i} – borrowed capital (liabilities), A_{O_i} – area of agricultural land possessed, A_{R_i} – area of agricultural land rented,

$\gamma > 0$ – productivity parameter, δ, δ_1 – factor share parameters, $\upsilon > 0$ – elasticity of scale parameter, ρ, $\rho_1 \geq -1$ – substitution parameters.

On the assumption that agricultural producers who belong to the same group (according to the FADN typology) use the same technology, they can be characterized by the same production function. The results of estimation obtained using the Broyden–Fletcher–Goldfarb–Shann (BFGS) algorithm [12] are shown in Tables 1, 2.

Table 1. Estimation of the CES function

Parameter	Coefficient	Standard error	*p*-Value
γ	437.741	74.026	0.000
δ_1	0.984	0.007	$<2\times10^{-16}$
δ	0.084	0.039	0.031
ρ_1	–0.702	0.075	$<2\times10^{-16}$
ρ	–0.456	0.108	0.000
v	1.151	0.008	$<2\times10^{-16}$
Multiple *R*-squared	0.887		

Source: [20].

Table 2. Estimation of the elasticity of substitution

Elasticity of substitution	Coefficient	Standard error	*p*-Value
Hicks–McFadden (σ_{HM})	3.350	0.837	6.25×10^{-5}
Allen–Uzawa (σ_{AU})	1.839	0.367	5.23×10^{-7}

Source: [20].

For each agricultural producer, the following cost function is constructed:

$$C_i = c_i^L L_{P_i} + c_i^C C_{R_i} + c_i^A A_{R_i} + c_i^f \left(A_{O_i} + A_{R_i} \right) \tag{2}$$

where: C_i – i-th producer’s total cost, c_i^L – unit labor cost, c_i^C – unit capital cost, c_i^A – unit agricultural cost, c_i^f – unit farming (cultivation) cost, defined as the sum of the costs of fertilizers, seeds, plants and crop protection per agricultural unit of area.

Optimal solutions are represented by points in four-dimensional space:

$$x_i = \left[\varPi_i \quad A_i \quad L_i \quad C_i \right] \tag{3}$$

where $\varPi_i$ represents income, calculated as follows:

$$\varPi_i = F\left(L_{O_i}, L_{P_i}, C_{O_i}, C_{R_i}, A_{O_i}, A_{R_i} \right) - C_i \tag{4}$$

Optimal solutions are achieved by maximizing the distance to the solution which represents the most unfavorable situation from the decision-maker's standpoint. This situation is characterized by the negative point x_i^N, defined as follows:

$$x_i^N = \left[-\left(C_i^f + C_i^{PR}\right) \quad 0 \quad L_{P_i}^{\max} \quad C_{R_i}^{\max} \right] \tag{5}$$

where: C_i^{PR} – costs of employing and renting production factors, C_i^f – total cost of farming (cultivation cost), defined as the sum of the costs of fertilizers, seeds, plants and crop protection.

We assume that the elements of x_i^N are dependent on the environment in which each agricultural producer exists. Therefore, $L_{P_i}^{\max}$ denotes the maximum expenditure on labor in the voivodeship (province) in which the *i*-th farm is located, whereas $C_{R_i}^{\max}$ represents the maximum expenditure on rented capital in the respective voivodeship.

The distance-to-the-negative-solution x_i^N maximization problem has the following form:

$$d_i^{x^N}\left(L_{O_i}, L_{P_i}, C_{O_i}, C_{R_i}, A_{O_i}, A_{R_i}\right) \to \max \tag{6}$$

with

$$L_{O_i} \le L_{O_i}^E, \qquad C_{O_i} \le C_{O_i}^E, \qquad A_{O_i} \le A_{O_i}^E$$

$$C_i \le C_i^f + C_i^{PR}, \qquad L_{O_i}, L_{P_i}, C_{O_i}, C_{R_i}, A_{O_i}, A_{R_i} \ge 0$$

where: $L_{O_i}^E$ – real input of own labor, $C_{O_i}^E$ – real input of own capital, $A_{O_i}^E$ – real input of own agricultural land, $d_i^{x^N}$ – weighted Euclidean distance from object i to x_i^N based on scaled data.

2.2. Sets of criteria

In [20], 7 sets of decision criteria connected to decisions regarding allocation and use of the factors of production were applied. It should be noted that some of these criteria can also be in accordance with goals of a non-economic nature which cannot be expressed directly within the proposed approach. For example, the minimization of a farmer's own labor can be interpreted as the maximization of his leisure time.

Criteria were chosen on the basis of their appearance in the literature, availability of data and possibility of quantification. On this basis, the following models were constructed:

- Two-criteria model:

Maximization of income Π and agricultural area A,

Maximization of income Π and minimization of expenditure on labor L_P,

Maximization of income Π and minimization of expenditure on rented capital (liabilities) C_R.

- Three-criteria model:

Maximization of both income Π and agricultural area A, minimization of expenditure on labor L_P,

Maximization of income Π, minimization of both expenditure on labor L_P and expenditure on rented capital (liabilities) C_R,

Maximization of both income Π and agricultural area A, minimization of expenditure on rented capital (liabilities) C_R.

- Four-criteria model:

Maximization of both income Π and agricultural area A and minimization of both expenditure on labor L_P and expenditure on rented capital (liabilities) C_R.

2.3. Data

The data are obtained from the Polish Farm Accountancy Data Network (FADN) database. In order to preserve continuity with the study conducted in [20], we used the same data on a group of agricultural producers specializing in field crops in 2009. Due to the assumptions concerning the production function, farms for which the sums of both owned and external factors of production were non-positive were excluded from the sample. Based on this, data on 3241 farms remained.

3. Weight elicitation methods

Weights are usually employed to describe the relative importance of goals or criteria in optimization models. Due to the fact that an interactive approach was not possible, we used methods which allowed us to calculate weights simply based on their rank. The 1st method employed is the rank order centroid (ROC) method [3]. Using this approach, the value of the weight of the i-th ranked criterion is calculated as follows:

$$w_i = \frac{1}{n}\sum_{j=i}^{n}\frac{1}{j}, \qquad i = 1, 2, ..., n \tag{7}$$

The 2nd approach adopted is the rank sum (RS) method. In this case, the weights are calculated from:

$$w_i = \frac{n+1-i}{\sum_{j=i}^{n} j} = \frac{2(n+1-i)}{n(n+1)}, \qquad i = 1, 2, ..., n \tag{8}$$

The last method used is the RR (rank reciprocal) approach. Using this approach, the value of the weight of the *i*-th ranked criterion is calculated from the formula:

$$w_i = \frac{\frac{1}{i}}{\sum_{j=i}^{n} \frac{1}{j}}, \qquad i = 1, 2, ..., n \tag{9}$$

In general, the weights obtained using these various methods are different, apart from weights calculated using the RS and the RR approaches in the two-criterion case.

The values of the weights obtained using the RS method descend linearly according to the rank of the criterion, whereas in the case of the RR and the ROC approaches, the decrease is nonlinear when there are at least 3 criteria. The most differentiated weights are those obtained using the ROC method, the least differentiated using RS.

Due to the large number of sets of weights in the study, we refer to each particular set by its number according to Tables 3–5. The numbers in these tables represent the ranks of the criteria, i.e. the lower the number, the larger the weight of the respective criterion is.

Table 3. Possible permutations of the ranks of the criteria for four-criteria models[a]

Set of weights	Π	L_P	C_R	A	Set of weights	Π	L_P	C_R	A
1	1	2	3	4	13	3	4	1	2
2	1	2	4	3	14	3	4	2	1
3	1	3	4	2	15	3	1	2	4
4	1	3	2	4	16	3	1	4	2
5	1	4	2	3	17	3	2	4	1
6	1	4	3	2	18	3	2	1	4
7	2	3	4	1	19	4	1	2	3
8	2	3	1	4	20	4	1	3	2
9	2	4	1	3	21	4	2	3	1
10	2	4	3	1	22	4	2	1	3
11	2	1	3	4	23	4	3	1	2
12	2	1	4	3	24	4	3	2	1

[a]Each permutation corresponds to a set of weights. Source: author's work.

Table 4. Possible permutations of the ranks of criteria for three-criteria models

Set of weights	Criteria								
	П, C_R, A			*П, L_R, A*			*П, L_R, C_R*		
	П	C_R	*A*	*П*	L_P	*A*	*П*	L_P	C_R
1	1	2	3	1	2	3	1	2	3
2	1	3	2	1	3	2	1	3	2
3	2	3	1	2	3	1	2	3	1
4	2	1	3	2	1	3	2	1	3
5	3	1	2	3	1	2	3	1	2
6	3	2	1	3	2	1	3	2	1

Source: author's work.

Table 5. Possible permutations of the ranks of criteria for two-criteria models

Set of weights	Criteria	
	П	$C_R/L_P/A$
1	1	2
2	2	1

Source: author's work.

4. Assessing the quality of a model

The goodness of fit of the model to the data (quality of a model) was assessed by comparing the values of the decision variables (inputs $L_{O_i}, L_{P_i}, C_{O_i}, C_{R_i}, A_{O_i}, A_{R_i}$) in the optimal solution and those used in reality (the empirical values of these inputs for each farm are further referred to as standard) [20]. In order to include all the decision variables in the comparison, we calculated the distance based on Clark's metric according to the following formula:

$$d_{i,k} = \sqrt{\frac{1}{m}\sum_{j=1}^{m}\left(\frac{x_{i,j} - x_{i,k}}{x_{i,j} + x_{i,k}}\right)^2} \qquad (10)$$

where *i*, *k* represents the objects compared.

The advantage of this metric lies in the fact that if the coordinates of the objects compared are non-negative, then $d_{i,k} \in [0,1]$. This condition is fulfilled in our study.

In order to assess the similarity of multi-modal distributions, we employed the similarity measure (*SM*), which is based on the distances between respective percentiles of

Clark's distance between the optimal solutions and the standard. *SM* is defined for two models $M1$ and $M2$ as follows [20]:

$$SM_{M1,M2} = \sqrt{\frac{1}{101}\sum_{i=1}^{101}\left(\frac{p_{M1,i} - p_{M2,i}}{p_{M1,i} + p_{M2,i}}\right)^2} \tag{11}$$

where $p_{M1,i}$ and $p_{M2,i}$ represent the $(i - 1)/100$-th percentile of Clark's distance from the optimal solution to the standard calculated for models $M1$ and $M2$, respectively.

Low values of the *SM* measure indicate that the distance distributions compared are similar and, hence, the results obtained by models $M1$ and $M2$ are similar. The higher the value of the *SM*, the greater the dissimilarity [20].

4.1. Goodness of fit for equal and unequal weights

As shown in Figures 1–3, introducing unequal weights allows us to obtain different distributions of Clark's distance from the optimal solution to the standard than in the case of equal weights. In the case of unequal weights, using any of the three weighting methods considered it is possible to obtain a relatively greater number of results which better represent the data (denser left tails) than in the case when no weighting is employed. However, the distributions remain clearly multimodal and there are no distinct differences regarding local maxima or minima. As a consequence, the values of the *SM* measure calculated for the distributions presented are low.

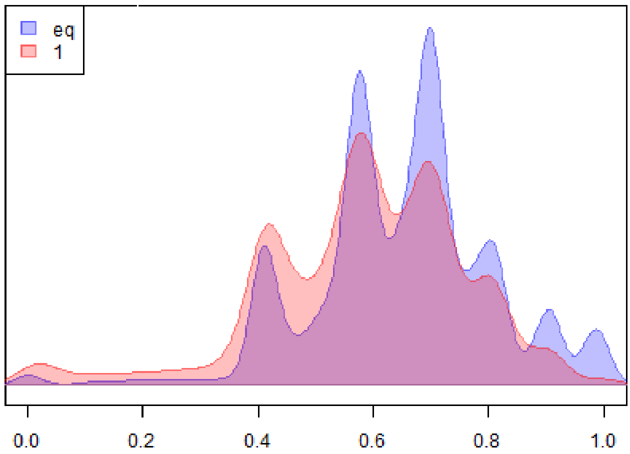

Fig. 1. The distance distributions for the cases of equal weights (eq) and the 1st set of weights calculated using the ROC method (4 criteria case) *SM* = 0.1388. Source: author's calculations based on the FADN data

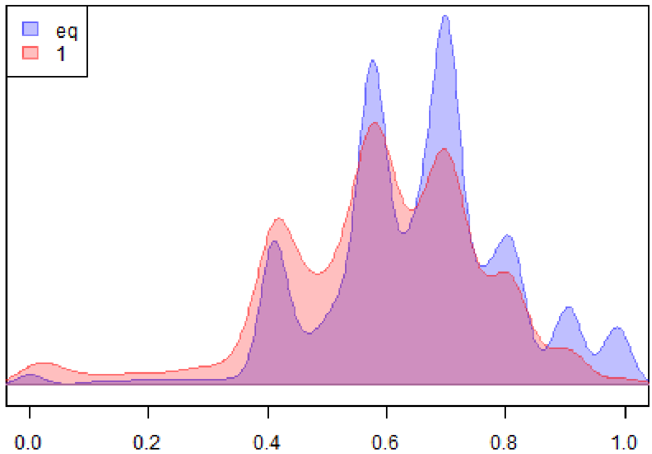

Fig. 2. Comparison of the distance distributions for the cases of equal weights (eq) and the 1st set of weights calculated using the RR method (4 criteria case) *SM* = 0.1385. Source: author's calculations based on the FADN data

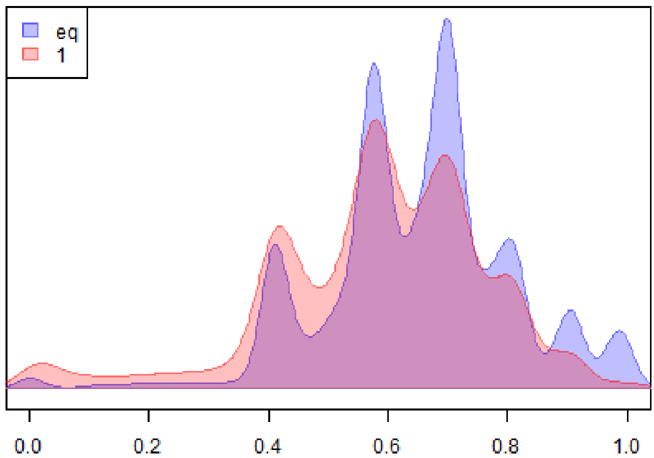

Fig. 3. The distance distributions for the cases of equal weights (eq) and the 1st set of weights calculated using the RS method (4 criteria case) *SM* = 0.1512. Source: author's calculations based on the FADN data

4.2. Similarities and differences according to the method of weight elicitation

In the next step, we analyze the similarities between the results obtained for each particular method of weighting and various set of criteria. For each method, *SM* values were calculated.

4.2.1. Two-criteria models

In the case of two-criteria models, the least similar results between different weightings were obtained for the 1st and 2nd sets of weights using the RR (RS) method, together with the Π, C_R set of criteria (*SM* = 0.0698). A comparison of the distributions of Clark's distance is shown in Fig. 4. Both density functions attain local maxima and minima at similar values. For the 2nd set of weights, relatively more cases of both better (dense left tail) and worse (Clark's distance greater than 0.7) fits can be noticed. The 1st set of weights gives relatively more cases of medium fit (Clark's distance near 0.5). It should be noted that the differences are quite small. In the case of the ROC method, the least similar results were obtained for the 1st and 2nd sets of weights with *SM* = 0.0641. The average dissimilarity of the results, measured by the median of *SM*, was higher for the ROC method than for RR (RS).

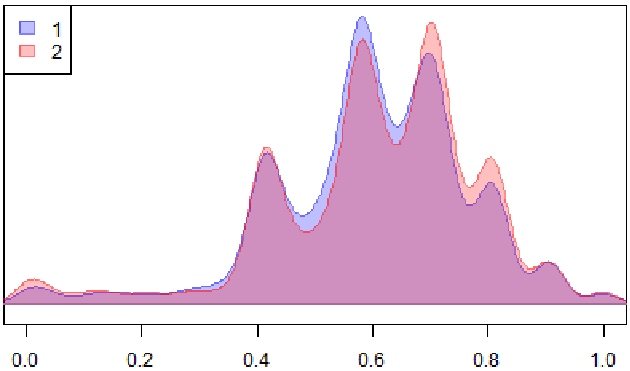

Fig. 4. The distance distributions for the 1st and 2nd set of weights calculated using the RR method.
Source: author's calculations based on the FADN data

4.2.2. Three-criteria models

In the case of three-criteria models, the least similar results were obtained for the ROC method with the 2nd and 6th sets of weights. The *SM* value calculated for these models was 0.1249. The shapes of the distributions of Clark's distance are similar to those previously presented (Fig. 5). Again, the differences are very small. For the 2nd set of weights, there are relatively more cases of medium fit (Clark's distance between the optimal solution and the standard near 0.5). For comparison, the 6th set of weights gives relatively more cases of both good (left tail) and poor model fits.

For the RR method, the least similar results were also obtained for the Π, A, C_R set of criteria. The *SM* value calculated for the 1st and 5th sets of weights was lower than in the case of the ROC method and equal to 0.0811. Likewise, for the RS method, the greatest dissimilarity also occurred for the Π, A, C_R set of criteria but in this case for the

3rd and 5th sets of weights (*SM* = 0.0819). Two out of these three pairs of weights sets are characterized by a clear difference between the importance of income.

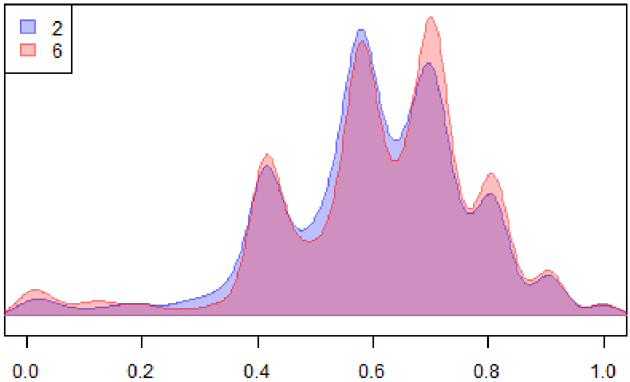

Fig. 5. The distance distributions for the 2nd and 6th set of weights calculated using the ROC method and criteria *П*, *A*, C_R.
Source: author's calculations based on the FADN data

Apart from our prior observation that the least similar results were obtained for the *П*, *A*, C_R set of criteria, it can be noticed that the values of the *SM* depend on the weighting method as well. After excluding the case of equal weights from the analysis, the least similar results were obtained for the ROC method (Fig. 6). The ratio between the maximum and minimum values of the *SM* was the highest for the *П*, *A*, C_R set of criteria as well (Fig. 7). For all three sets of criteria, the average dissimilarity between the results, measured by the median of the *SM*, was the greatest in the case of the ROC method.

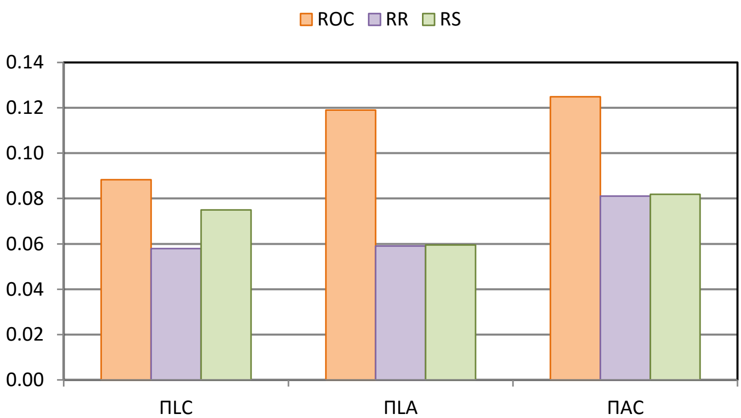

Fig. 6. Maximum values of the *SM* calculated for three-criteria models.
Source: author's own calculations on the basis of the FADN data

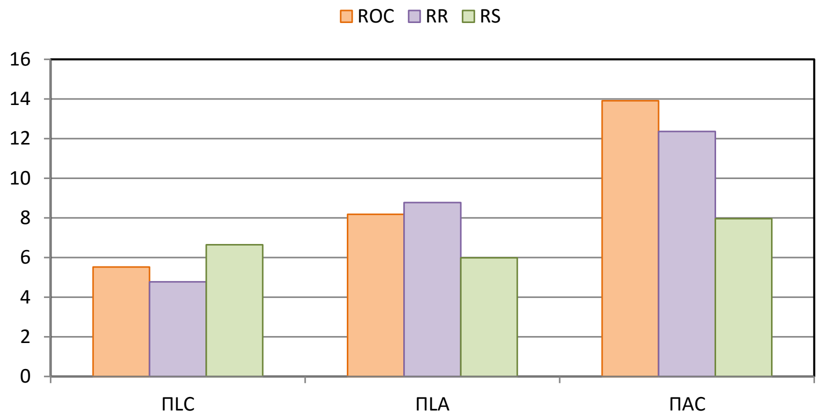

Fig. 7. Ratio between the maximum and minimum values
of the *SM* calculated for three-criteria models.
Source: author's calculations based on the FADN data

4.2.3. Four-criteria models

In the case of the ROC method and four criteria, the value of the *SM* calculated for the least similar distributions of Clark's distance (i.e. for the 6th and 23rd sets of weights) is low (0.1207). It can be observed that the 23rd set of weights gives relatively more cases of a good model fit (Fig. 8).

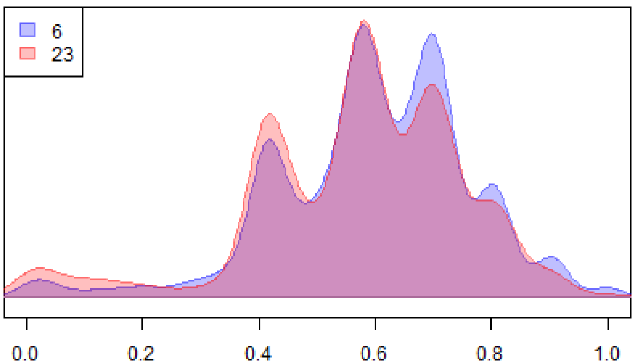

Fig. 8. The distance distributions for the 6th and 23rd
set of weights calculated using the ROC method.
Source: author's calculations based on the FADN data

In the case of the RS method, the maximum value of the *SM* was observed for the 5th and 14th sets of weights (0.0949). For the RR method, the least similar results were obtained for the 6th and ninth sets of weights. In this case, the value of the *SM* was even lower (0.0908). No clear difference with respect to the importance of the L_P criterion can be observed between these three pairs of sets of weights. The ratio between the maximum and minimum non-negative values of *SM* was the highest for the ROC method, as in the case of the three-criteria models.

Table 6. Medians and dispersions of the *SM* calculated for four-criteria models by the method of eliciting weights

Method	Median	Dispersion
ROC	0.0403	0.4944
RR	0.0309	0.4561
RS	0.0291	0.4251

Source: author's calculations based on the FADN data.

Both the average dissimilarity of the results (measured, as before, by the median of the *SM*) and their dispersion (measured by the ratio between the interquartile range and median) are greatest in the case when the weights elicited using the ROC method were used. The lowest values were observed for the RS method (see Table 6).

4.3. Similarities and differences according to the set of weights

In this section we present results on the assessment of similarity of the three methods of weight elicitation, given a fixed ranking, for each particular set of criteria.

4.3.1. Four-criteria models

The distributions of Clark's distance from the optimal solution to the standard were very similar. The minimum and maximum values of the *SM* are presented in Table 7. They are not clearly dispersed and the absolute difference between the *SM* values obtained for the most and the least similar distributions does not exceed 0.05, although the relative difference is large. The least similar results were obtained for the RS and ROC methods and the 15th set of weights (*SM* = 0.0596), the most similar – for the RR and ROC methods and the 1st set of weights (*SM* = 0.0030).

In addition, it should be noted that the majority of the least similar results were observed using the RS and ROC methods, while the least differentiated results were obtained using the RS and RR methods (Fig. 9).

Table 7. Minimum and maximum values of the *SM* calculated for four-criteria models

Set of weights	Maximum	Minimum	Set of weights	Maximum	Minimum
1	0.0295	0.0030	13	0.0064	0.0040
2	0.0132	0.0043	14	0.0413	0.0115
3	0.0254	0.0142	15	0.0596	0.0145
4	0.0419	0.0078	16	0.0328	0.0129
5	0.0408	0.0162	17	0.0300	0.0124
6	0.0458	0.0181	18	0.0379	0.0188
7	0.0129	0.0073	19	0.0393	0.0065
8	0.0357	0.0192	20	0.0300	0.0124
9	0.0369	0.0148	21	0.0362	0.0157
10	0.0398	0.0150	22	0.0482	0.0207
11	0.0290	0.0122	23	0.0506	0.0137
12	0.0372	0.0183	24	0.0464	0.0094

Source: author's calculations based on the FADN data.

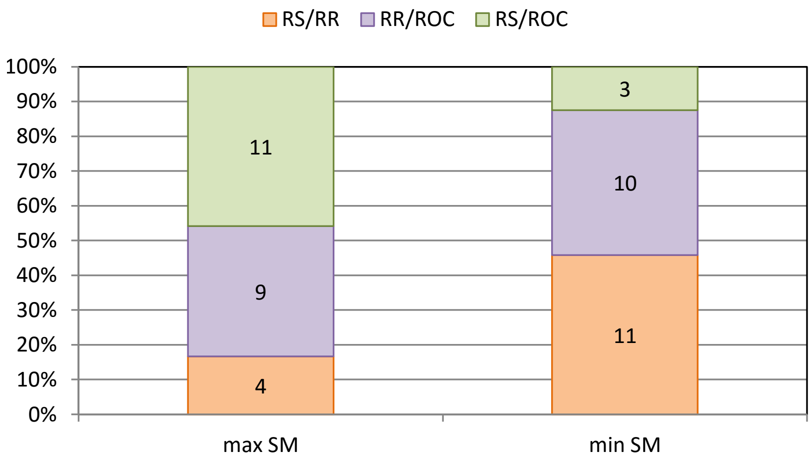

Fig. 9. Frequencies with which the methods of weight elicitation give the most and the least similar results for four-criteria models. Source: author's calculations based on the FADN data

4.3.2. Three-criteria models

We present the minimum and maximum values of the *SM* for each particular set of weights in Table 8. These values are more dispersed than in the case of four-criteria models. The most dissimilar results were obtained using the RS and ROC methods for the 5th set of weights and the Π, A, L_P set of criteria. The greatest similarity was observed for the RS and RR methods, the 2nd set of weights and the Π, A, C_R set of criteria. As before, we obtained the least similar results for the RS and ROC methods and the most similar for the RS and RR (Fig. 10).

Table 8. Minimum and maximum values
of the *SM* calculated for three-criteria models

Criteria	Set of weights	Maximum	Minimum
Π, L_P, C_R	1	0.0180	0.0097
	2	0.0425	0.0122
	3	0.0443	0.0159
	4	0.0192	0.0177
	5	0.0292	0.0134
	6	0.0368	0.0065
Π, A, L_P	1	0.0379	0.0139
	2	0.0238	0.0053
	3	0.0297	0.0049
	4	0.0232	0.0082
	5	0.1039	0.0145
	6	0.0083	0.0057
Π, A, C_R	1	0.0234	0.0143
	2	0.0999	0.0045
	3	0.0101	0.0062
	4	0.0251	0.0119
	5	0.0148	0.0108
	6	0.0125	0.0093

Source: author's calculations based on the FADN data.

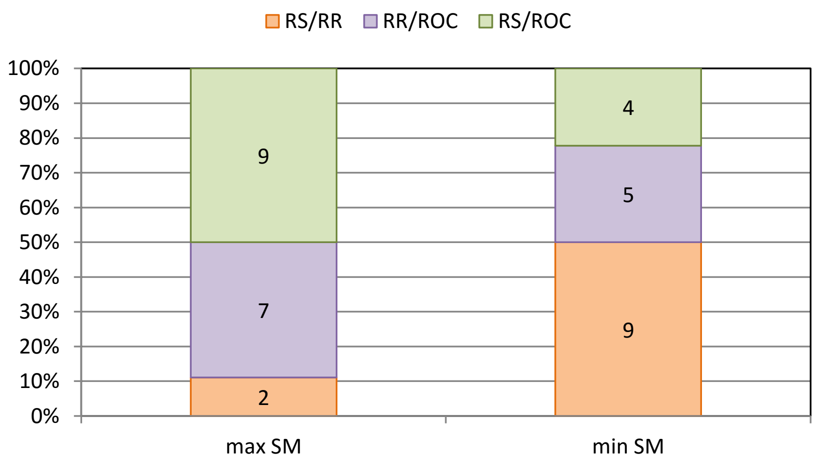

Fig. 10. Frequencies with which the methods of weight elicitation give the most and the least similar results for three-criteria models.
Source: author's calculations based on the FADN data

4.3.3. Two-criteria models

Finally, we present the results obtained for two-criteria models. Due to the fact that the weights elicited by the RS and RR methods are equal, we analyze the similarity of results only with respect to the set of criteria. The most and the least similar results were obtained for the Π, C_R and Π, L_P set of criteria, respectively (see Table 9).

Table 9. *SM* values calculated for the RR (RS) and ROC methods

Criteria	Set of weights	*SM*
Π, C_R	1	0.0042
	2	0.0142
Π, L_P	1	0.0394
	2	0.0127
Π, A	1	0.0027
	2	0.0068

Source: author's calculations based on the FADN data.

5. Conclusions

We have analyzed the influence of criterion weights on the goodness of fit of multicriteria models. These results show that even though the outcomes obtained using different sets of weights can be very different for individual agricultural producers, when numerous farms are taken into account, the differences in the general quality of these models are small. The distributions of Clark's distance between the values of the decision variables in the optimal solutions and the ones observed are similar. The greatest difference can be observed between the case of equal weights and the situation in which methods of weight elicitation are introduced. These differences are smaller when non-equal weights are used. In the case when it is assumed that the agricultural producer aims to maximize both income and agricultural area, while minimizing expenditure on rented capital (liabilities), the relative importance of the criteria plays the greatest role.

None of the methods of weight elicitation employed in the study can be considered as leading to the best performing model. However, it should be noted that both for three- as well as for four-criteria models, the least similarities were observed between the results obtained using the RS and ROC methods. The results obtained using the RS and RR methods were most similar. These differences are slight. Thus, the methods of weight elicitation analyzed in this paper may be used interchangeably for modeling decisions about production when criteria have unequal weights.

Establishing a hierarchy of goals and criteria, which could be crucial in modelling the decisions of agricultural producers, involves substantial difficulties and costs. Whereas they are justifiable in the case of an individual producer or a small group of farms, the results of this study question the relevance of eliciting one set of weights for a large group of agricultural producers, even for those specializing in the same field.

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Received 28 April 2015
Accepted 19 November 2015