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AHP BASED GROUP DECISION MAKING IN RANKING LOAN APPLICANTS FOR PURCHASING IRRIGATION EQUIPMENT: A CASE STUDY

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Abstract

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The aim of this paper is to propose an approach for minimizing the risk of negligent, incompetent, or irresponsible group decision making by assigning weights to the decision makers (DMs) according to their demonstrated individual inconsistencies. A decision-making framework is based on the analytic hierarchy process (AHP). The consistency ratio (CR) and total Euclidean distance (ED) are used to 'weight' involved decision makers. The approach is demonstrated in a practical example of ranking the agricultural producers who applied to the Provincial Fund for Agricultural Development of Vojvodina Province (Serbia) for loans for purchasing irrigation equipment.

Key words: Group decision making, AHP, Loan, Irrigation equipment
Abbreviations: AHP - Analytic Hierarchy Process, DM - Decision Maker, CR - Consistency Ratio, ED - Euclidean Distance

Introduction

The Executive Council of Autonomous Province of Vojvodina (Serbia) authorized the Fund for Agricultural Development (referred hereafter as the Fund) to support agricultural development in the Province of Vojvodina. The constitutional act states the following responsibilities of the Fund:

- Supporting the agricultural development in Vojvodina and financing the activities that lead to the improvement of different fields of agriculture
- Supporting the activities resulting in intensive and continuous agricultural production and export,
- Supporting the establishment of agricultural companies,
- Supporting the development of agricultural cooperatives, and
- Proposing incentives on the provincial level.

In line with stated aims and responsibilities, the activities of the Fund are the acquisition of new irrigation systems and reconstruction of existing ones, the acquisition of new greenhouses, funding livestock production activities, stimulating the planting of apples, grapes, nuts and berries, etc. The Norwegian government donated one million

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euros to the Fund to support its efforts in improving irrigation in Vojvodina. In 2003 twenty irrigation systems were reconstructed from this donation. The allocation of the donation has been realized by the Fund. Financial support is provided to selected farmers and small agricultural enterprises as a loan with a grace period of 9 and 12 months, and a repayment period of 24 to 30 months at an interest rate of 1.7% per annum. Repayments are scheduled as semi-annual annuities. Since 2003, an open call and competition for the acquisition of new irrigation systems and irrigation equipment has been announced each year in the spring and autumn.

In this paper, we present an approach for how to improve the decision-making process in the Fund by enabling an objective evaluation and ranking of the loan applicants, i.e. reducing the risk of making negligent, incompetent, or irresponsible decisions. The analytic hierarchy process (AHP) (Saaty, 1980) is selected as the supporting multicriteria decision-making tool and an evaluation of the applicants is performed with real data obtained in September 2009 under a public call that has been launched with limited funds available and five potential loan user applications received.

The group decision-making process is organized to meet the following goal: to evaluate and rank potential applicants for irrigation equipment loans. The three key decision makers (DMs) from the Fund were accompanied by an independent academic expert in decision-making methodologies and a representative from the Serbia Ministry of Agriculture, Forestry and Water Management. This way, a group of five decision-makers participated in the assessment and evaluation of application documents submitted by five applicants. By consensus in the five-person group, three criterions are adopted to assess the candidates.

To support the decision-making process, a detailed pre-assessment and scoring of the applicants' documents is undertaken by the technical staff in the Fund and made available to the DMs. Also, official scoring of eligible national and international irrigation equipment suppliers (and/or manufacturers) was made available and received from the Ministry. The moderator of the decision-making process was an independent academic expert who played a twofold role, one as a moderator and the other as a DM. Regarding the first role, the expert behaved in a fully neutral manner towards the other DMs.

The group decision is derived in two ways: first, assuming that the DMs' importance is in correlation with their demonstrated consistency measures of CR and ED on every level of the hierarchy tree; and second, assuming that the DMs' importance is in correlation with the individual global CR on the global level. The final aggregation of individual decisions led to the conclusion that the approach and decision-making methodology were efficient and justified. The DMs have been satisfied both with their participation and the final result obtained.

This paper is organized as follows. After the introduction, a brief description of the AHP is presented in section 2. A statement of the problem on how to assign DM importance weights in the group, and an efficient procedure for its solving is presented in Section 3. The loan allocation problem and the procedure applied to solve it are presented in section 4. Section 5 contains the main conclusions, and the paper is closed with selected pertinent literature and an appendix with all the individual judgments of those who participated in the group.

The Analytic Hierarchy Process– Brief Overview

The AHP is a multicriteria decision-making approach in which the relevant factors of a decision are arranged in a hierarchic structure. Arranging the goal, attributes, and alternatives as a hierarchy tree provides an overall view of the complex relationships relevant to the decision-making problem and helps the DM to assess and compare elements accurately. The AHP is very popular in research because its usefulness outweighs other rating methods (Scholl et al., 2005). Besides, the AHP methodology has been accepted by the international scientific community as a robust and flexible multicriteria decision-making tool for dealing with complex decision problems (Chatzimouratidis and Pilavachi, 2007; Elkarmi and Mustafa, 1993 and Srdjevic, 2005).

Basically, the AHP has three underlying concepts: (a) structuring the complex decision problem as a hierarchy of goal, criteria, and alternatives; (b) a pair-wise comparison (i.e. judgment) of elements at each level of the hierarchy with respect to each element on the preceding level; and finally, (c) vertically synthesizing the judgments over the different levels of the hierarchy (Saaty, 1980). It has been applied to numerous decision-making problems in individual and group contexts, including the problems related to financial issues (Yurdakul and Tansel, 2004; Chou et al., 2006; Gang et al., 2008; Srdjevic et al., 2008 and Sueyoshi et al., 2009). Also, it has been applied to irrigation project improvement (Okada et al., 2008a; Okada et al., 2008b and Montazar and Behbahani, 2007).

The AHP determines the preferences among the set of elements at a given level of a hierarchy by employing pair-wise comparisons of theses elements with respect to the elements at the higher level, using Saaty's scale given in Table 1. Here, the assigned value 1 corresponds to the case where two elements, say A and B, contribute in the same way to the element in the upper level, and 9 corresponds to the case in which one of the two elements is extremely more important than the other. Also, if the judgment is that B is more important then A, the reciprocal of the relevant index value is assigned. For example, if B is felt very strongly to be more important as a criterion for the decision then A, then the value 1/7 would be assigned to A relative to B.

The results of all the comparisons are placed in positive reciprocal quadratic matrices. Then, for each matrix, the so-called local priority vector is calculated using the principal eigenvector of a comparison matrix, as suggested by Saaty (1980). This method is considered to be the standard AHP method and known as the eigenvector method (EV). However, there are other prioritization methods proposed from different authors, all briefly presented in (Srdjevic, 2005). Worthy of mention are the additive normalization method (AN), direct least squares method (DLS), weighted least squares method (WLS), logarithmic least squares method (LLS), logarithmic least absolute values method (LLAV), logarithmic goal programming method (LGP), and fuzzy preference programming method (FPP).

After all priority vectors are computed, the synthesis consists of multiplying the criteria-specific priority vector of the alternatives with the corresponding criterion weight and summing up the results to obtain the final composite alternatives' priorities (weights) with respect to the goal.

Deriving Weights of the Decision Makers

Ramanathan and Ganesh (1994) proposed to determine group members' relative weights by means of pair wise interpersonal comparisons of importance or influence among group members (where importance or influence can be measured as one or more of power, experience, wealth, ability to disrupt, etc.) by each individual in the group, within the framework of the AHP (Saaty, 1980). Ramanathan and Ganesh's methodology proposes that each DM evaluate all group members, including him or herself. Bodily (1979) observed that in such situations, there is a tendency for an individual to increase his or her own importance, especially when there may be something to be gained from this. The second approach assumes the application of the SMART technique (Lootsma, 1997 and Lootsma, 1999) in the context of eliciting a group member's decisional power or weight. Each DM evaluates all other members of the group by choosing a value between a lower limit (to represent the least powerful position possible) and an upper limit (to represent the most powerful position possible). Whichever of two mentioned approaches is in question, it can be speculated that the DM can tacitly appraise the importance of certain members of the group to form a decisional coalition (Van Den Honert, 2001).

To avoid problems related to determining the group members' weights, one of the possible approaches is the consensus building procedure. Jimenez et al. (2008) presented a new decision tool for consensus building called the consistency consensus matrix, which enables identification of the core of consistency in AHP group decision making. This facilitates knowledge extraction derived in two different situations. First, the above information can be considered as the solution to an automatic negotiation process between actors involved in the resolution of the process. Secondly, the above-mentioned information will be used as the starting point of a participatory negotiating process in which actors identify areas of agreement and disagreement in eliciting judgments and establish consensus paths in an interactive manner. This method can be an effective way to find a quality group decision. To find the disadvantages of this method is a quite long and mathematically complicated procedure.

A new and efficient procedure is presented hereafter for deriving weights of the DMs, based on their demonstrated individual consistencies.

Two well known consistency measures are used to enable an objective aggregation of individual priority vectors. The first one is the well known coefficient CR = CI/RI defined in (Saaty, 1980), where CI is computed as (λ max-n)/(n-1), and RI is the random index derived from numerous randomly generated nxn matrices. CI is computed for a given comparison matrix of order n and its maximum eigenvalue λ. The value of CR should be less than 0.1 in order to validate the consistency of a given comparison matrix. The other consistency measure is more general, and is well known as the generalized L^2 Euclidean distance (ED), an error criterion that compares the entries of the comparison matrix (a_{ij}), as entered by the DM, and related ratios w_i/w_j of computed weights (which should at the final instance approximate the elicited entries, i.e. $a_{ij} = w_i/w_j$). Therefore, the ED, as given by equation (1):

$$\text{ED} = [\sum_{i=1}^{n}\sum_{j=1}^{n}(a_{ij} - w_i / w_j)^2]^{1/2} \qquad (1)$$

measures the total distance between all judgment elements in the comparison matrix and the related ratios of the priorities contained in the derived vector ***w***.

The procedure to derive weights of the DMs is as follows:

1. CR and ED values are computed for all comparison matrices for each DM.
2. CR values for all matrices are summed for each DM separately; the same is done for ED values.
3. Reciprocals of sums obtained in step 2 are computed for each DM.
4. Additive normalization is performed in a way that the individual reciprocals from step 3 are divided by the sum of all reciprocals obtained in step 3; normalization is performed separately for CR and ED.
5. Averages of the normalized values for CR and ED obtained in step 4 are adopted as the final weights of the DMs.

The presented approach screens the hierarchy tree and adds local CRs as well as local EDs, respecting in this way the DMs' judgments that are elicited over a small set of decision elements at a time. By using both CR and ED measures within the proposed procedure, consistency is assessed in a more precise way, and we consider it more justified than using the global CR solely with the imbedded weights of local vectors.

Group Decision Making in Selecting the Best Loan-User Applicant Supported by AHP

Problem statement

The loans for the acquisition of new irrigation systems and irrigation equipment have already been granted to the applicants that satisfied the open competition priorities. A part of the financial funds remain, and five potential loan users (that do not fulfill the priorities) are in competition for these remaining funds. The problem is how to rank the applicants and how to decide who will receive the loan following the principle of funds allocation until the funds are totally used, so that the best ranked applicant gets all that he applied for; then, the second ranked applicant gets what he requested from the remaining amount; if more funds are available, the third ranked gets what he asked for, and so on until there are no remaining funds.

Goal and criteria

The goal is to select one or more applicants for the loan that best fit the defined requirements. The AHP multicriteria method is selected to rank the applicants. To enable evaluation of the five applicants, criteria set is defined based on (1) the text of the open competition call, (2) the structure of the application form, and at the final stage, (3) the consensus of the five DMs involved. The outlined criteria are as follows:

- SERVICE (Did the applicant present in his/her application the costs of equipment, and especially the costs of authorized service of the equipment obtained from possible suppliers?)

Priority is given to the applicants that have a cost estimate from the manufacturers' authorized service, regardless of the manufacturers' origin, national or foreign. Based on the experience of the Fund employees, this requirement minimizes the risk that the funds invested would not provide the expected results. If the manufacturers' authorized service exists, a new piece of equipment for repair can be easily insured in case of failure or damage of the irrigation equipment.

- LOAN HISTORY (LOANH) (Was the applicant a prior Fund beneficiary?)

It is concluded in the Fund that it is more socially justified to allocate the financial resources to the applicant who has not been a Fund beneficiary before. There are three possible types of applicants for loans: applicants who are applying for the first time, applicants that were Fund beneficiaries but paid off all accrued annuities, and applicants who were Fund beneficiaries but did not pay off all annuities.

- INSURANCE (Does the applicant have insurance for the crops?)

It is a common situation in the Fund that the loan users ask to postpone the annuity payment because a natural disaster has destroyed their yield. Unfortunately, the Fund can not meet such requests. To avoid solving this problem in Court, the Fund recommends that applicants insure their crops.

After interviewing the Fund employees and consulting an independent external expert in decision making (experienced in AHP theory and practice), it was concluded that these three criteria are sufficient for allocating the remaining funds.

Alternatives

Five agricultural producers (applicants for loan) are considered as the decision alternatives. Their YES-NO global performance with respect to the given criteria are presented in Table 2.

Since it is not possible to apply AHP on a matrix with a yes-no performance description, the supporting technical staff of the Fund is asked to perform a pre-assessment of the applicants' documents to point to their performance across the criterions. Another reason for the pre-assessment lies in the fact that a yes-no description cannot cover the whole range of an applicant's performance; for example, if two applicants insure their crops, a better performance regarding the criterion INSURANCE has is a producer whose crop is insured against the majority of risks (in Serbia, those are hail, fire, storm, floods, loss related to seed quality, and winter frost).

The scales of 1-5 and 1-10 are used for the last two criterions (LOAN HISTORY and INSURANCE) respectively, and points (given in

Table 1
Saaty's importance scale

Definition	Assigned value
Equally important	1
Weak importance	3
Strong importance	5
Demonstrated importance	7
Absolute importance	9
Intermediate values	2,4,6,8

Table 2
Loan applicants' performance

Loan Applicants / Criteria	Service	Loan history	Insurance
Producer 1 (P1)	YES(6)	YES(1)	YES (4)
Producer 2 (P2)	YES (5)	NO (5)	YES (2)
Producer 3 (P3)	YES(8)	NO (5)	NO (1)
Producer 4 (P4)	NO (1)	YES(3)	YES (5)
Producer 5 (P5)	YES (3)	YES (4)	YES (9)

parentheses) are allocated to the applicants; the lower values correspond to a 'less desirable performance', as opposed to the higher values that describe a 'more desirable performance'. For example, regarding applicants who received prior loans, a scale of 1 to 10 is used with 10 denoting that the applicant 'did not use the loan at all', and 1 denoting the applicant 'used a large loan'.

To rate the SERVICE performance of the applicants, grades from a scale of 1-10 are inserted into Table 1 as obtained from the Ministry of Agriculture, Forestry and Water Management. Grades are set based on information the Ministry has about available manufacturers of irrigation equipment such as their position in the market, costing, brand, response time to repair and service the requests, etc. For example, here 1 denotes that the producer uses a manufacturer that 'does not guarantee any service, or providing service is a completely unclear issue', while 10 denotes that the applicant will contract services with a 'trustful and well positioned manufacturer in the market, who provides good service'.

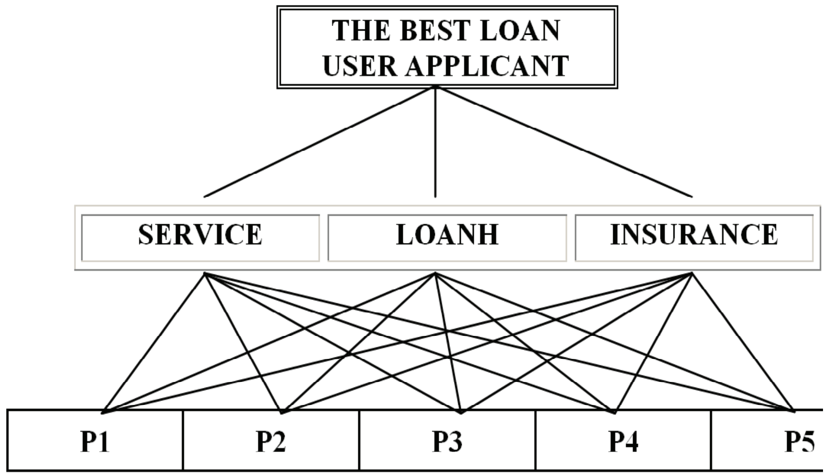
Table 2 is later used by the DMs to facilitate pair-wise comparisons of applicants in the AHP framework.

Hierarchy tree

In order to assess the applicants' qualifications to receive a loan, a hierarchy tree has been created for the application of the AHP. In general, the AHP requires a goal to be specified at the top level followed by criteria and the alternatives that will be assessed to display at the lowest level. A schematic representation of these levels appears in Figure 1. In the same manner that criteria were assessed against a goal after construction of the hierarchy tree, the five alternative loan applicants (P1-P5) must also be assessed against criteria. The score of each applicant with respect to each criterion is assessed by the value of preference when pair-wise comparing their pre-scores (numbers in parentheses in Table 2) according to that criterion. Notice that the scores come from different scales, and the pair-wise comparisons are made by use of Saaty's fundamental scale in Table 1. Finally, the criteria weights are used for the weighted synthesis of the partial scores of the applicants in order to assess the overall goal, e.g. to obtain their final ranks based on the computed final weights synthesized in a top-down manner across the hierarchy tree.

Decision makers

The five DMs participated in the ranking process: DM1 – President of the Fund Council, DM2 – Senior advisor of the Fund, DM3 – Fund manager, DM4 – External expert advisor, and DM5 – Expert representative of the Ministry. The expert from the Ministry participated and finally agreed with the other DMs about the selection criteria. In fact, during the criteria identification phase, it was concluded in this 5-member group that in future assessments and evaluations, especially if the number of applicants increases significantly,



Appendix A. Comparison matrices and priority vectors for 5 DMs:
President of the Fund Council (DM1)

Comparison matrix Criteria vs. Goal and derived priority vector

CRITERIA	SERVICE	LOANH	INSURANCE	Wc
SERVICE		5		0.527
LOANH	2	9		0.404
INSURANCE				0.069

Comparison matrices for alternatives vs. criteria and the final priority vector

SERVICE

	P1	P2	P3	P4	P5	Wa
P1		3	1/2	8	4	0.298
P2			1/3	7	3	0.163
P3				9	6	0.432
P4					1/4	0.030
P5						0.077

LOANH

	P1	P2	P3	P4	P5	Wa
P1		1/9	1/9	1/4	1/6	0.033
P2			1	3	2	0.334
P3				3	2	0.334
P4					1/2	0.112
P5						0.188

INSURANCE

	P1	P2	P3	P4	P5	Wa
P1		2	5	1/2	1/6	0.123
P2			5	1/3	1/8	0.084
P3				1/7	1/9	0.031
P4					1/3	0.212
P5						0.549

SYNTHESIS (DM1)

	Ws	**Rank**
P1	**0.179**	**3**
P2	**0.227**	**2**
P3	**0.365**	**1**
P4	**0.076**	**5**
P5	**0.154**	**4**

Senior advisor of the Fund (DM2)

Comparison matrix Criteria vs. Goal and derived priority vector

CRITERIA	SERVICE	LOANH	INSURANCE	Wc
SERVICE		5	9	0.728
LOANH			6	0.218
INSURANCE				0.054

continued

Comparison matrices for alternatives vs. criteria and the final priority vector

SERVICE

	P1	P2	P3	P4	P5	Wa
P1		4	1/3	6	5	0.277
P2			1/4	5	3	0.128
P3				9	8	0.499
P4					1/3	0.034
P5						0.061

LOANH

	P1	P2	P3	P4	P5	Wa
P1		1/6	1/6	1/3	1/3	0.052
P2			1	2	2	0.313
P3				2	2	0.313
P4					1/2	0.138
P5						0.184

INSURANCE

	P1	P2	P3	P4	P5	Wa
P1		2	4	1/2	1/4	0.137
P2			4	1/4	1/6	0.086
P3				1/8	1/9	0.035
P4					1/2	0.274
P5						0.468

SYNTHESIS (DM2)

	Ws	**Rank**
P1	**0.221**	**2**
P2	**0.166**	**3**
P3	**0.433**	**1**
P4	**0.070**	**5**
P5	**0.110**	**4**

Fund manager (DM3)

Comparison matrix Criteria vs. Goal and derived priority vector

CRITERIA	SERVICE	LOANH	INSURANCE	Wc
SERVICE		1/5	1/3	0.094
LOANH			6	0.722
INSURANCE				0.184

Comparison matrices for alternatives vs. criteria and the final priority vector

SERVICE

	P1	P2	P3	P4	P5	Wa
P1		2	1/3	7	6	0.250
P2			1/5	5	3	0.138
P3				9	7	0.513
P4					1/4	0.032
P5						0.067

LOANH

	P1	P2	P3	P4	P5	Wa
P1		1/5	1/5	1/2	1/4	0.058
P2			1	2	2	0.308
P3				2	2	0.308
P4					1/2	0.129
P5						0.197

INSURANCE

	P1	P2	P3	P4	P5	Wa
P1		3	6	1/2	1/7	0.129
P2			2	1/4	1/7	0.057
P3				1/6	1/9	0.034
P4					1/5	0.188
P5						0.592

SYNTHESIS (DM3)

	Ws	**Rank**
P1	**0.089**	**5**
P2	**0.246**	**3**
P3	**0.277**	**1**
P4	**0.131**	**4**
P5	**0.258**	**2**

External expert advisor (DM4)

Comparison matrix Criteria vs. Goal and derived priority vector

CRITERIA	SERVICE	LOANH	INSURANCE	Wc
SERVICE		3	7	0.649
LOANH			5	0.279
INSURANCE				0.072

continued

Comparison matrices for alternatives vs. criteria and the final priority vector

SERVICE

	P1	P2	P3	P4	P5	Wa
P1		3	1/3	8	5	0.278
P2			1/4	6	3	0.143
P3				9	5	0.475
P4					1/4	0.030
P5						0.074

LOANH

	P1	P2	P3	P4	P5	Wa
P1		1/8	1/8	1/5	1/6	0.033
P2			1	3	2	0.325
P3				3	2	0.325
P4					1/3	0.110
P5						0.208

INSURANCE

	P1	P2	P3	P4	P5	Wa
P1		4	6	1/3	1/5	0.142
P2			2	1/4	1/7	0.055
P3				1/6	1/9	0.035
P4					1/4	0.229
P5						0.539

SYNTHESIS (DM4)

	Ws	**Rank**
P1	**0.200**	**2**
P2	**0.187**	**3**
P3	**0.401**	**1**
P4	**0.067**	**5**
P5	**0.145**	**4**

Expert representative of the Ministry (DM5)

Comparison matrix Criteria vs. Goal and derived priority vector

CRITERIA	SERVICE	LOANH	INSURANCE	Wc
SERVICE		7	9	0.772
LOANH			5	0.173
INSURANCE				0.055

Comparison matrices for alternatives vs. criteria and the final priority vector

SERVICE

	P1	P2	P3	P4	P5	Wa
P1		3	1/5	7	5	0.219
P2			1/6	6	5	0.135
P3				9	7	0.563
P4					1/3	0.030
P5						0.053

LOANH

	P1	P2	P3	P4	P5	Wa
P1		1/9	1/9	1/5	1/7	0.027
P2			1	7	5	0.389
P3				7	5	0.389
P4					1/4	0.062
P5						0.133

INSURANCE

	P1	P2	P3	P4	P5	Wa
P1		3	6	1/3	1/5	0.129
P2			4	1/5	1/7	0.066
P3				1/7	1/9	0.030
P4					1/4	0.242
P5						0.534

SYNTHESIS (DM5)

	Ws	**Rank**
P1	**0.181**	**2**
P2	**0.175**	**3**
P3	**0.504**	**1**
P4	**0.047**	**5**
P5	**0.093**	**4**

additional criteria should be used, e.g. whether an applicant produces organic crops or not. It was also pointed out that more governmental institutions and the public sector could participate in defining the criteria set and thus account for strategies of agricultural development and the types of agricultural production that should be stimulated.

Decision-making process

The AHP method is applied individually, and the final ranking of applicants is performed by the aggregation of five priority vectors computed for each DM. The group decision is derived in two ways: by assuming that the DMs' importance is in correlation with their demonstrated consistency measures CR and ED on every level of the hierarchy tree, as proposed in Section 3, and by assuming that the DMs' importance is in correlation with the individual global consistency ratios CR on the global level.

Results

The comparison matrices obtained from the five DMs are given in Appendix A. The computed local priority vectors for criteria (Wc) and alternatives (Wa) are shown in the same Appendix and used

Table 3
The final priorities computed for all the DMs individually

	DM1		DM2		DM3		DM4		DM5	
	Ws	Rank	Ws	Rank	Ws	Rank	Ws	Rank	Ws	Rank
P1	0.179	3	0.221	2	0.089	5	0.200	2	0.181	2
P2	0.227	2	0.166	3	0.246	3	0.187	3	0.175	3
P3	0.365	1	0.433	1	0.277	1	0.401	1	0.504	1
P4	0.076	5	0.070	5	0.131	4	0.067	5	0.047	5
P5	0.154	4	0.110	4	0.258	2	0.145	4	0.093	4

Table 4
Consistency indicators CR and ED

	DM1		DM2		DM3		DM4		DM5	
	CR	ED	CR	ED	CR	ED	CR	ED	CR	ED
Criteria vs Goal	0.16	4.176	0.141	5.141	0.16	3.546	0.056	2.413	0.18	6.032
Alternatives vs SERVICE	0.046	6.196	0.066	6.623	0.064	7.964	0.068	7.701	0.116	11.595
Alternatives vs LOANH	0.005	1.734	0.013	1.119	0.014	1.258	0.027	3.243	0.099	9.407
Alternatives vs INSURANCE	0.055	9.221	0.025	4.954	0.066	9.864	0.071	7.943	0.085	9.677
∑	0.266	21.327	0.245	17.837	0.304	22.632	0.222	21.3	0.48	36.711

in the AHP synthesis to obtain the final priorities (Ws) of the agricultural producers for each DM, as shown in Table 3.

Based on results presented in Table 3, it is obvious that the best ranked applicant, as decided by all participating DMs, is the P3 applicant. The ranks of the remaining applicants differ in a way that could be important in case of insufficient funds. Forman and Peniwati (1998) discussed the concepts of aggregation of individual judgments (AIJ) and aggregation of individual priorities (AIP) in AHP, and stated that AIJ is most often performed using the geometric mean; whereas, AIP is typically performed using the arithmetic mean. Lai et

Table 5
Computing the DMs' weights based on consistency measures CR and ED (Cf. Table 4)

	DM1	DM2	DM3	DM4	DM5	
1/∑CR	3.759	4.082	3.289	4.505	2.083	∑(1/∑CR) = 17.718
1/∑ED	0.047	0.056	0.044	0.047	0.027	∑(1/∑ED) = 0.221
norm CR	0.212	0.23	0.186	0.253	0.118	
norm ED	0.213	0.253	0.199	0.213	0.122	
The final DMs' weights	0.212	0.242	0.192	0.233	0.12	(norm CR + norm ED)/2

Table 6

The final ranking of applicants based on consistency measures CD and ED

	P1	P2	P3	P4	P5
The final weights and ranks	0.176 (3)	0.205 (2)	0.401 (1)	0.078 (5)	0.144 (4)

Table 7

DMs' weights based on individual global consistency ratios

	DM1	DM2	DM3	DM4	DM5	
CR	0.08	0.09	0.08	0.06	0.14	
1/CR	12.5	11.11	12.5	16.67	7.14	∑(1/CR)=59.92
A = norm CR	0.209	0.185	0.209	0.278	0.119	

Table 8

The final ranking of applicants based on individual DMs' global consistency ratios

	P1	P2	P3	P4	P5
The final weights and ranks	0.173 (3)	0.207 (2)	0.397 (1)	0.078 (5)	0.146 (4)

al. (2002) suggested that four approaches can be used to integrate expert opinions: consensus, vote or compromise, geometric means, and separation of models or players. Aull-Hyde et al. (2006) stated that the most commonly used aggregation methods are the geometric mean method and the weighed arithmetic mean method. Saaty (2001) suggested that, under certain reasonable assumptions, the use of geometric means provides an effective way to aggregate group decision weights. Therefore, the aggregation of individual priority vectors of the DMs is required to derive the final group priority vector. The geometric averaging is achieved by

$$, \quad z_i^G = \prod_{k=1}^{K} \left[z_i(k) \right]^{\alpha_k} \qquad (2)$$

where K stands for the number of DMs, $z_i(k)$ for the priority of the i-th alternative for the k-th DM, α_k for the 'weight' of k-th DM, and z_i^G for the aggregated group priority value.

Notice that the weights α_k should be additively normalized prior to their use in equation (2) and the final additive normalization of priorities z_i^G is required.

The results of step 1 of the procedure given in Section 3 are presented in Table 4. The results of the remaining steps 2-5 are given in Table 5, with the last row representing the final weights of the DMs that are used in the geometric aggregation according to equation (2).

Based on the DMs' weights computed in the described way and aggregation performed according to equation (2), the final ranking of applicants is given in Table 6. The best ranked applicant is P3, followed by P2, P1, P5 and P4.

In standard AHP applications, a global consistency ratio CR is computed based on the local weights of decision elements in a hierarchy tree and the consistency ratios CR computed for each local matrix. If a simplified procedure for assigning weights to individuals is applied as presented in Table 7, and aggregation is repeated, the final ranks of the applicants are the same with only minor differences in their weights (see Table 8 and compare it with Table 6).

Conclusions

Contemporary decision making often assumes participation of more than one DM. The DMs usually have different attitudes, interests, and knowledge about the problem and show certain inconsistency in the decision-making process. The aim of this paper is to indicate the possibility of obtaining more objective decisions on allocating financial resources by assigning importance weights to the DMs in the group according to their demonstrated inconsistency.

This proposed approach is based on AHP, a recognized decision support tool for individual and group decision making, and it is applied for the evaluation of the loan applicants in the Provincial Fund for Agricultural Development of Vojvodina Province, Serbia. Five DMs evaluated and ranked candidates for the loan using a pre-assessment of the applicants provided by the technical staff of the Fund. Two measures (CR and ED) are used to evaluate the DMs' consistency and to define their importance weights in the group. The concept of assigning weights based on calculating the CR and ED on a local hierarchy level is verified by calculating the DMs' weights using their global consistency ratio CR.

After aggregation of the individual decisions, a final ranking of loan applicants is obtained. The result was acceptable to all DMs, in the sense that the group ranking corresponded well with their personal attitudes and expectations within the group context.

This proof-of-concept application of AHP for solving a real problem in the domain of finances can help the DMs from other fields to organize their related decision-making processes and come up with a group decision more objectively.

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