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# **Assessment of actions in a multi-actor and multicriteria framework: application to the refunding of microfinance institutions**

**Jean Robert Kala Kamdjoug, Philippe Lenca, Jean-Pierre Barthélemy**

**Abstract** This article formulates a methodology that describes the decision making process in which a group of actors (in this case, microfinance experts) become involved in actions. The actions, Microfinance Institutions (MFIs) being selected for refinancing, are described using several conflictual, ordinal criteria. This methodology is constructed in three consecutive steps: the first involves obtaining decision strategies from interactive input received from experts, the second compiles and merges individual decision strategies so as to create a common decision base and the third involves using this common decision base to construct a decision-making aid destined to help experts with the decision-making process. This methodology was tested with five microfinance experts in Cameroon.

**Keywords** Refunding · Microfinance · Multi-actor · Multicriteria · Decision rules · Judgment

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## 1 Introduction

Actions that occur within human organizations usually entail many decision-making processes. Whenever analysing these processes it is essential to take the multitude of actors involved into account. It is rare to find concrete applications where a single point of view is sufficient to uncover all the necessary information and several points of view must be taken into consideration and any accurate analysis of a decision-making process should be made from a multi-criteria point of view (Roy & Vincke, 1981).

The decision-making methodology defined and discussed in this article is based on work described in Jessi and Beauclair (1987), Islei and Lockett (1991), and Marchant (1997), where decision-makers come to a consensus on a single working model while keeping separate preferences for the evaluation of actions in a multi-criteria framework. It has been created with the dual purpose of extracting human decision-making strategies from real-life situations and providing decision-makers with a tool for guiding them in efficient decision making.

This decision-making methodology can be conceptualized according to two approaches: the process approach and the recommendation approach. The process approach involves reference actions which are those actions that decision-makers can use as *if then* rules for carrying out their decisions (e.g. *acceptance/rejection*). In a multi-actor context, these reference actions are computed by the aggregation of individual decision rules. Sub-sequently, the recommendation approach involves a new Multi-Criteria Decision Aid method (MCDA), *Analysis by Trichotomy and Risk Evaluation Evidence* (ATREE). ATREE is designed to help decision-makers in the final deliberation process.

This article is organized as follows: Sect. 2 outlines the working hypotheses of our methodology. Section 3 describes the decision space and the procedure used to extract expert decision strategies. Section 4 describes the conceptual framework and the process approach used to determine reference actions. Section 5 describes the MCDA method ATREE, and finally, Sect. 6 is devoted to a practical application of this methodological tool in the context of the refinancing of Microfinance Institutions (MFIs) organized as a network.

## 2 The working hypotheses

At the individual level, we consider expert decision-makers as individuals having a great experience in their domain of expertise. An expert is someone who can make sense out of chaos (Shanteau, 1988). We assume that each decision-maker uses stable strategies to evaluate actions (i.e. situations, alternatives, etc.) described by a set of criteria for a specific task (categorization, selection/elimination, etc.) (Barthélemy & Mullet, 1986). The decision-maker uses thresholds on criteria values in order to take a decision. This threshold hypothesis is a monotonicity property and implies that the criteria and the decision categories are linearly ordered. Decision rules can then be expressed in terms of conjunction/disjunction on criteria value thresholds.

At the group level, a decision-maker is expected to adhere to a principle of goodwill that is composed of three requirements. According to the first requirement, he must not be motivated by personal interest. In the second, he must agree with group decisions that are based on a consensus arrived at during a committee meeting. Finally, he must cooperate with the group even if his point of view conflicts with those of others.

In this way, the proposed methodology is intended to support individual as well as group decision making.

Finally, our working hypotheses can be summarized in the four following base hypotheses:

- $H_1$ : The decision-makers describe actions using  $m$  criteria in order to express their preferences. These criteria are ordinal.
- $H_2$ : The decision-maker accepts or rejects a given action. Therefore, it is not a choice task (to choose the best action in a given set), but a judgment task (to decide if an action is acceptable or not).
- $H_3$ : The decision-maker is assumed to be a rational being. This means that he will automatically accept an action that, according to all the criteria, is better than the one already adopted. Inversely, he will reject any action that, in the same context, is less preferable than one that has already been rejected.
- $H_4$ : Decisions must be made in a group and the decision-makers involved are required to cooperate and bear in mind that they are working towards the success of a common goal, even though they have conflicting points of view.

One objective of this study is to imitate as closely as possible expert decision-maker behaviour.

First, our approach should take into account cognitive constraints. Amongst these, the main cognitive hypotheses for the process of decision-making are: decision making viewed as the articulation of elementary strategies (Montgomery & Svenson, 1976; Svenson, 1979); decision making as a search for dominance structure (Montgomery, 1983).

Second, our approach should be based on decision-maker expertise. Generally, to assist expert decision-makers, it is essential to understand their strategies, but, if this is not the case, it will be necessary to obtain this vital information from them. Indeed, expert decision-makers use stable and efficient dominance structures, therefore it should be possible to acquire them (Barthélemy & Mullet, 1986, 1992).

On the basis of these four hypothesis, we propose a three-step methodology:

- (1) extraction of each individual's decision strategies in a multi-criteria framework taking into account cognitive modelling;
- (2) constitution of a common consensus base of decision strategies (construction of an epistemic decision-maker representing the group of decision-makers);
- (3) recommendation and decision support for the group of decision-makers based on the consensus base.

### 3 Acquisition of decision strategies

The purpose of this section is to briefly describe the process by which experts' decision strategies are obtained from real-life situations. It is divided into the two following parts: the definition of the decision space as it is used in this study and the extraction of decision strategies.

#### 3.1 Decision space

Let us denote by  $\mathcal{A}$  the set of actions. As mentioned in our working hypothesis we consider actions  $a \in \mathcal{A}$  described by a set of  $m$  criteria. Each criterion  $g_j$ ,  $j \in \{1, 2, \dots, m\}$  is defined on an ordinal scale  $\Omega_j = \{0 < 1 < \dots < c_{j-1}\}$  (e.g.  $g_j$  takes  $c_j$  values). At this point we will not present or develop fully the way in which these criteria can be obtained (e.g. by interviewing experts, interactive processes, etc.) because it is a long, drawn-out complex process. In addition, the family of criteria should be built in such a way that decision-makers' opinions are as well represented as possible (i.e. the family of criteria should be coherent; Roy & Bouyssou, 1993).

Set  $\mathcal{A}$  has a natural representation in the direct product of the  $m$  total orders  $\Omega = \prod_{j=1}^m \Omega_j$ . An action  $a \in \mathcal{A}$  is described by an element  $x = (g_1(x), g_2(x), \dots, g_m(x)) \in \Omega$  where  $g_k(x)$  indicates the value of  $x$  on the criterion  $g_k$ .  $\Omega$  is ordered by the classical order  $\geq$ :  $\forall x, y \in \Omega, x \geq y \Leftrightarrow \forall j, x_j \geq y_j$  (literally,  $x \in \Omega$  is better than  $y \in \Omega$  or  $x$  dominates  $y$ ).

#### 3.2 Extraction of decision strategies

Each decision-maker has his own decision rules that we one can express in the classical way of production rules if <condition> then <conclusion>, where:

- <condition> expresses a sequence of tests on the criteria. As the criteria are ordinal (hypothesis  $H_1$ ) and the experts rational (hypothesis  $H_3$ ), all tests have the following structure  $\langle g_1(\cdot) \geq \sigma_1 \dots \text{ and } g_j(\cdot) \geq \sigma_j \dots \text{ and } g_m(\cdot) \geq \sigma_m \rangle$ , where  $\sigma_j$  is the minimal value to be respected on  $g_j(\cdot)$ ,  $\forall j \in \{1, \dots, m\}$ . Of course, the thresholds  $\sigma_i$  (for criterion  $g_j$ ) can change from one conjunction to another and from one decision-maker to another.
- <conclusion> is acceptance or rejection (hypothesis  $H_2$ ). Due to the nature of the preceding tests (<condition>), only the acceptance cases are considered. However, if none of the tests are valid, the conclusion is the rejection of the action. This indicates that an action is rejected when it does not fulfill any of the acceptance requirements.

An expert decision-maker's strategies, i.e. a set of production rules, is then a disjunction of conjunctions (as defined above).

The decision rules of a decision-maker divide  $\Omega$  into two subsets: the set  $\Omega^a$  of accepted elements and the set  $\Omega^r$  of rejected elements. The  $H_3$  hypothesis

implies that no element of  $\Omega^r$  dominates an element of  $\Omega^a$ . In addition, the minimal elements of  $\Omega^a$  constitute the acceptance rules for decision making. These decision rules constitute an *antichain* which is a subset of incomparable elements in  $\Omega$ . In this case, an antichain is a disjunction of decision rules as well as a set of minimal conditions that, according to the dominance principle, must be met before an action can be accepted. Thus, learning decision-makers' strategies is equivalent to seeking an antichain in the decision space  $\Omega$  (Pichon, Lenca, Guillet, & Wang, 1994). Note that we can use the same representation space  $\Omega$  for coding objects of  $\mathcal{A}$  or decision strategies. We will then use  $\Omega$  and  $\mathcal{A}$  equally.

In order to imitate decision-makers' behaviour as closely as possible, particularly so as to take into account cognitive constraints, we used the *Moving Basis Heuristics* (MBH) model (Barthélemy & Mullet, 1986, 1987). This model is based upon a multi-attribute representation space that uses several attributes to describe the set of actions. The model assumes that the decision-maker behaves rationally in the sense that he operates optimally when solving problems within his scope of expertise. Nevertheless, this rationality is bounded (Simon, 1979) by the decision-maker's cognitive abilities (short-term memory and computing capacity) and job satisfaction (pleasure, risk, etc.).

In this framework, MBH pre-supposes the coordinated use of four types of rules: lexicography, threshold, conjunction and disjunction. However, during the decision-making process, the main rule used by the decision-maker is the dominance principle, all the other rules being only used to provide a dominance structure as quickly as possible (Montgomery, 1983). The extraction of decision strategies is achieved using the *Acquisition Par Apprentissage de Connaissances Humaines Expertes: Acquisition by Learning of Expert Knowledge* (APACHE) tool which is an implementation of MBH (Lenca, 1995, 1997).

#### 4 The construction of reference actions

The focus of this section is to construct a kind of conceptual decision-maker that combines an individual decision-maker's decision strategies in a single set of rules, i.e. a set of reference actions. Typically, when faced with a specific kind of problem, a group of decision-makers will not have a single set of decision making rules, but rather they will have variety of decision strategies. A large review of this theoretical context has been done recently in Jabeur (2003).

Thus, when constructing a decision making model, it is essential that, as stated in hypothesis  $H_4$ , decision-makers cooperate, even though they have conflicting points of view. This enables a consensus to be reached: at the end of the process they agree to adopt one single decision. This final decision is the cumulative of their individual decision processes. The set of reference actions corresponds to a consensus of decision strategies. Of course it may contain some rules that do not correspond to any individual strategies (or real actions) but it represents the group of decision-makers' strategies. This set is a construction obtained with the decision-makers' agreement.

In the present methodology, there is a set of rules that describes the precise moment at which a decision-maker endorses an action. A decision-maker  $i$  endorses action  $o$  when  $o$  dominates at least one element of his set of decision rules denoted  $R_i$  (i.e. the set of minimal elements of  $\Omega^a$  computed by the APACHE tool; Lenca, 1997). Thus, it must compile all the decision strategies of the group and reach a consensus, a sort of cumulative decision strategy (Kamdjoug & Lenca, 2000).

The rule which we call the *cumulative decision strategy rule* is stated thus: for every action  $o \in \Omega$ , we count the number  $t(o)$  of decision-makers who endorse it. This value  $t(o)$  is the *total* of  $o$ . The reference actions can then be guaranteed by the following cohesion principle:  $\forall o, o' \in \Omega$ , if  $t(o) \geq t(o')$ , then we cannot have  $o'$  dominating  $o$ . We thus use two thresholds  $\tau_1 \geq \tau_2 \geq 0$  ( $\tau_1 \leq d$ , where  $d$  is the number of decision-makers), and  $o \in \Omega$  is accepted (resp. rejected) if  $t(o) \geq \tau_1$  (resp. if  $t(o) < \tau_2$ ).

In the above process, we obtain two subsets of  $\Omega$ :  $R^a$  composed of the minimal elements of the subset  $\Omega^a$  of accepted elements and  $R^r$  which is made up of the maximal elements of the subset  $\Omega^r$  of rejected elements. Therefore,  $\Omega$  is divided into three subsets  $\Omega^a$ ,  $\Omega^d$  and  $\Omega^r$  bounded by the borders  $R^a$  and  $R^r$ . The set  $\Omega^d$  contains elements  $o$  for which  $t_2 \leq t(o) \leq t_1$ . Therefore,  $R^a$  and  $R^r$  are the decision making rules of the consensual decision-maker:  $R^a$  for the acceptance subset  $\Omega^a$  and  $R^r$  for the refusal subset  $\Omega^r$ . Unfortunately, for the elements of  $\Omega^d$ , we cannot decide whether to accept or reject them. Thus, in order to make recommendations for these elements, it is necessary to formulate an additional process to deal with them. This is the third step of our methodology presented in the next section.

## 5 A description of ATREE

Once the consensus procedure described above has been carried out, then the recommendations for actions in  $\Omega^a$  and  $\Omega^r$  are obvious. Nevertheless, in order to come up with recommendations for actions in  $\Omega^d$ , it is still necessary for these actions to undergo additional treatment. This treatment is done using an ad hoc multicriteria decision making methodology called *Analysis by Trichotomic and Risk Evaluation Evidence* (ATREE) which is based on two working hypotheses:

- Each expert evaluates and determines the contribution level of the criteria involved in a recommendation. This evaluation is based on the decision-maker's decision rules.
- Each criterion contributes to the acceptance or rejection of an action.

Each criterion has a level at which it contributes to the recommendation for a given action in  $\Omega^d$ . This level of contribution is not necessarily numerical (for example it can be *low*, *medium* or *high*) but we will estimate it with numerical values that we call likelihoods.

### 5.1 Definition of criterion likelihoods

The acceptance or rejection of an element  $o \in \Omega$  has consequences that impact the contribution level of each criterion  $g_j$  ( $j \in \{1, \dots, m\}$ ). The acceptance of  $o$  tends to increase the contribution level of those criteria on whose basis  $o$  is *positively evaluated*. Similarly, the rejection of  $o$  tends to decrease the contribution level of those criteria on whose basis  $o$  is *negatively evaluated*.

Therefore, four likelihoods for each criterion  $g_j$  can be defined:

- $p_{j,+}^a(o)$  is the *likelihood that the contribution of the criterion  $g_j$  is high when  $o$  is accepted*, which can reinforce its acceptance;
- $p_{j,-}^a(o)$  is the *likelihood that the contribution of the criterion  $g_j$  is low when  $o$  is accepted*, which can weaken its acceptance;
- $p_{j,+}^r(o)$  is the *likelihood that the contribution of the criterion  $g_j$  is high when  $o$  is rejected*, which can reinforce its rejection;
- $p_{j,-}^r(o)$  is the *likelihood that the contribution of the criterion  $g_j$  is low when  $o$  is rejected*, which can weaken its rejection.

Before proceeding to the evaluation of these likelihoods, it is essential to define a sort of numerical evaluation for each criterion  $g_j$  that can be used to carry out arithmetic operations. This numerical evaluation, denoted  $\gamma_j(o)$  ( $j \in \{1, \dots, m\}$ ), measures the magnitude of a criterion  $g_j$  that defines action  $o$  and is defined as follows: when  $o \in \Omega^d$ ,  $\gamma_j(o) \in [-1, 1]$ , where  $-1$  corresponds to the lowest value on the scale of  $g_j$  and  $1$  to the highest value. Depending on the magnitude of the difference in preference that exists between any two consecutive values on the evaluation scale for  $g_j$ , the measurement  $\gamma_j$  can be linear, by step, concave, convex, etc.

The evaluation of likelihoods must of course follow our working hypothesis especially the dominance one (hypothesis  $H_3$ ) that implies that decision categories are linearly ordered. In Kamdjoug (2003) we also add a second constraint, *domination*. Domination requires that the values of the likelihoods of an action  $o$  should be in conformity with the number of elements in  $\Omega^d$  that  $o$  dominates (this property must be verified of course for the elements which dominate  $o$ ). Therefore, we propose the following functions for calculating the likelihoods for criterion  $g_j$  for action  $o \in \Omega^d$ . These functions respect the two requirements.

$$p_{j,+}^a(o) = \sum_{\gamma_j(x) > \rho_j, x \in [o]^-} \frac{\gamma_j(x)}{\Lambda_j^a}, \quad (1)$$

$$p_{j,-}^a(o) = \sum_{\gamma_j(x) < -\rho_j, x \in [o]^+} \frac{-\gamma_j(x)}{\Lambda_j^r}, \quad (2)$$

$$p_{j,+}^r(o) = \sum_{\gamma_j(x) < -\rho_j, x \in [o]^-} \frac{-\gamma_j(x)}{\Lambda_j^a}, \quad (3)$$

$$p_{j,-}^r(o) = \sum_{\gamma_j(x) > \rho_j, x \in [o]^+} \frac{\gamma_j(x)}{\Lambda_j^r}, \quad (4)$$

where the threshold  $\rho_j \geq 0$  is used to define the notions of *strongly evaluated* action  $o$  ( $\gamma_j(o) > \rho_j$ ) and *weakly evaluated* action ( $\gamma_j(o) < -\rho_j$ ) for each criterion  $g_j$ ; the  $\gamma_j(x)$  are linear functions in this study:  $\gamma_j(x) = -1$  for  $x = 0$ ,  $\gamma_j(x) = 1$  for  $x = c_j - 1$  and  $\gamma_j(x) = \frac{2x}{c_j-1} - 1$  for  $0 < x < c_j - 1$ ; the quantities  $\Lambda_j^a$  and  $\Lambda_j^r$  guarantee that  $p_{j,+}^a(o)$ ,  $p_{j,-}^a(o)$ ,  $p_{j,+}^r(o)$  and  $p_{j,-}^r(o)$  remain limited to the interval  $[0, 1]$  and are defined by:  $\Lambda_j^a = \max_{y \in \Omega^d} \Gamma_j([y]^-)$  and  $\Lambda_j^r = \max_{y \in \Omega^d} \Gamma_j([y]^+)$ , where for  $\Delta \subseteq \Omega^d$ ,  $\Gamma_j(\Delta) = \sum_{x \in \Delta} |\gamma_i(x)|$ ;  $[o]^+ \subset \Omega^d$  contains the elements which dominate  $o$  and  $[o]^- \subset \Omega^d$  contains the elements which are dominated by  $o$ .

## 5.2 The degrees of confidence

The likelihoods defined above explain in a measurable way how each criterion contributes to the rejection or the acceptance of an action. The objective of this section is the calculation of global measurements called *degrees of confidence for acceptance and rejection*.

For a given action  $o \in \mathcal{A}^d$ , the *degree of confidence for acceptance* is defined as follows:

$$\Phi^a(o) = \sum_{1 \leq j \leq m} \phi_j^a(o)(1 + p_{j,+}^a(o) - p_{j,-}^a(o)), \quad (5)$$

where  $\phi_j^a$  is a positive function so that, for  $o, o' \in \Omega$ , if  $g_j(o) \leq g_j(o')$ , then  $\phi_j^a(o) \leq \phi_j^a(o')$ . This function is intended to regulate the value of  $\Phi^a(o)$ .

Likewise, for a given action  $o \in \Omega$  the *degree of confidence for rejection* is defined as follows:

$$\Phi^r(o) = \sum_{1 \leq j \leq m} \phi_j^r(o)(1 + p_{j,-}^r(o) - p_{j,+}^r(o)), \quad (6)$$

where  $\phi_j^r$  is a positive function so that, for  $o, o' \in \Omega$ , if  $g_j(o) \leq g_j(o')$ , then  $\phi_j^r(o) \geq \phi_j^r(o')$ . It is intended to regulate the value of  $\Phi^a(o)$ .

$\Phi^a(o)$  is an additive form which measures the proximity of  $o$  to  $\Omega^a$ , and  $\Phi^r(o)$  is an additive form which measures the proximity of  $o$  to  $\Omega^r$ . The principles of *dominance* and *domination*, presented in Sect. 5.1, guarantee that  $\Phi^a$  is a monotonous-increasing function and  $\Phi^r$  is monotonous-decreasing function, just as is demonstrated in Kamdjoug (2003).

Several regulating functions might be considered, but the majority introduce a significant scale-based bias. Exponential functions make an ideal compro-

mise in a way that is suitable to the present methodological context. These exponential functions are defined as follows:

$$\phi_j^a(o) = e^{\omega_j \gamma_j(o) + \alpha_j}, \quad \phi_j^r(o) = e^{-\omega_j \gamma_j(o) - \alpha_j}, \quad \text{where } \omega_j \geq 0, \alpha_j \geq 0. \quad (7)$$

Finally, for a given action  $o \in \Omega^d$ , the acceptance of  $o$  is recommended when the value of  $\Phi^a(o)$  is sufficiently greater than the value of  $\Phi^r(o)$ , otherwise rejection is recommended:

$$\begin{array}{ll} \text{if } \frac{\Phi^a(o)}{\Phi^a(o) + \Phi^r(o)} \geq \eta \text{ (where } \eta \in [0.5, 1]) \text{ then} & o \text{ is accepted,} \\ \text{else} & o \text{ is refused.} \end{array}$$

The threshold  $\eta \in [0.5, 1]$  defines exactly at what point an action is accepted or rejected. The precise limits of this threshold are established empirically, during discussions with the decision-makers.

## 6 A practical application of the proposed methodology to the refinancing of MFIs

Very few projects in the field of MCDA studies deal with microfinance. Nevertheless, a study by Kamdjoug (1999) applies the ELECTRE III method (Roy & Bouyssou, 1993) to the problem of new MFI site selection. However, existing multi-criteria methods were not adapted to the selection process for MFI seeking refinancing. Therefore, to meet this theoretical and methodological need, the present methodology is proposed. This methodology was tested with success on the selection process for candidates in the second year ENST Bretagne engineering programme (Kamdjoug, 2003). Following the positive results of this test, the methodology was applied with confidence in the field of microfinance. In this section, we describe how the methodology was applied to the microfinance decision-making process of an organized network of rural financial institutions in Cameroon. Five *Microfinance and Development* (MIFED) experts were involved. Their task was to decide whether a *Microfinance Institution* (MFI) is financially viable or not. The group of institutions used to test the theoretical model was composed of 18 real MFIs.

### 6.1 Evaluation criteria

Five criteria were designed to identify financially viable MFI on the basis of their sustainability and ability to provide quality services to their clients:

- A: *The real funding needs of the MFI*. This criterion gauges if the income generating activities of the MFI clients can justify the quantity of funds

requested. This is because loan repayment feasibility and timing depend very much on MFI lending activity as well as on the business activity of the MFI clients.

- B: *MFI credit portfolio management*. This criterion assesses the quality of credit portfolio management using instruments such as financial ratios, credit recovery and loan repayment periods.
- C: *MFI-active member relations*. This criterion evaluates MFI managerial staff-support team relations, member dedication to operational efficiency and the level of involvement of women in managerial positions.
- D: *MFI information disclosure levels*. This criterion evaluates the MFI on the basis of the frequency of work-oriented meetings between different levels of MFI management and the real impact these sessions have on MFI members.
- E: *MFI outreach and growth potential*. This criterion evaluates the MFI on the basis of the relative increase in the number of MFI clients and the size of the average savings and loan transaction.

These criteria allow us to gauge MFI administration levels, MFI sustainability levels and MFI efficiency in administering financial services that support productive client micro-projects. Even though the criteria are based on a mixture of quantitative and qualitative data, we use ordinal scales to evaluate them. Each criterion is evaluated using the following evaluation scale and codes: 0 for “totally unacceptable”, 1 for “unacceptable”, 2 for “acceptable” and 3 for “very acceptable”. Therefore, the decision space  $\Omega$  contains 1,024 objects.

## 6.2 Decision-makers rules

Table 1 presents, the set of decision rules, for each decision-maker. For example, decision rule (2 3 1 0 0) of Expert 3 should be interpreted as *Expert 3 recommends accepting the MFI whenever it is judged “acceptable” on the basis of criterion A, “very acceptable” for criterion B and “unacceptable” for criterion C* (no matter the outcome of the evaluation of criteria **D** and **E**).

Table 2 gives the evaluation scale proportions and standard deviations for the five decision rule criteria.<sup>1</sup> These proportions and standard deviations give us information regarding the rules applied by each expert. When an expert attaches great importance to a criterion, this criterion is considered to be proportionally high with minimal standard deviation. For example, in Expert 3’s decision rules, criterion **B** is said to be proportionally high (1) with min-

<sup>1</sup> In order to compute the proportion and standard deviation for each criterion, we proceed in the following way: for each expert, we use the value assigned to each criterion by each decision rule (e.g.  $x_i$ ). From this value, we construct a Bernoulli variable using the number 1, when  $x_i > 1$ —otherwise 0 is used. Then we calculate the sum of the Bernoulli variables obtained from the decision rules of the corresponding expert. This constitutes a Binomial variable. The ratio of the sum of the Bernoulli variable over the number of decision rules corresponds to the proportion of the criterion for that expert. The standard deviation of the criterion is the standard deviation of the Binomial variable obtained by summing the Bernoulli variables.

**Table 1** The experts' decision rules

Expert 1	{(2 2 0 0 0), (1 3 3 1 0), (1 3 0 2 1), (1 2 2 3 1), (1 3 1 0 2), (1 3 0 1 2), (0 2 2 2 2), (1 2 3 1 3), (0 3 3 1 3), (3 1 3 2 3), (1 2 0 3 3)}
Expert 2	{(3 3 1 0 0), (2 2 2 0 0), (3 3 0 1 0), (3 2 1 1 0), (2 2 0 2 0), (1 3 1 2 0), (3 1 2 2 0), (2 1 2 3 0), (1 2 2 3 0), (3 2 0 0 1), (2 3 1 0 1), (2 3 0 1 1), (1 2 2 2 1), (2 1 3 2 1), (1 2 0 3 1), (2 1 1 3 1), (2 3 0 0 2), (2 2 1 0 2), (2 2 0 1 2), (1 3 0 2 2), (1 2 1 2 2), (0 3 3 3 2), (2 2 0 0 3), (1 3 3 0 3), (2 1 2 1 3), (2 1 0 2 3), (0 3 2 3 3)}
Expert 3	{(2 3 1 0 0), (2 2 2 0 0), (0 3 2 0 0), (0 2 3 0 0), (2 2 1 1 0), (0 2 2 1 0), (2 2 0 2 0), (1 2 0 3 0), (0 3 0 3 0), (1 2 2 0 1), (2 3 0 1 1), (0 3 0 2 1), (2 3 0 0 2), (2 2 1 0 2), (0 2 2 0 2), (2 2 0 1 2), (1 3 0 1 2), (1 2 0 2 2), (0 2 0 3 2), (2 2 0 0 3), (1 3 1 0 3)}
Expert 4	{(3 2 2 0 0), (2 2 3 0 0), (1 3 3 0 0), (3 3 1 1 0), (2 2 2 1 0), (0 3 3 2 0), (3 3 0 3 0), (1 2 2 3 0), (3 0 3 3 0), (0 2 3 3 0), (1 3 2 1 1), (3 1 3 1 1), (0 3 3 1 1), (2 1 2 2 1), (1 2 2 2 1), (0 3 2 2 1), (3 2 0 3 1), (2 0 3 3 1), (3 3 1 0 2), (1 2 3 0 2), (2 2 0 2 2), (0 2 2 2 2), (3 0 3 2 2), (2 0 2 3 2), (2 2 2 0 3), (2 1 2 1 3), (0 3 2 1 3), (1 2 1 3 3)}
Expert 5	{(2 2 2 0 0), (3 1 3 0 0), (2 3 1 1 0), (3 0 2 1 0), (3 2 0 2 0), (2 2 1 2 0), (2 0 2 2 0), (2 2 0 3 0), (3 3 0 0 1), (3 2 1 0 1), (2 2 0 2 1), (3 0 1 3 1), (3 2 0 0 2), (2 3 0 0 2), (3 0 2 0 2), (2 1 2 0 2), (2 0 3 0 2), (3 1 0 2 2), (2 0 1 2 2), (2 0 0 3 2), (2 2 1 1 3), (2 0 2 1 3), (2 0 0 2 3)}

**Table 2** Statistics on the criteria in expert decision rules

	Statistics	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>
Expert 1	Proportion	2/11	10/11	6/11	5/11	7/11
	Standard deviation	1.28	0.95	1.65	1.65	1.59
Expert 2	Proportion	18/27	21/27	10/27	14/27	11/27
	Standard deviation	2.45	2.16	2.51	2.60	2.55
Expert 3	Proportion	9/21	21/21	6/21	6/21	9/21
	Standard deviation	2.27	0.00	2.07	2.07	2.27
Expert 4	Proportion	16/28	21/28	22/28	15/28	10/28
	Standard deviation	2.62	2.29	2.17	2.64	2.53
Expert 5	Proportion	23/23	11/23	8/23	10/23	11/23
	Standard deviation	0.00	2.40	2.28	2.38	2.40

imal standard deviation (0). Since criterion **B** measures the credit portfolio management quality, it implies that Expert 3 is more likely to reject an MFI with an inclination towards risk-incurring credit portfolio management. And so, according to Expert 3's decision rules, if the MFI is to become sustainable, it must maintain an average level of acceptability with respect to criterion **B**.

### 6.3 Consensus base

A closer look at the decision rules in Table 1 reveals that, in some cases, there are differences in the way that the experts formulate their decision rules. This indicates that, in the beginning, the experts do not assign criteria the same level of contribution to the decision even though they must eventually reach a consensual final decision. In practice, however, it is difficult to capture and conceptualise the negotiating process that the experts carry out when working to reach a cumulative consensus on their final recommendations for the MFI.

**Table 3** Consensus decision rules

Thresholds	Decision rules $R^a$ and $R^r$
$\tau_1 = 3 \ \tau_2 = 1$	$R^a = \{(03313), (12313), (31330), (12033), (13212), (13302), (21213), (21231), (21321), (31221), (02222), (12221), (12230), (13022), (13031), (13121), (13310), (22003), (22012), (22102), (23002), (23011), (23101), (23110), (32002), (32101), (32110), (33001), (33100), (22020), (22200)\}$
[Majority vote]	$R^r = \{(33000), (32100), (32010), (23010), (23001), (22101), (22011), (22002), (13210), (13201), (13120), (13111), (13102), (13030), (13003), (12130), (12121), (03310), (31310), (31130), (21320), (21131), (20330), (12320), (12311), (12023), (03230), (03212), (02321), (02231), (31212), (31122), (31113), (31032), (30321), (30231), (21312), (12213), (03303), (02313), (31303), (30313), (30223), (30133), (20323), (03133), (11333)\}$
$\tau_1 = 4 \ \tau_2 = 2$	$R^a = \{(31323), (03233), (03332), (12133), (13303), (12222), (12231), (13221), (13320), (22113), (23111), (32003), (32012), (32102), (32111), (33011), (33101), (33110), (22021), (22030), (22120), (23002), (32020), (22200)\}$
[Intermediate vote]	$R^r = \{(32100), (23100), (23001), (22002), (33010), (32011), (22111), (13021), (13301), (13220), (13211), (13130), (12320), (31320), (31230), (21330), (21222), (13203), (13113), (12312), (12303), (12213), (12132), (12123), (03312), (03303), (03213), (02313), (31312), (31303), (03331), (03133), (31133), (11333), (30333)\}$
$\tau_1 = 5 \ \tau_2 = 1$	$R^a = \{(22203), (32031), (33030), (33102), (22022), (33110), (22210), (22300), (32200)\}$
[Unanimity vote]	$R^r = \{(33000), (32100), (32010), (23010), (23001), (22101), (22011), (22002), (13210), (13201), (13120), (13111), (13102), (13030), (13003), (12130), (12121), (03310), (31310), (31130), (21320), (21131), (20330), (12320), (12311), (12023), (03230), (03212), (02321), (02231), (31212), (31122), (31113), (31032), (30321), (30231), (21312), (12213), (03303), (02313), (31303), (30313), (30223), (30133), (20323), (03133), (11333)\}$

Therefore, if one is to determine how common decision rules are made, it is necessary to explore different ways in which experts might reach a cumulative consensus. We propose and test three alternative voting rules (or cumulative decision rules): for the unanimity vote, the suggested values are  $\tau_1 = 5$  and  $\tau_2 = 1$ , the majority values are  $\tau_1 = 3$  and  $\tau_2 = 1$ , and the intermediate values are  $\tau_1 = 4$  and  $\tau_2 = 2$ .

Table 3 presents the cumulative decision rules of the consensus. There are 31 decision rules for representing the minimum conditions for obtaining an “acceptance” recommendation for MFI refinancing when the majority vote option is applied. The number is reduced to 9 decision rules when the unanimity vote is applied. These results illustrate the diversity of the minimal profile for representing when an MFI is approved for refinancing under a majority vote.

Note that, from a practical point of view, the theoretical model applies the decision strategies to sample data taken from a village bank. Then model recommendations are compared to real decisions that have been taken in the past.

**Table 4** The theoretical model versus the experts' recommendations

cveca	$\tau_1 = 3, \tau_2 = 1$	$\tau_1 = 4, \tau_2 = 2$	$\tau_1 = 5, \tau_2 = 1$	Decisions
(3 2 2 2 2)	Accepted	Accepted	Accepted	Accepted
(3 3 3 3 2)	Accepted	Accepted	Accepted	Accepted
(2 2 3 3 2)	Accepted	Accepted	Accepted	Accepted
(2 2 2 2 1)	Accepted	Accepted	Accepted	Accepted
(2 0 2 1 1)	Rejected	Rejected	Rejected	Rejected
(2 1 1 2 1)	Rejected	Rejected	Rejected	Rejected
(2 3 3 3 2)	Accepted	Accepted	Accepted	Accepted
(2 0 1 2 1)	Rejected	Rejected	Rejected	Rejected
(1 1 2 1 2)	Rejected	Rejected	Rejected	Rejected
(2 2 2 3 2)	Accepted	Accepted	Accepted	Accepted
(3 3 2 3 2)	Accepted	Accepted	Accepted	Accepted
(2 0 1 2 1)	Rejected	Rejected	Rejected	Rejected
(3 3 3 3 2)	Accepted	Accepted	Accepted	Accepted
(2 1 2 3 2)	Rejected	Rejected	Rejected	Accepted
(1 0 0 2 1)	Rejected	Rejected	Rejected	Rejected
(2 1 2 1 1)	Rejected	Rejected	Rejected	Accepted
(2 2 3 3 3)	Accepted	Accepted	Accepted	Accepted
(2 1 1 1 1)	Rejected	Rejected	Rejected	Rejected

Finally, parameters  $\tau_1$  and  $\tau_2$  are adjusted to best fit recommendations and past decisions. These two thresholds can also be used as control parameters that will allow “easy” or “difficult” conditions for refinancing.

#### 6.4 Analysis and recommendations

The acceptance and rejection subsets lead to fairly well defined scenarios that leave limited space for ambiguity. The subset for dubious MFI, however, is an entirely different matter and needs to be adjusted before it can be useful for formulating recommendations from the present model. For this reason, before processing the MFI in the dubious subset, we must first adjust our model's ATREE parameters so that it will produce results that are closer to the experts' recommendations (see Table 4). Furthermore, there is the matter of dubious subset voting rules. In the case of the unanimity vote, no MFI is in the dubious subset, therefore it is not possible to change the recommendations by modifying the parameters. But in the case of intermediate and majority votes, only one MFI, (2 1 2 3 2), is in the dubious subset's.

A closer analysis of Table 4 demonstrates that all MFI shown to have poor credit portfolio management were rejected by our model (which is because they were assigned a value of 0 or 1 for criterion **B**). This recommendation confirms the importance of meticulous MFI credit management and is consistent with the decision-makers' concerns. In the case of two MFI however, we observe two contradictions between the model's recommendations and those of the experts: (2 1 2 1 1) and (2 1 2 3 2). These two MFI were accepted by the decision-makers even though their credit portfolio management is considered

to be risk-incurring. It is for this reason that our model rejects them. When this discrepancy was raised with the experts, they justified their acceptance of these two MFI by pointing out that, at the time of the evaluation, the credit management team for those MFI had just been changed and the new team was seen to be practising sound management. Unfortunately, the experts' recommendations on these two MFI (values (2 1 2 1 1) and (2 1 2 3 2)) were based on additional information that the model could not take into account. In such situations, the decision-makers can disregard the model's recommendation and base their decision on background knowledge that their professional experience has shown to be significant.

## 7 Conclusion

This paper proposes a three-step multicriteria decision aid methodology to assist a group of decision-makers in an *acceptance/rejection* recommendation task. The first phase is based on decision-makers' strategies, the second one on the construction of a consensus base and the last on an original multi-criteria decision aid tool.

We also present a case study in microfinance decision making for 18 concrete decisions taken by a group of five experts. The recommendations provided by our methodology are very similar to those of the experts.

Moreover our approach allows us to build a system that accumulates and shares expert knowledge. This system would allow MIFED experts to process a greater number of refinancing applications with more efficiency than is currently possible. It would also enable foreign and local experts to exchange knowledge and resources. The usefulness of this methodological tool can be justified for two reasons. First, there are not enough microfinance experts to meet current demands in Cameroon and second, those foreign consultants who have made themselves available to supervise the project only do so temporarily.

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