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Application of the Choquet Integral: A Case Study on a Personnel Selection Problem

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Abstract: Personnel selection plays a decisive role in human resource management since it determines the input quality of personnel. One approach, fuzzy decision-making methods, has become popular in decision making for personnel selection, considering those methods provide a wide range of tools for dealing with uncertainty. Choquet integral is an aggregation operator, frequently used to unite interrelated information. Choquet integral, with respect to fuzzy, allows consideration of the phenomenon of dependence between criteria. In this paper, personnel selection was performed using the Choquet integral, based on a fuzzy measure. The problem of the evaluation of employees is performed with respect to the personal characteristics of the employees, task performance, employee–employee relationship approaches, and effectiveness of communication.

Keywords: personnel selection; multi decision criteria; Choquet integral; fuzzy measure

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1. Introduction

The 2030 Agenda for Sustainable Development proposed by the United Nations (UN) in 2015, created a framework to tackle poverty, education, climate change, gender equality etc., at a global level [1]. To achieve sustainable development, 17 Sustainable Development Goals (SDGs) were identified as crucial to address, including many different actions from different fields. Decision making is recognized as key in supporting SDG targets [2] and should comprehend targets from various goals. Implementing sustainable decision-making processes is identified as essential for businesses, and it should be implemented at every level [3]. Authors in [4] investigate sustainability as a method for decision-making, highlighting decision-making qualities such as realism and impartiality.

In the field of human resources, scholars have also investigated the principle of the sustainable Human Resources Management (HRM). Three dimensions of sustainable HRM have been identified as equity, well-being, and employee development [5]. Long-term human resources development should be a strategic approach for management [6]. Evaluation of human resources and decision making are interlinked in many organisations [7]. The most important link of the HRM chain is personnel selection [8].

Personnel selection involves the assessment of candidates based on pre-defined criteria. It represents strategic decision-making process that many organizations have been implementing. Defining the criteria that candidates should meet is a very demanding task and depends on the business responsibilities and tasks that the candidates should meet, dynamic environments, and evolving technologies. The basic task is to select the candidates who best suit the business tasks they need to fulfil. It is important to choose an evaluation procedure that is reliable, valid, and unbiased. For that goal, various selection systems have originated. Different authors propose different sets of criteria and methods.

In [9], authors investigated the adaptive performance for a project manager and identified eight major performance components: (i) Learning work tasks, technologies and

procedures, (ii) Dealing with uncertain and unpredictable work situations, (iii) Demonstrating physically oriented adaptability, (iv) Solving problems creatively, (v) Handling emergencies or crisis situations, (vi) Handling work stress, (vii) Demonstrating interpersonal adaptability, and (viii) Demonstrating cultural adaptability.

In [10], eight adaptive performances: (i) Handling emergencies or crisis situations, (ii) Handling work stress, (iii) Solving problems creatively, (iv) Dealing with uncertain and unpredictable work situations, (v) Learning work tasks, technologies, and procedures, (vi) Demonstrating interpersonal adaptability, (vii) Demonstrating cultural adaptability, and (viii) Demonstrating physically oriented adaptability, are considered.

Selecting the best employees in [11] was performed by paying attention to the following criteria: (i) Work performance, (ii) Attitude and Personality, (iii) Teamwork, and (iv) Intellectual capacity.

A new hybrid MCDM model for personnel selection, based on a novel grey PIPRECIA and a grey OCRA method is proposed in [12]. The new extension of the PIPRECIA-G was used to determine criteria weights, and for ranking of alternatives for the purposes of personnel selection, authors used the OCRA-G method. For the evaluation of the criteria, the 0–1 scale was used.

In paper [7], authors proposed a new rule-based expert system with the ability to imitate human thinking and identify the facts of importance for decision making that provide a reduction in errors, enables transparency, and improves the efficiency of the decision-making process. The researchers implemented expert systems within the human performance evaluation in the case of the Croatian PTI system.

A methodology that combines the fuzzy combinative distance-based assessment method with the fuzzy envelopes for hesitant fuzzy linguistic term sets was presented by authors in paper [8]. Authors performed a sensitivity analysis demonstrating the validity and stability of the obtained ranking results and compared their results with the results of numerous fuzzy multi-criteria decision-making methods.

A two-phase model for personnel selection was developed in [13]. The research proposes a decision-making method based on computing with linguistic variables. The proposed method reduces the time for evaluating a huge number of applicants and eliminates unsuitable applicants in the first stage using TOPSIS. It avoids subjective judgement by experts who are using 2 types of 2-tuple linguistic variables for expressing opinions. The PROMETHEE method is used for calculating the outranking index of each suitable candidate.

In [14], the authors aimed at extending the fuzzy MULTIMOORA for linguistic reasoning under group decision making. It was further modified in this study, and it enables the aggregation of subjective assessments of the decision-makers and thus offers an opportunity to perform more robust personnel selection procedures.

Since both quantitative and qualitative criteria are considered in the personnel selection process, the research presented in [15] introduces crisp numbers and linguistic neutrosophic numbers (LNNs) simultaneously, to express hybrid evaluation information.

In [16], a fuzzy method based on the Hamming distance and a Matching Level Index for staff selection based on competence management, and the comparison with the valuation that the company considers the best in each competence (ideal candidate) is proposed. To evaluate and rank the candidates for a job, authors study the similarity between each candidate and the ideal candidate (the virtual candidate).

In [17], the authors proposed a personnel selection system based on the Fuzzy Analytic Hierarchy Process (FAHP) and SAW method. The proposed model is applied to a personnel selection problem in a Telecommunication company.

Furthermore, a fuzzy multi-decision criteria making (MDCM) method was enhanced with hesitant fuzzy linguistic term sets (HFLTS), developing a tool for personnel selection [8].

Individual performance is a key indicator of the company, which can contribute to productivity and competitiveness [18].

In [19], possible approaches to design a suitable aggregation operation and describe a method for such a kind of design process, that explicitly models expert-elicited relationships among criteria, enforcing some properties on a Choquet capacity, are reviewed.

The major goals of the study conducted in [20] are to determine the most important customer satisfaction criterion and to determine which fast-food restaurant is preferred over the other, from the perception of consumers' satisfaction, using the Choquet integral.

The identification method proposed in [21] is integrated into an aiding system of tomographic image interpretation. The proposed method fuses attributes extracted from the tomographic images with the Choquet integral and it increases the quality of the cartography compared with the results obtained with an identification method based on the entropy.

Since the efficiency of software measurement is determined by highly unpredictable software quality, the Choquet integral is used in [22] to quantify the various quality parameters and efficiently compare the set of software products.

In paper [23], the author presented chosen applications of the Choquet integral in some fields of economics, for example for studying the model describing the investor's behavior in the financial market, where his decision depends on the expected future price of an asset. He used the Choquet integral in decision making under risk and uncertainty.

Paper [24] proposes the pedestrian navigation system, which deals with subjective information, where the route setting part chooses the route with the highest subjective satisfaction degree. Fuzzy measures and integrals are applied to the calculation of the satisfaction degree of the route, which reflects the users' taste for routes.

A method of estimating software cost based on the application of the Choquet integral, a form of multicriteria decision-making where the numeric value computed by the Choquet integral is an expression of the degree of preference of one technology over another in developing a software system, is given in [25].

Paper [26] reviews the main advances regarding the use of the Choquet and Sugeno integrals in a multi-criteria decision. Paper [27] also gives the overview of practical examples describing the application of fuzzy measures and the Choquet integral, including interface properties evaluation, technical diagnostics, navigation, and image processing.

Choquet integral research has been applied to various management problems (see [20,28,29]). In this study, a decision support tool using an integrated Choquet integral is applied for a postal company to support personnel selection. The aim is to present a personnel selection method based on pre-defined criteria using the Choquet integral.

The paper is organized in the following way. Section 1 gives a state-of-the-art literature review focused on the personnel selection and sustainability. The problem description and descriptive statistics of input data is presented in Section 2. Section 3 contains the ranking of employees using the TOPSIS method and the PROMETHEE method. Section 4 comprises the main results—the application of the discrete Choquet integral in staff selection. Discussion, including the comparison of the results with the existing multi-criteria decision-making methods, and the concluding remarks are given in the Section 5.

2. Problem Description and Descriptive Statistics of Input Data

The goal of employee ranking is the selection of employees to new positions. The input data for employee ranking are the answers from the questionnaire filled out by the manager. For selecting the most competent workers to perform tasks in the system of automated sorting of shipments in the postal and logistics center of the Public Enterprise The Post of Serbia, with its headquarters in Novi Sad, their evaluation and selection were performed. The questionnaire consists of four parts and each part (group) is a separate criterion in the multi-criteria decision-making analysis. In answer to each question, from each part of the questionnaire, the employee was rated by the manager with a grade from 1 to 5, according to the Likert Scale, whereby:

1. Strongly Disagree,
2. Disagree,

3. Undecided,
4. Agree,
5. Strongly Agree.

The survey is shown in Table 1.

Table 1. Questions in the survey.

A—The Personal Characteristics of Employee
A_1—The employee maintains personal discipline
A_2—The employee could modify knowledge and skills
A_3—The employee easily learns new tasks, technologies, and procedures
A_4—The employee gives suggestions for improving the work processes
B—Task performance
B_1—The employee follows the rules and procedures of the organization
B_2—Employee's mistakes were not critical in terms of safety and work quality
B_3—The employee almost never breaks rules
C—Employee employee relationship approaches
C_1—The employee is willing to devote time, energy, and effort to adapts to the changing work environment and new employees in the team
C_2—The employee willingly adjusting on-the-job behavior and shows respect for others' values and customs
C_3—The employee active participates in joint activities with other employees.
D—Effectiveness of communication
D_1—The employee has good verbal skills in the interaction between members of the working team
D_2—The communication between the employee and manager is careful and effective
D_3—The employee has good verbal skills to organize work in small groups

For 35 employees, their superiors filled in the given survey. Among the 35 workers, there were 5 female workers and 30 male workers. The average length of service of employees is 17.11 years with a standard deviation of 9.803. The minimum length of service is 1 year, and the maximum length of service is 38 years.

The results of the survey for 35 employees are shown in Table A1. Descriptive statistics for each sub-criterion are given in Table 2.

Table 2. Descriptive statistics.

	n	Minimum	Maximum	Mean	Std. Deviation
A_1	35	2.00	5.00	4.4571	1.03875
A_2	35	1.00	5.00	3.5429	1.14642
A_3	35	1.00	5.00	3.4000	1.26491
A_4	35	1.00	5.00	2.7429	1.31379
B_1	35	2.00	5.00	4.1714	0.61767
B_2	35	2.00	5.00	3.6571	0.99832
B_3	35	1.00	5.00	3.0571	1.23533
C_1	35	2.00	5.00	3.6857	0.90005
C_2	35	1.00	5.00	4.4000	0.97619
C_3	35	1.00	5.00	3.2286	1.33032

Table 2. *Cont.*

	n	Minimum	Maximum	Mean	Std. Deviation
D_1	35	2.00	5.00	4.6571	0.63906
D_2	35	3.00	5.00	4.5429	0.61083
D_3	35	1.00	5.00	2.5714	1.44070

3. Rankings Obtained Using Some Standard Methods

In this part of the paper, the ranking of 35 employees was performed using two standard methods, TOPSIS and PROMETHEE.

3.1. Ranking Employees Using TOPSIS Method

The TOPSIS method (Technique for Order Preference by Similarity to Ideal Solution) has often been used successfully to help decision-makers solve many practical problems in different areas of the reference application where it has been applied, [30–34].

Criteria (C) with assigned weights (w_j) are given in Table 3.

Table 3. Criteria weights.

C	The Personal Characteristics of Employee	Task Performance	Employee–Employee Relationship Approaches	Effectiveness of Communication
w_j	0.3	0.4	0.1	0.2

The values x_{ij} are the arithmetic means of the individual answers in the group of questions. First, the values x_{ij} are replaced with the normalized or relative numbers

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, \tag{1}$$

where m is the number of alternatives. Then, the weighted normalized decision matrix $V = [v_{ij}]_{m \times n}$, $v_{ij} = w_j^* r_{ij}$ is calculated, where $w_j^* = \frac{w_j}{\sqrt{\sum_{k=1}^{n} w_k}}$ and w_j is the original weight assigned to the criterion j, $j = 1, \ldots, n$.

The ideal solution (A^+) is a vector whose coordinates are all the best values of alternatives by criteria, i.e., the highest values by criteria that are maximized and the lowest values by criteria that are minimized. On the other hand, the coordinates of the anti-ideal solution (A^-) are the lowest values according to the maximizing criteria and the highest values according to the minimizing criteria, see [31]:

$$\begin{aligned} A^+ &= \left(\left(\max_i v_{ij} \middle| \forall K_j \in K' \right), \left(\min_i v_{ij} \middle| \forall K_j \in K'' \right) \right) \\ &= \left(v_1^+, v_2^+, \ldots, v_j^+, \ldots, v_n^+ \right),\ i = 1, \ldots, m \end{aligned} \tag{2}$$

$$\begin{aligned} A^- &= \left(\left(\min_i v_{ij} \middle| \forall K_j \in K' \right), \left(\max_i v_{ij} \middle| \forall K_j \in K'' \right) \right) \\ &= \left(v_1^-, v_2^-, \ldots, v_j^-, \ldots, v_n^- \right),\ i = 1, \ldots, m \end{aligned} \tag{3}$$

where K' is associated with the criteria having a positive impact and K'' is associated with the criteria having a negative impact.

The distance of alternatives $(v_1, v_2, \ldots, v_m)$ and the ideal solution A^+ and anti-ideal solution A^- are calculated using the Euclidean distance in n-dimensional space (see [31]):

$$d_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^+ \right)^2},\ i = 1, \ldots, m, \tag{4}$$

$$d_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2},\ i = 1, \ldots, m. \quad (5)$$

The relative closeness of alternatives to the ideal solution is calculated as follows (see [31])

$$C_i = \frac{d_i^-}{d_i^- + d_i^+},\ i = 1, \ldots, m. \quad (6)$$

The relative closeness of alternatives to the ideal solution for all 35 workers was calculated and their ranking is presented in Table A2.

Based on the calculated relative closeness of alternatives to the ideal solution for all 35 workers the following ranking is obtained

$E_1, E_2, E_4, E_7, E_9, E_6, E_{13}, E_{34}, E_{16}, E_{31}, E_{24}, E_8, E_{29}, E_{23}, E_{19}, E_3, E_{15}, E_{12}, E_{17}, E_{22}, E_{28}, E_{35}, E_{10}, E_{33}, E_{21}, E_{14}, E_{11}, E_{20}, E_{27}, E_5, E_{26}, E_{18}, E_{30}, E_{32}, E_{25}$,

where the rank of employees E_{26} and E_{18} is the same, as well as the rank of employees E_{32} and E_{25}.

3.2. Ranking Employees Using the PROMETHEE Method

PROMETHEE, as well as other multicriteria methods, evaluates alternatives based on all defined criteria if the weight values of the individual criteria in relation to the goal are already known (see [35]). The process of evaluating alternatives begins by selecting the preference function for each criterion, keeping in mind the type of alternatives being compared and evaluated, the metrics in which the alternatives are expressed, and the reference and thresholds that can be set, while the alternatives can be treated equally in the evaluation process.

Let $\{a_1, a_2, \ldots, a_m\}$ be the set of alternatives and let $K_1, K_2, \ldots, K_n$ be the criteria. For every alternative a_i, the set of evaluation criteria $\{f_1(a_i),\ f_2(a_i),\ \ldots,\ f_n(a_i)\}$ is given. The difference between the evaluations of two alternatives for the criteria K_l is

$$d_l(a_i,\ a_j) = f_l(a_i) - f_l(a_j). \quad (7)$$

Let $P_l : R \to [0,1]$ be a positive non-decreasing preference function such that $P_j(0) = 0$, $F_l(0) = 0$, for $l = 1, 2, \ldots, n$. The function P_l is called a preference function. In this paper, a linear preference function

$$P_l(d_l(a_i,\ a_j)) = \begin{cases} 0, & d_l(a_i,\ a_j) \le q_l \\ \frac{d_l(a_i,\ a_j) - q_l}{p_l - q_l}, & q_l < d_l \le p_l \\ 1, & d_l > p_l \end{cases}, \quad (8)$$

where q_l is a threshold or indifference and p_l is a threshold of strict preference, is considered.

For each criterion K_l the decision-maker considers a function

$$\pi_l(a_i,\ a_j) = P_l(d_l(a_i,\ a_j)), \quad (9)$$

such that $0 \le \pi_l(a_i,\ a_j) \le 1$.

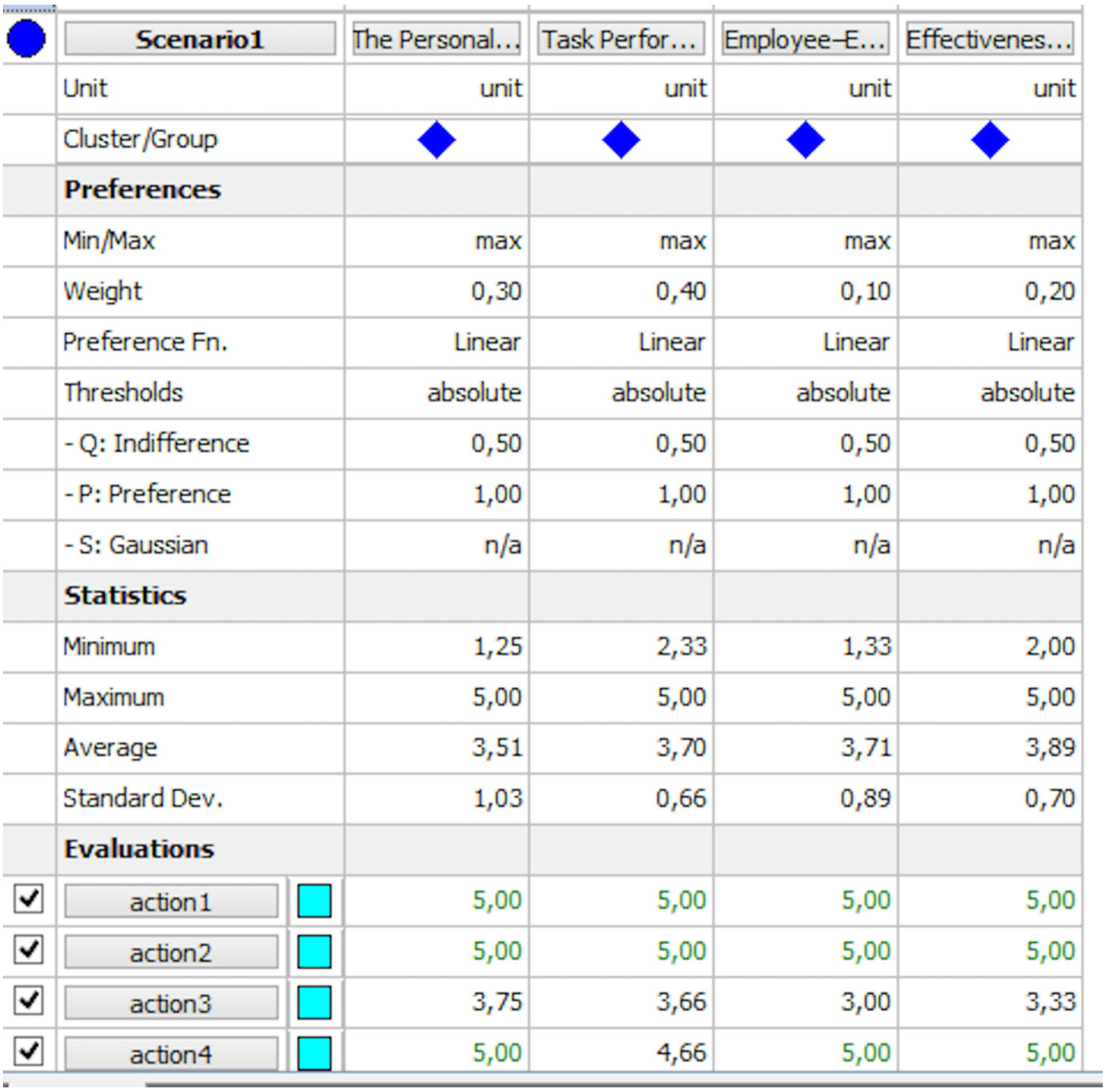
To determine the degree to which one alternative outperforms another (outranking degree), the following formula is applied

$$\Pi(a_i,\ a_j) = \sum_{j=1}^{n} w_j\, P_j\ (a_i, a_j), \quad (10)$$

where $P_j\ (a_i, a_j)$ is the value of the preference function of alternative a_i in relation to alternative a_j for criterion j, w_j is the weight of criterion j.

The obtained value $\Pi(a_i, a_j)$ is used for the calculation of the so-called positive outranking flow (*Phi*+), negative outranking flow (*Phi*−) and total outranking flow (*Phi*). Formulas for flow calculations can be found in [36].

The employee evaluation process was performed in the Visual PROMETHEE program. For each criterion, linear preference function is considered, and the boundary preference values (q_l and p_l) are determined, and after that, each alternative was evaluated with respect to each criterion (see Figure 1).



Scenario1		The Personal...	Task Perfor...	Employee-E...	Effectivenes...
Unit		unit	unit	unit	unit
Cluster/Group					
Preferences					
Min/Max		max	max	max	max
Weight		0,30	0,40	0,10	0,20
Preference Fn.		Linear	Linear	Linear	Linear
Thresholds		absolute	absolute	absolute	absolute
- Q: Indifference		0,50	0,50	0,50	0,50
- P: Preference		1,00	1,00	1,00	1,00
- S: Gaussian		n/a	n/a	n/a	n/a
Statistics					
Minimum		1,25	2,33	1,33	2,00
Maximum		5,00	5,00	5,00	5,00
Average		3,51	3,70	3,71	3,89
Standard Dev.		1,03	0,66	0,89	0,70
Evaluations					
action1		5,00	5,00	5,00	5,00
action2		5,00	5,00	5,00	5,00
action3		3,75	3,66	3,00	3,33
action4		5,00	4,66	5,00	5,00

Figure 1. User interface.

Visual PROMETHEE offers numerous possibilities for analysis and visualization of the obtained results (see Figure 2).

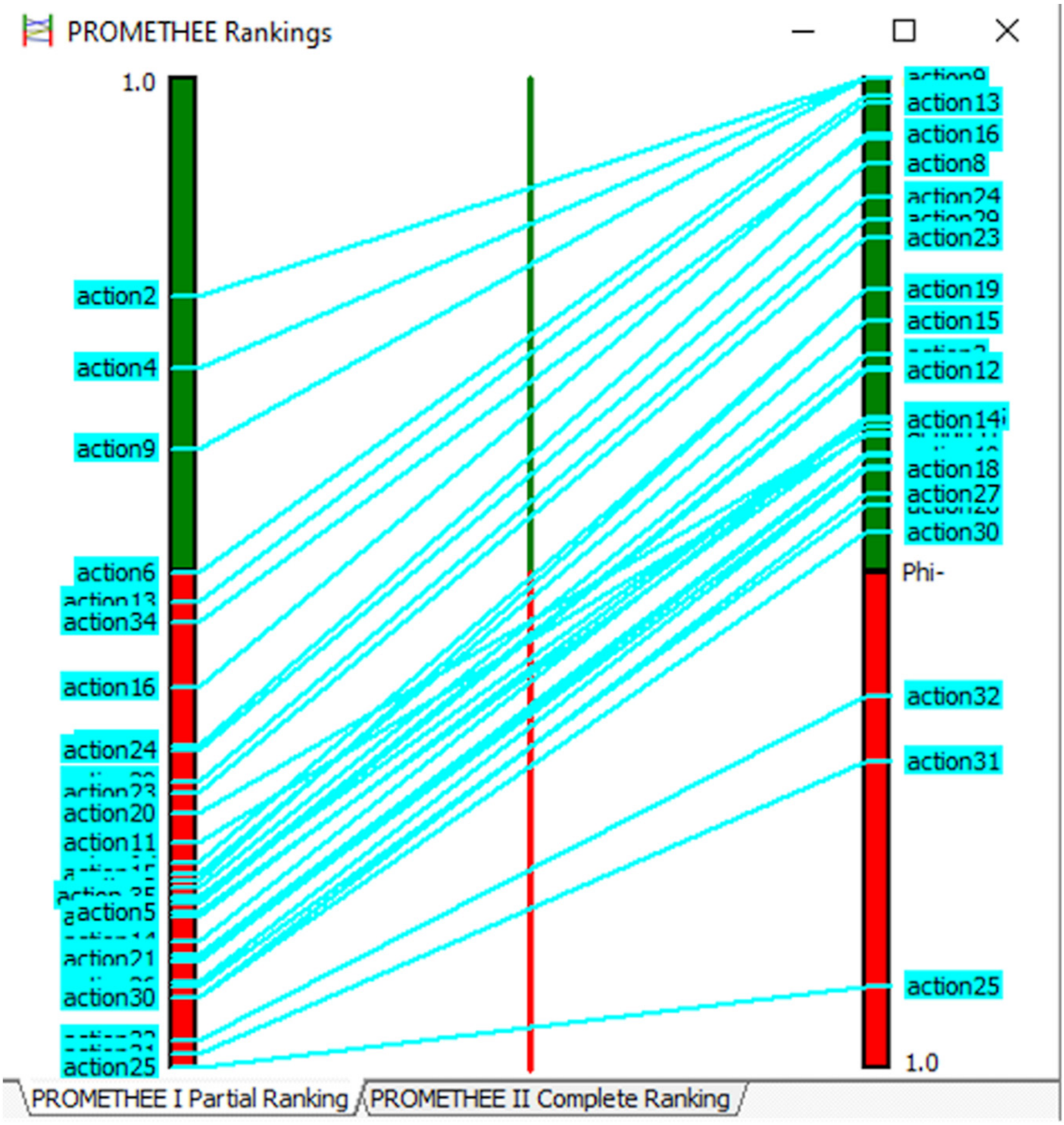


Figure 2. Final ranking of alternatives.

Figure 3 gives an overview of the results. Employees (shown in the software as action) that are within the green color are those that are rated above average and that these employees could be considered for employment. Employees in the red area are those who are below average. The best ranked are employees E_1, E_2, E_4, E_7, E_9, E_6.

When analyzing the results of the application of the PROMETHEE method, the value of the total flow (Phi) is the most significant, because this value determines the final ranking of alternatives, see Figure 3. In addition, positive outranking flow (Phi+) and negative outranking flow (Phi−) values can be analyzed for each alternative.

The values of the total outranking flow indicate how much a certain alternative is better than the average value [36], so it is concluded that employees 1,2,4,7,9 are better than the imagined average. For these employees, the value of positive outranking flow is the highest, and the value of negative outranking flow is the lowest, and that is why they are finally ranked the best.

Rank	action	Phi	Phi+	Phi-
1	action1	0,7789	0,7789	0,0000
1	action2	0,7789	0,7789	0,0000
3	action4	0,7069	0,7069	0,0000
4	action7	0,6254	0,6254	0,0000
4	action9	0,6254	0,6254	0,0000
6	action6	0,4826	0,5006	0,0180
7	action13	0,4447	0,4704	0,0256
8	action34	0,3879	0,4498	0,0619
9	action16	0,3276	0,3841	0,0565
10	action8	0,2372	0,3246	0,0874
11	action24	0,1991	0,3206	0,1216
12	action29	0,1467	0,2894	0,1426
13	action23	0,1160	0,2781	0,1621
14	action17	-0,0067	0,2076	0,2144
15	action19	-0,0250	0,1896	0,2146
16	action15	-0,0496	0,1961	0,2457
17	action3	-0,0968	0,1825	0,2792
18	action20	-0,0973	0,2557	0,3530
19	action22	-0,1237	0,1702	0,2939
20	action12	-0,1276	0,1670	0,2946
21	action11	-0,1329	0,2275	0,3604
22	action 35	-0,1704	0,1731	0,3435
23	action28	-0,1910	0,1521	0,3431
24	action5	-0,2022	0,1561	0,3582
25	action14	-0,2196	0,1269	0,3466
26	action33	-0,2645	0,1144	0,3789
27	action10	-0,2744	0,1079	0,3824
28	action21	-0,2843	0,1098	0,3941
29	action18	-0,3099	0,0858	0,3957
30	action26	-0,3499	0,0811	0,4311
31	action27	-0,3502	0,0705	0,4206
32	action30	-0,3894	0,0704	0,4598
33	action32	-0,5981	0,0271	0,6252
34	action31	-0,6758	0,0144	0,6902
35	action25	-0,9178	0,0000	0,9178

Figure 3. Total, positive, and negative flow.

In this study, all criteria were assigned a weight in the same way as in the TOPSIS method. A change in the weight of criteria does not cause a change in the ranking of the first six employees (they remain the best ranked). The most significant change in ranking occurs among the last ranked alternatives (employees). The final ranking results are

$$E_1, E_2, E_4, E_7, E_9, E_6, E_{13}, E_{34}, E_{16}, E_8, E_{24}, E_{29}, E_{23}, E_{17}, E_{19}, E_{15}, E_3, E_{20}, E_{22}, E_{12}, E_{11}, E_{35}, E_{28}, E_5, E_{14}, E_{33}, E_{10}, E_{21}, E_{18}, E_{26}, E_{27}, E_{30}, E_{32}, E_{31}, E_{25},$$

where the rank of employees E_1 and E_2 is the same, as well as the rank of employees E_7 and E_9.

All criteria were assigned a weight in the same way as in the TOPSIS method. The most significant change in ranking occurs among the last ranked alternatives (employees).

4. The Main Results

The significance of the Choquet integral (and other fuzzy integrals) is that it can represent the interaction between decision criteria because a weight of importance is attributed to every subset of criteria. If the manager wants to favor well-equilibrated employees without weak points, the ranking obtained by the weighted arithmetic mean is not fully satisfactory, since the employee who has a weakness in some aspects has been considered better than an employee with no weak points.

The first part of this section, Section 4.1 contains some basic notions and definitions from the theory of fuzzy measure and the Choquet integral. The definition of a fuzzy measure and discrete Choquet integral based on a fuzzy measure are given. Section 4.2 presents the methodology of the research. Section 4.3 includes the main results of the paper, ranking of personnel based on the Choquet integral.

4.1. Discrete Choquet Integral

The Choquet integral is based on a fuzzy measure, and it is a very popular tool for representation of preferences instead of weighted arithmetic mean. Results given in this subsection are based on [37,38].

Let S be a non-empty set and $P(S)$ be the set of all possible subsets of S. A function $m : P(A) \to [0,1]$ such that

1. $m(\varnothing) = 0$
2. $m(S) = 1$;
3. $X \subset Y \Rightarrow m(X) \leq m(Y)$, for all $X, Y \in P(S)$

is a fuzzy measure on $P(S)$.

Let $S = \{S_1, S_2, \ldots, S_n\}$ be a finite set. The discrete Choquet integral of the function $f : S \to \mathrm{R}$ with respect to the fuzzy measure $m : P(S) \to [0,1]$ is given by

$$Ch_m(a_1,\ a_2,\ \ldots, a_n) = \sum_{i=1}^{n} (a_{(i)} - a_{(i-1)}) m_{A_{(i)}}, \tag{11}$$

Each alternative or act is associated with a vector $x = [x_1, x_2, \ldots, x_k]^T$ of attributes or criteria, which represents what the decision maker will get if he chooses this alternative, and k is the number of attributes or criteria. Let X be a set of alternatives, i.e., the set of all vectors x. Based on results from [37] a preference relation $\succcurlyeq$ with respect to a fuzzy measure m and the Choquet integral for $x, y \in X$ is given by

$$x \succcurlyeq y \Leftrightarrow Ch_m(x_1, x_2, \ldots, x_k) \geq Ch_m(y_1, y_2, \ldots, y_k) \tag{12}$$

As in [38], $x \succ y$ means that $x \succcurlyeq y$ holds but $y \succcurlyeq x$ does not hold. $x = y$ means that both $x \succcurlyeq y$ and $y \succcurlyeq x$ hold. Through the paper, all preference relations are complete, i.e., all pairs of alternatives are comparable.

4.2. Methodology of Research

The first step is defining the goal of the research which is the ranking of employees. The next step was defining the ranking criteria. Each criterion consists of several sub-criteria.

The manager evaluated 35 employees with respect to four groups of criteria, performance components: A, B, C and D, with a score of 1–5 according to the Likert Scale presented in Section 2. Data from a survey on certain characteristics of employees are used as input data necessary for conducting the research. These criteria are important for the redistribution of the employees to new job positions to improve the company efficiency.

Some of the characteristics of employees are more desirable to the employer than others, so they are favored. On the other hand, there is a need for employees with weak

points to be ranked lower. For all subsets of the set of criteria, fuzzy measure is defined. Similarly fuzzy measures are assigned to each subset of the set of sub-criteria for each sub-criterion.

All fuzzy measures are defined based on the opinion of their manager on their importance in performing future business tasks.

Therefore, the ranking of workers is based on 13 questions divided into four groups, forming four criteria.

Emphasis is placed on the application of the Choquet integral—a known fuzzy integral based on the non-additive, i.e., fuzzy measure. The advantage of using the Choquet integral is reflected in the fact that in the final ranking of employees without weak points are better-ranked, which was not the case using the observed standard methods.

For the first criterion A, based on the grades assigned by the manager to the employees for sub-criteria $A_1 - A_4$, the values of the Choquet integral for criterion A were calculated for each employee. The described procedure was then repeated for criteria B, C and D.

The calculated values of the Choquet integrals for criteria A, B, C, and D were used as the input values for the final evaluation obtained by another calculation of the Choquet integral. In the end, the ranking of the employees was performed based on the obtained numerical results.

The representation of the proposed methodology based on the Choquet integral, with the considered case study, is depicted in Figure 4.

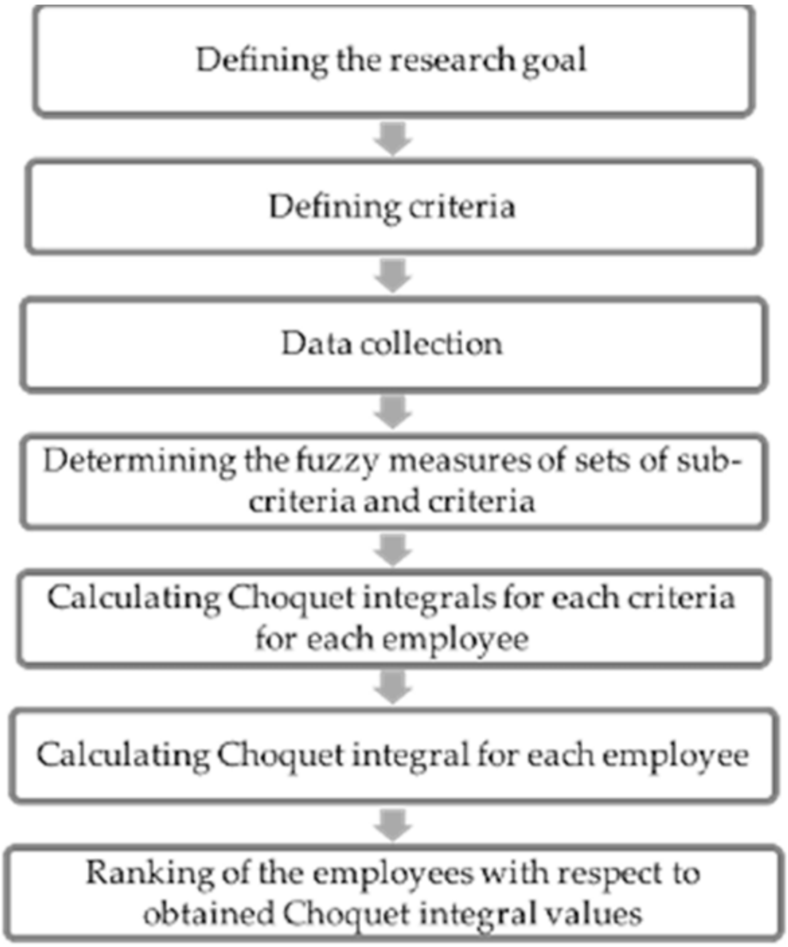


Figure 4. The procedure of the proposed methodology.

The flow chart of the computational procedure of the proposed methodology from the formulated need to the decision-making process is depicted in Figure 5.

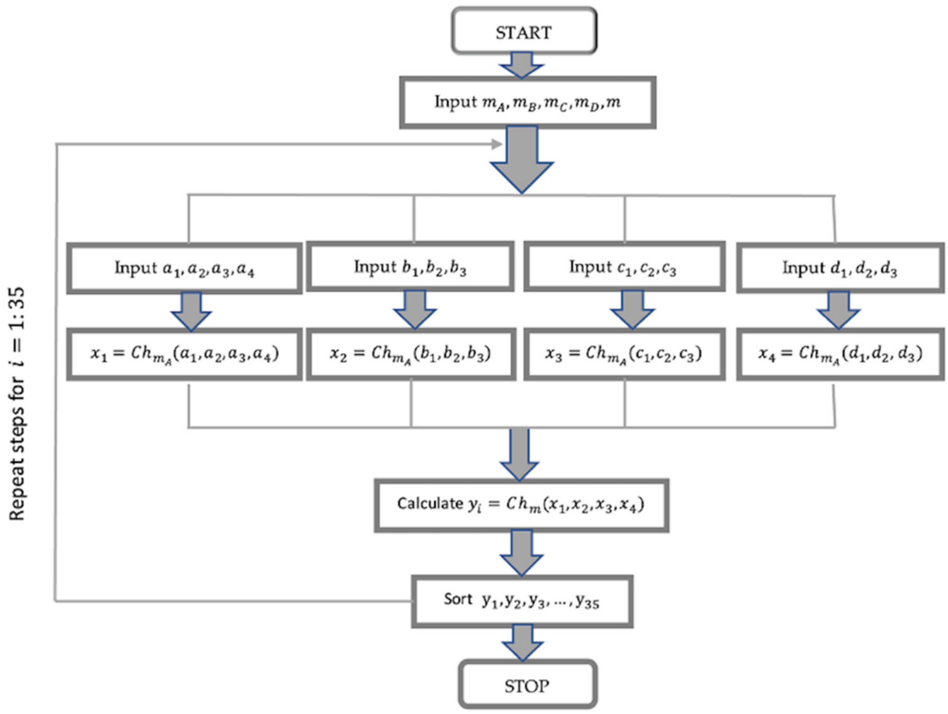


Figure 5. Flow chart of the decision-making process.

The following labels were used in the flow chart in Figure 5:

- m_A, m_B, m_C, m_D, m are fuzzy measures
- a_1, a_2, a_3, a_4 are grades for sub-criteria A_1, A_2, A_3, A_4, respectively
- b_1, b_2, b_3 are grades for sub-criteria B_1, B_2, B_3, respectively
- c_1, c_2, c_3 are grades for sub-criteria C_1, C_2, C_3, respectively
- d_1, d_2, d_3 are grades for sub-criteria D_1, D_2, D_3, respectively
- x_1 is the value of the Choquet integral of a_1, a_2, a_3, a_4 w.r.t. fuzzy measure m_A
- x_2 is the value of the Choquet integral of b_1, b_2, b_3 w.r.t. fuzzy measure m_B
- x_3 is the value of the Choquet integral of c_1, c_2, c_3 w.r.t. fuzzy measure m_C
- x_4 is the value of the Choquet integral of d_1, d_2, d_3 w.r.t. fuzzy measure m_D
- y_i is the value of the Choquet integral of x_1, x_2, x_3, x_4 w.r.t. fuzzy measure m for the i-th employee, $i = 1, 2, \ldots, 35$.

4.3. Application of the Discrete Choquet Integral for Personnel Selection

The problem of evaluation of employees is performed with respect to four subjects:

- The personal characteristics of employee,
- Task performance,
- Employee employee relationship approaches,
- Effectiveness of communication.

Usually, the problem of evaluation of employees is performed using the weighted arithmetic mean (see [18–21]).

As each of the evaluated subject consists of several sub-criteria (see Table 1), the Choquet integral was used to evaluate each of them for all employees. Using those results, each employee was evaluated, using the Choquet integral one more time

(A) The personal characteristics of employee

Consider the problem of evaluating the personal characteristics of the employee with respect to four sub-criteria: A_1—the employee maintains personal discipline, A_2—The employee could modify knowledge and skill, A_3—The employee easily learns new tasks,

technologies, and procedures and A_4—the employee gives suggestions for improving the work processes.

Each sub-criterion is rated with a value from the set $\{1, 2, 3, 4, 5\}$. The fuzzy measure m for the personal characteristics of the employee is formed in the following manner.

The sub-criterion A_4 is more important to the manager than the sub-criteria A_1, A_2 and A_3. The sub-criteria A_2 and A_3 are equally important to the manager and more important than the sub-criterion A_1. Therefore,

$$m_A(A_1) = 0.2,\ m_A(A_2) = 0.4,\ m_A(A_3) = 0.4,\ \text{and}\ m_A(A_4) = 0.5.$$

For the weights attributed to the sets $\{A_i, A_j\}$ for $i, j \in \{1, 2, 3, 4\}$ and $i \neq j$ holds $m_A(A_i, A_j) < m_A(A_i) + m_A(A_j)$, and

$$\begin{array}{l} m_A(A_1, A_2) = 0.4,\ m_A(A_1, A_3) = 0.4,\ m_A(A_1, A_4) = 0.5 \\ m_A(A_2,\ A_3) = 0.4,\ m_A(A_2, A_4) = 0.5,\ m_A(A_3, A_4) = 0.5. \end{array}$$

The manager prefers the pairs of sub-criteria A_1 and A_4, A_2 and A_4, and A_3 and A_4 over the pairs of sub-criteria A_1 and A_2, A_1 and A_3, and A_2 and A_3.

The weights attributed to the sets $\{A_i, A_j, A_k\}$ for $i, j, k \in \{1, 2, 3, 4\}$, $i \neq j$, $i \neq k$ and $j \neq k$ are

$$m_A(A_1, A_2, A_3) = 0.5,\ m_A(A_1, A_2, A_4) = 0.7,\ m_A(A_1, A_3, A_4) = 0.7,\ m_A(A_2, A_3, A_4) = 0.6.$$

The manager favors employees rated good in all three criteria $A_1,\ A_2$ and A_4, and in all three criteria $A_1,\ A_3$ and A_4. The sub-criteria $A_2,\ A_3$ and A_4 are more important to the manager than $A_1,\ A_2$ and A_3.

By definition, fuzzy measure, holds that

$$m_A(\varnothing) = 0 \text{ and } m_A(A_1, A_2, A_3, A_4) = 1.$$

For example, for the first employee, denoted by E_1, the sub-criteria A_i is rated with 5 for all i, i.e.,

$$A_{(1)} = \{A_1, A_2, A_3, A_4\}$$

and

$$Ch_{m_A}(5,5,5,5) = (5-0)m_A\left(A_{(1)}\right) + (5-5)m_A\left(A_{(2)}\right) + (5-5)m_A\left(A_{(3)}\right) + (5-5)m_A\left(A_{(4)}\right) = 5.$$

For the nineteenth employee, denoted by E_{19}, the sub-criterion A_1 is rated with 5, the sub-criterion A_2 is rated with 3, the sub-criterion A_3 is rated with 4 and the sub-criterion A_4 is rated with 2, i.e.,

$$A_{(1)} = \{A_1, A_2, A_3, A_4\}, A_{(2)} = \{A_1, A_2, A_3\}, A_{(3)} = \{A_1, A_3\} \text{ and } A_{(1)} = \{A_1\}$$

and

$$\begin{aligned} Ch_{m_A}(2,3,4,5) = (2-0)m_A\left(A_{(1)}\right) + (3-2)m_A\left(A_{(2)}\right) + (4-3)m_A\left(A_{(3)}\right) \\ +(5-4)m_A\left(A_{(4)}\right) = 2 \times 1 + 1 \times 0.5 + 1 \times 0.4 + 1 \times 0.2 = 3.1. \end{aligned}$$

Since $Ch_{m_A}(5,5,5,5) > Ch_{m_A}(2,3,4,5)$ it is obviously that employee E_1 is preferred to employee E_{19}, i.e., $E_1 \succ E_{19}$, with respect to the sub-criterion A_1.

The results of the evaluation of personal characteristics of the employee for all 35 employees obtained using the Choquet integral are presented in Table 4.

Table 4. The results of evaluation of personal characteristics of employee.

Employee	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	E_{11}	E_{12}
$Ch_{m_A}(a_1, a_2, a_3, a_4)$	5.0	5.0	3.6	5.0	2.6	4.5	4.5	4.0	4.5	2.8	3.7	3.7
Employee	E_{13}	E_{14}	E_{15}	E_{16}	E_{17}	E_{18}	E_{19}	E_{20}	E_{21}	E_{22}	E_{23}	E_{24}
$Ch_{m_A}(a_1, a_2, a_3, a_4)$	4.2	2.1	3.7	4.2	3.0	2.2	3.1	3.6	2.6	2.6	3.2	3.6
Employee	E_{25}	E_{26}	E_{27}	E_{28}	E_{29}	E_{30}	E_{31}	E_{32}	E_{33}	E_{34}	E_{35}	
$Ch_{m_A}(a_1, a_2, a_3, a_4)$	1.2	2.4	2.3	2.2	3.2	2.1	2.0	1.4	2.8	5.0	3.9	

More details can be found in Table A3.

(B) Task performance

Consider the problem of evaluation of task performance with respect to three sub-criteria: B_1—the employee follows the rules and procedures of the organization, B_2—employee's mistakes were not critical in terms of safety and work quality and B_3—the employee almost never breaks rules.

Each sub-criterion is rated with a value from the set $\{1, 2, 3, 4, 5\}$. The fuzzy measure m for the task performance is formed in the following manner.

For the manager, the sub-criterion B_2 is more important than the subject B_1 which is more important than the sub-criterion B_3. Therefore, let

$$m_B(B_1) = 0.4, m_B(B_2) = 0.5, \text{ and } m_B(B_3) = 0.3.$$

For the weights attributed to the sets $\{B_i, B_j\}$ for $i, j \in \{1, 2, 3\}$ and $i \neq j$ holds $m_B(B_i, B_j) < m_B(B_i) + m_B(B_j)$ and

$$m_B(B_1, B_2) = 0.6, m_B(B_1, B_3) = 0.5 \text{ and } m_B(B_2, B_3) = 0.6.$$

The manager prefers the pairs of sub-criteria B_1 and B_2, and B_2 and B_3 over the pair of sub-criteria B_1 and B_3.

By the definition of the fuzzy measure, it holds that

$$m_B(\varnothing) = 0 \text{ and } m_B(B_1, B_2, B_3) = 1.$$

The final results of the evaluation of task performance for all 35 employees obtained using the Choquet integral are presented in Table 5.

Table 5. The results of evaluation of task performance.

Employee	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	E_{11}	E_{12}
$Ch_{m_B}(b_1, b_2, b_3)$	5.0	5.0	3.6	4.6	4.0	4.4	4.5	3.4	4.6	3.6	2.8	3.4
Employee	E_{13}	E_{14}	E_{15}	E_{16}	E_{17}	E_{18}	E_{19}	E_{20}	E_{21}	E_{22}	E_{23}	E_{24}
$Ch_{m_B}(b_1, b_2, b_3)$	4.5	3.6	3.2	2.8	2.8	3.2	3.5	2.8	3.6	4.0	4.0	4.0
Employee	E_{25}	E_{26}	E_{27}	E_{28}	E_{29}	E_{30}	E_{31}	E_{32}	E_{33}	E_{34}	E_{35}	
$Ch_{m_B}(b_1, b_2, b_3)$	2.6	2.6	2.8	3.2	3.2	2.8	2.7	3.2	3.6	3.5	2.9	

More details can be found in Table A4.

(C) Employee–employee relationship approaches

Consider the problem of evaluation of employee–employee relationship approaches with respect to three sub-criteria: C_1—the employee is willing to devote time, energy and effort to adapting to the changing work environment and new employees in the team; C_2—the employee is willingly adjusting their on-the-job behavior and shows respect for

others' values and customs; and C_3—the employee actively participates in joint activities with other employees.

Each sub-criterion is rated with a value from the set $\{1,2,3,4,5\}$. The fuzzy measure m for the task performance is formed in the following manner.

The sub-criterion C_1 is more important for the manager than the sub-criterion C_2, which is more important than the sub-criterion C_3. Therefore, let

$$m_C(C_1) = 0.4, m_C(C_2) = 0.3 \text{ and } m_C(C_3) = 0.2.$$

For the weight attributed to the set $\{C_i, C_j\}$ for $i, j \in \{1,2,3\}$ and $i \neq j$ holds $m_C(C_i, C_j) < m_C(C_i) + m_C(C_j)$ and

$$m_C(C_1, C_2) = 0.6, m_C(C_1, C_3) = 0.2 \text{ and } m_C(C_2, C_3) = 0.2.$$

The manager prefers the pairs of sub-criteria C_1 and C_2, over the pair of sub-criteria C_1 and C_3, and over the pair of sub-criteria C_2 and C_3.

By the definition of the fuzzy measure, it holds that

$$m_C(\varnothing) = 0 \text{ and } m_C(C_1, C_2, C_3) = 1.$$

The results of the evaluation of the employee employee relationship approaches for all 35 employees obtained using the Choquet integral are presented in Table 6.

Table 6. The results of evaluation of employee employee relationship approaches.

Employee	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	E_{11}	E_{12}
$Ch_{m_C}(c_1, c_2, c_3)$	5.0	5.0	2.9	5.0	2.2	4.2	4.6	4.0	4.6	2.3	4.0	3.4
Employee	E_{13}	E_{14}	E_{15}	E_{16}	E_{17}	E_{18}	E_{19}	E_{20}	E_{21}	E_{22}	E_{23}	E_{24}
$Ch_{m_C}(c_1, c_2, c_3)$	4.2	3.4	4.2	4.2	3.9	2.9	3.2	4.3	3.6	3.6	4.3	3.9
Employee	E_{25}	E_{26}	E_{27}	E_{28}	E_{29}	E_{30}	E_{31}	E_{32}	E_{33}	E_{34}	E_{35}	
$Ch_{m_C}(c_1, c_2, c_3)$	1.4	1.4	3.6	3.5	3.2	3.5	2.5	1.9	5.0	5.0	2.5	

More details can be found in Table A5.

(D) Effectiveness of communication

Consider the problem of evaluation of effectiveness of communication with respect to three sub-criteria: D_1—the employee has good verbal skills in the interaction between members of the working team, D_2—the communication between the employee and manager is careful and effective, and D_3—the employee has good verbal skills to organize work in small groups.

Each sub-criterion is rated with a value from the set $\{1,2,3,4,5\}$. The fuzzy measure m for the employee's effectiveness of communication is formed in the following manner.

The sub-criterion D_1 is more important for the manager than the sub-criterion D_2, which is more important than the sub-criterion D_3. Therefore, let

$$m_D(D_1) = 0.3,\ m_D(D_2) = 0.4, \text{ and } m_D(D_3) = 0.5.$$

For the weights attributed to the sets $\{D_i, D_j\}$ for $i, j \in \{1,2,3\}$ and $i \neq j$ holds $m_D(D_i, D_j) < m_D(D_i) + m_D(D_j)$ and

$$m_D(D_1, D_2) = 0.6, m_D(D_1, D_3) = 0.7 \text{ and } m_D(D_2, D_3) = 0.7.$$

The manager gives preference to the pairs of sub-criteria D_1 and D_2, over the pair of sub-criteria D_1 and D_3, and over the sub-criteria D_2 and D_3.

By the definition of the fuzzy measure, it holds that

$$m_D(\varnothing) = 0 \text{ and } m_D(D_1, D_2, D_3) = 1.$$

The results of the evaluation of task performance for all 35 employees obtained using the Choquet integral are presented in Table 7.

Table 7. The results of evaluation of effectiveness of communication.

Employee	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	E_{11}	E_{12}
$Ch_{m_D}(d_1, d_2, d_3)$	5.0	5.0	3.2	5.0	4.0	4.3	4.6	4.4	4.6	4.6	3.2	4.2
Employee	E_{13}	E_{14}	E_{15}	E_{16}	E_{17}	E_{18}	E_{19}	E_{20}	E_{21}	E_{22}	E_{23}	E_{24}
$Ch_{m_D}(d_1, d_2, d_3)$	4.6	3.1	3.8	4.6	4.2	3.8	3.8	4.6	2.8	3.4	3.5	4.2
Employee	E_{25}	E_{26}	E_{27}	E_{28}	E_{29}	E_{30}	E_{31}	E_{32}	E_{33}	E_{34}	E_{35}	
$Ch_{m_D}(d_1, d_2, d_3)$	2.0	2.0	3.4	3.1	3.1	3.4	2.8	2.5	2.8	5.0	3.8	

More details can be found in Table A6.

(E) Employee ranking

Employee ranking was performed with respect to four sub-criteria considered in *A*–*D*: *A*—the personal characteristics of employee, *B*—task performance, *C*—employee–employee relationship approaches, and *D*—communicative and organizational skills.

Each of the four sub-criteria is rated with a value from the interval $[1, 5]$, as shown in the previous sections. Based on the opinion of the manager, the following fuzzy measure m for the employee appraisal was considered.

$$m(A) = 0.5,\ m(B) = 0.6,\ m(C) = 0.2, \text{ and} m(D) = 0.4.$$

For the weights attributed to the subsets of the set $\{A, B,\ C, D\}$ that have two elements it holds that $m(A, B) = 0.7$, $m(A, C) = 0.6$, $m(A, D) = 0.65$, $m(B, C) = 0.5$, $m(B, D) = 0.55$ and $m(C, D) = 0.45$.

For the weights attributed to the subsets of the set $\{A, B, C, D\}$ that have three elements it holds that

$$m(A, B, C) = 0.85, m(A, B, D) = 0.9, m(A, C, D) = 0.65, m(B, C, D) = 0.8.$$

By the definition of the fuzzy measure, it holds that

$$m(\varnothing) = 0 \text{ and } m(A, B, C, D) = 1.$$

The final results of the ranking of 35 employees with respect to the personal characteristics of the employee, their task performance, employee–employee relationship approaches, and their communicative and organizational skills obtained using the Choquet integral are presented in Table 8.

Table 8. The final results of evaluation of empluyees w.r.t. *A*–*D* obtained using the Choquet integral.

Employee	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	E_{11}	E_{12}
$Ch_m(x_1, x_2, x_3, x_4)$	5.00	5.00	3.45	4.65	3.23	4.41	4.55	3.95	4.58	3.21	3.60	3.52
Employee	E_{13}	E_{14}	E_{15}	E_{16}	E_{17}	E_{18}	E_{19}	E_{20}	E_{21}	E_{22}	E_{23}	E_{24}
$Ch_m(x_1, x_2, x_3, x_4)$	4.41	3.17	3.65	3.87	3.46	3.17	3.47	3.76	3.20	3.58	3.75	3.98
Employee	E_{25}	E_{26}	E_{27}	E_{28}	E_{29}	E_{30}	E_{31}	E_{32}	E_{33}	E_{34}	E_{35}	
$Ch_m(x_1, x_2, x_3, x_4)$	2.05	2.34	3.01	3.04	3.19	2.95	2.55	2.55	3.48	4.48	3.60	

More details can be found in Table A7.

5. Discussion and Conclusions

In this paper, the Choquet Integral is used to model the decision-making process. It should be noted that the fuzzy measure weight was assigned to each group of criteria, rather than to the individual criteria. It offers a flexible way of modelling the complex decision-making process of the employees.

The approach is very attractive as it reflects more accurately what we can expect from a decision-maker, yet remains simple and still allows us to represent dependencies between attributes, which is not possible with more traditional approaches such as the weighted sum.

Based on results from Table 4, for evaluation of the personal characteristics of the employee it holds that

$$E_1 = E_2 = E_4 = E_{34} \succ E_6 = E_7 = E_9 \succ E_{13} = E_{16} \succ E_8 \succ E_{35} \succ E_{11} = E_{12} = E_{15} \succ E_3 = E_{20} = E_{24} \succ E_{23} = E_{29} \succ E_{19} \succ E_{17} \succ E_{10} = E_{33} \succ E_5 = E_{21} = E_{22} \succ E_{26} \succ E_{27} \succ E_{18} = E_{28} \succ E_{14} = E_{30} \succ E_{31} \succ E_{32} \succ E_{25}.$$

Based on results from Table 5, for evaluation of task performance it holds that

$$E_1 = E_2 \succ E_4 = E_9 \succ E_7 = E_{13} \succ E_6 \succ E_5 = E_{22} = E_{23} = E_{24} \succ E_3 = E_{10} = E_{21} = E_{33} = E_{14} \succ E_{19} = E_{34} \succ E_8 = E_{12} \succ E_{15} = E_{18} = E_{28} = E_{29} = E_{32} \succ E_{35} \succ E_{11} = E_{16} = E_{17} = E_{20} = E_{27} = E_{30} \succ E_{31} \succ E_{25} = E_{26}.$$

Based on results from Table 6, for evaluation of the employee–employee relationship approaches it holds that

$$E_1 = E_2 = E_4 = E_{33} = E_{34} \succ E_7 = E_9 \succ E_{23} = E_{20} \succ E_6 \succ E_{13} = E_{15} = E_{16} \succ E_8 = E_{11} \succ E_{24} = E_{17} \succ E_{21} = E_{22} = E_{27} \succ E_{28} = E_{30} \succ E_{12} = E_{14} \succ E_{19} = E_{29} \succ E_3 = E_{18} \succ E_{31} = E_{35} \succ E_{10} \succ E_5 \succ E_{32} \succ E_{25} = E_{26}.$$

Based on results from Table 7, for evaluation of the effectiveness of communication it holds that

$$E_1 = E_2 = E_4 = E_{33} = E_{34} \succ E_7 = E_9 \succ E_{23} = E_{20} \succ E_6 \succ E_{13} = E_{15} = E_{16} \succ E_8 = E_{11} \succ E_{24} = E_{17} \succ E_{21} = E_{22} = E_{27} \succ E_{28} = E_{30} \succ E_{12} = E_{14} \succ E_{19} = E_{29} \succ E_3 = E_{18} \succ E_{31} = E_{35} \succ E_{10} \succ E_5 \succ E_{32} \succ E_{25} = E_{26}.$$

Finally, based on results from Table 8, the final ranking is

$$E_1 = E_2 \succ E_4 \succ E_9 \succ E_7 \succ E_{34} \succ E_6 = E_{13} \succ E_{24} \succ E_8 \succ E_{16} \succ E_{20} \succ E_{23} \succ E_{15} \succ E_{11} = E_{35} \succ E_{22} \succ E_{12} \succ E_{33} \succ E_{19} \succ E_{17} \succ E_3 \succ E_5 \succ E_{10} \succ E_{21} \succ E_{29} \succ E_{14} \succ E_{18} \succ E_{28} \succ E_{27} \succ E_{30} \succ E_{31} = E_{32} \succ E_{26} \succ E_{25}.$$

Obviously, the value of the Choquet integral depends on considered fuzzy measure. Let us suppose that each of the considered four criteria: A—the personal characteristics of the employee, B—task performance, C—employee–employee relationship approaches, and D—communicative and organizational skills is of equal importance in decision-making. Therefore, let

$$m_1(A) = m_1(B) = m_1(C) = m_1(D) = 0.5,$$
$$m_1(A,B) = m_1(A,C) = m_1(A,D) = m_1(B,C) = m_1(B,D) = m_1(C,D) = 0.65,$$
$$m_1(A,B,C) = m_1(A,B,D) = m_1(B,C,D) = 0.8.$$

By the definition of the fuzzy measure $m_1(\varnothing) = 0$ and $m_1(A,B,C,D) = 1$. Repeating the procedure shown in Figure 5, the following ranking is obtained.

$$E_1 = E_2 \succ E_4 \succ E_{34} \succ E_9 \succ E_7 \succ E_{13} \succ E_6 \succ E_{16} \succ E_8 \succ E_{20} \succ E_{33} \succ E_{24} \succ E_{23} \succ E_{15} \succ E_{11} \succ E_{17} \succ E_{22} \succ E_{35} \succ E_{12} \succ E_{19} \succ E_5 \succ E_3 \succ E_{21} \succ E_{18} \succ E_{14} \succ E_{27} \succ E_{29} \succ E_{10} \succ E_{28} \succ E_{30} \succ E_{31} \succ E_{32} \succ E_{26} \succ E_{25}.$$

A chart that represents the final evaluation results for all 35 workers obtained with respect to fuzzy measures m and m_1, is shown in Figure 6.

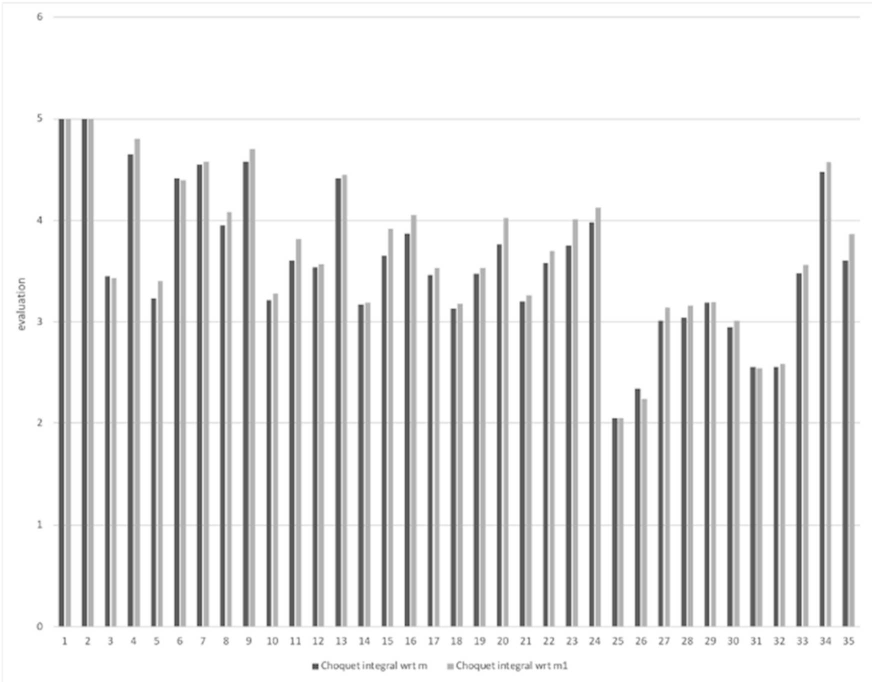


Figure 6. The results of evaluation of employees using the Choquet integral w.r.t. fuzzy measures m and m_1.

A chart that represents the final rankings for all 35 workers obtained using the Choquet integral with respect to fuzzy measures m and m_1, is shown in Figure 7.

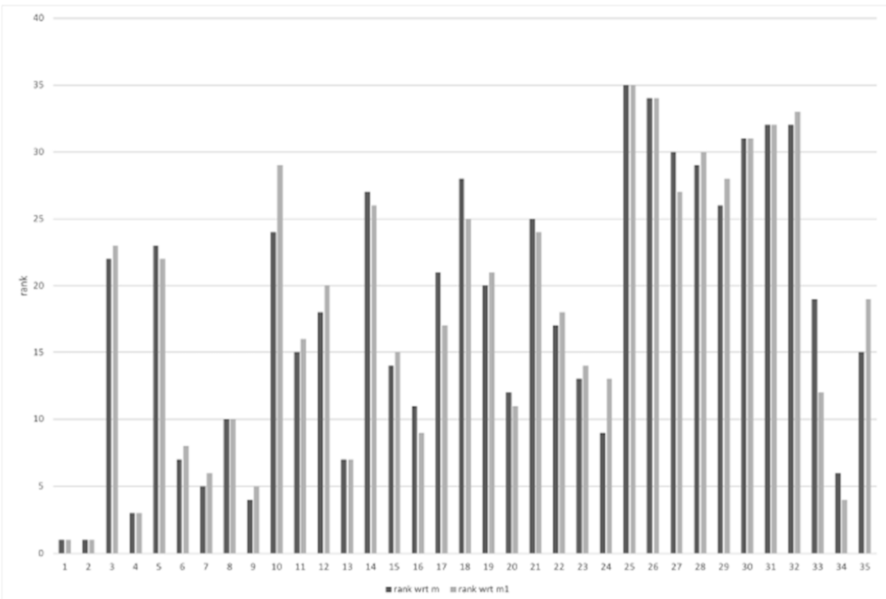


Figure 7. Employees ranking using the Choquet integral w.r.t. fuzzy measures m and m_1.

Note that the standard TOPSIS and PROMETHEE methods ranked the same nine employees in the first nine places, in the same order $E_1, E_2, E_4, E_7, E_9, E_6, E_{13}, E_{34}, E_{16}$. If the manager wants to favor well equilibrated employees without weak points, the above ranking is not fully satisfactory, since employee E_{16} has a severe weakness in task performance, but has been considered better than employee E_{24}, who has no weakpoints. Note that the sum of grades of the employee E_{16} and the sum of grades of the employee E_{24} are equal, see Table A1.

A chart that represents the final rankings for all 35 workers, obtained using the Choquet integral with respect to fuzzy measure m, TOPSIS and PROMETHEE methods, is shown in Figure 8.

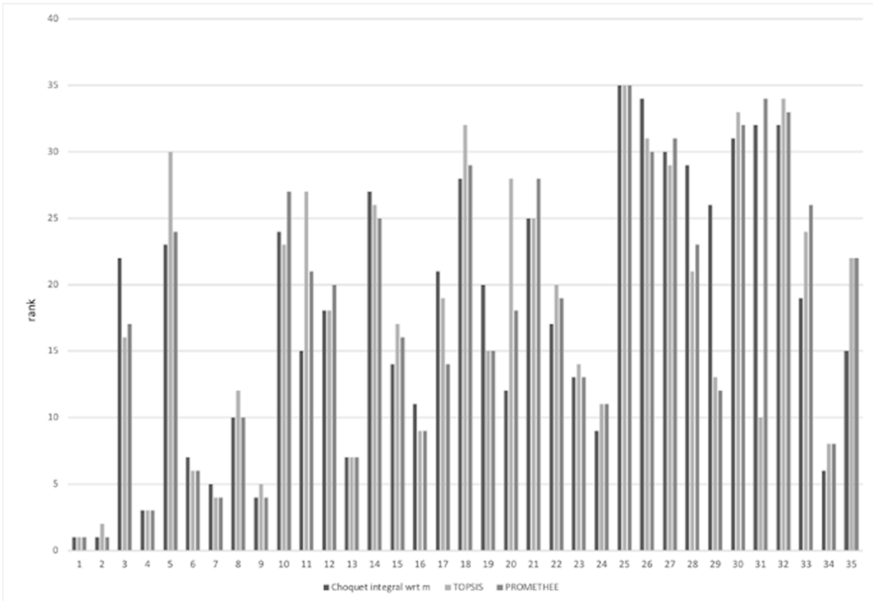


Figure 8. Employees ranking using the Choquet integral w.r.t. fuzzy measure m, TOPSIS and PROMETHEE method.

The requirements of the decision maker were translated into coefficients of the fuzzy measure. Task performance was considered as the most important criterion. Since the task performance is a weak point for employee 16, employee 16 fell from position 9 (in both standard methods) to position 11 by the ranking conducted using the Choquet integral. Similarly, employee E_{24} who has no weak points, was on position 11 based on the considered standard methods and in the ranking conducted using the Choquet integral, and the rank of this employee has improved and he ended up on position 9.

Therefore, by applying the Choquet integral, employees without a weak point are better ranked, which was not the case with the observed standard methods.

When applying the Choquet integral, it is not recommended to assume that the fuzzy measure of each criterion is equal. It can cause an employee without weak points to be ranked lower than an employee with weak points. Let us look again at employees E_{16} and E_{24}. The employee E_{16} has a weak point, while E_{24} has no weak points. When ranking employees with the proposed method, with respect to the fuzzy measure m, employee E_{24} is ranked better than employee E_{16}, while by applying the proposed method with respect to measure m_1, employee E_{16} is ranked better than employee E_{24}.

Standard methods define criteria weights, which, for different criteria, also usually differ from each other because the decision-maker wants to give more importance to criteria that are more important for the research.

The advantage of the proposed method in relation to the standard methods is reflected in the fact that when defining a fuzzy measure, measures of criteria interactions are also

defined. In addition, fuzzy measures of sub-criteria and fuzzy measures of sub-criteria interactions are defined.

For example, an employee who scores highly on sub-criterion D_1 is expected to have a high grade on sub-criterion D_2, while no such association is expected between employee's grades for sub-criteria D_1 and D_3. Therefore, when defining a fuzzy measure m, of sub-criteria interactions, $m(D_1, D_3)$ should be greater than $m(D_1, D_2)$.

The choice of fuzzy measure significantly affects the ranking. For the fuzzy measure m observed in the research and criteria $A,\ B,\ C$ and D, it holds that

$$m(C) < m(D) < m(A) < m(B)$$

If we consider a fuzzy measure $\widetilde{m}$ different from m such that also holds

$$\widetilde{m}(C) < \widetilde{m}(D) < \widetilde{m}(A) < \widetilde{m}(B),$$

the ranking would remain the same. If we were to observe some fuzzy measure m^* for which at least one of the relations $m^*(C) < m^*(D) < m^*(A) < m^*(B)$ does not hold, the final ranking would change. This also applies to fuzzy measures of all subsets of criteria, fuzzy measures of all sub-criteria, and fuzzy measures of all subsets of sub-criteria.

Let us emphasize that the data used in the presented procedure are crisp data. The proposed ranking method can be easily adapted if it is necessary to include additional criteria, according to which the ranking needs to be performed. Its advantage over other methods based on fuzzy mathematics is its ease of application. Unlike other fuzzy methods, it involves the interaction between criteria and the interaction between sub-criteria. The comparison of the proposed procedure with two standard methods, TOPSIS and PROMETHEE, which also use crisp data, is performed. In future work, instead of crisp data, interval-valued data and fuzzy-valued data and the corresponding Choquet integral will be considered.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Survey results.

Employee	A_1	A_2	A_3	A_4	B_1	B_2	B_3	C_1	C_2	C_3	D_1	D_2	D_3
E_1	5	5	5	5	5	5	5	5	5	5	5	5	5
E_2	5	5	5	5	5	5	5	5	5	5	5	5	5
E_3	5	3	4	3	4	4	3	3	4	2	4	4	2
E_4	5	5	5	5	5	5	4	5	5	5	5	5	5
E_5	2	3	3	3	4	4	4	3	2	3	4	4	4
E_6	5	5	5	4	5	4	4	5	5	3	5	4	4
E_7	5	5	5	4	5	4	5	5	5	4	5	5	4
E_8	5	5	5	3	5	2	4	4	4	4	4	5	4
E_9	5	5	5	4	5	5	4	5	5	4	5	5	4
E_{10}	5	3	2	2	4	4	3	2	3	2	4	4	2
E_{11}	5	4	4	3	4	2	2	4	4	4	5	5	3
E_{12}	5	4	4	3	5	2	3	4	3	3	4	4	2
E_{13}	5	4	4	4	4	5	4	4	5	5	5	5	4
E_{14}	5	2	2	1	4	4	3	3	5	5	5	4	1
E_{15}	5	4	4	3	4	4	2	4	5	5	5	5	2
E_{16}	5	4	4	4	4	2	2	4	4	5	5	5	4
E_{17}	4	4	4	2	4	2	2	4	5	3	5	5	3
E_{18}	3	2	2	2	4	4	2	3	4	2	5	5	2
E_{19}	5	3	4	2	4	3	4	3	5	2	5	5	2
E_{20}	3	4	4	4	4	2	2	4	5	4	5	5	4
E_{21}	5	2	2	2	4	4	3	3	5	3	4	4	1
E_{22}	5	2	2	2	4	4	4	3	5	3	5	5	1
E_{23}	5	4	4	2	4	4	4	4	5	4	5	4	2
E_{24}	5	4	3	3	4	4	4	4	5	3	5	5	3
E_{25}	2	1	1	1	2	4	1	2	1	1	2	3	1
E_{26}	5	3	3	1	4	4	1	3	5	3	5	5	1
E_{27}	4	4	2	1	4	4	2	4	5	2	5	4	1
E_{28}	4	3	3	1	4	4	2	3	5	2	5	4	1
E_{29}	5	4	4	2	4	4	4	4	5	3	5	5	2
E_{30}	5	2	2	1	4	4	1	3	5	4	5	5	1
E_{31}	2	2	2	2	3	4	1	3	4	1	4	4	1
E_{32}	2	2	1	1	4	4	2	2	3	1	4	3	1
E_{33}	5	3	2	2	4	4	3	4	4	2	4	4	1
E_{34}	5	5	5	5	5	2	5	5	5	5	5	5	5
E_{35}	5	4	3	4	4	2	3	3	4	1	5	5	2

Table A2. Employees ranked by the TOPSIS method.

Rank	Employee	Relative Closeness
1	E_1	2.362994
2	E_2	2.362992
3	E_4	2.133280
4	E_7	2.098566
5	E_9	2.043925
6	E_6	2.031870
7	E_{13}	2.015559
8	E_{34}	2.012834
9	E_{16}	1.997021
10	E_{31}	1.982772

Table A2. *Cont.*

Rank	Employee	Relative Closeness
11	E_{24}	1.959623
12	E_8	1.913884
13	E_{29}	1.911120
14	E_{23}	1.868947
15	E_{19}	1.839883
16	E_3	1.822605
17	E_{15}	1.821991
18	E_{12}	1.784999
19	E_{17}	1.761233
20	E_{22}	1.746783
21	E_{28}	1.613952
22	E_{35}	1.592135
23	E_{10}	1.581164
24	E_{33}	1.573219
25	E_{21}	1.565685
26	E_{14}	1.468762
27	E_{11}	1.400000
28	E_{20}	1.358742
29	E_{27}	1.358090
30	E_5	1.316060
31	E_{26}	1.172919
32	E_{18}	1.172919
33	E_{30}	1.136000
34	E_{32}	1.000000
35	E_{25}	1.000000

Table A3. The evaluation of the personal characteristics of employee using the Choquet integral.

Employee	a_i	$a_{(i)}$	$a_{(i)} - a_{(i-1)}$	$A_{(i)}$	$m(A_{(i)})$	$x_1 = Ch_{m_A}(a_1,a_2,a_3,a_4)$
E_1		0	0			5.0
	5	5	5	$\{A_1, A_2, A_3, A_4\}$	1	
	5	5	0	-	-	
	5	5	0	-	-	
	5	5	0	-	-	
E_2		0				5.0
	5	5	5	$\{A_1, A_2, A_3, A_4\}$	1	
	5	5	0	-	-	
	5	5	0	-	-	
	5	5	0	-	-	
E_3		0		A		3.6
	5	3	3	$\{A_1, A_2, A_3, A_4\}$	1	
	3	3	0	-	-	
	4	4	1	$\{A_1, A_3\}$	0.4	
	3	5	1	$\{A_1\}$	0.2	

Table A3. *Cont.*

Employee	a_i	$a_{(i)}$	$a_{(i)} - a_{(i-1)}$	$A_{(i)}$	$m(A_{(i)})$	$x_1 = Ch_{m_A}(a_1,a_2,a_3,a_4)$
		0				
	5	5	5	$\{A_1, A_2, A_3, A_4\}$	1	
E_4	5	5	0	-	-	5.0
	5	5	0	-	-	
	5	5	0	-	-	
		0				
	2	2	2	$\{A_1, A_2, A_3, A_4\}$	1	
E_5	3	3	1	$\{A_2, A_3, A_4\}$	0.6	2.6
	3	3	0	-	-	
	3	3	0	-	-	
		0				
	5	4	4	$\{A_1, A_2, A_3, A_4\}$	1	
E_6	5	5	1	$\{A_1, A_2, A_3\}$	0.5	4.5
	5	5	0	-	-	
	4	5	0	-	-	
		0				
	5	4	4	$\{A_1, A_2, A_3, A_4\}$	1	
E_7	5	5	1	$\{A_1, A_2, A_3\}$	0.5	4.5
	5	5	0	-	-	
	4	5	0	-	-	
		0				
	5	3	3	$\{A_1, A_2, A_3, A_4\}$	1	
E_8	5	5	2	$\{A_1, A_2, A_3\}$	0.5	4.0
	5	5	0	-	-	
	3	5	0	-	-	
		0				
	5	4	4	$\{A_1, A_2, A_3, A_4\}$	1	
E_9	5	5	1	$\{A_1, A_2, A_3\}$	0.5	4.5
	5	5	0	-	-	
	4	5	0	-	-	
		0				
	5	2	2	$\{A_1, A_2, A_3, A_4\}$	1	
E_{10}	3	2	0	-	-	2.8
	2	3	1	$\{A_1, A_2\}$	0.4	
	2	5	2	$\{A_1\}$	0.2	
		0				
	5	3	3		1	
E_{11}	4	4	1	$\{A_1, A_2, A_3, A_4\}$	0.5	3.7
	4	4	0	-	-	
	3	5	1	$\{A_1\}$	0.2	
		0	0			
	5	3	3	$\{A_1, A_2, A_3, A_4\}$	1	
E_{12}	4	4	1	$\{A_1, A_2, A_3\}$	0.5	3.7
	4	4	0	-	-	
	3	5	1	$\{A_1\}$	0.2	
		0				
	5	4	4	$\{A_1, A_2, A_3, A_4\}$	1	
E_{13}	4	4	0	-	-	4.2
	4	4	0	-	-	
	4	5	1	$\{A_1\}$	0.2	
		0				
	5	1	1	$\{A_1, A_2, A_3, A_4\}$	1	
E_{14}	2	2	1	$\{A_1, A_2, A_3\}$	0.5	2.1
	2	2	0	-	-	
	1	5	3	$\{A_1\}$	0.2	

Table A3. *Cont.*

Employee	a_i	$a_{(i)}$	$a_{(i)} - a_{(i-1)}$	$A_{(i)}$	$m(A_{(i)})$	$x_1 = Ch_{m_A}(a_1,a_2,a_3,a_4)$
E_{15}		0				3.7
	5	3	3	$\{A_1, A_2, A_3, A_4\}$	1	
	4	4	1	$\{A_1, A_2, A_3\}$	0.5	
	4	4	0	-	-	
	3	5	1	$\{A_1\}$	0.2	
E_{16}		0				4.2
	5	4	4	$\{A_1, A_2, A_3, A_4\}$	1	
	4	4	0	-	-	
	4	4	0	-	-	
	4	5	1	$\{A_1\}$	0.2	
E_{17}		0				3.0
	4	2	2	$\{A_1, A_2, A_3, A_4\}$	1	
	4	4	2	$\{A_1, A_2, A_3\}$	0.5	
	4	4	0	-	-	
	2	4	0	-	-	
E_{18}		0				2.2
	3	2	2	$\{A_1, A_2, A_3, A_4\}$	1	
	2	2	0	-	-	
	2	2	0	-	-	
	2	3	1	$\{A_1\}$	0.2	
E_{19}		0				3.1
	5	2	2	$\{A_1, A_2, A_3, A_4\}$	1	
	3	3	1	$\{A_1, A_2, A_3\}$	0.5	
	4	4	1	$\{A_1, A_3\}$	0.4	
	2	5	1	$\{A_1\}$	0.2	
E_{20}		0				3.6
	3	3	3	$\{A_1, A_2, A_3, A_4\}$	1	
	4	4	1	$\{A_2, A_3, A_4\}$	0.6	
	4	4	0	-	-	
	4	4	0	-	-	
E_{21}		0				2.6
	5	2	2	$\{A_1, A_2, A_3, A_4\}$	1	
	2	2	0	-	-	
	2	2	0	-	-	
	2	5	3	$\{A_1\}$	0.2	
E_{22}		0				2.6
	5	2	2	$\{A_1, A_2, A_3, A_4\}$	1	
	2	2	0	-	-	
	2	2	0	-	-	
	2	5	3	$\{A_1\}$	0.2	
E_{23}		0				3.2
	5	2	2	$\{A_1, A_2, A_3, A_4\}$	1	
	4	4	2	$\{A_1, A_2, A_3\}$	0.5	
	4	4	0	-	-	
	2	5	1	$\{A_1\}$	0.2	
E_{24}		0				3.6
	5	3	3	$\{A_1, A_2, A_3, A_4\}$	1	
	4	3	0	-	-	
	3	4	1	$\{A_1, A_2\}$	0.4	
	3	5	1	$\{A_1\}$	0.2	
E_{25}		0				1.2
	2	1	1	$\{A_1, A_2, A_3, A_4\}$	1	
	1	1	0	-	-	
	1	1	0	-	-	
	1	2	1	$\{A_1\}$	0.2	

Table A3. *Cont.*

Employee	a_i	$a_{(i)}$	$a_{(i)} - a_{(i-1)}$	$A_{(i)}$	$m(A_{(i)})$	$x_1 = Ch_{m_A}(a_1,a_2,a_3,a_4)$
E_{26}		0				2.4
	5	1	1	$\{A_1, A_2, A_3, A_4\}$	1	
	3	3	2	$\{A_1, A_2, A_3\}$	0.5	
	3	3	0	-	-	
	1	5	2	$\{A_1\}$	0.2	
E_{27}		0				2.3
	4	1	1	$\{A_1, A_2, A_3, A_4\}$	1	
	4	2	1	$\{A_1, A_2, A_3\}$	0.5	
	2	4	2	$\{A_1, A_2\}$	0.4	
	1	4	0	-	-	
E_{28}		0				2.2
	4	1	1	$\{A_1, A_2, A_3, A_4\}$	1	
	3	3	2	$\{A_1, A_2, A_3\}$	0.5	
	3	3	0	-	-	
	1	4	1	$\{A_1\}$	0.2	
E_{29}		0				3.2
	5	2	2	$\{A_1, A_2, A_3, A_4\}$	1	
	4	4	2	$\{A_1, A_2, A_3\}$	0.5	
	4	4	0	-	-	
	2	5	1	$\{A_1\}$	0.2	
E_{30}		0				2.1
	5	1	1	$\{A_1, A_2, A_3, A_4\}$	1	
	2	2	1	$\{A_1, A_2, A_3\}$	0.5	
	2	2	0	-	-	
	1	5	3	$\{A_1\}$	0.2	
E_{31}		0				2.0
	2	2	2	$\{A_1, A_2, A_3, A_4\}$	1	
	2	2	0	-	-	
	2	2	0	-	-	
	2	2	0	-	-	
E_{32}		0				1.4
	2	1	1	$\{A_1, A_2, A_3, A_4\}$	1	
	2	1	0	-	-	
	1	2	1	$\{A_1, A_2\}$	0.4	
	1	2	0	-	-	
E_{33}		0				2.8
	5	2	2	$\{A_1, A_2, A_3, A_4\}$	1	
	3	2	0	-	-	
	2	3	1	$\{A_1, A_2\}$	0.4	
	2	5	2	$\{A_1\}$	0.2	
E_{34}		0				5
	5	5	5	$\{A_1, A_2, A_3, A_4\}$	1	
	5	5	0	-	-	
	5	5	0	-	-	
	5	5	0	-	-	
E_{35}		0				3.9
	5	3	3	$\{A_1, A_2, A_3, A_4\}$	1	
	4	4	1	$\{A_1, A_2, A_4\}$	0.7	
	3	4	0	-	-	
	4	5	1	$\{A_1\}$	0.2	

Table A4. The evaluation of task performance using the Choquet integral.

Employee	b_i	$b_{(i)}$	$b_{(i)} - b_{(i-1)}$	$A_{(i)}$	$m(A_{(i)})$	$x_2 = Ch_{mB}(b_1,b_2,b_3)$
E_1		0				5.0
	5	5	5	$\{B_1, B_2, B_3\}$	1	
	5	5	0	-	-	
	5	5	0	-	-	
E_2		0				5.0
	5	5	5	$\{B_1, B_2, B_3\}$	1	
	5	5	0	-	-	
	5	5	0	-	-	
E_3		0				3.6
	4	3	3	$\{B_1, B_2, B_3\}$	1	
	4	4	1	$\{B_1, B_2\}$	0.6	
	3	4	0	-	-	
E_4		0				4.6
	5	4	4	$\{B_1, B_2, B_3\}$	1	
	5	5	1	$\{B_1, B_2\}$	0.6	
	4	5	0	-	-	
E_5		0				4.0
	4	4	4	$\{B_1, B_2, B_3\}$	1	
	4	4	0	-	0.6	
	4	4	9	-	-	
E_6		0				4.4
	5	4	4	$\{B_1, B_2, B_3\}$	1	
	4	4	0	-	-	
	4	5	1	$\{B_1\}$	0.4	
E_7		0				4.5
	5	4	4	$\{B_1, B_2, B_3\}$	1	
	4	5	1	$\{B_1, B_3\}$	0.5	
	5	5	0	-	-	
E_8		0				3.4
	5	2	2	$\{B_1, B_2, B_3\}$	1	
	2	4	2	$\{B_1, B_3\}$	0.5	
	4	5	1	$\{B_1\}$	0.4	
E_9		0				4.6
	5	4	4	$\{B_1, B_2, B_3\}$	1	
	5	5	1	$\{B_1, B_2\}$	0.6	
	4	5	0	-	-	
E_{10}		0				3.6
	4	3	3	$\{B_1, B_2, B_3\}$	1	
	4	4	1	$\{B_1, B_2\}$	0.6	
	3	4	0	-	-	
E_{11}		0				2.8
	4	2	2	$\{B_1, B_2, B_3\}$	1	
	2	2	0	-	-	
	2	4	2	$\{B_1\}$	0.4	
E_{12}		0				3.4
	5	2	2	$\{B_1, B_2, B_3\}$	1	
	2	3	1	$\{B_2, B_2\}$	0.6	
	3	5	2	$\{B_1\}$	0.4	
E_{13}		0				4.5
	4	4	4	$\{B_1, B_2, B_3\}$	1	
	5	4	0	-	-	
	4	5	1	$\{B_2\}$	0.5	

Table A4. *Cont.*

Employee	b_i	$b_{(i)}$	$b_{(i)} - b_{(i-1)}$	$A_{(i)}$	$m(A_{(i)})$	$x_2 = Ch_{mB}(b_1,b_2,b_3)$
		0				
E_{14}	4	3	3	$\{B_1, B_2, B_3\}$	1	3.6
	4	4	1	$\{B_1, B_2\}$	0.6	
	3	4	0	-	-	
		0				
E_{15}	4	2	2	$\{B_1, B_2, B_3\}$	1	3.2
	4	4	2	$\{B_1, B_2\}$	0.6	
	2	4	0	-		
		0				
E_{16}	4	2	2	$\{B_1, B_2, B_3\}$	1	2.8
	2	2	0	-	-	
	2	4	2	$\{B_1\}$	0.4	
		0				
E_{17}	4	2	2	$\{B_1, B_2, B_3\}$	1	2.8
	2	2	0	-	-	
	2	4	2	$\{B_1\}$	0.4	
		0				
E_{18}	4	2	2	$\{B_1, B_2, B_3\}$	1	3.2
	4	4	2	$\{B_1, B_2\}$	0.6	
	2	4	-	-	-	
		0				
E_{19}	4	3	3	$\{B_1, B_2, B_3\}$	1	3.5
	3	4	1	$\{B_1, B_3\}$	0.5	
	4	4	0	-	-	
		0				
E_{20}	4	2	2	$\{B_1, B_2, B_3\}$	1	2.8
	2	2	0	-	-	
	2	4	2	$\{B_1\}$	0.4	
		0				
E_{21}	4	3	3	$\{B_1, B_2, B_3\}$	1	3.6
	4	4	1	$\{B_1, B_2\}$	0.6	
	3	4	0	-	-	
		0				
E_{22}	4	4	4	$\{B_1, B_2, B_3\}$	1	4.0
	4	4	0	-	-	
	4	4	0	-	-	
		0				
E_{23}	4	4	4	$\{B_1, B_2, B_3\}$	1	4.0
	4	4	0	-	-	
	4	4	0	-	-	
		0				
E_{24}	4	4	4	$\{B_1, B_2, B_3\}$	1	4.0
	4	4	0	-	-	
	4	4	0	-	-	
		0				
E_{25}	2	1	1	$\{B_1, B_2, B_3\}$	1	2.6
	4	2	1	$\{B_1, B_2\}$	0.6	
	1	4	2	$\{B_2\}$	0.5	
		0				
E_{26}	2	1	1	$\{B_1, B_2, B_3\}$	1	2.6
	4	2	1	$\{B_1, B_2\}$	0.6	
	1	4	2	$\{B_2\}$	0.5	

Table A4. *Cont.*

Employee	b_i	$b_{(i)}$	$b_{(i)} - b_{(i-1)}$	$A_{(i)}$	$m(A_{(i)})$	$x_2 = Ch_{mB}(b_1,b_2,b_3)$
E_{27}	 4 4 1	0 1 4 4	 1 3 0	 $\{B_1, B_2, B_3\}$ $\{B_1, B_2\}$ -	 1 0.6 -	2.8
E_{28}	 4 4 2	0 2 4 4	 2 2 0	 $\{B_1, B_2, B_3\}$ $\{B_1, B_2\}$ -	 1 0.6 -	3.2
E_{29}	 4 4 2	0 2 4 4	 2 2 0	 $\{B_1, B_2, B_3\}$ $\{B_1, B_2\}$ -	 1 0.6 -	3.2
E_{30}	 4 4 1	0 1 4 4	 1 3 0	 $\{B_1, B_2, B_3\}$ $\{B_1, B_2\}$ -	 1 0.6 -	2.8
E_{31}	 3 4 1	0 1 3 4	 1 2 1	 $\{B_1, B_2, B_3\}$ $\{B_1, B_2\}$ $\{B_2\}$	 1 0.6 0.5	2.7
E_{32}	 4 4 2	0 2 4 4	 2 2 0	 $\{B_1, B_2, B_3\}$ $\{B_1, B_2\}$ -	 1 0.6 -	3.2
E_{33}	 4 4 3	0 3 4 4	 3 1 0	 $\{B_1, B_2, B_3\}$ $\{B_1, B_2\}$ -	 1 0.6 -	3.6
E_{34}	 5 2 5	0 2 5 5	 2 3 0	 $\{B_1, B_2, B_3\}$ $\{B_1, B_3\}$ -	 1 0.5 -	3.5
E_{35}	 4 2 3	0 2 3 4	 2 1 1	 $\{B_1, B_2, B_3\}$ $\{B_1, B_3\}$ $\{B_1\}$	 1 0.5 0.4	2.9

Table A5. The evaluation of employee employee relationship approaches using the Choquet integral.

Employee	c_i	$c_{(i)}$	$c_{(i)} - c_{(i-1)}$	$A_{(i)}$	$m(A_{(i)})$	$x_3 = Ch_{m_C}(c_1,c_2,c_3)$
E_1	 5 5 5	0 5 5 5	 5 0 0	 $\{C_1, C_2, C_3\}$ - -	 1 - -	5
E_2	 5 5 5	0 5 5 5	 5 0 0	 $\{C_1, C_2, C_3\}$ - -	 1 - -	5
E_3	 3 4 2	0 2 3 4	 2 1 1	 $\{C_1, C_2, C_3\}$ $\{C_1, C_2\}$ $\{C_2\}$	 1 0.6 0.3	2.9

Table A5. *Cont.*

Employee	c_i	$c_{(i)}$	$c_{(i)} - c_{(i-1)}$	$A_{(i)}$	$m(A_{(i)})$	$x_3 = Ch_{m_C}(c_1,c_2,c_3)$
E_4		0				5
	5	5	5	$\{C_1, C_2, C_3\}$	1	
	5	5	0	-	-	
	5	5	0	-	-	
E_5		0				2.2
	3	2	2	$\{C_1, C_2, C_3\}$	1	
	2	3	1	$\{C_1, C_3\}$	0.2	
	3	3	0	-	-	
E_6		0				4.2
	5	3	3	$\{C_1, C_2, C_3\}$	1	
	5	5	2	$\{C_1, C_3\}$	0.6	
	3	5	0	-	-	
E_7		0				4.6
	5	4	4	$\{C_1, C_2, C_3\}$	1	
	5	5	1	$\{C_1, C_2\}$	0.6	
	4	5	0	-	-	
E_8		0				4
	4	4	4	$\{C_1, C_2, C_3\}$	1	
	4	4	0	-	-	
	4	4	0	-	-	
E_9		0				4.6
	5	4	4	$\{C_1, C_2, C_3\}$	1	
	5	5	1	$\{C_1, C_2\}$	0.6	
	4	5	0	-	-	
E_{10}		0				2.3
	2	2	2	$\{C_1, C_2, C_3\}$	1	
	3	2	0	-	-	
	2	3	1	$\{C_2\}$	0.3	
E_{11}		0				4
	4	4	4	$\{C_1, C_2, C_3\}$	1	
	4	4	0	-	-	
	4	4	0	-	-	
E_{12}		0				3.4
	4	3	3	$\{C_1, C_2, C_3\}$	1	
	3	3	0	-	-	
	3	4	1	$\{C_1\}$	0.4	
E_{13}		0				4.2
	4	4	4	$\{C_1, C_2, C_3\}$	1	
	5	5	1	$\{C_2, C_3\}$	0.2	
	5	5	0	-	-	
E_{14}		0				3.4
	3	3	3	$\{C_1, C_2, C_3\}$	1	
	5	5	2	$\{C_2, C_3\}$	0.2	
	5	5	0	-	-	
E_{15}		0				4.2
	4	4	4	$\{C_1, C_2, C_3\}$	1	
	5	5	1	$\{C_2, C_3\}$	0.2	
	5	5	0	-	-	
E_{16}		0				4.2
	4	4	4	$\{C_1, C_2, C_3\}$	1	
	4	4	0	-	-	
	5	5	1	$\{C_3\}$	0.2	

Table A5. *Cont.*

Employee	c_i	$c_{(i)}$	$c_{(i)} - c_{(i-1)}$	$A_{(i)}$	$m(A_{(i)})$	$x_3 = Ch_{m_C}(c_1,c_2,c_3)$
E_{17}		0				3.9
	4	3	3	$\{C_1, C_2, C_3\}$	1	
	5	4	1	$\{C_1, C_2\}$	0.6	
	3	5	1	$\{C_2\}$	0.3	
E_{18}		0				2.9
	3	2	2	$\{C_1, C_2, C_3\}$	1	
	4	3	1	$\{C_1, C_2\}$	0.6	
	2	4	1	$\{C_2\}$	0.3	
E_{19}		0				3.2
	3	2	2	$\{C_1, C_2, C_3\}$	1	
	5	3	1	$\{C_1, C_2\}$	0.6	
	2	5	2	$\{C_2\}$	0.3	
E_{20}		0				4.3
	4	4	4	$\{C_1, C_2, C_3\}$	1	
	5	4	0	-	-	
	4	5	1	$\{C_2\}$	0.3	
E_{21}		0				3.6
	3	3	3	$\{C_1, C_2, C_3\}$	1	
	5	3	0	-	-	
	3	5	2	$\{C_2\}$	0.3	
E_{22}		0				3.6
	3	3	3	$\{C_1, C_2, C_3\}$	1	
	5	3	0	-	-	
	3	5	2	$\{C_2\}$	0.3	
E_{23}		0				4.3
	4	4	4	$\{C_1, C_2, C_3\}$	1	
	5	4	0	-	-	
	4	5	1	$\{C_2\}$	0.3	
E_{24}		0				3.9
	4	3	3	$\{C_1, C_2, C_3\}$	1	
	5	4	1	$\{C_1, C_2\}$	0.6	
	3	5	1	$\{C_2\}$	0.3	
E_{25}		0				1.4
	2	1	1	$\{C_1, C_2, C_3\}$	1	
	1	1	0	-	-	
	1	2	1	$\{C_1\}$	0.4	
E_{26}		0				1.4
	2	1	1	$\{C_1, C_2, C_3\}$	1	
	1	1	0	-	-	
	1	2	1	$\{C_1\}$	0.4	
E_{27}		0				3.6
	3	3	3	$\{C_1, C_2, C_3\}$	1	
	5	3	0	-	-	
	3	5	2	$\{C_2\}$	0.3	
E_{28}		0				3.5
	4	2	2	$\{C_1, C_2, C_3\}$	1	
	5	4	2	$\{C_1, C_2\}$	0.6	
	2	5	1	$\{C_2\}$	0.3	
E_{29}		0				3.2
	3	2	2	$\{C_1, C_2, C_3\}$	1	
	5	3	1	$\{C_1, C_2\}$	0.6	
	2	5	2	$\{C_2\}$	0.3	

Table A5. *Cont.*

Employee	c_i	$c_{(i)}$	$c_{(i)} - c_{(i-1)}$	$A_{(i)}$	$m(A_{(i)})$	$x_3 = Ch_{m_C}(c_1,c_2,c_3)$
E_{30}		0				3.5
	3	3	3	$\{C_1, C_2, C_3\}$	1	
	5	4	1	$\{C_2, C_3\}$	0.2	
	4	5	1	$\{C_2\}$	0.3	
E_{31}		0				2.5
	3	1	1	$\{C_1, C_2, C_3\}$	1	
	4	3	2	$\{C_1, C_2\}$	0.6	
	1	4	1	$\{C_2\}$	0.3	
E_{32}		0				1.9
	2	1	1	$\{C_1, C_2, C_3\}$	1	
	3	2	1	$\{C_1, C_2\}$	0.6	
	1	3	1	$\{C_2\}$	0.3	
E_{33}		0				5
	4	5	5	$\{C_1, C_2, C_3\}$	1	
	4	5	0	-	-	
	2	5	0	-	-	
E_{34}		0				5
	5	5	5	$\{C_1, C_2, C_3\}$	1	
	5	5	0	-	-	
	5	5	0	-	-	
E_{35}		0				2.5
	3	1	1	$\{C_1, C_2, C_3\}$	1	
	4	3	2	$\{C_1, C_2\}$	0.6	
	1	4	1	$\{C_2\}$	0.3	

Table A6. The evaluation of effectiveness of communication using the Choquet integral.

Employee	d_i	$d_{(i)}$	$d_{(i)} - d_{(i-1)}$	$A_{(i)}$	$m(A_{(i)})$	$x_4 = Ch_{m_C}(d_1,d_2,d_3)$
E_1		0				5
	5	5	5	$\{D_1, D_2, D_3\}$	1	
	5	5	0	-	-	
	5	5	0	-	-	
E_2		0				5
	5	5	5	$\{D_1, D_2, D_3\}$	1	
	5	5	0	-	-	
	5	5	0	-	-	
E_3		0				3.2
	4	2	2	$\{D_1, D_2, D_3\}$	1	
	4	4	2	$\{D_1, D_2\}$	0.6	
	2	4	0	-	-	
E_4		0				5
	5	5	5	$\{D_1, D_2, D_3\}$	1	
	5	5	0	-	-	
	5	5	0	-	-	
E_5		0				4
	4	4	4	$\{D_1, D_2, D_3\}$	1	
	4	4	0	-	-	
	4	4	0	-	-	
E_6		0				4.3
	5	4	4	$\{D_1, D_2, D_3\}$	1	
	4	4	0	-	-	
	4	5	1	$\{D_1\}$	0.3	

Table A6. *Cont.*

Employee	d_i	$d_{(i)}$	$d_{(i)} - d_{(i-1)}$	$A_{(i)}$	$m(A_{(i)})$	$x_4 = Ch_{m_C}(d_1,d_2,d_3)$
E_7		0				4.6
	5	4	4	$\{D_1, D_2, D_3\}$	1	
	5	5	1	$\{D_1, D_2\}$	0.6	
	4	5	0	-	-	
E_8		0				4.4
	4	4	4	$\{D_1, D_2, D_3\}$	1	
	5	4	0	-	-	
	4	5	1	$\{D_2\}$	0.4	
E_9		0				4.6
	5	4	4	$\{D_1, D_2, D_3\}$	1	
	5	5	1	$\{D_1, D_2\}$	0.6	
	4	5	0	-	-	
E_{10}		0				3.2
	4	2	2	$\{D_1, D_2, D_3\}$	1	
	4	4	2	$\{D_1, D_2\}$	0.6	
	2	4	0	-	-	
E_{11}		0				4.2
	5	3	3	$\{D_1, D_2, D_3\}$	1	
	5	5	2	$\{D_1, D_2\}$	0.6	
	3	5	0	-	-	
E_{12}		0				3.2
	4	2	2	$\{D_1, D_2, D_3\}$	1	
	4	4	2	$\{D_1, D_2\}$	0.6	
	2	4	0	-	-	
E_{13}		0				4.6
	5	4	4	$\{D_1, D_2, D_3\}$	1	
	5	5	1	$\{D_1, D_2\}$	0.6	
	4	5	0	-	-	
E_{14}		0				3.1
	5	1	1	$\{D_1, D_2, D_3\}$	1	
	4	4	3	$\{D_1, D_2\}$	0.6	
	1	5	1	$\{D_1\}$	0.3	
E_{15}		0				3.8
	5	2	2	$\{D_1, D_2, D_3\}$	1	
	5	5	3	$\{D_1, D_2\}$	0.6	
	2	5	0	-	-	
E_{16}		0				4.6
	5	4	4	$\{D_1, D_2, D_3\}$	1	
	5	5	1	$\{D_1, D_2\}$	0.6	
	4	5	0	-	-	
E_{17}		0				4.2
	5	3	3	$\{D_1, D_2, D_3\}$	1	
	5	5	2	$\{D_1, D_2\}$	0.6	
	3	5	0	-	-	
E_{18}		0				3.8
	5	2	2	$\{D_1, D_2, D_3\}$	1	
	5	5	3	$\{D_1, D_2\}$	0.6	
	2	5	0	-	-	
E_{19}		0				3.8
	5	2	2	$\{D_1, D_2, D_3\}$	1	
	5	5	3	$\{D_1, D_2\}$	0.6	
	2	5	0	-	-	

Table A6. *Cont.*

Employee	d_i	$d_{(i)}$	$d_{(i)} - d_{(i-1)}$	$A_{(i)}$	$m(A_{(i)})$	$x_4 = Ch_{m_C}(d_1,d_2,d_3)$
		0				
E_{20}	5	4	4	$\{D_1, D_2, D_3\}$	1	4.6
	5	5	1	$\{D_1, D_2\}$	0.6	
	4	5	0	-	-	
		0				
E_{21}	4	1	1	$\{D_1, D_2, D_3\}$	1	2.8
	4	4	3	$\{D_1, D_2\}$	0.6	
	1	4	0	-	-	
		0				
E_{22}	5	1	1	$\{D_1, D_2, D_3\}$	1	3.4
	5	5	4	$\{D_1, D_2\}$	0.6	
	1	5	0	-	-	
		0				
E_{23}	5	2	2	$\{D_1, D_2, D_3\}$	1	3.5
	4	4	2	$\{D_1, D_2\}$	0.6	
	2	5	1	$\{D_1\}$	0.3	
		0				
E_{24}	5	3	3	$\{D_1, D_2, D_3\}$	1	4.2
	5	5	2	$\{D_1, D_2\}$	0.6	
	3	5	0	-	-	
		0				
E_{25}	2	1	1	$\{D_1, D_2, D_3\}$	1	2
	3	2	1	$\{D_1, D_2\}$	0.6	
	1	3	1	$\{D_2\}$	0.4	
		0				
E_{26}	2	1	1	$\{D_1, D_2, D_3\}$	1	2
	3	2	1	$\{D_1, D_2\}$	0.6	
	1	3	1	$\{D_2\}$	0.4	
		0				
E_{27}	5	1	1	$\{D_1, D_2, D_3\}$	1	3.4
	5	5	4	$\{D_1, D_2\}$	0.6	
	1	5	0	-	-	
		0				
E_{28}	5	1	1	$\{D_1, D_2, D_3\}$	1	3.1
	4	4	3	$\{D_1, D_2\}$	0.6	
	1	5	1	$\{D_1\}$	0.3	
		0				
E_{29}	5	1	1	$\{D_1, D_2, D_3\}$	1	3.1
	4	4	3	$\{D_1, D_2\}$	0.6	
	1	5	1	$\{D_1\}$	0.3	
		0				
E_{30}	5	1	1	$\{D_1, D_2, D_3\}$	1	3.4
	5	5	4	$\{D_1, D_2\}$	0.6	
	1	5	0	-	-	
		0				
E_{31}	4	1	1	$\{D_1, D_2, D_3\}$	1	2.8
	4	4	3	$\{D_1, D_2\}$	0.6	
	1	4	0	-	-	
		0				
E_{32}	4	1	1	$\{D_1, D_2, D_3\}$	1	2.5
	3	3	2	$\{D_1, D_2\}$	0.6	
	1	4	1	$\{D_1\}$	0.3	

Table A6. *Cont.*

Employee	d_i	$d_{(i)}$	$d_{(i)} - d_{(i-1)}$	$A_{(i)}$	$m(A_{(i)})$	x_4 = $Ch_{m_C}(d_1,d_2,d_3)$
E_{33}		0				2.8
	4	1	1	$\{D_1, D_2, D_3\}$	1	
	4	4	3	$\{D_1, D_2\}$	0.6	
	1	4	0	-	-	
E_{34}		0				5
	5	5	5	$\{D_1, D_2, D_3\}$	1	
	5	5	0	-	-	
	5	5	0	-	-	
E_{35}		0				3.8
	5	2	2	$\{D_1, D_2, D_3\}$	1	
	5	5	3	$\{D_1, D_2\}$	0.6	
	2	5	0	-	-	

Table A7. The evaluation of empluyees w.r.t. *A*–*D* using the Choquet integral.

Employee	x_i	$x_{(i)}$	$x_{(i)} - x_{(i-1)}$	$A_{(i)}$	$m(A_{(i)})$	y_i = $Ch_m(x_1,x_2,x_3,x_4)$
E_1		0				5
	5	5	5	$\{A, B, C, D\}$	1	
	5	5	0	-	-	
	5	5	0	-	-	
	5	5	0	-	-	
E_2		0				5
	5	5	5	$\{A, B, C, D\}$	1	
	5	5	0	-	-	
	5	5	0	-	-	
	5	5	0	-	-	
E_3		0				3.45
	3.6	2.9	2.9	$\{A, B, C, D\}$	1	
	3.6	3.2	0.3	$\{A, B, D\}$	0.9	
	2.9	3.6	0.4	$\{A, B\}$	0.7	
	3.2	3.6	0	-	-	
E_4		0				4.65
	5	4	4	$\{A, B, C, D\}$	1	
	4.6	5	1	$\{A, C, D\}$	0.65	
	5	5	0	-	-	
	5	5	0	-	-	
E_5		0				3.23
	2.6	2.2	2.2	$\{A, B, C, D\}$	1	
	4	2.6	0.4	$\{A, B, D\}$	0.65	
	2.2	4	1.4	$\{B, D\}$	0.55	
	4	4	0	-	-	
E_6		0				4.41
	4.5	4.2	4.2	$\{A, B, C, D\}$	1	
	4.4	4.3	0.1	$\{A, B, D\}$	0.9	
	4.2	4.4	0.1	$\{A, B\}$	0.7	
	4.3	4.5	0.1	$\{A\}$	0.5	
E_7		0				4.55
	4.5	4.5	4.5	$\{A, B, C, D\}$	1	
	4.5	4.5	0	-	-	
	4.6	4.6	0.1	$\{C, D\}$	0.45	
	4.6	4.6	0	-	-	

Table A7. *Cont.*

Employee	x_i	$x_{(i)}$	$x_{(i)} - x_{(i-1)}$	$A_{(i)}$	$m(A_{(i)})$	$y_i = Ch_m(x_1, x_2, x_3, x_4)$
E_8		0				3.95
	4	3.4	3.4	$\{A, B, C, D\}$	1	
	3.4	4	0.6	$\{A, C, D\}$	0.65	
	4	4	0	-	-	
	4.4	4.4	0.4	$\{D\}$	0.4	
E_9		0				4.58
	4.5	4.5	4.5	$\{A, B, C, D\}$	1	
	4.6	4.6	0.1	$\{B, C, D\}$	0.8	
	4.6	4.6	0	-	-	
	4.6	4.6	0	-	-	
E_{10}		0				3.21
	2.8	2.3	2.3	$\{A, B, C, D\}$	1	
	3.6	2.8	0.5	$\{A, B, D\}$	0.9	
	2.3	3.2	0.4	$\{B, D\}$	0.55	
	3.2	3.6	0.4	$\{B\}$	0.6	
E_{11}		0				3.6
	3.7	2.8	2.8	$\{A, B, C, D\}$	1	
	2.8	3.7	0.9	$\{A, C, D\}$	0.65	
	4	4	0.3	$\{C, D\}$	0.45	
	4.2	4.2	0.2	$\{D\}$	0.4	
E_{12}		0				3.52
	3.7	3.2	3.2	$\{A, B, C, D\}$	1	
	3.4	3.4	0.2	$\{A, B, C\}$	0.85	
	3.4	3.4	0	-	0.7	
	3.2	3.7	0.2	$\{A\}$	0.5	
E_{13}		0				4.41
	4.2	4.2	4.2	$\{A, B, C, D\}$	1	
	4.5	4.2	0	-	-	
	4.2	4.5	0.3	$\{B, D\}$	0.55	
	4.6	4.6	0.1	$\{D\}$	0.4	
E_{14}		0				3.17
	2.1	2.1	2.1	$\{A, B, C, D\}$	1	
	3.6	3.1	1	$\{B, C, D\}$	0.8	
	3.4	3.4	0.3	$\{B, D\}$	0.5	
	3.1	3.6	0.2	$\{B\}$	0.6	
E_{15}		0				3.65
	3.7	3.2	3.2	$\{A, B, C, D\}$	1	
	3.2	3.7	0.5	$\{A, C, D\}$	0.65	
	4.2	3.8	0.1	$\{A, D\}$	0.45	
	3.8	4.2	0.4	$\{D\}$	0.2	
E_{16}		0				3.87
	4.2	2.8	2.8	$\{A, B, C, D\}$	1	
	2.8	4.2	1.4	$\{A, C, D\}$	0.65	
	4.2	4.2	0	-	-	
	4.6	4.6	0.4	$\{D\}$	0.4	
E_{17}		0				3.46
	3	2.8	2.8	$\{A, B, C, D\}$	1	
	2.8	3	0.2	$\{A, C, D\}$	0.65	
	3.9	3.9	0.9	$\{C, D\}$	0.45	
	4.2	4.2	0.3	$\{D\}$	0.4	

Table A7. *Cont.*

Employee	x_i	$x_{(i)}$	$x_{(i)} - x_{(i-1)}$	$A_{(i)}$	$m(A_{(i)})$	y_i = $Ch_m(x_1,x_2,x_3,x_4)$
E_{18}		0				3.17
	2.2	2.2	2.2	$\{A,B,C,D\}$	1	
	3.2	2.9	0.7	$\{B,C,D\}$	0.8	
	2.9	3.2	0.3	$\{B,D\}$	0.55	
	3.8	3.8	0.6	$\{D\}$	0.4	
E_{19}		0				3.47
	3.1	3.1	3.1	$\{A,B,C,D\}$	1	
	3.5	3.2	0.1	$\{B,C,D\}$	0.8	
	3.2	3.5	0.3	$\{B,D\}$	0.55	
	3.8	3.8	0.3	$\{D\}$	0.4	
E_{20}		0				3.76
	3.6	2.8	2.8	$\{A,B,C,D\}$	1	
	2.8	3.6	0.8	$\{A,C,D\}$	0.65	
	4.3	4.3	0.7	$\{C,D\}$	0.45	
	4.6	4.6	0.3	$\{D\}$	0.4	
E_{21}		0				3.2
	2.6	2.6	2.6	$\{A,B,C,D\}$	1	
	3.6	2.8	0.2	$\{B,C,D\}$	0.8	
	3.6	3.6	0.8	$\{B,C\}$	0.55	
	2.8	3.6	0	-	-	
E_{22}		0				3.58
	2.6	2.6	2.6	$\{A,B,C,D\}$	1	
	4	3.4	0.8	$\{B,C,D\}$	0.8	
	3.6	3.6	0.2	$\{B,C\}$	0.5	
	3.4	4	0.4	$\{C\}$	0.6	
E_{23}		0				3.75
	3.2	3.2	3.2	$\{A,B,C,D\}$	1	
	4	3.5	0.3	$\{B,C,D\}$	0.8	
	4.3	4	0.5	$\{B,C\}$	0.5	
	3.5	4.3	0.3	$\{C\}$	0.2	
E_{24}		0				3.98
	3.6	3.6	3.6	$\{A,B,C,D\}$	1	
	4	3.9	0.3	$\{B,C,D\}$	0.8	
	3.9	4	0.1	$\{B,D\}$	0.55	
	4.2	4.2	0.2	$\{D\}$	0.4	
E_{25}		0				2.05
	1.2	1.2	1.2	$\{A,B,C,D\}$	1	
	2.6	1.4	0.2	$\{B,C,D\}$	0.8	
	1.4	2	0.6	$\{B,D\}$	0.55	
	2	2.6	0.6	$\{B\}$	0.6	
E_{26}		0				2.34
	2.4	1.4	1.4	$\{A,B,C,D\}$	1	
	2.6	2	0.6	$\{A,B,D\}$	0.9	
	1.4	2.4	0.4	$\{A,B\}$	0.7	
	2	2.6	0.2	$\{B\}$	0.6	
E_{27}		0				3.01
	2.3	2.3	2.3	$\{A,B,C,D\}$	1	
	2.8	2.8	0.5	$\{B,C,D\}$	0.8	
	3.6	3.4	0.6	$\{C,D\}$	0.45	
	3.4	3.6	0.2	$\{C\}$	0.2	

Table A7. *Cont.*

Employee	x_i	$x_{(i)}$	$x_{(i)} - x_{(i-1)}$	$A_{(i)}$	$m(A_{(i)})$	y_i = $Ch_m(x_1,x_2,x_3,x_4)$
E_{28}		0				3.04
	2.2	2.2	2.2	$\{A,B,C,D\}$	1	
	3.2	3.1	0.9	$\{B,C,D\}$	0.8	
	3.5	3.2	0.1	$\{B, C\}$	0.55	
	3.1	3.5	0.3	$\{C\}$	0.2	
E_{29}		0				3.19
	3.2	3.1	3.1	$\{A,B,C,D\}$	1	
	3.2	3.2	0.1	$\{A,B,C\}$	0.85	
	3.2	3.2	0	-	-	
	3.1	3.2	0	-	-	
E_{30}		0				2.95
	2.1	2.1	2.1	$\{A,B,C,D\}$	1	
	2.8	2.8	0.7	$\{B,C,D\}$	0.8	
	3.5	3.4	0.6	$\{C,D\}$	0.45	
	3.4	3.5	0.1	$\{C\}$	0.2	
E_{31}		0				2.55
	2	2	2	$\{A,B,C,D\}$	1	
	2.7	2.5	0.5	$\{B,C,D\}$	0.8	
	2.5	2.7	0.2	$\{B,D\}$	0.55	
	2.8	2.8	0.1	$\{D\}$	0.4	
E_{32}		0				2.55
	1.4	1.4	1.4	$\{A,B,C,D\}$	1	
	3.2	1.9	0.5	$\{B,C,D\}$	0.8	
	1.9	2.5	0.6	$\{B,D\}$	0.55	
	2.5	3.2	0.7	$\{B\}$	0.6	
E_{33}		0				3.48
	2.8	2.8	2.8	$\{A,B,C,D\}$	1	
	3.6	2.8	0	-	-	
	5	3.6	0.8	$\{B, C\}$	0.5	
	2.8	5	1.4	$\{C\}$	0.2	
E_{34}		0				4.48
	5	3.5	3.5	$\{A,B,C,D\}$	1	
	3.5	5	1.5	$\{A,C,D\}$	0.65	
	5	5	0	-	-	
	5	5	0	-	0	
E_{35}		0				3.6
	3.9	2.5	2.5	$\{A,B,C,D\}$	1	
	2.9	2.9	0.4	$\{A,B,D\}$	0.9	
	2.5	3.8	0.9	$\{A,D\}$	0.65	
	3.8	4.1	0.3	$\{A\}$	0.5	

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