UNIVERSIDADE FEDERAL DE PERNAMBUCO

CENTER FOR DECISION SYSTEMS AND INFORMATION DEVELOPMENT

PRATICAL USER GUIDE - FITRADEOFF

Recife, 2024

In case of unexpected errors or doubts, please contact us at fitradeoff@cdsid.org.br.

SUMMARY

1. The System

The decision support system FITradeoff - Flexible and Interactive Tradeoff (code FU_T3MMM_WF1a) elicits the scale constants for the multicriteria decision problems in a flexible and interactive way, using the scope of the deterministic additive model. It works for the problematic of choice (De Almeida et al., 2016; De Almeida et al., 2021), ranking (Frej et al., 2019; De Almeida et al., 2021), sorting (Kang et al., 2020), portfolio with benefit-to-cost ratio (Frej et al., 2021) and portfolio combinatorial (Marques et al., 2022).

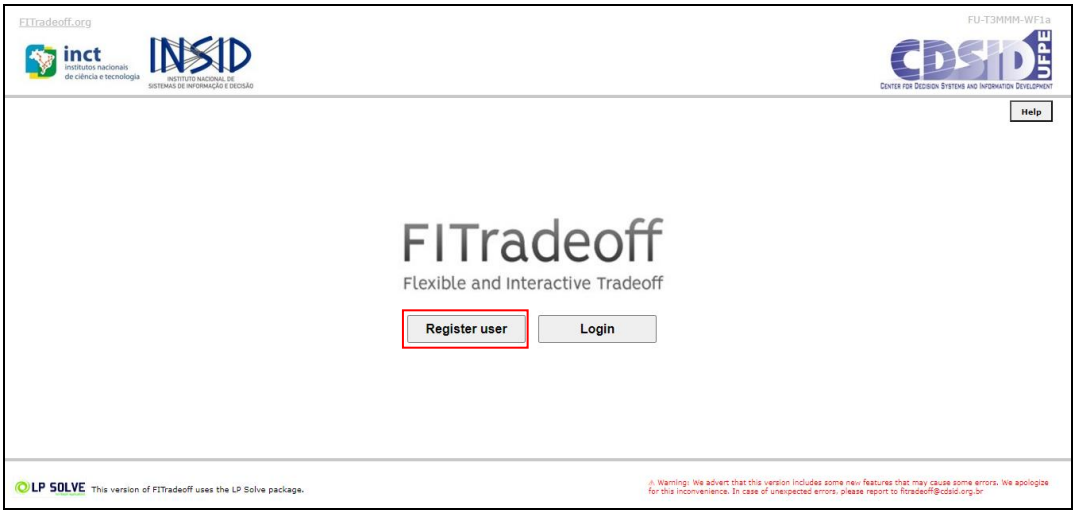
The system is available online at http://cdsid.org.br/fitradeoff/. This guide aims to lead the user through the system, illustrating its screens and functionalities. The user can also access at https://fitradeoff.org/video-lecture/ videos demonstrating how each step of the system occurs. For more information regarding the FITradeoff method for the different types of problems, its mathematical model and characteristics, the original references listed at the bottom of the document should be consulted.

Also, the system was developed by students and researchers of CDSID-UFPE, and it is in evolution process, with continuous improvement and testing. Therefore, in case of unexpected errors, doubts, or suggestions, please contact at fitradeoff@cdsid.org.br.

2. Access

To access the FITradeoff system, the user must register through the CDSID registration system (www.cdsid.org.br/registration) to access it, simply choose the "Register user" button on the system's home screen (Figure 2.1).

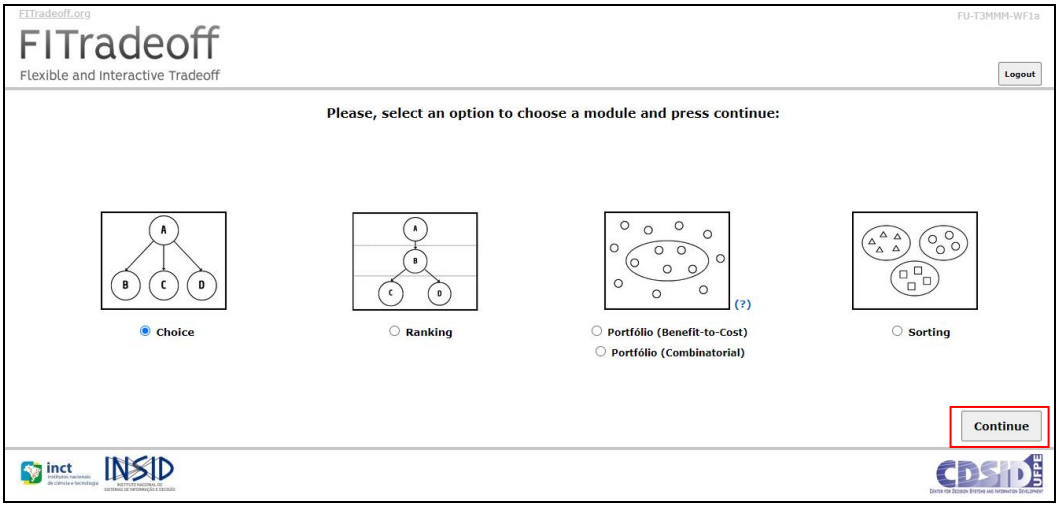
Figure 2.1 – Home page of the FITradeoff system



3. Data Entry

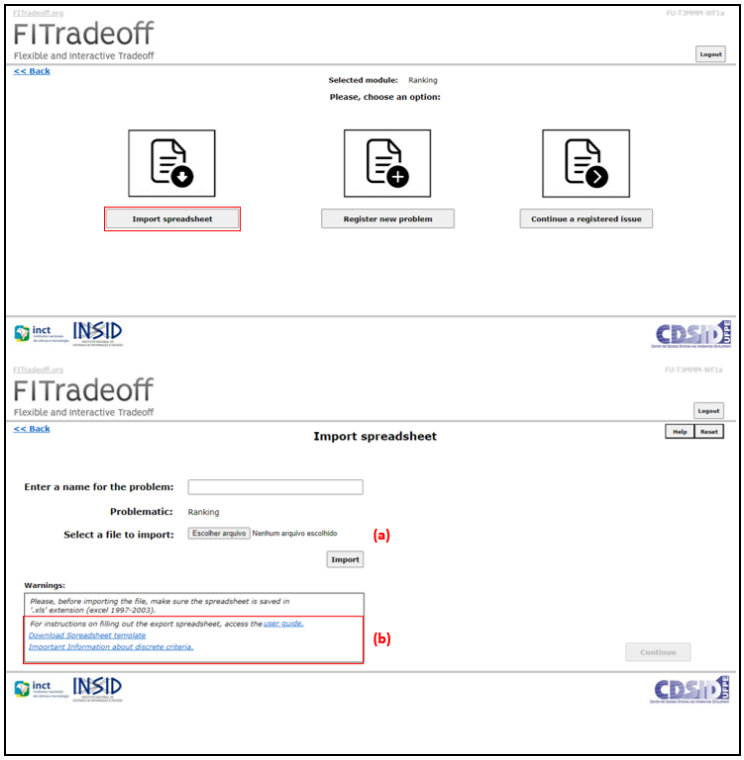
When logging into the system, the user is directed to a screen where the type of problem for its respective problem must be selected (Figure 3.1), and then click on the "*Continue*" option.

Figure 3.1 – Screen for choosing the type of problem



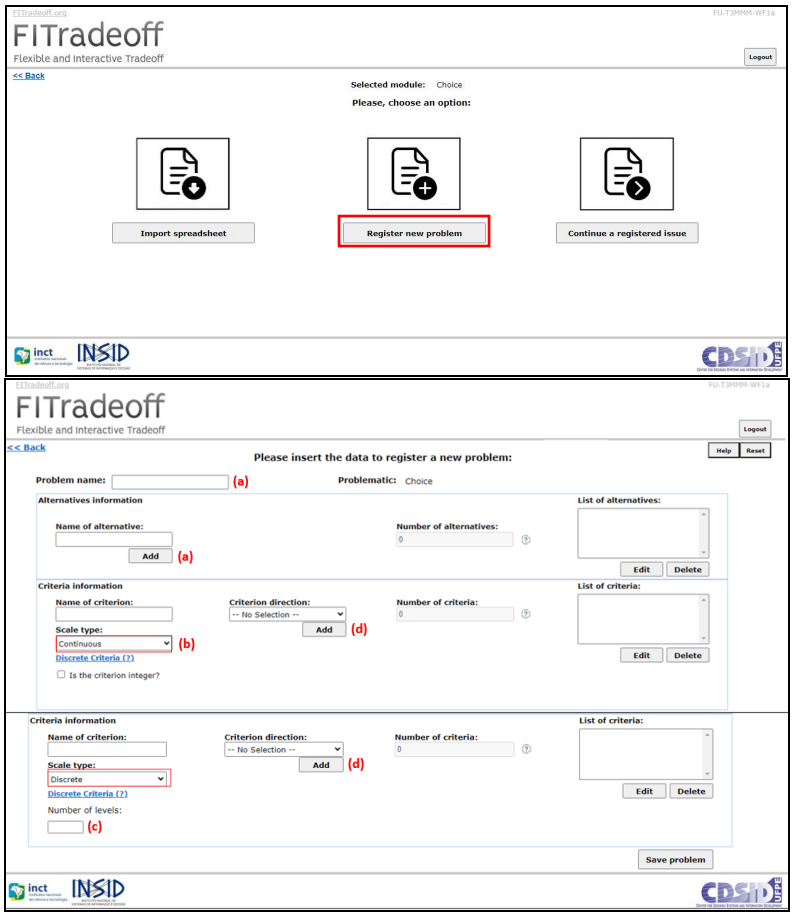
The new FITradeoff system allows the entry of data via Excel spreadsheet in the format *.xls* (compatibility 97-2003) **(a)**. To do this, the user must click on the "*Import spreadsheet*" option that appears right after choosing the problem type (Figure 3.2). In the Input screen you can download a template spreadsheet to introduce the problem and view practical information regarding the use of discrete criteria **(b)**.

Figure 3.2 – Excel spreadsheet import process



It is also possible to enter the data manually, which is especially useful for people who do not use Excel. For that, the user should click on the "*Register new problem*" option (Figure 3.3).

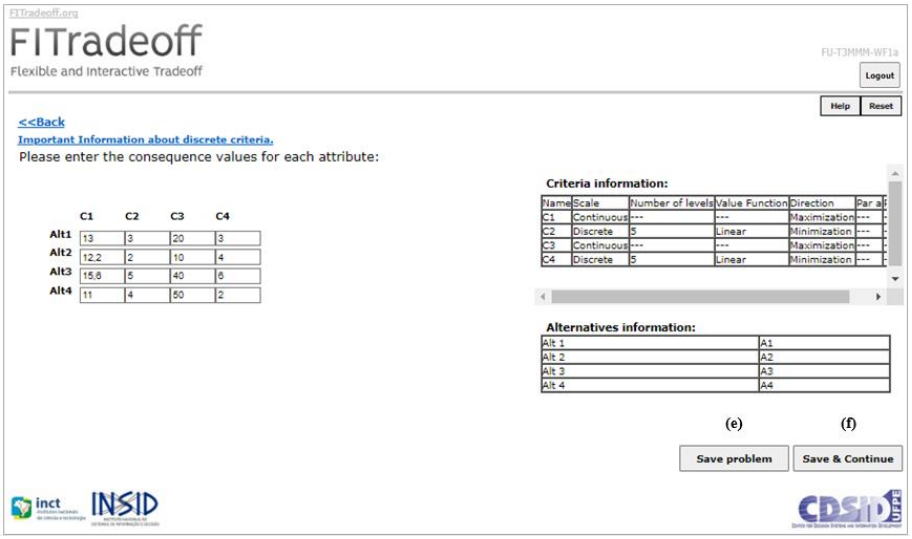
Figure 3.3 – Process of entering data manually



In order to the FITradeoff decision support system operate correctly, all the fields on the page shown in (Figure 3.3) must be completed. Initially, the DM – Decision-Maker must enter the name of the problem and add one by one the names of the alternatives, so that they can be counted **(a)**.

Next, the DM must declare: the names of the criteria one by one, counting them in the same way as in the alternatives; the type of scale (continuous/discrete) and the direction of the criterion (maximization/minimization). For continuous criteria, the option to declare the criterion as an integer is available, when applicable **(b)**, when the criterion is discrete, the number of levels must be defined **(c)**, and, finally, the "*Add*" button must be selected for all cases **(d)**.

Figure 3.4 – Saving the problem after the manual data entry is completed



By clicking on "*Save problem*" **(e)**, the system will save all the information introduced so far, which will be available if there is a need to resume the registration of the problem later. Another option is the "*Save & Continue*" button, which allows the DM to proceed to the next steps in solving the problem immediately, in this case all the data should have already been informed **(f)**.

Important information:

- All characteristics referring to the criterion being inserted, at a given moment, must be declared;
- In the screens in the upper left corner, you have a "*Back*" link responsible for returning to a previous screen;
- Through the links "*Discrete criteria*" and "*Important information about discrete criteria*" it will be possible to view practical information regarding the use of discrete criteria.

3.1 Data entry: constructed scale (discrete criteria)

The discrete criteria evaluation considers a global scale. In other words, if the user informs the system that the scale constructed consists of 'n' levels, all these will be considered in the intra-criteria evaluation even if there are no consequences belonging to all levels in the matrix.

Consider a criterion consisting of seven discrete and maximization levels, when performing the intra-criteria evaluation, the system will consider that the best and worst consequence are respectively seven and one, even if in the matrix of consequences, the highest and lowest value are different from these. In addition, the DM should be aware of

the predefined scales accepted by the DSS. The table below presents the possible consequences for the discrete scale criteria according to the number of levels reported.

Table 3.1 – Number of levels and its respective possible consequences

Number of levels	Scale levels (Discretization)
2	0,1 (binary criterion)
3	1,2,3
4	1,2,3,4
5	1,2,3,4,5
6	1,2,3,4,5,6
7	1,2,3,4,5,6,7

Important information:

- If the criterion cannot be evaluated according to the scales presented above, it is possible to make an approximation by considering them as integer continuous;
- For 2-level discrete criteria, a consequence with a value of 0 does not necessarily indicate the absence of property, but only that the alternative was less well evaluated.

4. Model Sheet

To enter the data via Excel spreadsheet, the DM must follow some recommendations, which may change according to the type of problem. Currently, two spreadsheet templates are available that can be used to enter the data into the FITradeoff system. One worksheet refers to the introduction of choice, ranking and sorting problems, and the other refers only to the introduction of portfolio problem, which requires additional information.

4.1. Model Sheet for choice, ranking and sorting problematics

To enter the input data into the system, the Excel spreadsheet used must have the FITradeoff standard formatting, represented in Figures 4.1 and 4.2. It should be filled with the criteria names (row 1); the types of criteria (row 2); the number of scale levels, for discrete criteria (row 7); the alternatives (row 9) and the values of the consequence matrix (cell 9B).

Important information: Each information highlighted above must be filled in the respective line indicated, i.e., lines 3 to 6 remain blank.

Figure 4.1 – Formatting for Excel spreadsheet in the FITradeoff standard

	A	B	C	D	E	F
1	**Criteria:**	Crit 1	Crit 2	Crit 3	...	Crit n
2	Criterion type (FITradeoff)					
3						
4		Do not fill in or delete lines 3 to 6.				
5						
6						
7	**FITradeoff**: Number of levels of discrete criteria					
8	**Alternatives:**	Consequence Matrix:				
9	Alt. 1					
10	Alt. 2					
11	Alt. 3					
12	...					
13	Alt. 4					

Filling out the spreadsheet:

- **Criteria:** Starting from column B, row 1 should be filled in with the name of the problem criteria. The number of columns will change according to the number of criteria considered in the problem;
- **Type of criteria:** There are six types that can be assigned: Continuous minimization; Continuous maximization; Discreet minimization; Discreet maximization; Minimization integer; Maximizing integer;

Table 4.1 – Types of criteria and description

Type of criteria	Description
0 – Continuous minimization	Criterion with any value within the range limited by the minimum and maximum performances assumed. The lower the value in the criterion, the more preferred.
1 – Continuous maximization	Criterion with any value within the range limited by the minimum and maximum performances assumed. The higher the value in the criterion, the more preferred.
2 – Discreet minimization	Discrete criteria admit only values on an established point scale (Section 3.1). The lower the value in the criterion, the more preferred.
3 – Discreet maximization	Discrete criteria admit only values on an established point scale (Section 3.1). The higher the value in the criterion, the more preferred.
4 – Minimization integer	Criteria with any integer value within the range limited by the minimum and maximum performances assumed (e.g., Number of people). The lower the value in the criterion, the more preferred.
5 – Maximizing integer	Criteria with any integer value within the range limited by the minimum and maximum performances assumed (Ex: Number of people). The higher the value in the criterion, the more preferred.

- **Scale levels:** See information presented in Section 3.1;
- **Alternatives:** From row 9 onward, column A of the Excel worksheet represents the alternatives names of the problem. The number of rows will change according to the number of alternatives considered in the problem;
- **Consequence Matrix Values:** Each cell in the consequence matrix represents the performance of an alternative evaluated against a criterion. For example, cell B10 should be filled with the value that represents the performance of Alternative 2 in Criterion C1 (Figure 4.1).

4.2. Model Sheet for portfolio problematic

For the portfolio problems, the Excel spreadsheet will contain additional information, as shown in Figure 4.2 below.

Figure 4.2 – Formatting for Excel spreadsheet in the FITradeoff standard (Portfolio)

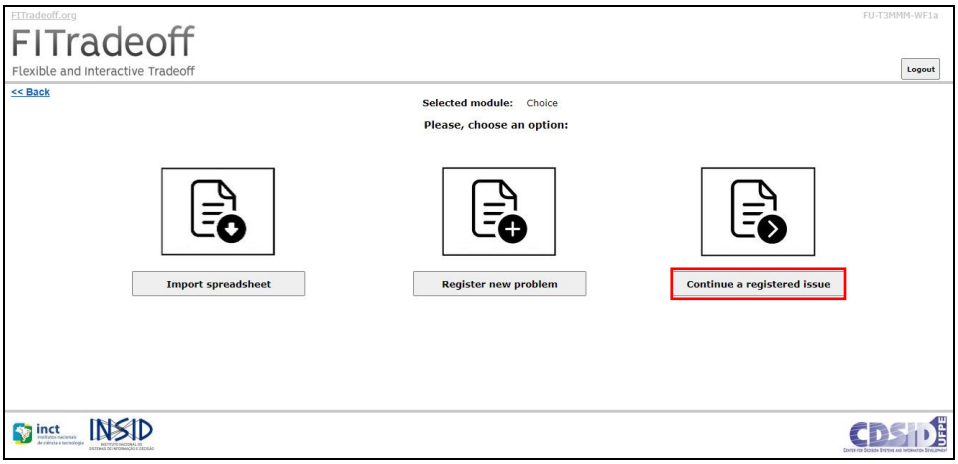
	A	B	C	D	E	F	G
1	**Criteria:**	Crit 1	Crit 2	Crit 3	...	Crit n	BUDGET
2	Criterion type (FITradeoff)						
3							
4		Do not fill in or delete lines 3 to 6.					
5							
6							
7	**FITradeoff**: Number of levels of discrete criteria						
8	**Alternatives:**	Consequence Matrix:					COST
9	Alt. 1						
10	Alt. 2						
11	Alt. 3						
12	...						
13	Alt. 4						

- **Budget:** The maximum amount of money set by the decision-maker that is available to be spent on the projects. This data should be included in row 2 below the "*Budget*" cell;
- **Cost:** The cost associated with the implementation of each of the projects. It shoud be inserted from line 9 onward, below "*Cost*".

5. Resuming Problems

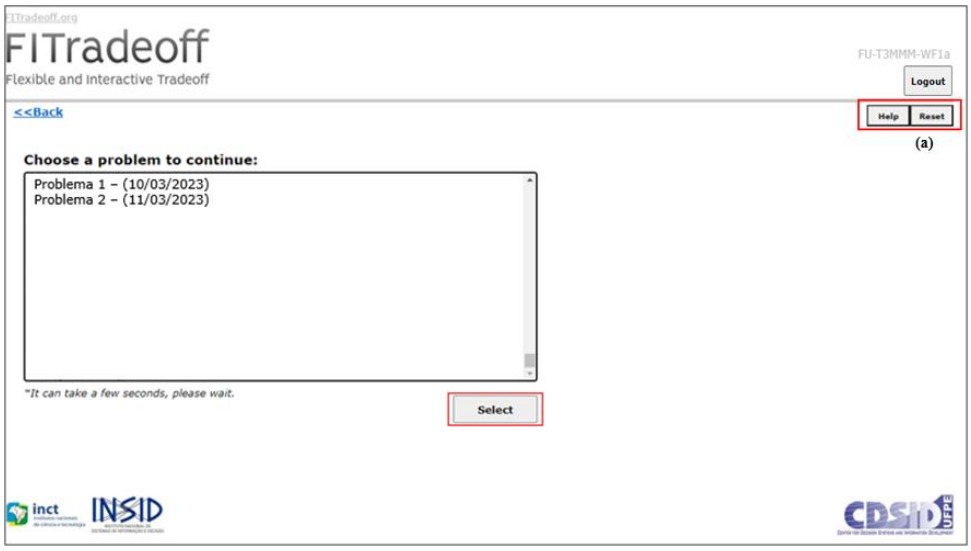
By choosing "*Continue a registered issue*" on the screen shown in Figure 5.1, you can resume registered problems, even those that final solutions have already been found. This option is useful in case some situation leads to the interruption of the problem resolution process or in cases where the decision-maker wants to redo it.

Figure 5.1 – Resuming a registered problem



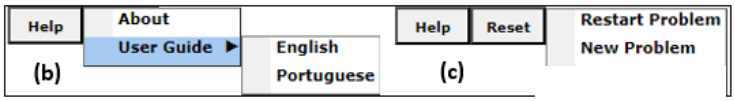
When selecting this option, the user will be directed to another screen (Figure 5.2) in which a list containing all the problems registered by the DM will be presented, in this way, a problem is selected and the system redirects it to the point where the execution was running by the time of interruption.

Figure 5.2 – Screen of registered problems



Another important feature available throughout the process of solving a problem in the system are the "*Help*" and "*Reset*" buttons, always located in the upper right corner of the screen **(a)**.

Figure 5.3 – Functionalities of the "*Help*" and "*Reset*" buttons



In case of doubts about the system, the "*Help*" button **(b)** allows the user to download this guide and *"About"* can also provide the references of the FITradeoff Method.

If the user wishes to restart the resolution of the problem, register a new problem, or leave the system, can use the "*Reset*" button **(c)** available on the various screens of the SAD.
Important Information: When choosing "*New Problem*" the user is directed to the screen of Figure 5.1, so if the DM also wanted to change the type of problem, it should also click on the "*Back*" link in the upper left corner that will return to the screen of Figure 3.1.

6. Intra-criteria Evaluation

The intra-criteria evaluation step has a great importance in the multicriteria problem modeling process, consisting in obtaining the marginal value function that can reflects the preferences of the DM at different levels of aspiration, on a scale measurable for each problem criterion, by associating a real number *v(x)* (in a scale from 0 to 1) at each point *x* (consequence evaluated on a criterion) in an evaluation space.

6.1 Intra-criteria Elicitation

Given a local scale, ranges of values are compared to peers, questioning the decision-maker for which of them there is a greater predilection. However, instead of identifying points of indifference between the values, it is desired to find admissible ranges, through statements of strict preference, considering partial information.

An *x* reference value is updated with each given response, reducing the range of values of between the lower and upper limits of the local scales of each criterion. Until a previously established stopping criterion is met.

In this way, the first and last points of the scale (0-1) will be determined through the worst and best values of the consequences reported in the problem, called x_0 and x_1, respectively. It remains to define the points $x_{0.25}$, $x_{0.5}$ and $x_{0.75}$. The systematic is repeated until the required points are determined for each criterion analyzed.

Illustrative example:

For instance, consider a maximization criterion that presents the following range of consequence values:

Crit1	**100**	20	40	80	**10**

By analyzing the values present in terms of local scale, it can be identified that the lowest consequence value is 10, representing the worst level of satisfaction and determining the reference value x_0. While the consequence that best represents the aspirations of the decision-maker, that is x_1, is worth 100. Thus, the next step of the process consists of identifying values of consequences that in fact represent the points $x_{0.5}$, $x_{0.25}$ and $x_{0.75}$, through questions that use strict preference relationships. Necessarily, these values will be

contained between the minimum and maximum values of the scale of this criterion [10, 100]. At the end, with the required reference points, it will be possible to extract the form of the value function of the analyzed criterion.

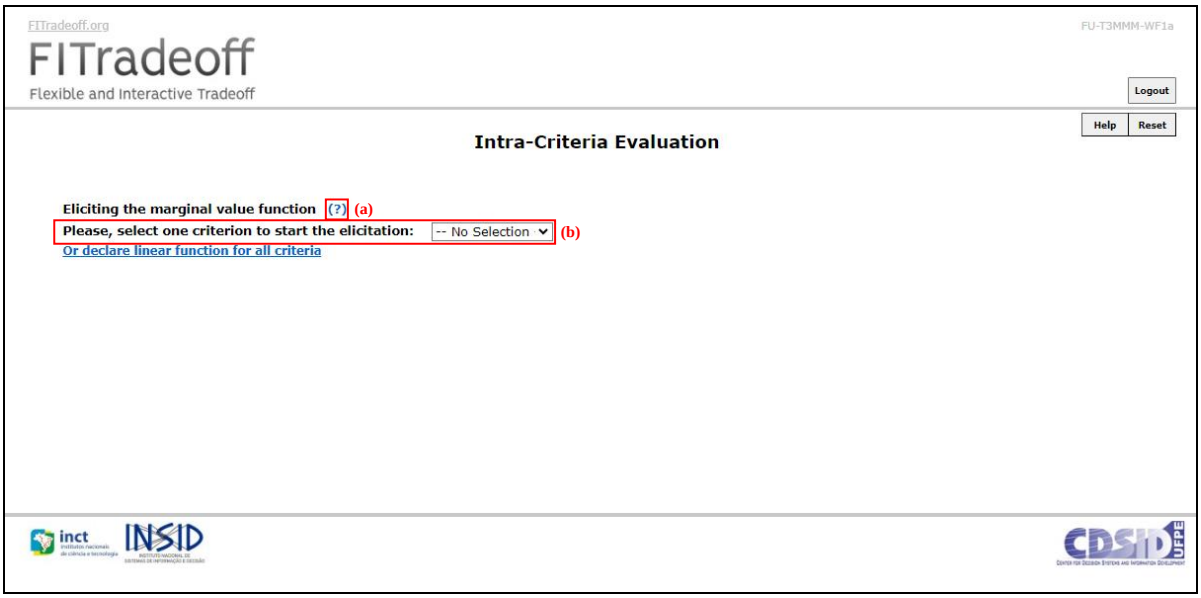
Important Information: The number of points elicited for extracting the function shape varies according to the scale type of the criterion.

6.2 Performing intra-criteria elicitation in the FITradeoff system

Once the data has been entered, either via Excel or manual input, the decision-maker will be directed to the intra-criteria elicitation screen (Figure 6.1). On that screen, firstly the DM will see a question mark link that leads to a pop-up with explanations about the intra-criteria evaluation **(a)**, and a dropdown menu containing all the problem criteria **(b)**, from which they should select one to start the procedure.

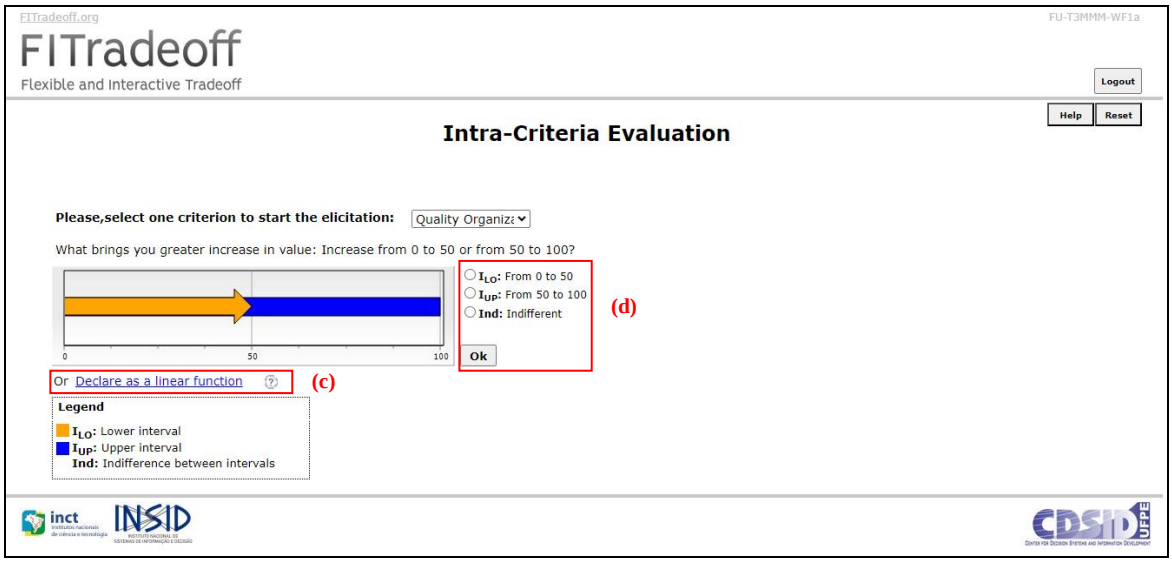
Important Information: If the decision maker wants to declare all criteria of the problem as linear, the option "*Declare linear function for all criteria"* must be selected.

Figure 6.1 – Start screen for intra-criteria elicitation



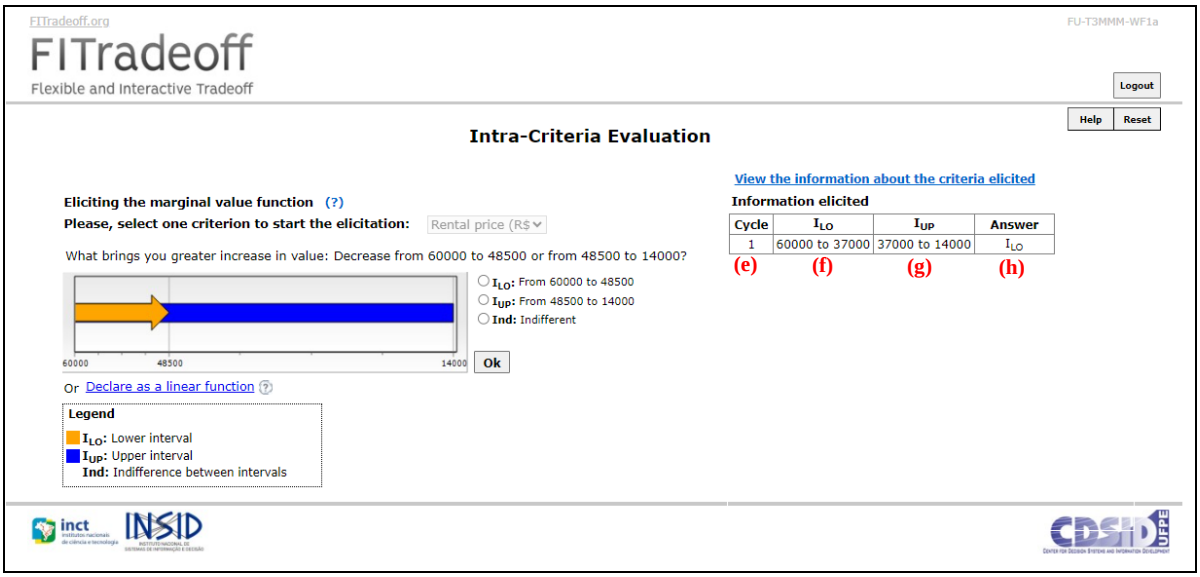
Therewith, it is possible to directly declare that the selected criterion is linear by clicking on "*Declare as a linear function*" **(c)** (Figure 6.2), ending its elicitation, or else, the DM can elicit the three values ($x_{0.5}$, $x_{0.25}$, $x_{0.75}$), always considering the space of consequences of the criterion to obtain the form of its value function.

Figure 6.2 – Intra-criteria elicitation procedure - Continuous criteria



After providing the first response **(d)**, the value ranges are updated, and a box with the responses is displayed (Figure 6.3).

Figure 6.3 – Intra-criteria elicitation procedure – Continuous Criteria



For each response, a row is displayed in the box, containing the cycle €, which represents the order of the given response, the values of the lower interval I_{LO} **(f)** and the upper interval I_{UP} **(g)**, and the response given in the specific cycle **(h)**. You can view the information about the elicited criteria in *"View the information about the criteria elicited"*. In this option, you can view the graph with the function shape or individually reset a criterion.

It is worth mentioning that the decision-maker can opt for the indifference between the intervals, evidencing the basic premise of the system, which is to allow a flexible process. The process is repeated until the stopping criterion is met and the elicited point is

defined. At the process end, it is possible to view the graph with the elicited function (Figure 6.4). You can save the image **(i)** or go to the next criterion to be elicited **(j)**.

Figure 6.4 – Intra-criteria elicitation procedure – Continuous Criteria

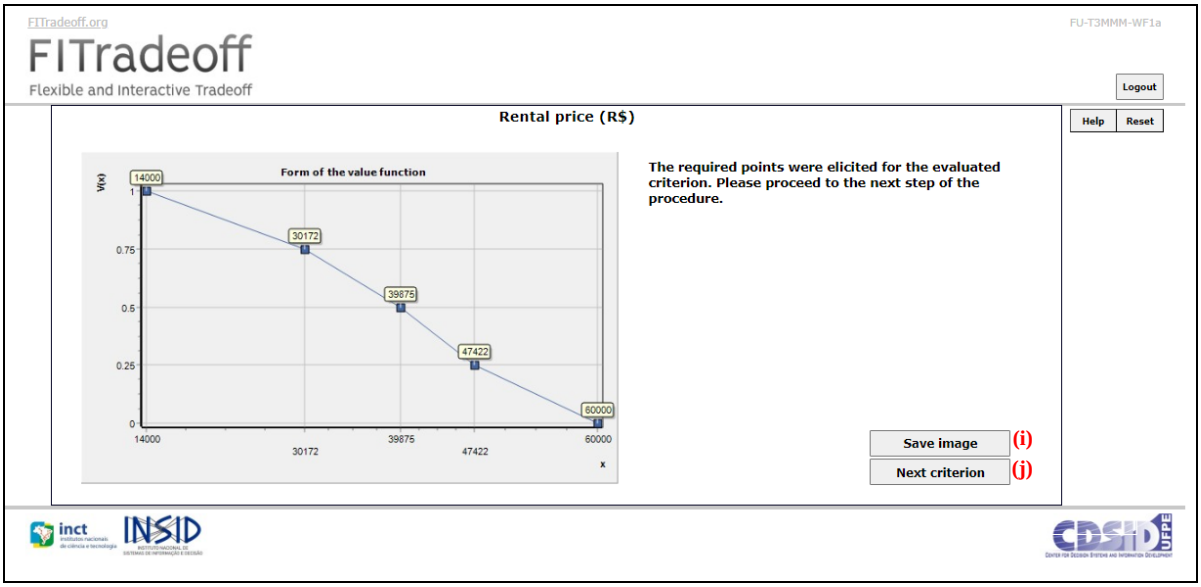
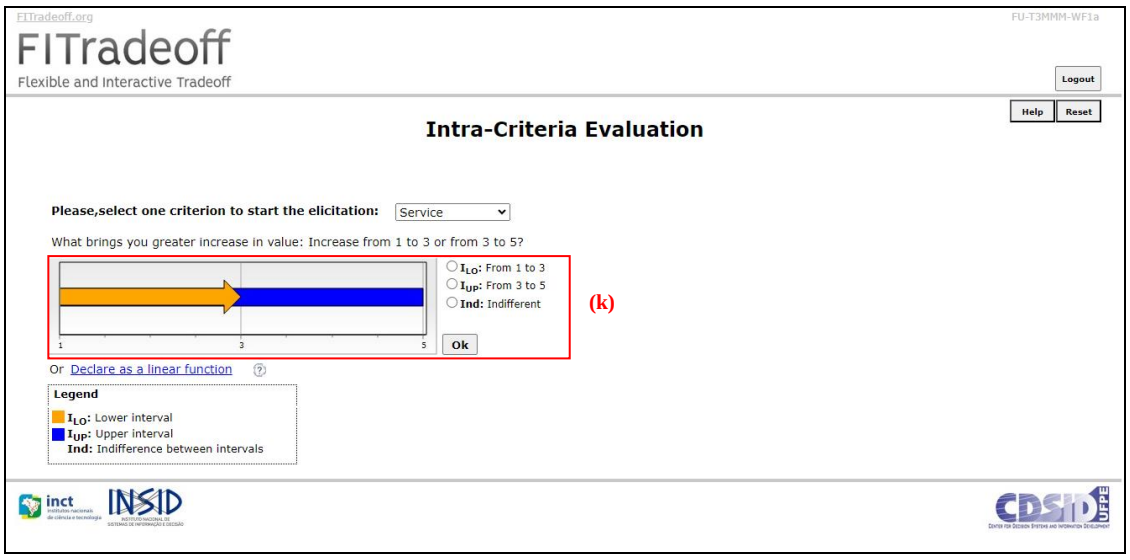


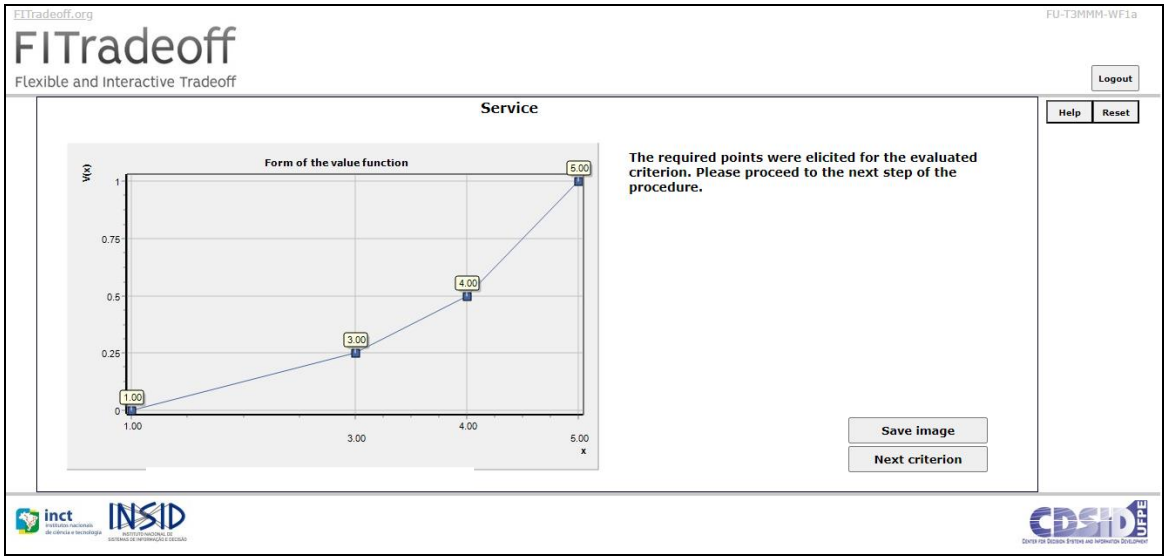
Figure 6.5 – Intra-criteria elicitation procedure - Discrete criterion



As for the discrete criteria, the stopping criterion corresponds to verifying if there are still levels between the analyzed limits. Considering the example shown in Figure 6.3, if the decision-maker chooses the interval "*From 3.00 to 5.00*" the system verifies the stopping criterion and concludes that it was not found, since there is the level 4 between the analyzed limits that has not been evaluated yet, requiring the formulation of a new question **(k)**.

Important information: The intra-criteria evaluation for discrete criteria is performed for criteria with 3, 4 and 5 levels. For the other levels, the linearity of the function is assumed.

Figure 6.6 – Elicitation process result in intra-criteria evaluation



The instant the stopping criterion is reached, or the decision-maker opts for the indifference of the intervals, the point is defined. The process occurs in the same way to obtain the reference values of the other points, when necessary, until the graph with the form of the final marginal value function is displayed to the DM, as represented in Figure 6.4 above. Once the elicitation of each reference value for the criterion has been completed, the system will allow starting the elicitation of the next one. And if all the desired criteria have been elicited, having a final marginal value function, it will be possible to proceed to the inter-criteria evaluation stage.

Once value functions of the criteria have been defined, the DM can proceed to the first screen of the inter-criteria evaluation stage. But if the user wishes to restart the intra-criteria elicitation phase, just click on ***Reset*** >> ***Restart problem*** located on the upper right side of the elicitation screen.

7. Input Page

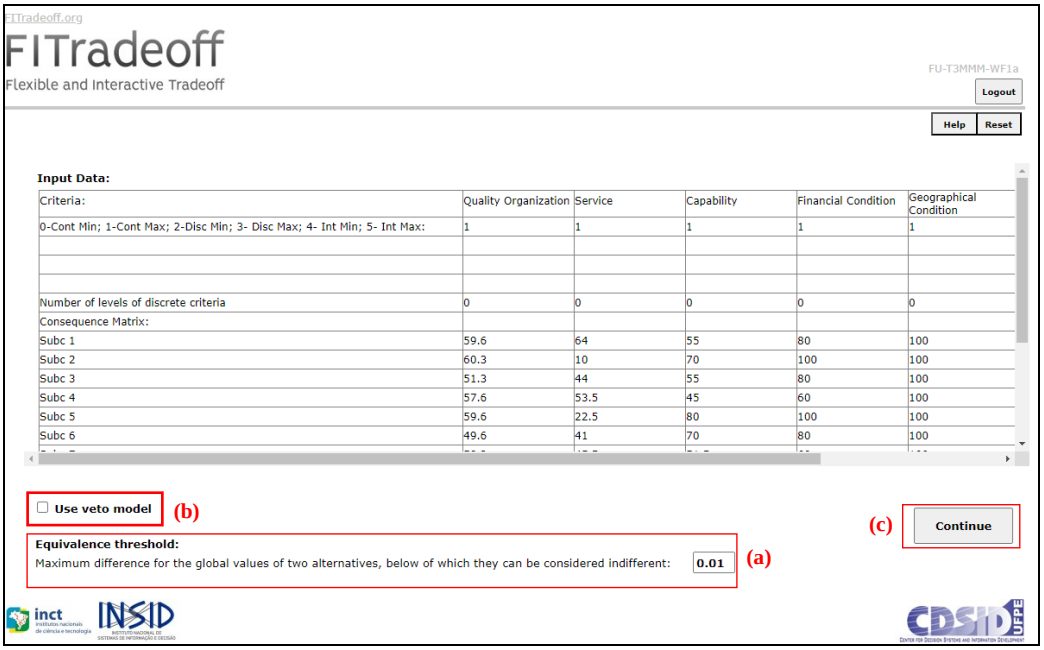
After the intracriteria evaluation, the Input Page will be shown to the user, where all the information imputed by the decision-maker is displayed (Figure 7.1). On this page it is extremely important to pay attention to the "*Equivalence threshold*" **(a)**. This value refers to the maximum difference that the global value referring to a pair of alternatives can assume so that such alternatives are considered indifferent to each other. If the user indicates the value zero, then a pair of alternatives will be considered indifferent, only if such alternatives have the same global value for the entire viable weight space.

In this version, the veto mechanism available in "Use veto model" **(b)** (Choice and ranking problematics) has been incorporated. This option should be selected in cases where

the user has a veto preference regarding the performance of one or more criteria, as shown in subsection 7.1.

On this same page, after checking the information provided, the decision-maker should use the "Continue" button **(c)** to sort the scale constants.

Figure 7.1 – Input Page visualization



7.1 The Veto mechanism

The veto preference condition should be applied in situations where the user willing to reject or penalize an alternative that performs below acceptance level established in a given criterion. This condition is incorporated into the system by means of upper and lower veto limits.

Thus, by choosing "Use veto model" **(b)**, the system displays the table **(d)** (Figure 7.2) in which the user must select the criterion to which they wish to assign the upper and lower veto limits by clicking on the name of the criterion highlighted in blue. The limit values must fall within the scale of the criterion chosen to assign the veto.

For maximization criteria, the upper limit represents the minimum performance value for the alternative in relation to the criterion that the user is willing to accept. The lower limit is the maximum performance value that will cause the user to reject the alternative in relation to the criterion. In cases of hesitation, i.e. the alternative's performance is between the upper and lower limits, the alternative will suffer a penalty in its overall value.

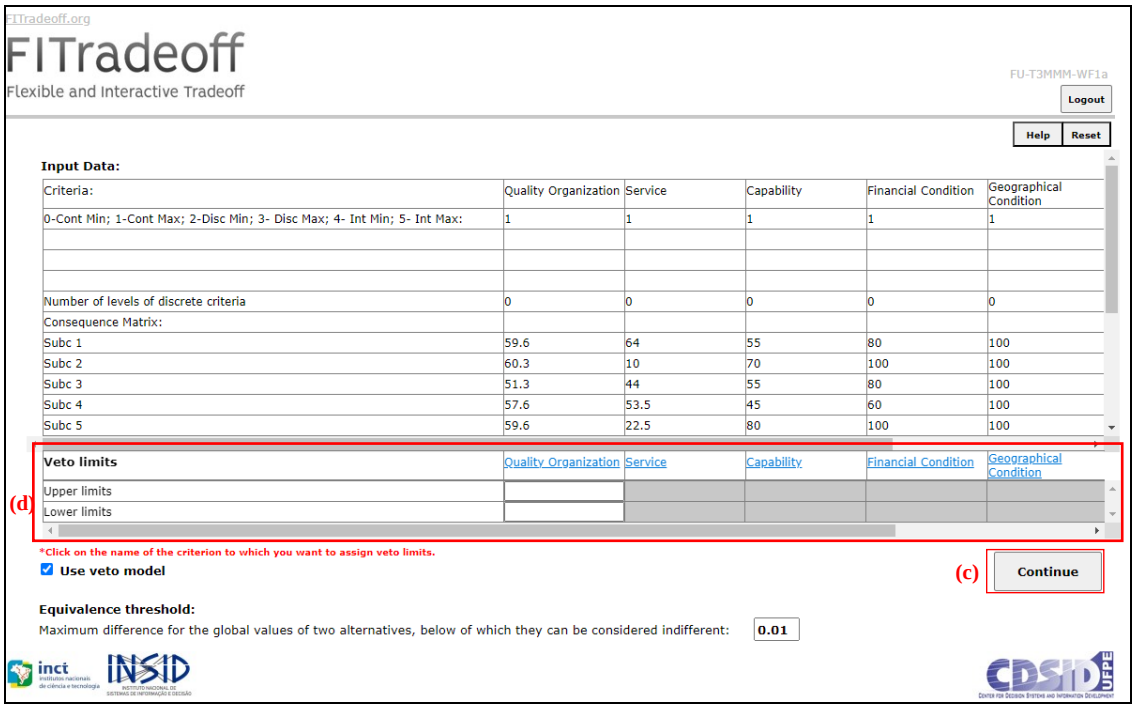
For minimization criteria, the reasoning is reversed, i.e. the upper limit represents the maximum performance value that will make the user reject the alternative in relation to the

criterion. The lower limit is the minimum performance value for the alternative in relation to the criterion that the user is willing to accept. In cases of hesitation, i.e. the alternative's performance is between the upper and lower limits, the alternative will suffer a penalty in its overall value.

It's worth noting that the user is the one who decides whether or not to veto the criteria in the problem, and if they do, it's not necessary to select all the criteria; the new version allows the DM to select only the group of criteria they wish to veto; in this case, the veto limits will not be incorporated for the criteria not selected.

After entering the limits, the user must use the "Continue" button **(c)** to sort the scale constants.

Figure 7.2 – Viewing the Input page with veto limits.



Illustrative example:

Considering the problem illustrated in (Figure 7.2), when analyzing the problem criteria, the user chose to assign a veto preference to the "Quality Organization" criterion. This is a maximization criterion with the following range of consequence values:

Quality Organization	**100**	20	40	80	**10**

Thus, the user is unwilling to select an alternative that performs below 60, considering that the ideal performance would be equal to or above 80. Therefore, the upper veto limit will be represented by 80, i.e. alternatives with performance equal to or above this value will not have their value changed, and the lower veto limit will be represented by 60,

i.e. alternatives with performance equal to or below this value will have their value changed. Alternatives that perform in the hesitation region, which are values between the upper and lower limits, receive a penalty.

Important information: The user can set the upper and lower limit for the criterion, as well as assign the limits separately, in which case you will not count the hesitation region.

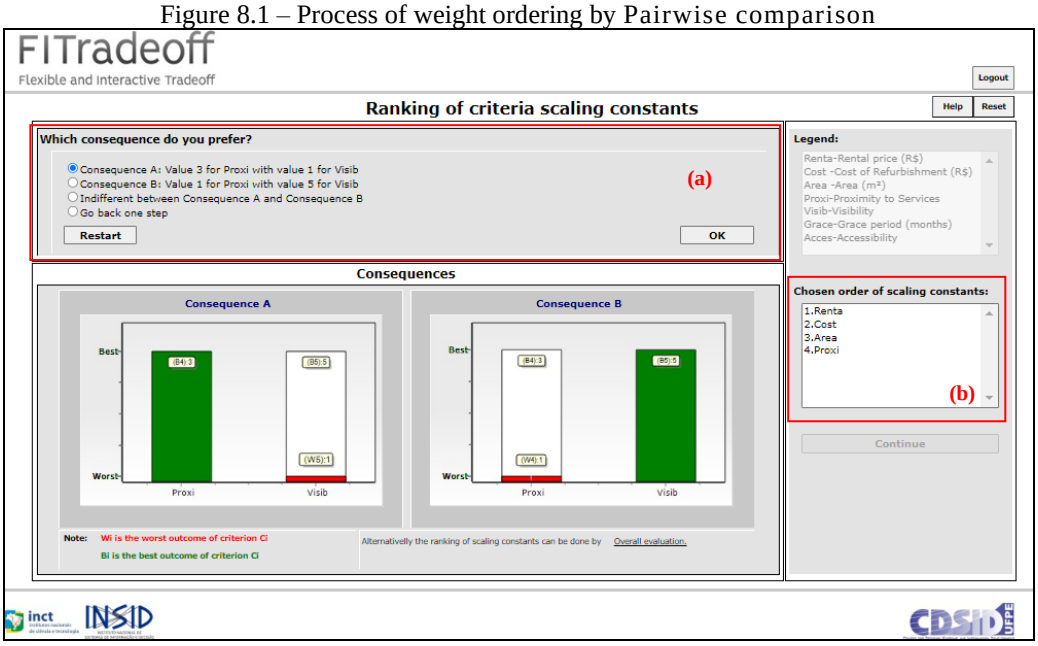
8. Weight Ordering

The FITradeoff DSS makes it possible to perform the ordering of weights through "Pairwise Comparison" (Figure 8.1) and, also, through "Overall Evaluation" (Figure 8.3) between the criteria.

Important information: From now on, the name of the alternatives and criteria are reduced. For the alternatives it is considered the first 8 letters of the name and for the criteria it is considered the first 5 letters of the name, this reduction takes place to facilitate the visualization of both. The system also uses other logics, if when using this one, there are still alternatives or criteria with equal acronyms.

Following the standard system mode, ordering the criteria starts with the "Pairwise Comparison" as shown in Figure 8.1. A hypothetical comparison situation is presented with graphs, and the decision-maker must select whether is preferred the maximum value of Consequence A, Consequence B, or the indifferent between the consequences **(a)**. The DSS uses a Heuristic to reduce the number of questions asked, where, as each response is stored, the criteria are displayed orderly **(b)**.

Figure 8.1 – Process of weight ordering by Pairwise comparison



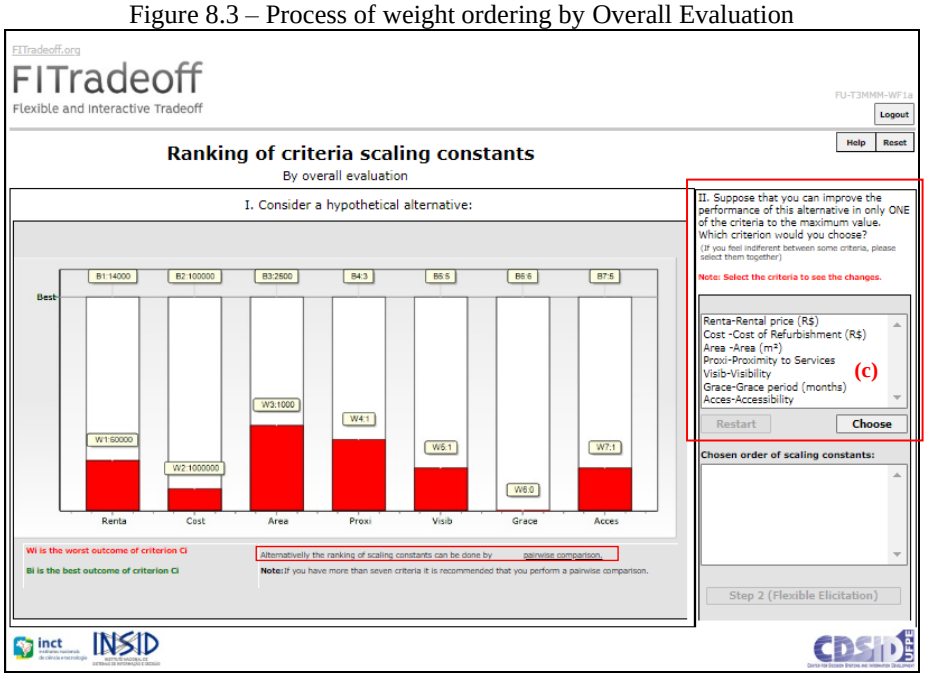
Important information:

- If the DM declares the indifference between the consequences, a screen is displayed (Figure 8.2) requesting the choice of the representative criterion, that is, the criterion that will be used in the questions of the elicitation by decomposition. When providing this information, the criteria assume the same order;
- In cases of indifference between two criteria in which one of them is binary, the screen in Figure 8.2 is **not** shown and the representative criterion is determined by the system, which is the one with a non-binary consequence;
- If when providing information, the DM presents any doubt, the option "Go back one step" **(a)** can be selected and it will be possible to answer again.

Figure 8.2 – Screen displayed in cases of indifference between consequences

Another option to ordering the criteria is by Overall Evaluation", available in the link at the bottom of the screen shown in Figure 8.1. In it, the criteria should be ordered according to the order of impact that will generate in the result of the problem, according to the DM's preferences. Initially, the user must click under the first criterion that he considers having the highest value of scale constant, assuming that it will have its performance optimized at the best possible value **(c)**. The performance bar of the selected criterion will be indicated in yellow and after clicking on the "*Choose*" button, it will turn green. This process should be repeated until all criteria are ordered.

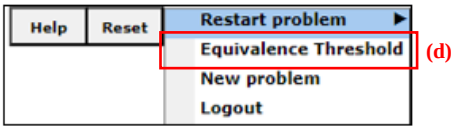
Figure 8.3 – Process of weight ordering by Overall Evaluation



Important information: The red bar in the graph represents the worst consequence evaluated in each criterion, it is presented on a ratio scale so that the decision-maker can more clearly visualize the range of values of the consequences during the ordering of the weights.

It is also noteworthy that in the problems of choice and ranking, from this stage onwards, the user is has available the option to change the "*Equivalence threshold*" throughout the elicitation **(d)**, as shown in Figure 8.4 below.

Figure 8.4 – Button of "*Equivalence threshold*"



9. Elicitation of Profiles – Sorting problematic

The elicitation of profiles is a step present in the sorting problems. These profiles are part of the decision-maker's preference structure and can be defined directly by providing their values, characterizing their respective classes. These values are established on a scale of 0 to 1, determining the classes of the problem. In this way, each class is defined by two consecutive profiles in order of magnitude. In summary, an alternative is allocated in a given class if its performance is between the two values that define that class. For example, if the decision maker defines the problem as having two classes and defines the profile with a value of 0.5, the first class would be formed by the alternatives with a global value between 0 and 0.5, while the second class would be formed by the alternatives with a global value

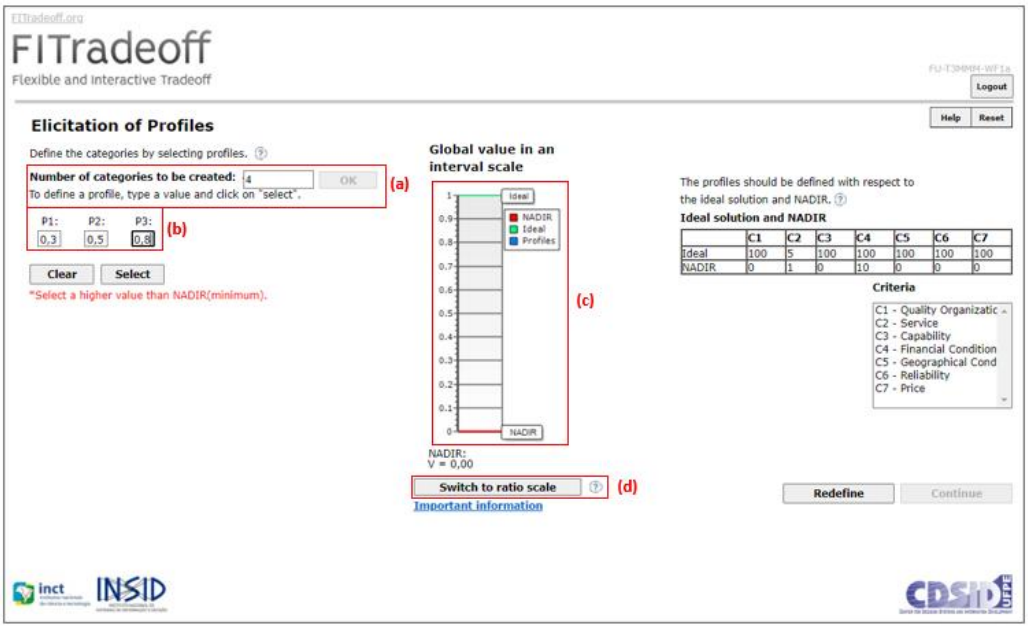
between 0.5 and 1.

Then, in this step, the DSS (Figure 9.1) requires the decision-maker to define the number of classes that will be used for their problem **(a)**. It should then define the reference values (profiles) that will be used **(b)**. After that, it is possible to graphically visualize these profiles **(c)**, as well as two fictitious alternatives: the ideal solution and NADIR.

The ideal solution can be defined as a hypothetical alternative whose performance is the best possible in all criteria. NADIR, on the other hand, can be defined as a hypothetical alternative whose performance is the worst possible in all criteria.

Initially in the graphical visualization the scale used is interval so that performance 0 is represented by NADIR while performance 1 is represented by the ideal solution. Thus, all defined profiles are between these two values. However, the DM may choose to switch the scale to a ratio scale **(d),** in which the value 0 means absence of the property considered, and proportions between consequence values can be established. Therefore, NADIR will not necessarily have a global value equal to 0 on this scale, but still necessarily all profiles must be larger than this fictitious alternative.

Figure 9.1 – Profile elicitation screen for sorting problems



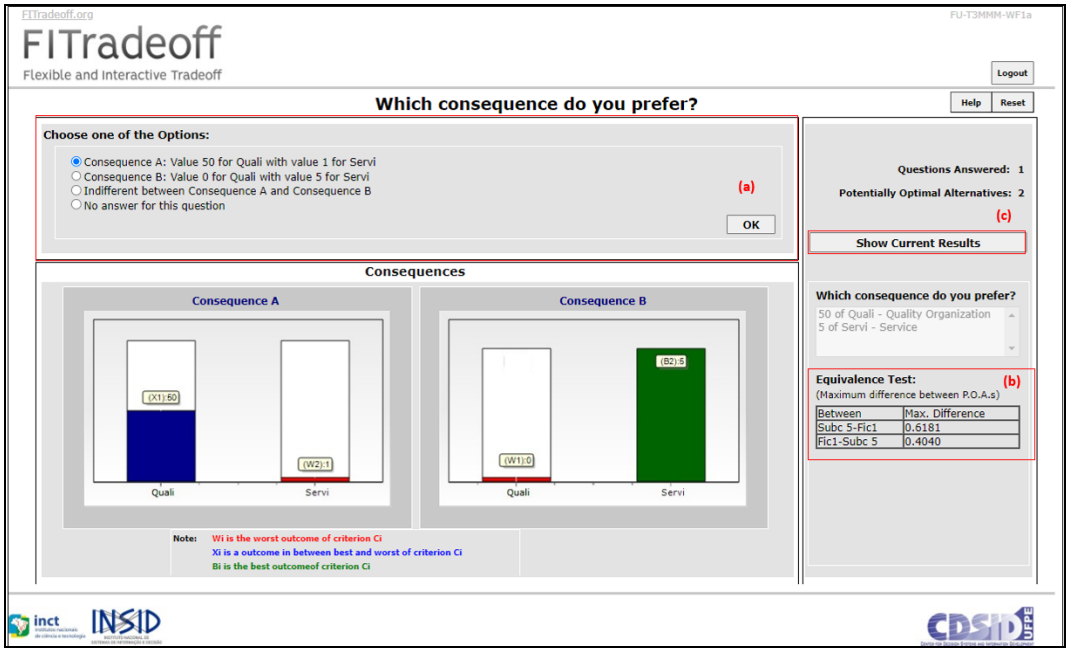
10. Elicitation by Decomposition

In the problems of choice, ranking and portfolio after ordering the weights, the user will be directed to a screen of partial results (**which will be detailed in Section 11 of this Guide**), where the user can choose to continue the process of preferences elicitation through Elicitation by Decomposition or Holistic Evaluation, allowing a flexible elicitation process. For the problem of classification this screen will be only available after the elicitation of the

profiles.

If the Elicitation by Decomposition is selected, the elicitation begins by comparing two elements in the space of consequences that are presented to the decision-maker, as can be seen in Figure 10.1 below.

Figure 10.1 – Elicitation by Decomposition screen



When necessary, the elicitation of adjacent criteria and intermediate levels (regarding to discrete criteria) is evaluated. For adjacent criteria an intermediate consequence is displayed at one criterion (for which the associated "weight" appears best placed in the ranking) and the worst consequence for all others. On the other side, the best consequence for another criterion and the worst performance for the others are presented.

The DM is then asked which consequence he prefers **(a),** and it can be answered "*Consequence A*" to prefer the first consequence shown in the left of the graph, "*Consequence B*" to prefer the second consequence, or it is also possible to opt for indifference, when the DM is equally satisfied with any of the consequences presented. The informed preferences will be used for the construction and the resolution of a LPP – Linear Programming Problem, allowing the establishment of relationships between the alternatives based on the partial information obtained from each question.

The "*No Answer*" option should be selected when for some reason the DM does not wish to answer the question presented, in this case, the DSS will ask the reason for such an answer and will not again ask questions for that pair of criteria.

Important information: These are the options for all elicitation.

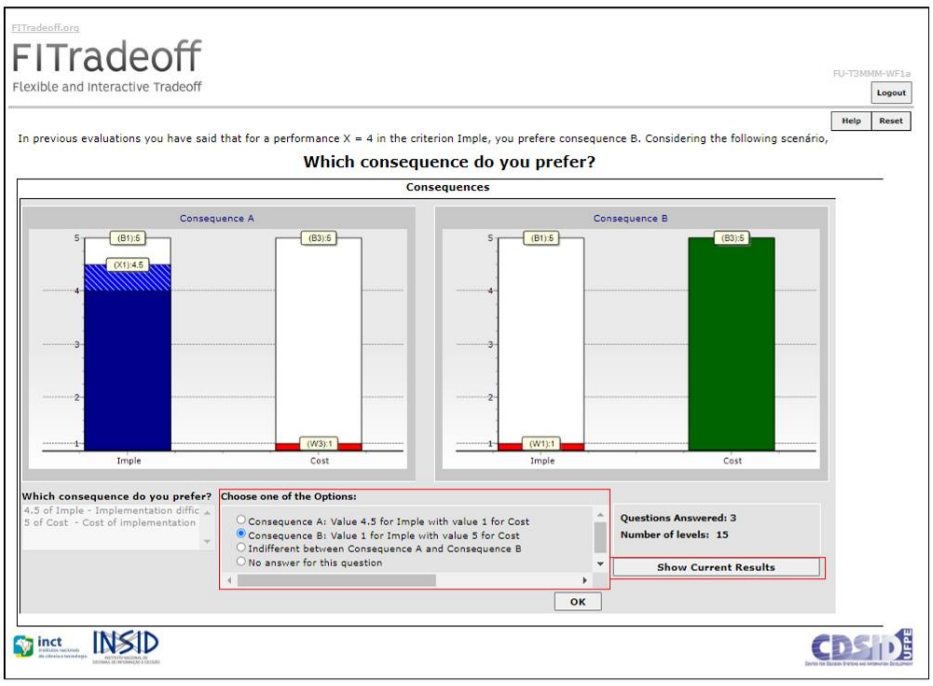
When, in the problem of choice, up to three potentially optimal alternatives remain, an equivalence test is performed between the remaining alternatives **(b)**. The test consists of verifying whether the maximum difference between each alternative of the group is less than or equal to the equivalent distance value previously informed, if the hypothesis is verified, the DSS returns the alternatives considered indifferent, otherwise it exhibits - whether the test results contain the maximum difference between the alternatives evaluated peer-to-peer (the decision-maker himself may use this information as a stopping criterion).

In the Figure 10.1 is available the option of viewing partial results **(c)**, which presents to the decision-maker the results obtained so far through a tabular and graphical visualizations. When analyzing the results, the decision-maker may choose to continue the elicitation by decomposition, switch to holistic evaluation, or finalize the decision process.

The elicitation of intermediate levels occurs if, during elicitation by decomposition, more information is needed to define the DM's predilection. For this, the screen of Figure 10.2 is displayed in which elements in the space of consequences are compared. The "Consequence A" corresponds to some intermediate level of a discrete criterion and "Consequence B" the best performance of another criterion, where the intermediate levels of the discrete criterion will be varied, that is, "Consequence A".

Important information: Although the discrete criteria do not present continuous consequences, this elicitation helps to obtain more information from the decision-maker.

Figure 10.2 – A case of intermediate levels elicitation



Then, the DM is asked if with the variation for the current level what will be his preference, in the frame of "Options" shown above. The user can still choose to view the results obtained up to that point in "Show Current Results".

As mentioned earlier, the DSS works with a flexible elicitation, and thus also allows the use of the Holistic Assessment process to obtain a result for the problem. This method is detailed in the Section 12 of this Guide.

11. Results Screen

The FITradeoff provides, throughout the decision-maker's preferences elicitation, a visualization of the partial results. On this page, are displayed the tabular and graphical visualizations of the results obtained with the information that has been provided so far.

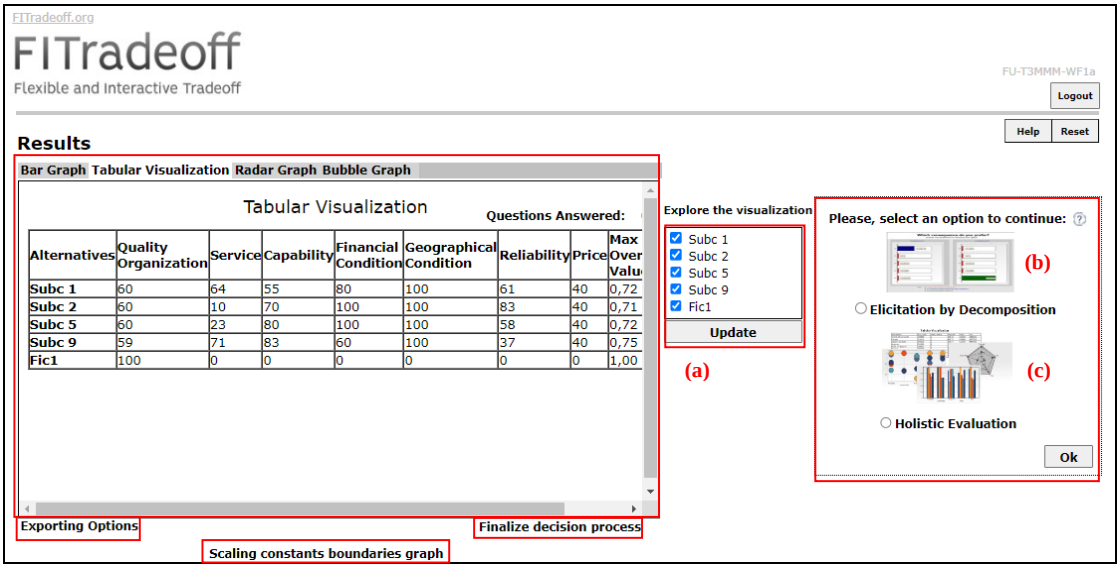
Different types of visualizations are offered: bar, bubble, and radar charts. Such visualizations help the DM to observe the differences of each alternative when confronted in each criterion in a more intuitive way, providing even more tools for a right decision.

Important information: The display of partial results varies based on the problem type: graphical and tabular visualizations for choice; Hasse diagram and tabular for ranking and portfolio; Gantt chart and tabular for sorting. It is also possible to export the data at any time in the "Exporting options" link.

11.1 Visualization for the choice problematic

The partial results in the choice problem consist of visualizing the set of potentially optimal alternatives to the problem (more details in De Almeida et al. (2016)). In this case, the display of results can occur in two ways: graphical and tabular visualization, and is represented in Figure 11.1.1.

Figure 11.1.1 – Screen of partial results

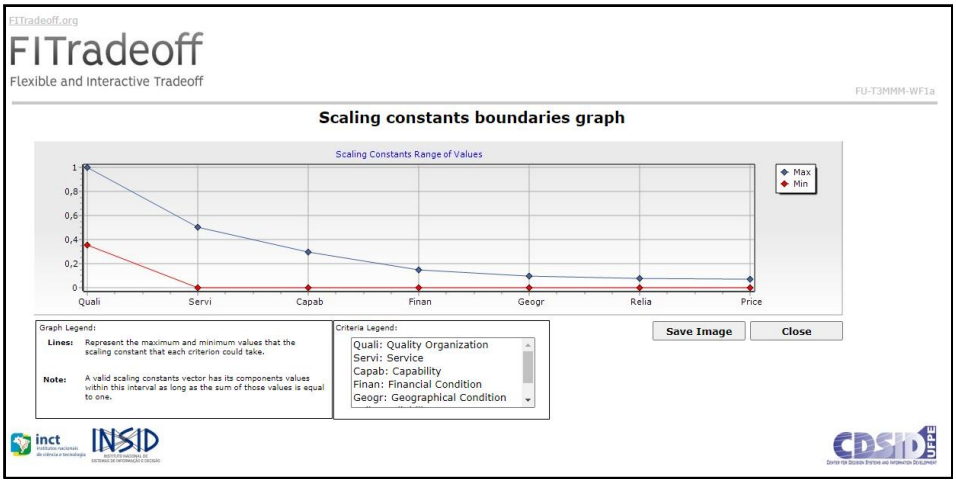


Important information: In the problem of choice, the decision-maker can select the alternatives that he wants to visualize **(a)**.

When viewing the results, if the results obtained until that moment are already satisfactory, the decision-maker can end the process in "*Finalize decision process*". Or if the DM decides to continue to elicit, it is possible to choose between resuming elicitation by decomposition **(b)** or switching to the holistic evaluation **(c).**

FITradeoff also provides a graph containing the range of permissible values for the scale constants of each criterion (Figure 11.1.2) – for all problems, to access it just click on "*Scaling constants boundaries graph*". This graph is updated while the questions are answered, which allows to track the behavior of the weight space throughout the process. It can be exported in image format.

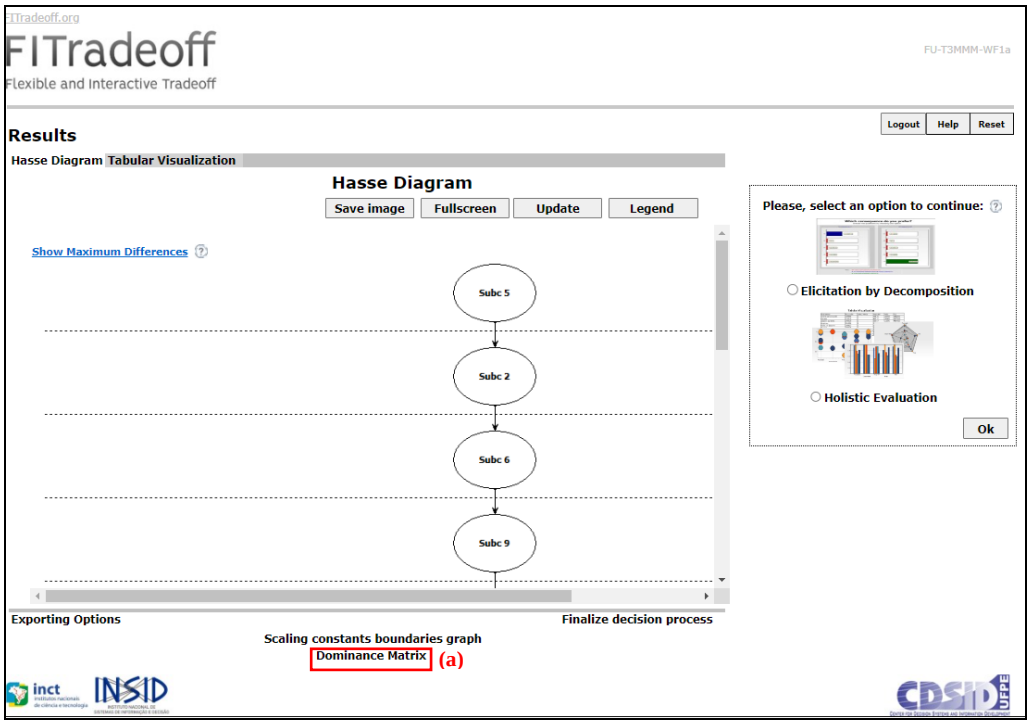
Figure 11.1.2 – Scale constants graph



11.2 Visualization for the ranking problematic

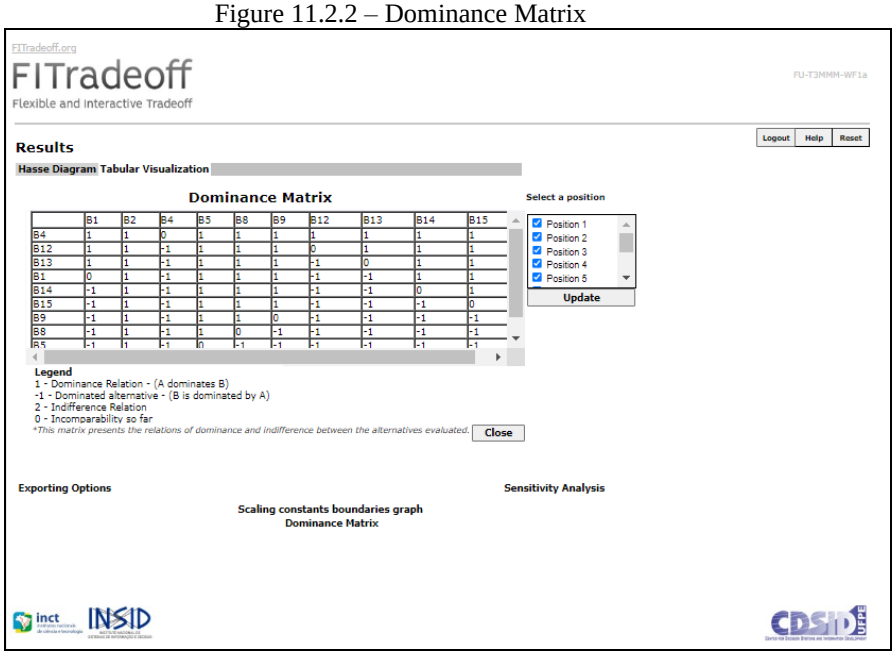
The partial result in ranking problems consists of the partial rank obtained based on the dominance relations found so far (more details in Frej et al., 2019). In the problems of ranking and portfolio the display of results can occur in two ways: Hasse Diagram (DH) and tabular visualization. This diagram presents the dominance relations established between the alternatives and the different levels that they occupy in the ranking.

Figure 11.2.1 – Partial results screen for ranking problematic.



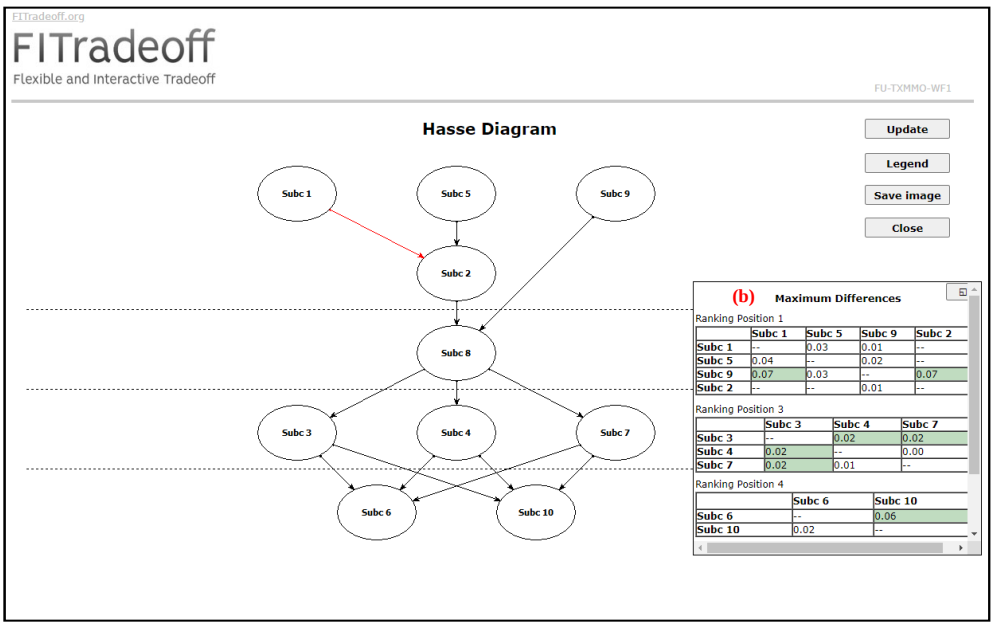
Upon clicking on “Dominance Matrix” **(a)**, the alternatives dominance matrix will appear, as shown in Figure 11.2.2. In this matrix, it is possible to see when one alternative dominates another (the cell receives -1), when it is dominated by another alternative (the cell receives a 1), when there is an indifference relationship between two alternatives (the cell receives a 2), and when the two alternatives are incomparable given the current level of information (the cell receives a 0).

Figure 11.2.2 – Dominance Matrix



In brief, the diagram presents the positions that the alternatives occupy in the ranking, highlighting the pair-to-pair dominance relationships established throughout the process with arcs ("links"), as shown in Figure 11.2.2. The diagram will be available three seconds after accessing the results page, even in the partial results stage.

Figure 11.2.3 – Hasse Diagram (DH) visualization



When it comes to the representation of dominance relationships, this version of FITradeoff DSS portrays it by using different colors of arcs. Alternatives that remain without arcs, up to the current level of information, can be understood as incomparable. The Table 11.1 below summarizes this information.

Table 11.1 – Dominance relationships in the Hasse Diagram (DH)

ARC COLOR	RELATION
Black	Dominates/Dominated by Elicitation by decomposition
Red	Dominates/Dominated by Holistic Assessment
Grey	Indifference

Finally, it is worth mentioning that for the problem of ranking, the table containing the maximum differences between the incomparable alternatives in each ranking position is available next to the Hasse Diagram **(b).** This table can be displayed by clicking on *"Show Maximum Differences"*.

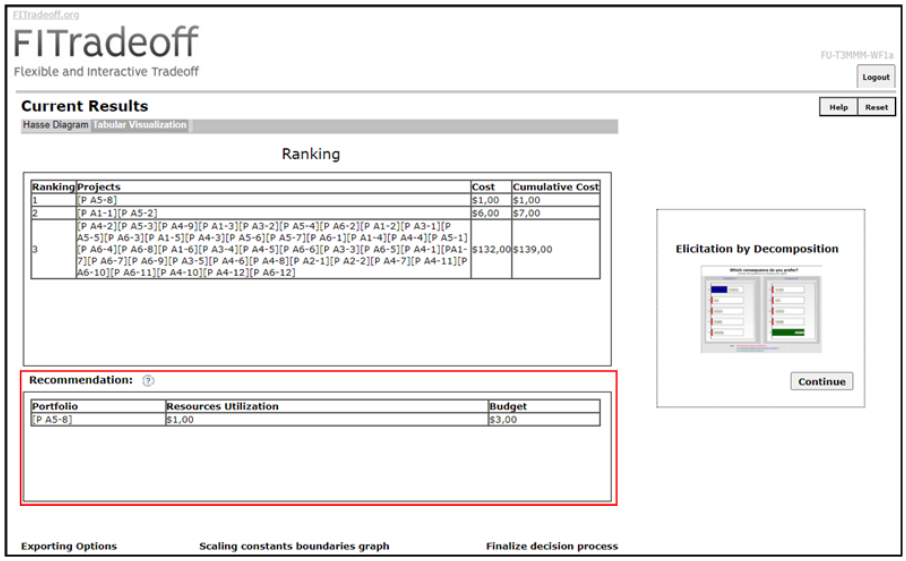
11.3 Visualization for the portfolio problematic

For portfolio problems, the projects are ranked in descending order of their cost-benefit ratio (more details in the reference Frej et al., 2021). Beyond the Hasse Diagram (DH), there is also a tabular view, where a ranking is displayed with the positions of the projects inserted in the portfolio (Figure 11.3.1), considering the "Budget" informed, the "Cost" of the projects by the ranking position, and the "Cumulative Cost".

Important information:

- The DH does not display the table of maximum difference between the portfolios projects;
- In this version, holistic assessment for portfolio problematic is not available yet.

Figure 11.3.1 – Screen of partial results for portfolio problematic



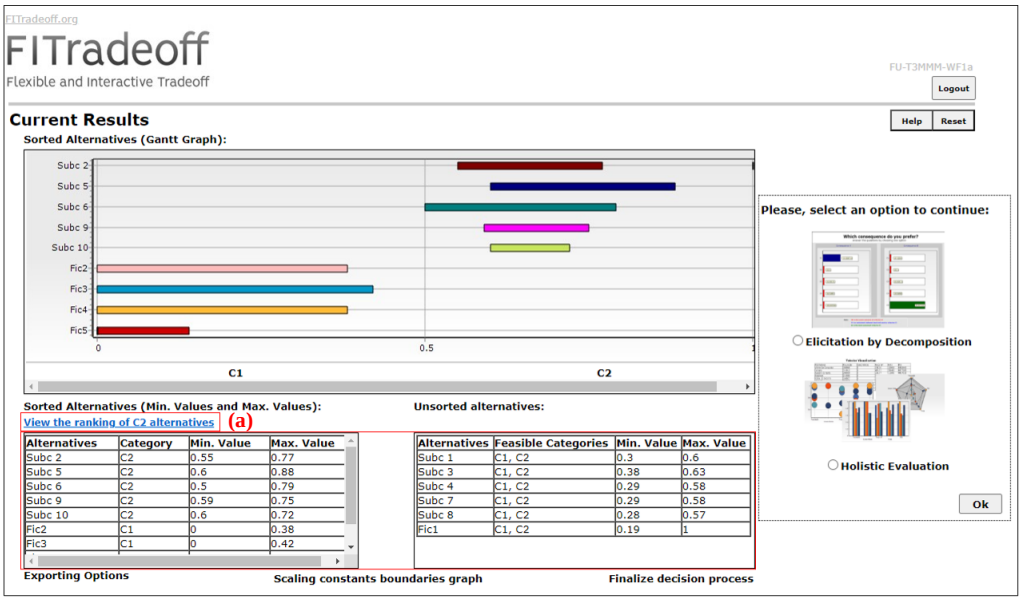
As can be seen on the screen above, a portfolio recommendation is given based on the ranking obtained and the dominance relations between projects. It should be notice that other portfolios can be chosen, depending on the decision-maker's analysis of the current ranking and dominance relations.

11.4 Visualization for the sorting problematic

In the sorting problematic, alternatives are classified according to their maximum and minimum global values (more details in the reference Kang et al., 2020). In this case, the Gantt Chart (Figure 11.4.1) is the results visualization available.

The Gantt Chart allows the decision-maker to observe the alternatives that have already been classified, as well as their minimum and maximum values, the profiles that define the classes and the respective classes. In addition, the tabular view below the chart allows the DM to see the numeric values for each alternative, and its possible classes (or its defined class, if it has already been classified).

Figure 11.4.1 – Screen of partial results for sorting problem



Alternatives	Category	Min. Value	Max. Value
Subc 2	C2	0.55	0.77
Subc 5	C2	0.6	0.88
Subc 6	C2	0.5	0.79
Subc 9	C2	0.59	0.75
Subc 10	C2	0.6	0.72
Fic2	C1	0	0.38
Fic3	C1	0	0.42

Alternatives	Feasible Categories	Min. Value	Max. Value
Subc 1	C1, C2	0.3	0.6
Subc 3	C1, C2	0.38	0.63
Subc 4	C1, C2	0.29	0.58
Subc 7	C1, C2	0.29	0.58
Subc 8	C1, C2	0.28	0.57
Fic1	C1, C2	0.19	1

Important information: By clicking the "View the ranking of C2 alternatives" link, it is possible to view the dominance relationships among all alternatives ranked in the first class.

12. Holistic Assessment

The Holistic Evaluation (HE) is undoubtedly the greatest differential of this FITradeoff decision support system version, since it combines different concepts for decision support, more details on holistic assessment in FITradeoff can be obtained from reference De Almeida et al. (2021). The new DSS enables the decision-maker to introduce information both through evaluations by decomposition and holistic evaluations.

12.1 What does this mean in practice?

In a simplified way, holistic evaluation consists of making a direct comparison between two or more alternatives, being able to select the best among them or exclude the worst one. In this way, additional information is provided to the system, which can be useful

in reducing the number of necessary questions until reaching the final result or even to solve the problem.

Another important aspect of holistic evaluation is the possibility for the decision maker to evaluate problems with many criteria in a simpler way, for example, where evaluation by decomposition could be complex and relatively laborious, thus avoiding possible inconsistencies.

With the introduction of holistic evaluation, the DM can make comparisons between problem alternatives throughout the elicitation process. When performing the ordering of the criteria, the user will be able to choose whether to continue with the elicitation by decomposition or to carry out the holistic evaluation. Once the option to perform the holistic assessment has been selected, it should use any of the four visualizations available in the system (bar chart, radar, bubble, or tabular view).

If the DM feels comfortable, preferences relationships between real alternatives of the problem can be informed. Such preferences will be included in the linear programming model, making all viable weight vectors, in agreement with the informed preference, considered. In this way, DSS incorporates a new source of relevant information to solving the problem.

12.2 Choice problematic

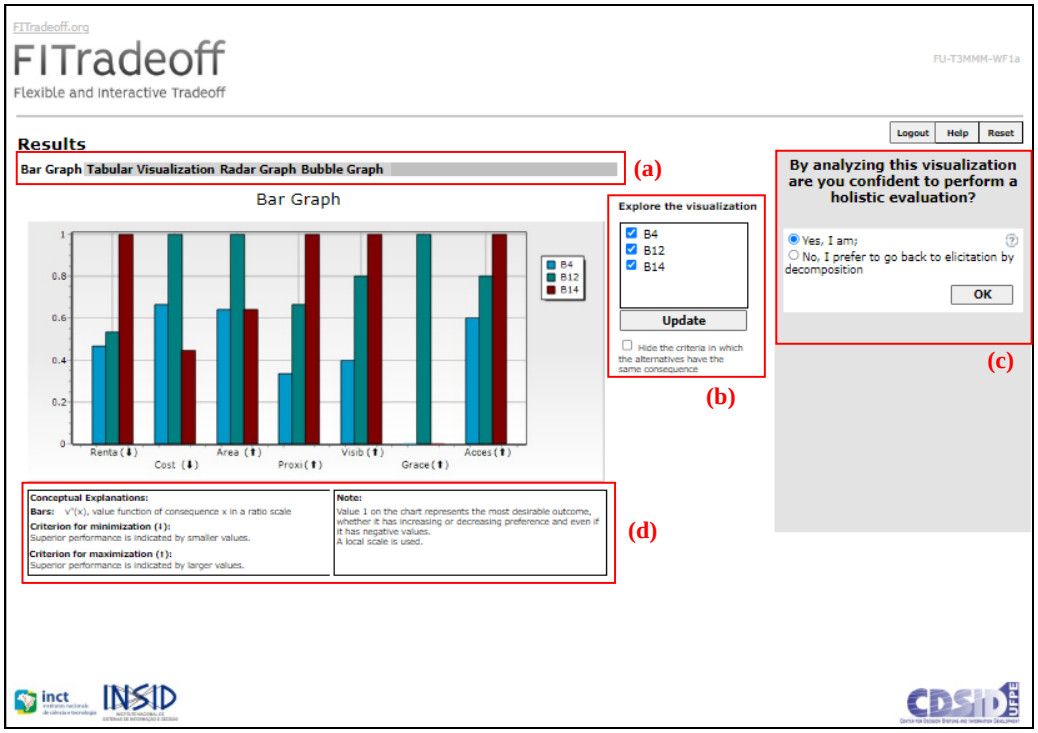
To perform the HE, follow the steps described below:

1st step: On the partial results screen (Figure 11.1.1, Section 11), choose to continue preference elicitation through holistic evaluation;

2nd step: Choose the type of visualization in which you feel most comfortable to perform the assessment **(a)**. It is possible to deselect alternatives and update the charts, so that only the desired alternatives are displayed, there is also the option to hide the criteria that have all the alternatives evaluated with the same consequences **(b)**;

3rd step: Answer the question displayed in the bar on the right side of the Figure 12.2.1 **(c)**, if you have found a type of visualization with which you are comfortable, answer "*Yes*", to continue the process. Otherwise, just reply "*No, I prefer to do back to elicitation by decomposition*".

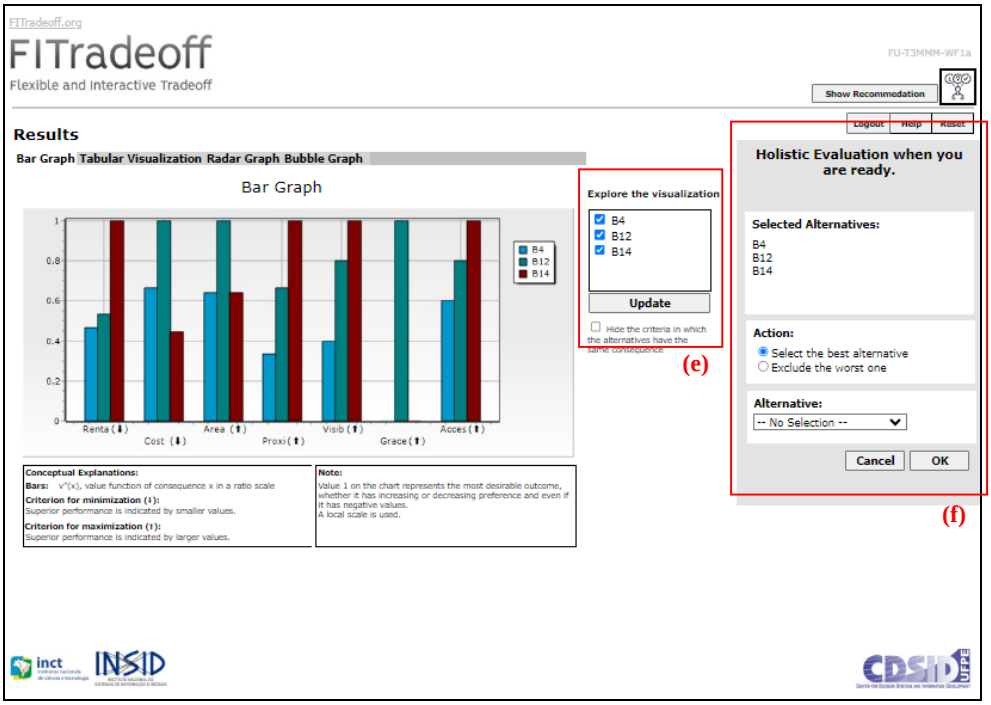
Figure 12.2.1 – Holistic assessment screen for the choice problematic



Important information:

- At the bottom of the screen is presented a conceptual explanation **(d)** for a better analysis of the graphs;
- When opting for the radar chart you have the criteria ordered clockwise on the graph.

Figure 12.2.2 – Second holistic assessment screen for the choice problematic



4th step: Having chosen to proceed, you must choose the group of alternatives (≥ 2) that you one wishes to evaluate holistically **(e)**. In this case, keeping selected only the alternatives that you want to evaluate, and then click on "*Update*";

5th step: If more than two alternatives have been chosen, you must choose between excluding one alternative from the group, or selecting the one that is considered the best **(f)**. If only two alternatives have been selected, the system automatically considers that it is the selection of the best alternative of the pair;

6th step: Choose the alternative. The chosen alternative will be eliminated or indicated as the best of the group, leading to the elimination of the others. This action will depend on what was done in the previous step.

12.3 Ranking problematic

To perform the HE, follow the steps described below:

1st step: On the partial results screen (Figure 11.2.1 – Section 11), choose to continue the elicitation of preferences through holistic evaluation;

2nd step: Having chosen to proceed, the Hasse Diagram (HD) should be used to choose a level ranking level for which you want to evaluate the alternatives. Note that only levels with at least a couple of alternatives that can't be compared between each other will be displayed in the drop-down menu, given the current level of information given **(a)**;

3rd step: Two alternatives should be chosen to be evaluated. To define such alternatives, it must select one at a time through the drop-down menus. Note that when selecting the first alternative to be evaluated, the system will update the second drop-down menu with the alternatives still incomparable with the first selected alternative;

4th step: Choose the type of visualization in which you feel most confident to carry out the evaluation;

5th step: The number of incomparable pairs is informed, so when clicking on "*Explore possible pairs*", and then on the "*Next*" button, all the pairs will be displayed, one by one, for evaluation, and to save a pair to evaluate at another time of the elicitation just select "*Save pair for further analysis*". If there are criteria in which the alternatives have the same consequence, the option "*Hide the criteria in which the alternatives have the same consequence*" **(b)** can be selected, to hide these criteria;

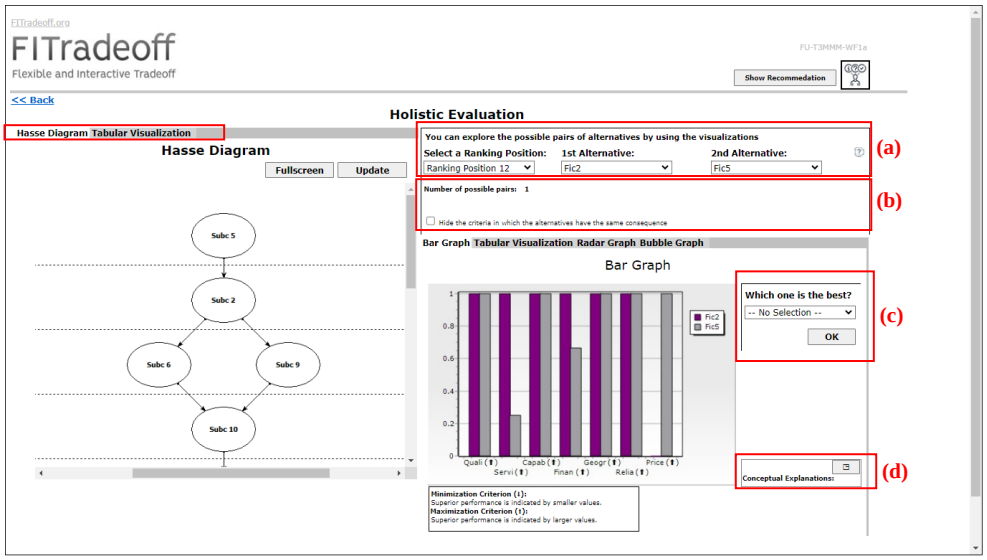
6th step: Choose an alternative **(c)**. In the problem of ranking it is only possible to perform the peer review, so the DSS will automatically understand that it is about choosing the best alternative of the pair. It is also worth mentioning that for this problem there is no exclusion of the alternative not chosen, but rather the selection of the one considered the best,

establishing a dominance relation between the pair analyzed. Following these steps, the holistic evaluation will have been informed and included in the linear programming model. Note that, if necessary, the process can be canceled by clicking the "*Back*" link, located in the upper left corner of the screen;

7th step: The drop-down menu **(d)** presents conceptual explanations about the graph for better understanding and analysis of the alternatives;

8th step: The tabular view contains the maximum differences **(e)** between the incomparable alternatives at each ranking position. This table can be minimized when not in use.

Figure 12.3.1 – Holistic assessment screen for ranking problematic.



It is worth mentioning that, when selecting the group of alternatives to evaluate, all the graphical visualizations of the DSS will be updated, so that, only the selected alternatives are displayed and have the values of their consequences adjusted, considering a local ratio scale, within the subset that is being evaluated.

12.4 Sorting problematic

Holistic evaluation for sorting issues involves comparing a real alternative that has not yet been classified with an inserted profile. This is done through a fictitious alternative called a profile-alternative, whose performance in each criterion is defined by the profile, taking into account the scale. For example, in Figure 12.4.2, it is possible to see the performance of the fictitious alternative generated from the "P2" profile (blue bars) when compared to a real alternative called "BU Canal 02" (yellow bars).

To perform the HE, follow the steps described below:

1st step: In the partial results screen (Figure 11.4.1 – Section 11), choose to continue the elicitation of preferences through holistic evaluation;

2nd step: Choose the alternative you want to compare with one of the profiles **(a).** From the Gantt Chart (Figure 12.4.1), it is possible to visualize the maximum and minimum values of all alternatives that have not yet been classified in a single class, as well as all the profiles that these alternatives can be compared to. Simply put, if the alternative is intersected by a profile on the chart, it is possible to perform a holistic analysis between that alternative and that specific profile.

3rd step: Choose the type of visualization in which you feel most comfortable performing the evaluation **(b)**;

4th step: Choose one of the profiles in which the chosen alternative can be compared **(c)**;

5th step: Choose between the best option: the selected alternative or the profile **(d)**.

Figure 12.4.1 – Holistic assessment screen for the sorting problematics

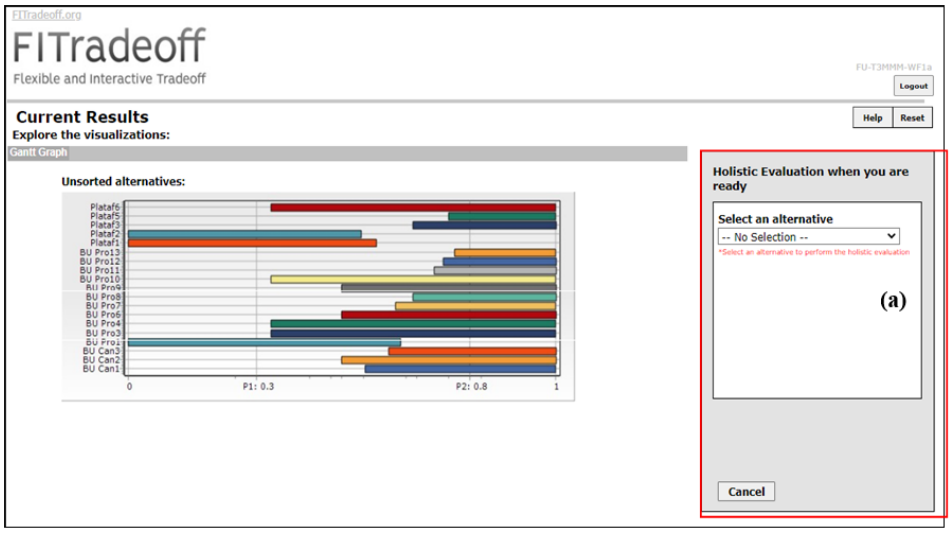


Figure 12.4.2 – Second holistic assessment screen for the sorting problematic

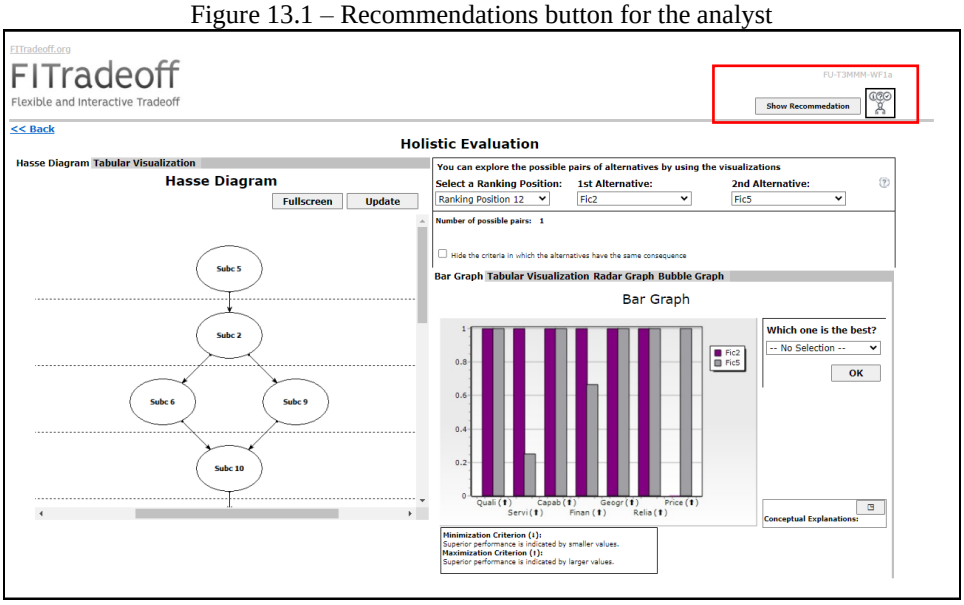
Important information: The comparison of a real alternative and an inserted profile takes place through a fictitious alternative called the profile-alternative whose performance in each criterion is defined by the profile, taking into account the scale.

Finally, such relationships will in turn be included in the linear programming model, ensuring that all feasible weight vectors considered are consistent with the given relationship. This way, the decision support system incorporates a new source of relevant information for solving the problem, in addition to significantly reducing the number of questions needed to reach the final result.

13. The Analyst's screen

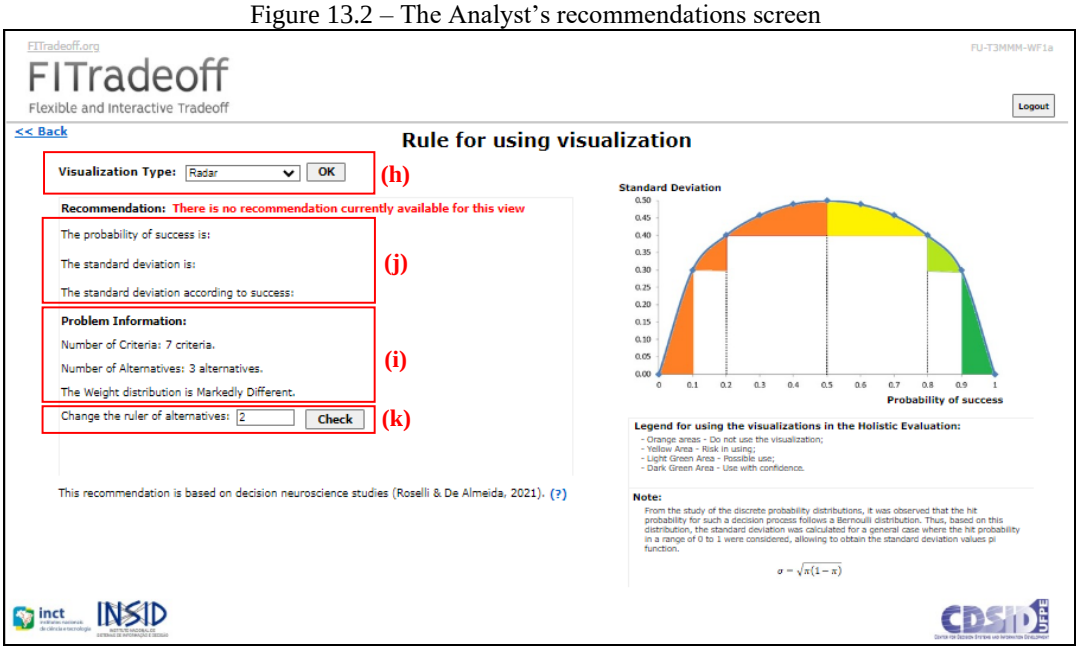
If desired, the analyst can view a recommendation for the type of chart to be used in the holistic evaluation. This recommendation appears only when at least one question in the decomposition elicitation is answered (the response is used to select the most appropriate heuristic to reduce the number of questions asked). On the holistic evaluation screen, the "Show Recommendation" button appears, as seen in Figure 13.1:

Figure 13.1 – Recommendations button for the analyst



By clicking on "Show Recommendation", the following screen is displayed (Figure 13.2):

Figure 13.2 – The Analyst's recommendations screen



It is possible to choose the visualization type from the dropdown menu **(h)**, and based on the problem information **(i)** the probability of success in the evaluation is calculed using the Success-Based decision Rule, as outlined by Roselli and Almeida (2021). This rule provides recommendations for the analyst and, consequently, for the decision-maker, on whether or not to use visualizations in the holistic evaluation. Upon selecting the visualization type, the system displays the probability of success, the standard deviation range, and the and the standard deviation according to the success **(j)**.

Important Information: For the choice problem, it is possible to enter the number of alternatives for the holistic evaluation, so that the analyst's screen generates the recommendation, as shown in **(k)**. For other problems, the number of alternatives in the evaluation is fixed and limited to two. It is worth noting that the number of alternatives must be equal to or less than the number of potentially optimal alternatives for the problem (in the choice problem).

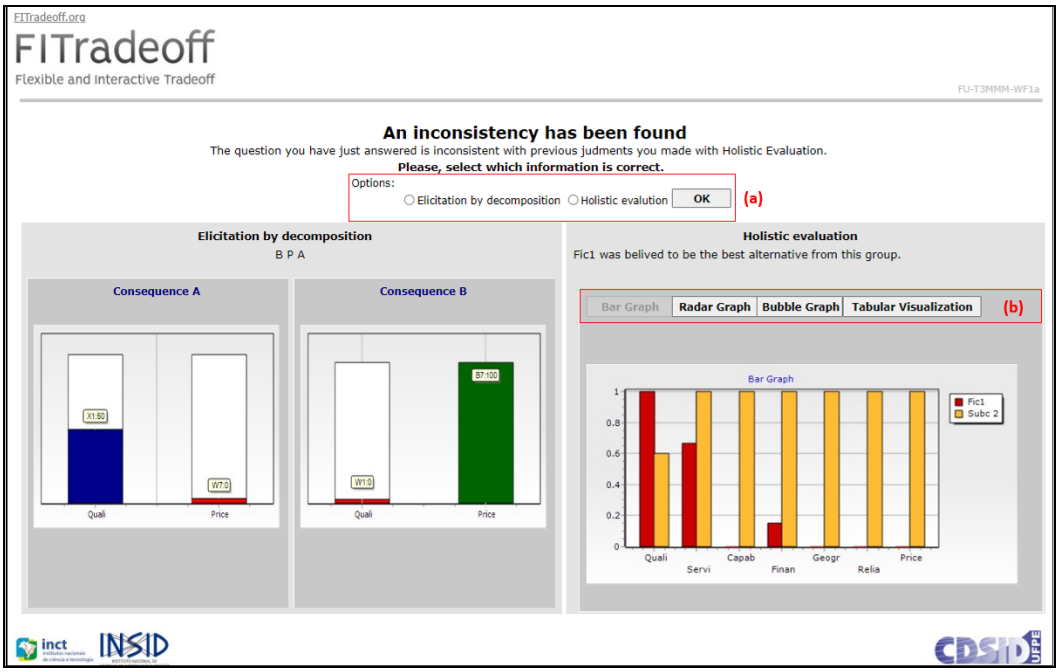
14. Inconsistency test

With the inclusion of holistic evaluation, DMs may provide conflicting information when comparing evaluation by decomposition and holistic evaluation. This can occur given to the distinct nature of the assessments and information generated. Therefore, it is extremely important to perform an inconsistency test throughout the process, in order to prevent the weight space to becoming unviable.

After performing at least one HE, the test begins to be performed with each question answered in the decomposition. If an inconsistency is found (Figure 14.1), a validation

process is carried out with the DM, in which the information given in the elicitation question and in the holistic evaluation is compared, thus asking which of the two information is in fact in accordance with the actual DM's preferences **(a)**.

Figure 14.1 – Inconsistency test screen



If the DM chooses the information provided in the elicitation by decomposition, then the information generated by the holistic evaluation is discarded and the alternatives are reevaluated with the information from the elicitation and other non-inconsistent holistic evaluations.

If on the other hand the DM chooses to keep the information of the holistic evaluation, then the preference informed in the elicitation is reversed, that is, if the answer given was A, it is inverted to B, if it was B, becomes A, and if the answer was an Indifference, then the preference is reversed to "No Answer".

During the inconsistency test, the decision-maker will have access to all previously available visualizations in order to allow a safe evaluation of the decision to be made **(b)**.

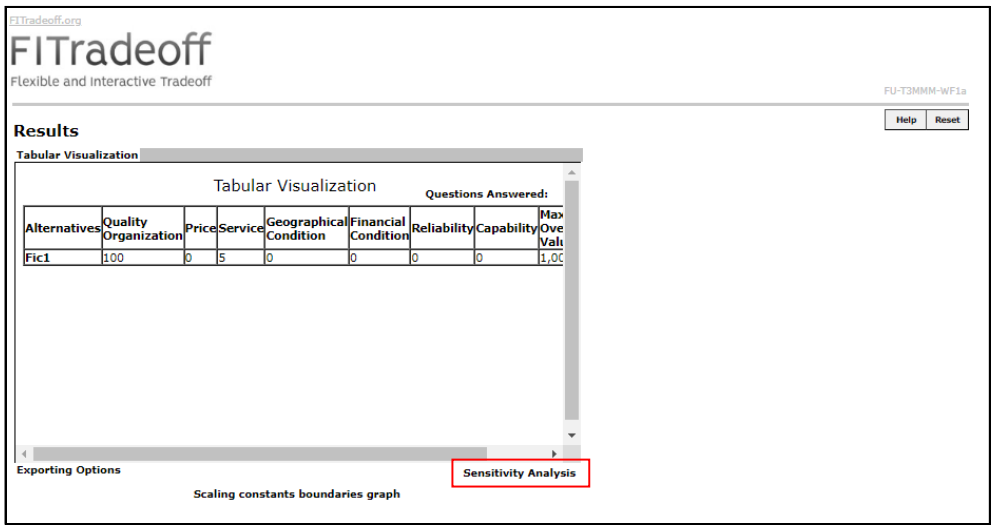
15. Sensitivity Analysis

The new version of the FITradeoff System also allows the performance of the Sensitivity Analysis (SA) for the consequences (Figure 15.1), and it is worth noting that the AS can be performed for the problems of choice, ranking and sorting.

The sensitivity analysis becomes available to the decision-maker when the problem is finalized, either because the solution set has been found, or by the DM's indication that they no longer wish to continue responding to the flexible elicitation.

To carry out the Sensitivity Analysis in the FITradeoff SAD, the decision-maker must indicate the range of variations in the values of the consequences for each criterion in the consequence matrix. The DSS runs a Monte-Carlo simulation process with 1,000 instances, where in each instance a new decision matrix is generated, with random values within the chosen range. The DM's preferences (weight space) elicited in the intercriteria evaluation stage are maintained and replicated, causing a new LPP to be generated in each instance of the SA. Also in each instance, the DSS solves and stores the solution of each LPP generated. The results are shown in graphical and tabular form, indicating the differences between the DSS solution and the SA solutions.

Figure 15.1 – Result screen with the option to perform Sensitivity Analysis (SA)



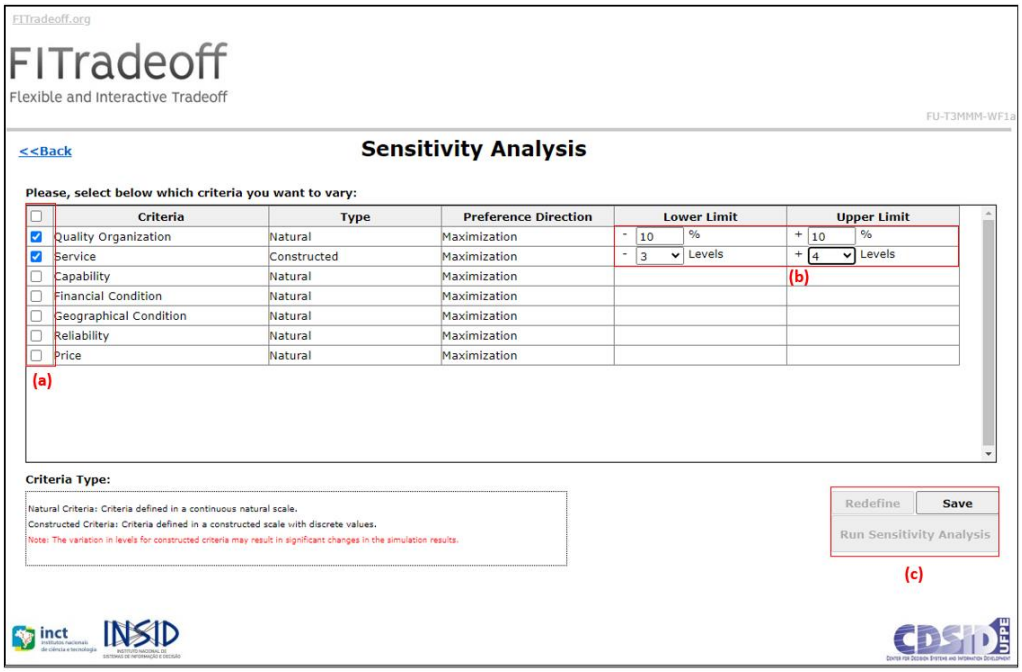
In Sensitivity Analysis (SA), different scenarios are generated by varying the consequences of alternatives according to the specified criteria and solving the problem based on the weight space identified up to that point.

By clicking the "Sensitivity Analysis" button on the tabular visualization screen, the user is taken to a screen where they must specify each criterion to be varied. The user can select all criteria at once by checking the box in the header **(a)**. The upper and lower limits of variation for each selected criterion must also be specified by the user **(b)**. These limits should be in percentages for natural criteria and in levels for constructed criteria. This is because constructed criteria can only assume discrete values, as continuous values are not used in the construction of scales for these criteria, thus making variation in levels appropriate.

After specifying the criteria to be varied and the upper and lower limits of variation, the user should click the "save" button **(c)** to save the information, enabling the start of the SA, which is initiated by clicking the "Run Sensitivity Analysis" button. The user can return

to make changes to the variations in the selected criteria and the upper and lower limits by clicking the "redefine" button **(c)**.

Figure 15.2 – Configuring the Sensitivity Analysis (SA)



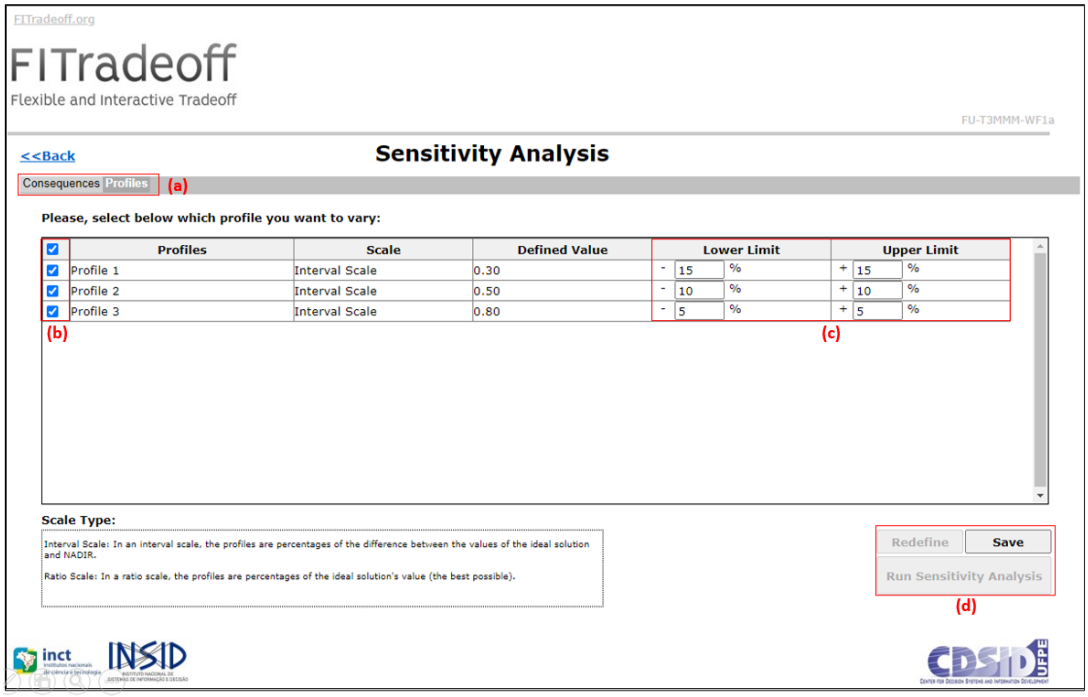
It is not necessary to select all the criteria and state whether they will be varied or not, the new version allows the decision-maker to select only the group of criteria they want to vary and start the process, in which case all the criteria not selected will be considered as not varied.

In addition, it is worth noting that for the sorting problematic (Figure 15.3), it is also possible to vary the values of the profiles, as well as the consequences. The process works in much the same way as it does for choosing and sorting. Thus, the user can simultaneously vary the consequences of the criteria and the profile values for the same sensitivity analysis.

Thus, to vary the profiles, the user must select the element to be varied **(a)**, enter each profile to be varied, and can select all the criteria at once if they check the box in the header **(b)**. The upper and lower variation limits for each profile selected must also be entered by the user **(c)**.

After entering the profiles to be varied and the upper and lower limits of variation, the user must click on the "save" button **(d)** so that the information is saved, and the start of the SA is enabled by clicking on the Run "Sensitivity Analysis" button. The user can go back to making changes to the variations in the selected profiles and the upper and lower limits by clicking on the "redefine" button **(d)**.

Figure 15.3 – Configuring the variation of profiles for the Sorting Problematic.

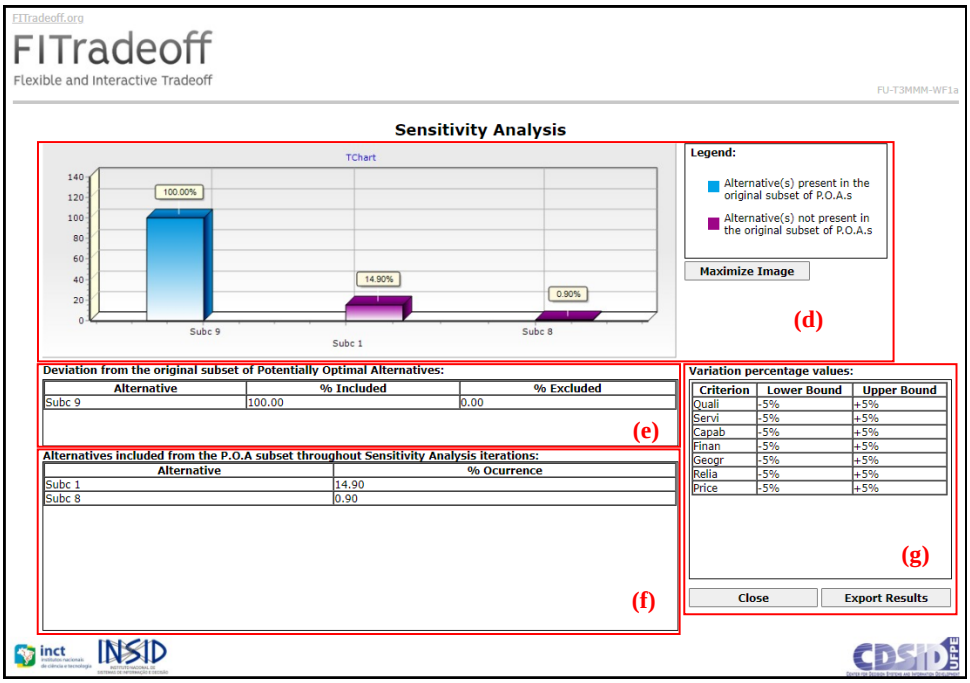


15.1 SA for choice problematic

After running all instances, the SA results screen for the consequences will be displayed (Figure 15.1.1), where the following elements can be observed:

- Graph showing the alternatives of the original solution set (blue series) and the alternatives that were included in the set (purple series), with the percentages referring to the number of scenarios in which they were in the solution set **(d)**;
- Table of the original solution set, which besides displaying the alternatives present in the original solution, indicates the number of instances and the percentage of change in the solution **(e)**;
- Table of included and excluded alternatives throughout the process, which indicates all the alternatives that entered or left the solution set as well as the percentage of instances in which they were included or excluded **(f)**;
- Table of varied criteria that shows the selected criteria and the percentage variance **(g)**.

Figure 15.1.1 – Sensitivity Analysis screen for choice problematics



Important information: When finishing an application, click on the "logout" button located in the top right corner of the system screens.

15.2 SA for ranking problematic

After the user has defined the inputs for the SA (variations in the values of the consequences), the DSS carries out a Monte-Carlo based simulation process, where the values of the consequences vary according to the upper and lower limits defined by the user and then the SA is carried out in 2 phases, in the first phase a robustness analysis of the solution obtained is carried out, where the robustness indices of each alternative are calculated and shown, as well as the percentage of variation in their dominance ratios (Figure 15.2.1), and in the second phase a Kendall correlation test (Figure 15.2.2) is carried out in order to incorporate statistical significance into the analysis obtained. These two phases are described below.

15.2.1. Robustness analysis

- In this phase, the robustness indices of each alternative are obtained, which consist of the percentage of times that the alternative maintains its dominance relationships with the other alternatives between the ranking generated in the original solution and the ranking generated in the SA simulations.
- A graph is constructed, showing the robustness indices of each alternative (in blue) and their complement, which is the percentage of times each alternative changes its

dominance relations with the others (in purple) **(d)**.

- Just below the graph, a table is assembled based on the composition of the ranking generated in the original solution, indicating the robustness indices and the variations in the dominance relationships between the alternatives **(e)**.
- At the bottom of the screen, a link is provided so that the user can access a table showing the frequency in which each alternative occupied each position in the ranking (15.2.1) **(f)**.
- By clicking on the link, a table is built based on the percentage of times each alternative occupies a certain position in the ranking, given the number of positions **(g)**.
- Because the FITradeoff method works with partial information, the DSS in the sorting problematic can generate orders with different numbers of positions, both in the order generated in the original solution and in the different instances of the SA. In this way, the user is given the option of changing the visualization of the table mentioned above depending on the number of positions in the ranking via the field located below the table. In addition, an information note displays the percentage of times rankings have been generated in the SA with the number of positions chosen by the user **(h)**.
- A table to the right of the screen displays the variation of the selected criteria and their upper and lower limits of variation defined by the user **(i)**.
- A link at the bottom of the screen takes the user to the second phase of the SA, which consists of the Kendall Test, which is explained in the next section **(j)**.

Figure 15.2.1 – Sensitivity Analysis screen for ranking problematics

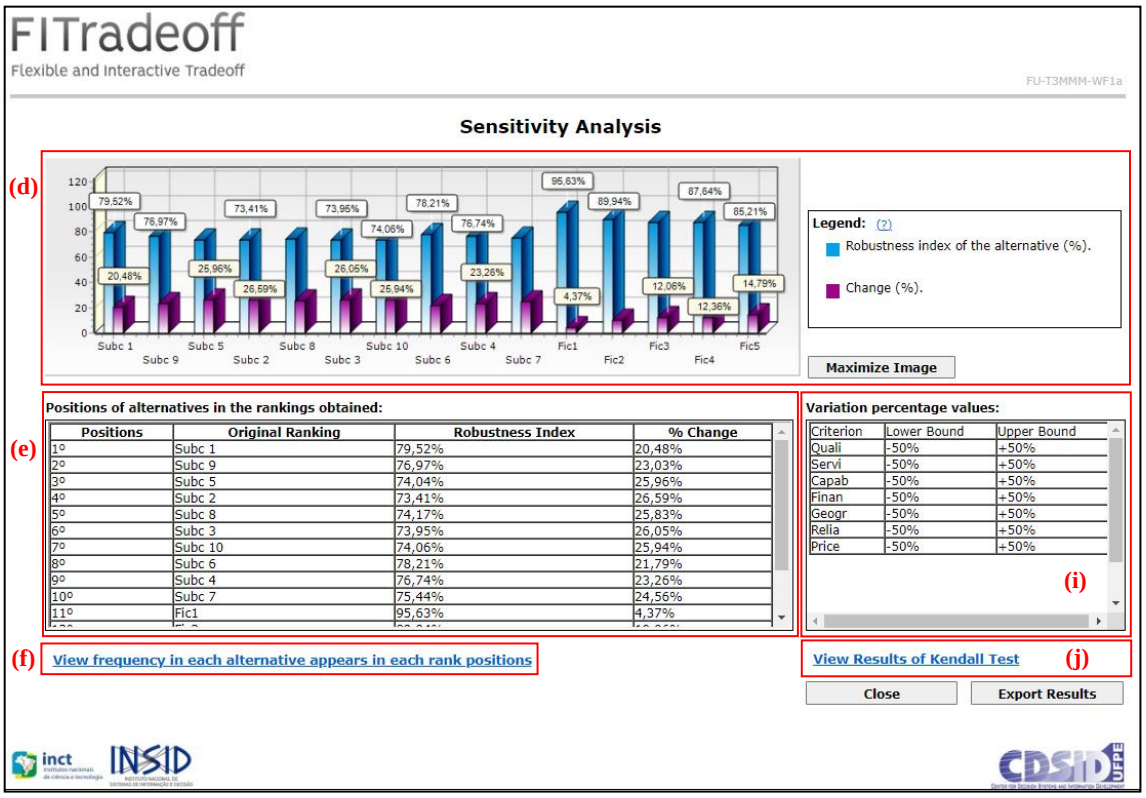
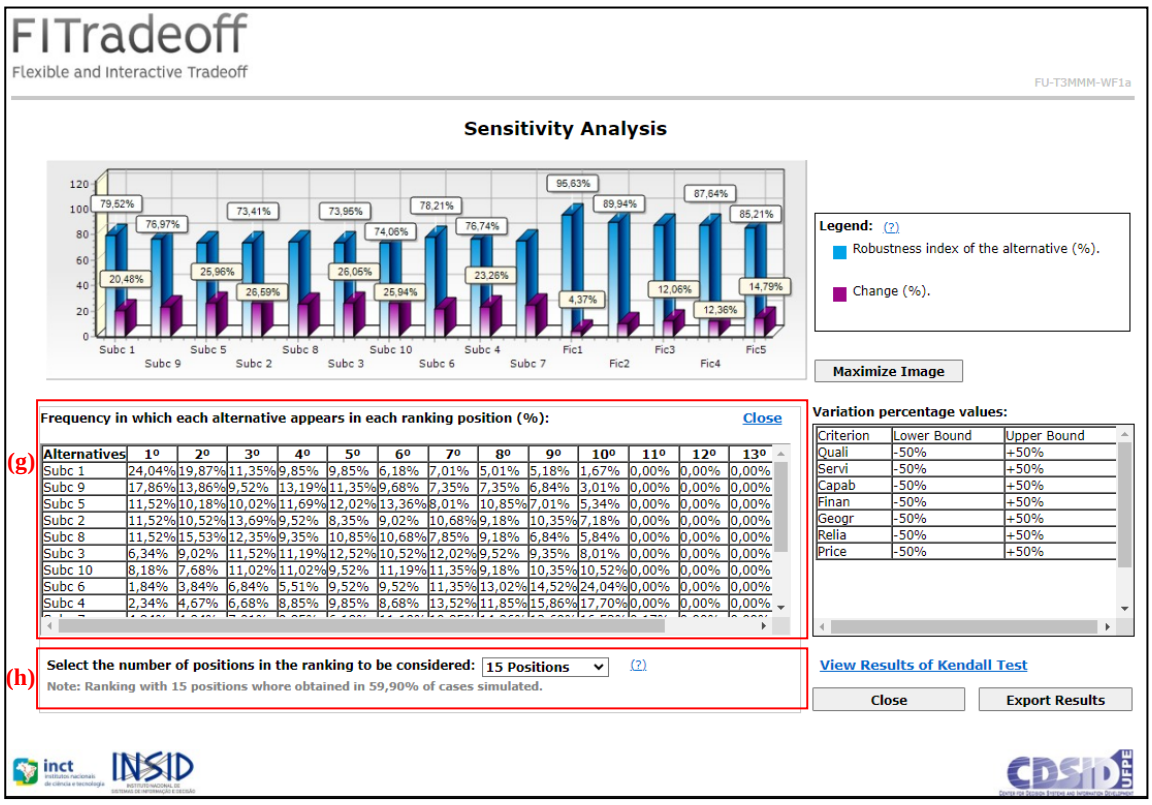


Figure 15.2.2 - Table showing the frequency with which each alternative occupied each position in the ranking.



Important information: When finishing an application, click on the "logout" button located in the top right corner of the system screens.

15.2.2 Kendall test in ranking SA

In the second phase of the SA of the sorting problem, the Kendall correlation statistical test (Figure 15.2.3) is run to determine whether or not there is a significant association between the sorting of the original solution and the sorts generated in the SA simulations.

- The Kendall test is carried out automatically by the DSS, based on the calculation of the Kendall coefficient test statistic (τ), which helps to infer the correlation between two sets of data based on the number of concordant and discordant pairs between them and has different ways of being calculated according to the number of elements in the samples. In the ranking SA, correlation tests are carried out between the sorting of the original solution to the problem and all the sorts generated in the instances of the SA.
- After this, a hypothesis test is carried out according to the significance level (α) chosen by the user **(k)**.
- Once the significance level has been selected, the hypothesis test is carried out and the SAD displays the result, which can indicate whether the null hypothesis is rejected (in green) or not rejected (in red) **(l)** and **(n)**.
- When the null hypothesis is rejected (Figure 15.2.3), it means that there are no significant variations between the ranking of the original solution and the ranking of the instances of the SA, i.e. there is a correlation between them, which indicates that the model/result is robust; and when the null hypothesis is not rejected (Figure 15.2.4), it means that there are significant variations between the ranking of the original solution and the ranking of the instances of the SA, i.e. there is no positive correlation between them, which indicates that the model/solution is sensitive to the changes established in the input screen.
- At the bottom of the screen, a link is provided for the user to access a table (Figure 15.2.5) that shows a report on the statistical data of Kendall's coefficient (τ) obtained at this stage of the SA **(o)**.

Figure 15.2.3 – Screen shot of the Kendall test in the sensitivity analysis for the sorting problematic with the null hypothesis rejected.

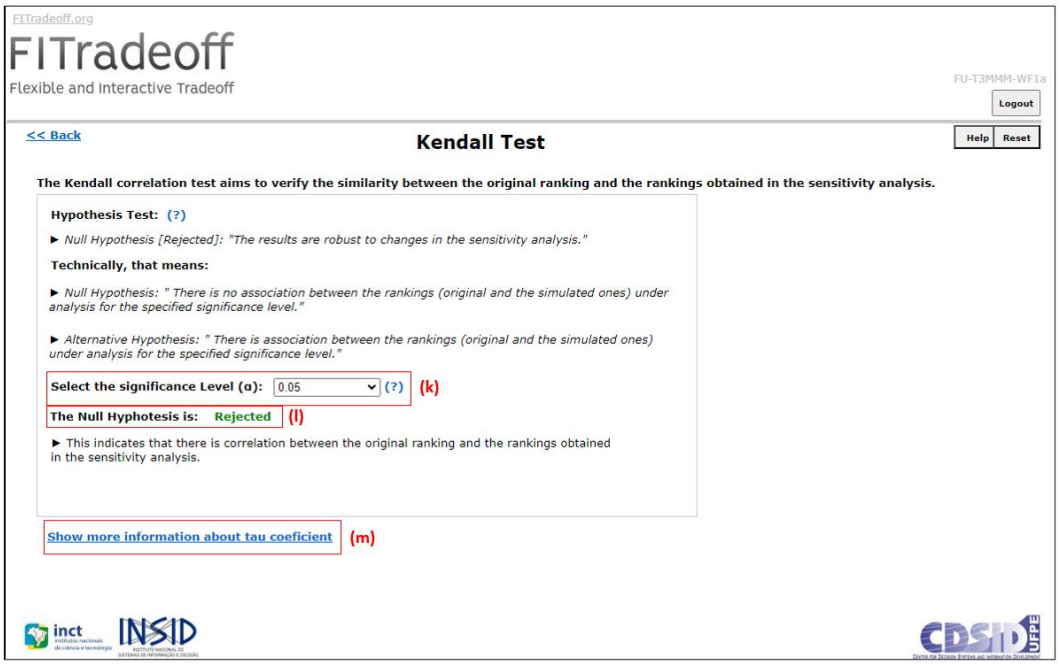


Figure 15.2.4 – Screen shot of the Kendall test in the sensitivity analysis for the sorting problematic with the null hypothesis not rejected.

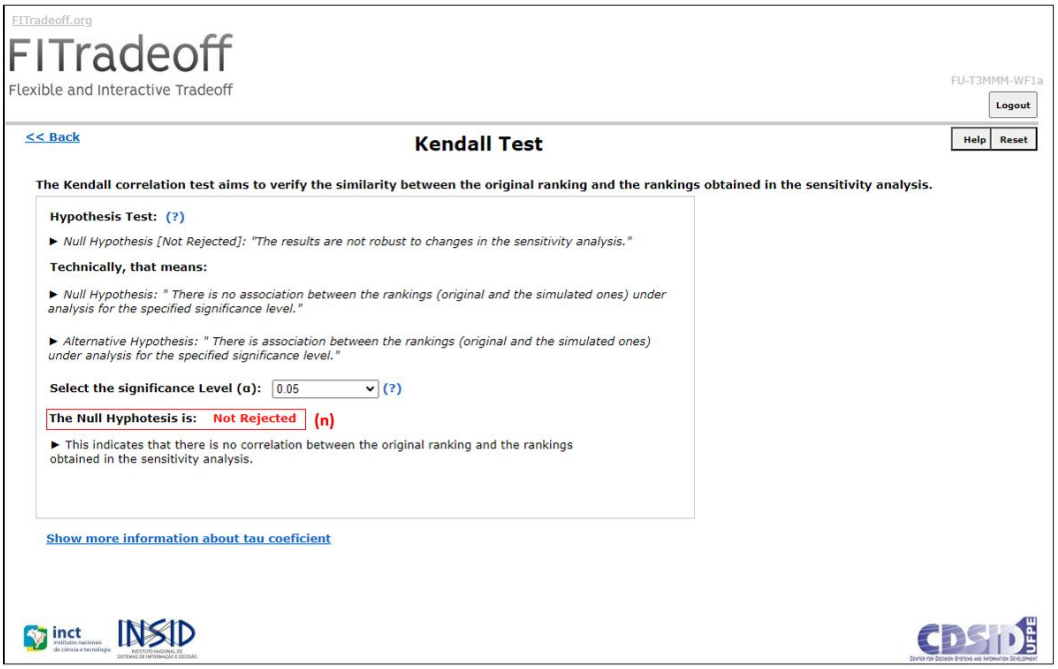
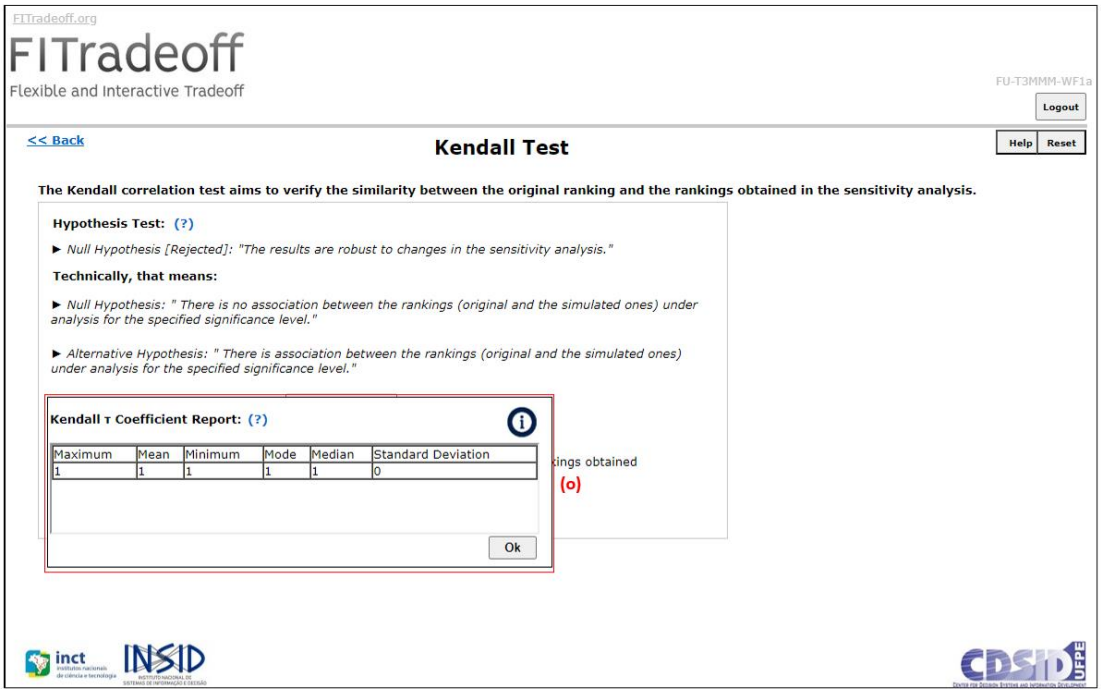


Figure 15.2.5 – Kendall test screen in sensitivity analysis for the sorting problem with Kendall coefficient report.



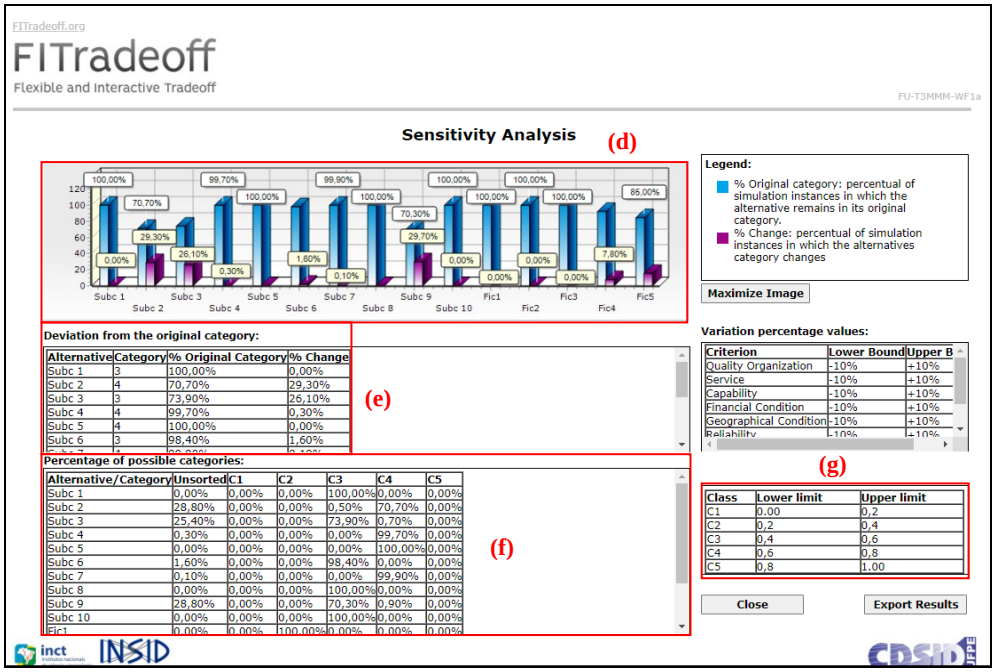
15.3 SA for sorting problematic

Regarding the SA of sorting problematics, for the profiles (Figure 15.3.1), the screen of the results brings the following elements:

- Graph with two series showing the percentage of times an alternative has remained in its original class (blue series), and how much has changed regardless of the occupied class (purple series) **(d)**;
- Table with the percentages of deviation of each alternative from its original classes in the solution ranking **(e)**;
- Table with the percentage of times in which each alternative occupied a certain class **(f)**;
- Table of classes, showing the lower and upper limits of each class **(g)**.

Important information: In the sorting problematic, the SA can be performed in relation to the consequences and the profiles, but it is important noting that each SA will be done separately.

Figure 15.3.1 – Sensitivity Analysis screen for sorting problematic

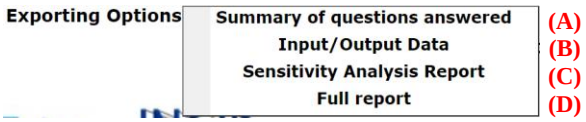


Important information: When finishing an application, click on the "logout" button located in the top right corner of the system screens.

16. Export spreadsheets of the analyses

The FU_T3MMM_WF1a system provides Excel export documents for the user to download the results and analyses of the problem studied (Figure 16.1). These can be exported on the results pages or after performing a sensitivity analysis. Different output templates are available for choice and ranking problematics.

Figure 16.1 – Excel export options



16.1 Exporting the summary of questions

The export report **(A)**, illustrated in Figure 16.2 below, is a document designed for situations where the user wants a detailed record of the sequence of responses and actions taken during the elicitation procedure. Standard output templates are available, differing only in whether the alternatives are displayed in terms of optimal potentiality (choice problem) or number of levels (ranking problem).

The spreadsheet will include data on the number of cycles, the characteristics of Consequence A, the characteristics of Consequence B, the decision-maker's responses, the solution set for each cycle, and information about the conducted Holistic Evaluations.

Figure 16.2 – Spreadsheet template for exporting input data and results

Application report					
Cycle	Consequence A	Consequence B	Answer	Number of levels	Holistic Evaluation (HE) performed?
0			Ordering...	3	no
1	75.000 of Quality Organization	Best of Price (5)	Consequence B	5	no
2	93.750 of Quality Organization	Best of Service (100)	Consequence A	6	no
3	50.000 of Quality Organization	Best of Service (100)	Consequence B	6	no
4	75.000 of Service	Best of Capability (100)	Consequence B	7	no
5	50.000 of Service	Best of Capability (100)	Consequence B	8	no
6	75.000 of Capability	Best of Financial Condition (100)	Consequence B	8	no
7	87.500 of Capability	Best of Financial Condition (100)	Consequence B	8	no
8	87.500 of Financial Condition	Best of Geographical Condition (100)	Consequence B	8	no
9	95.833 of Geographical Condition	Best of Reliability (1)	Consequence B	8	no
10	84.375 of Reliability	Best of Price (5)	Consequence B	8	no
11	89.063 of Quality Organization	Best of Service (100)	Consequence B	8	no
12	89.063 of Financial Condition	Best of Geographical Condition (100)	Consequence B	8	no
13	89.063 of Geographical Condition	Best of Reliability (1)	Consequence B	8	no
14	89.063 of Service	Best of Capability (100)	Consequence B	8	no
15	89.063 of Capability	Best of Financial Condition (100)	Consequence B	9	no
16	89.063 of Financial Condition	Best of Geographical Condition (100)	Consequence B	9	no

Additionally, the spreadsheet will contain a report of the responses given in the intracriteria evaluation, as shown in Figure 16.3.

Figure 16.3 – Export report (intracriteria evaluation)

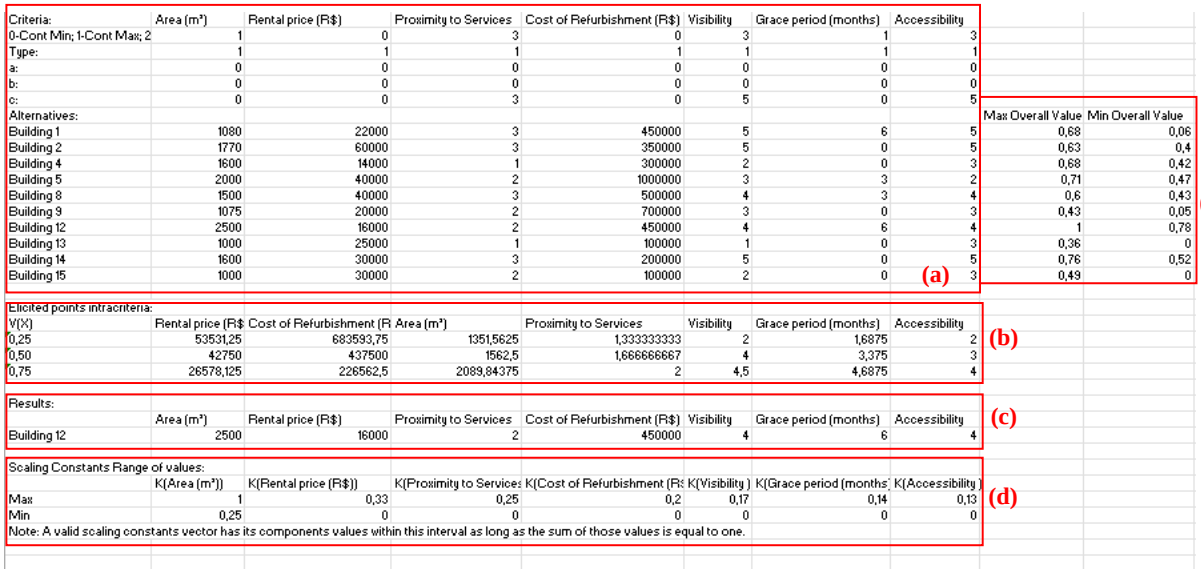
Intra-criteria Report				
Cycle	Criteria	ILO	IUP	Answer
0				Eliciting...
1	Not selected	null	null	All criteria have been declared as linear
0				Reset elicitation (Results)
1	Rental price (R$)	60000 to 37000	37000 to 14000	60000 to 37000
2	Rental price (R$)	60000 to 48500	48500 to 14000	48500 to 14000
3	Rental price (R$)	60000 to 42750	42750 to 14000	60000 to 42750
4	Rental price (R$)	60000 to 51375	51375 to 42750	60000 to 51375
5	Rental price (R$)	60000 to 55688	55688 to 42750	55688 to 42750
6	Rental price (R$)	42750 to 28375	28375 to 14000	28375 to 14000
7	Rental price (R$)	42750 to 21188	21188 to 14000	42750 to 21188
8	Rental price (R$)	42750 to 24781	24781 to 14000	42750 to 24781
9	Cost of Refurbishment (R$)	1000000 to 550000	550000 to 100000	550000 to 100000
10	Cost of Refurbishment (R$)	1000000 to 325000	325000 to 100000	1000000 to 325000
11	Cost of Refurbishment (R$)	1000000 to 437500	437500 to 100000	1000000 to 437500
12	Cost of Refurbishment (R$)	1000000 to 718750	718750 to 437500	718750 to 437500
13	Cost of Refurbishment (R$)	1000000 to 578125	578125 to 437500	1000000 to 578125
14	Cost of Refurbishment (R$)	1000000 to 648438	648438 to 437500	1000000 to 648438
15	Cost of Refurbishment (R$)	437500 to 268750	268750 to 100000	268750 to 100000

16.2 Export of input data and results

16.2.1 Export of input data and results (choice problem)

The spreadsheet (B), as shown in Figure 16.4, will include the input data provided by the user **(a)**, the points derived from the intracriteria evaluation **(b)**, the final results with corresponding real consequences of each evaluated criteria in relation to the alternative(s) **(c)**, the respective ranges of values from the weight space **(d)**, and the maximum and minimum global values of the alternatives **(e)**.

Figure 16.4 – Spreadsheet Template for exporting input data and results (Choice Problem)



Criteria:	Area (m²)	Rental price (R$)	Proximity to Services	Cost of Refurbishment (R$)	Visibility	Grace period (months)	Accessibility			
0-Cont Min; 1-Cont Max; 2	1	0	3	0	3	1	3			
Type:	1	1	1	1	1	1	1			
a:	0	0	0	0	0	0	0			
b:	0	0	0	0	0	0	0			
c:	0	0	3	0	5	0	5			
Alternatives:									Max Overall Value	Min Overall Value
Building 1	1080	22000	3	450000	5	6	5		0,68	0,06
Building 2	1770	60000	3	350000	5	0	5		0,63	0,4
Building 4	1600	14000	1	300000	2	0	3		0,68	0,42
Building 5	2000	40000	2	1000000	3	3	2		0,71	0,47
Building 8	1500	40000	3	500000	4	3	4		0,6	0,43
Building 9	1075	20000	2	700000	3	0	3		0,43	0,05
Building 12	2500	16000	2	450000	4	6	4		1	0,78
Building 13	1000	25000	1	100000	1	0	3		0,36	0
Building 14	1600	30000	3	200000	5	0	5		0,76	0,52
Building 15	1000	30000	2	100000	2	0	3	(a)	0,49	0

(e)

Elicited points intracriteria:								
V(X)	Rental price (R$	Cost of Refurbishment (R	Area (m²)	Proximity to Services	Visibility	Grace period (months)	Accessibility	(b)
0,25	53531,25	683593,75	1351,5625	1,333333333	2	1,6875	2	
0,50	42750	437500	1562,5	1,666666667	4	3,375	3	
0,75	26578,125	226562,5	2089,84375	2	4,5	4,6875	4	

Results:								
	Area (m²)	Rental price (R$)	Proximity to Services	Cost of Refurbishment (R$)	Visibility	Grace period (months)	Accessibility	(c)
Building 12	2500	16000	2	450000	4	6	4	

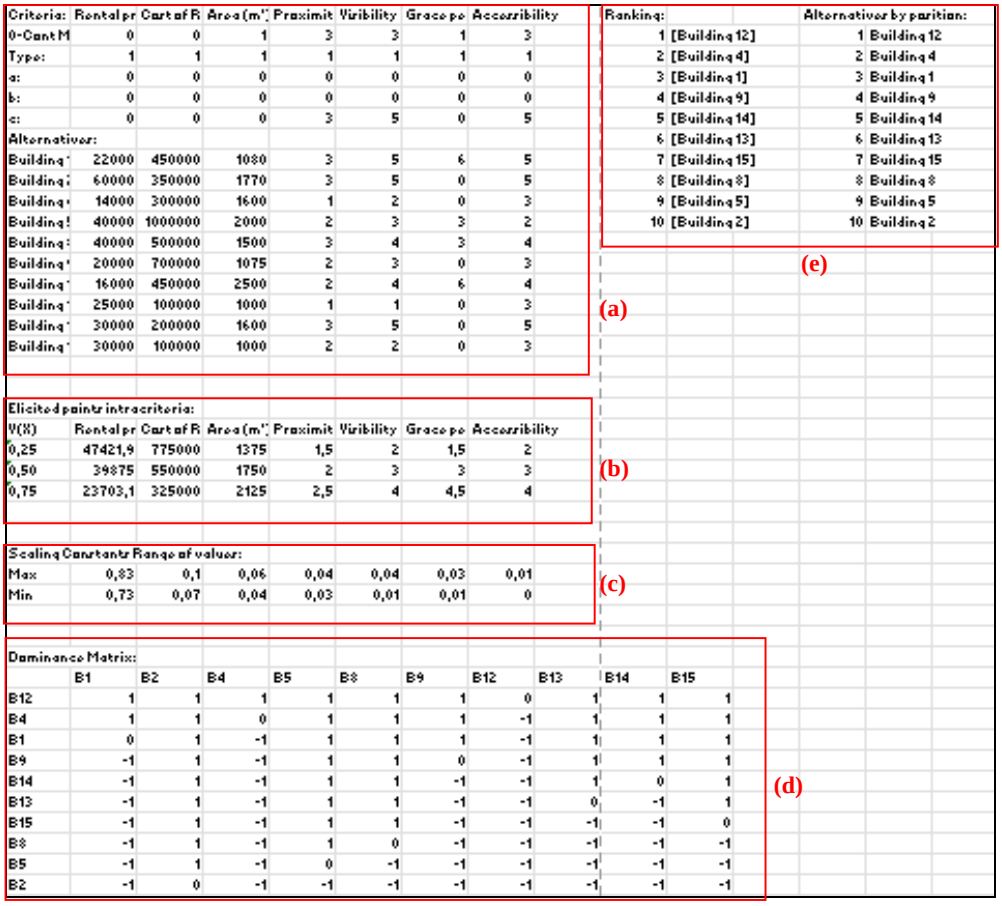
Scaling Constants Range of values:								
	K(Area (m²))	K(Rental price (R$))	K(Proximity to Services	K(Cost of Refurbishment (R$	K(Visibility)	K(Grace period (months)	K(Accessibility)	(d)
Max	1	0,33	0,25	0,2	0,17	0,14	0,13	
Min	0,25	0	0	0	0	0	0	

Note: A valid scaling constants vector has its components values within this interval as long as the sum of those values is equal to one.

16.2.2 Export of input data and results (ranking problem)

The Spreadsheet **(B)** for the ranking problem, as shown in Figure 16.5, will include the input data provided by the user **(a)**, the points derived from the intracriteria evaluation (b), the ranges of values from the weight space **(c)**, the dominance matrix **(d)**, and the positions of the alternatives in the ranking **(e)**.

Figure 16.5 – Spreadsheet Template for exporting input data and results (Ranking Problem)



Criteria:	Rental pr	Cost of R	Area (m²	Proximit	Viribility	Grace pe	Accessibility
0-Cont M	0	0	1	3	3	1	3
Type:	1	1	1	1	1	1	1
a:	0	0	0	0	0	0	0
b:	0	0	0	0	0	0	0
c:	0	0	0	3	5	0	5
Alternatives:							
Building	22000	450000	1080	3	5	6	5
Building	60000	350000	1770	3	5	0	5
Building	14000	300000	1600	1	2	0	3
Building	40000	1000000	2000	2	3	3	2
Building	40000	500000	1500	3	4	3	4
Building	20000	700000	1075	2	3	0	3
Building	16000	450000	2500	2	4	6	4
Building	25000	100000	1000	1	1	0	3
Building	30000	200000	1600	3	5	0	5
Building	30000	100000	1000	2	2	0	3

(a)

Ranking:		Alternatives by position:	
1	[Building 12]	1	Building 12
2	[Building 4]	2	Building 4
3	[Building 1]	3	Building 1
4	[Building 9]	4	Building 9
5	[Building 14]	5	Building 14
6	[Building 13]	6	Building 13
7	[Building 15]	7	Building 15
8	[Building 8]	8	Building 8
9	[Building 5]	9	Building 5
10	[Building 2]	10	Building 2

(e)

Elicited points intracriteria:							
V(X)	Rental pr	Cost of R	Area (m²	Proximit	Viribility	Grace pe	Accessibility
0,25	47421,9	775000	1375	1,5	2	1,5	2
0,50	39875	550000	1750	2	3	3	3
0,75	23703,1	325000	2125	2,5	4	4,5	4

(b)

Scaling Constants Range of values:							
Max	0,83	0,1	0,06	0,04	0,04	0,03	0,01
Min	0,73	0,07	0,04	0,03	0,01	0,01	0

(c)

Dominance Matrix:	B1	B2	B4	B5	B8	B9	B12	B13	B14	B15
B12	1	1	1	1	1	1	0	1	1	1
B4	1	1	0	1	1	1	-1	1	1	1
B1	0	1	-1	1	1	1	-1	1	1	1
B9	-1	1	-1	1	1	0	-1	1	1	1
B14	-1	1	-1	1	1	-1	-1	1	0	1
B13	-1	1	-1	1	1	-1	-1	0	-1	1
B15	-1	1	-1	1	1	-1	-1	-1	-1	0
B8	-1	1	-1	1	0	-1	-1	-1	-1	-1
B5	-1	1	-1	0	-1	-1	-1	-1	-1	-1
B2	-1	0	-1	-1	-1	-1	-1	-1	-1	-1

(d)

16.3 Sensitivity analysis export

The export report **(C),** exemplified in Figure 16.6, is made available to the user after performing a sensitivity analysis in cases where a record of the analysis is desired. The spreadsheet will contain the criteria and variations determined by the user **(a),** the percentages deviations from the original position **(b),** and the percentage of times the alternative was ranked in the position **(c).**

Figure 16.6 - Sensitivity analysis report spreadsheet template model

Consequences Sensitivity Analysis:								
Variation	Quality Organization	Service	Capability	Financial	Geographi	Reliability	Price	
Max	+10%	+10%	+10%	+10%	+10%	+10%	+10%	(a)
Min	-10%	-10%	-10%	-10%	-10%	-10%	-10%	

Deviation from the Original Ranking																
	Position in the rank	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Alternatives	Subc 9	Subc 1	Subc 5	Subc 2	Subc 8	Subc 3	Subc 10	Subc 6	Subc 4	Subc 7	Fic1	Fic2	Fic3	Fic4	Fic5
(b)	% Original Position	77.40%	16.50%	9.60%	1.90%	0.70%	0.00%	0.00%	0.10%	0.00%	0.00%	0.10%	0.10%	0.10%	0.10%	0.10%
	% Change	22.60%	83.50%	90.40%	98.10%	99.30%	100.00%	100.00%	99.90%	100.00%	100.00%	99.90%	99.90%	99.90%	99.90%	99.90%

Percentage of times that the alternative was ordered in the position: (c)																
	Alternative/Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Subc 1	83.10%	16.50%	0.30%	0.10%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Subc 2	39.90%	43.90%	14.10%	1.90%	0.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Subc 3	16.40%	46.10%	29.60%	7.10%	0.80%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Subc 4	0.10%	6.60%	29.50%	36.30%	21.10%	5.20%	1.00%	0.10%	0.00%	0.10%	0.00%	0.00%	0.00%	0.00%	0.00%
	Subc 5	47.20%	42.70%	9.60%	0.50%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Subc 6	0.70%	9.60%	34.50%	34.30%	15.70%	4.20%	0.90%	0.10%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Subc 7	0.00%	3.40%	21.00%	38.10%	25.30%	9.80%	1.70%	0.60%	0.10%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Subc 8	29.80%	47.00%	19.70%	2.70%	0.70%	0.00%	0.10%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Subc 9	77.40%	21.10%	1.50%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Subc 10	13.20%	43.90%	31.80%	8.80%	2.10%	0.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Fic1	0.00%	0.00%	1.90%	16.50%	35.20%	30.90%	12.00%	2.80%	0.60%	0.00%	0.10%	0.00%	0.00%	0.00%	0.00%
	Fic2	0.00%	0.00%	0.00%	1.90%	16.50%	35.20%	30.90%	12.00%	2.80%	0.60%	0.00%	0.10%	0.00%	0.00%	0.00%
	Fic3	0.00%	0.00%	0.00%	0.00%	1.90%	16.50%	35.20%	30.90%	12.00%	2.80%	0.60%	0.00%	0.10%	0.00%	0.00%
	Fic4	0.00%	0.00%	0.00%	0.00%	0.00%	1.90%	16.70%	35.10%	31.00%	11.90%	2.70%	0.60%	0.00%	0.10%	0.00%
	Fic5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.30%	16.40%	35.40%	30.80%	11.70%	2.70%	0.60%	0.00%	0.10%

Finally, by clicking on "Full Report" **(D)**, as seen in Figure 16.1, all reports are made available to the user at once in an HTML spreadsheet.

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