« Multi Criteria Decision Aid (MCDA) with focus on PROMETHEE: Research and Case Studies»

# Innovative project selection for technology transfer activities in a public University

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# Ad hoc technology transfer in AUA

A large number (about 40) innovative business ideas elaborated by faculty and research staff in the Agricultural University of Athens. These proposals may be classified in several types, such as new products in agriculture or in industry, innovative processes, novel test and/or certification methods, applications/software, services etc.

Funding is provided for a small number of selected proposals to implement fully fledged business plans for appropriate action (spin-off, licensing, etc.) and contacts with potential investors.

The selection will be based on various criteria grouped into three categories: technical maturity and degree of innovation

- business opportunity
- project team evaluation

# Assessment dimensions and specific criteria

| Dimension | Criteria |
| --- | --- |
| I. Technology - Innovation | I.1 Technology Readiness Level (TRL) |
| | I.2 Innovation added value |
| | I.3 Degree that technology addresses social/economic challenges |
| II. Market opportunity | II.1 Focus of the business proposal |
| | II.2 Competitive advantage |
| | II.3 Expected benefits vs development effort (cost effectiveness) |
| III. The business team | III.1 Clarity of the business scheme |
| | III.2 Degree to which key competencies are covered |
| | III.3 Degree of commitment of key research personnel |

# Assessment dimensions and specific criteria

The technology – innovation criterion is assessed by experts with relevant technical background.

For criterion I.1, the TRL scale is used (Technology Readiness Level). Introduced by NASA and adopted by other Research Institutions, TRL defines distinct levels from the stages of generation of the research idea to the one of commercial application.

The other criteria are assessed by business experts with experience in high tech / innovation financing.

A 4-grade scale is used (4: high/very high extend, 3: considerable extend, 2: some extend, 1: little or no extent).

# Ad hoc tech transfer in AUA

## ranking problematique with segmentation constraints

The decision situation becomes more complex if in addition to the multiple evaluation criteria the decision-maker has to comply with specific limitations

This is the case as the Tech transfer managers wish to select proposals in such a way that all University Departments and all different types of ideas are represented. Moreover, the University administration strategy may wish some kind of diversification, to target to a minimum number of spin-offs, a number of licences, providing services etc.

These constraints distort the independence of the alternatives
the decision problem becomes combinatorial
the actual options for the decision maker are the combinations of the alternatives that comply with the segmentation constraints.

## PROMETHEE V

**Brans JP, Mareschal B., 1992. Promethee V. MCDM problems with segmentation constraints. *INFOR 3*0: 85-96.**

The PROMETHEE V method comprises two phases:

- Implementation of the PROMETHEE II method to obtain the net flows (φ)

- Modeling and solution of the IP problem where binary decision variables ($x_i$) are attributed to the alternatives The objective function to be maximized is the aggregated net flow of the selected alternatives (($\Sigma\ \varphi_i\ x_i$) and the constraints of the model are defined by the segmentation constraints.

## PROMETHEE V uses the results of PROMETHEE II where all the alternatives are forced to be compared to each other.

Nevertheless, according to PROMETHEE I we may have cases where no solution clearly prevails due to incomparability among the alternatives.

the preference information expressed in terms of the leaving and entering flows is richer than expressed just in terms of the net flows.

this is the basic advantage of the outranking methods over the utility function methods: the tolerance to accept that alternatives be incomparable.

Mavrotas, G., Rozakis, S., 2009.
Extensions of the PROMETHEE method to deal with segmentation constraints application in a students' selection problem,
*Journal of Decision Systems*18 (2), 203-229.

The selection of the most preferred combination of alternatives can be divided in three phases:

- Implementation of PROMETHEE I to obtain the leaving ($\varphi^{+}$) and entering ($\varphi^{-}$) flows

- Formulation of the bi-objective IP problem with the segmentation constraints and the aggregate Φ+ and Φ- flows as objective functions (max and min respectively)

Generation of the Pareto solutions and classification of the alternatives to three subsets: "pass" alternatives, "cut" alternatives and the grey set (to be further investigated).

- Selection of alternatives from the grey set using an appropriate IP model taking into account the majority principle.

Incomparability: In PROMETHEE V the notion of incomparability is absent as it uses the net flows from PROMETHEE II as the objective function coefficients.

In PROMETHEE V2 the evidence of incomparability that may exist among the alternatives (and revealed by PROMETHEE I), is transferred to the obtained solutions of the IP model.

The results of the first phase (PROMETHEE I) are employed in the form of leaving ($\Phi^+_i$) and entering ($\Phi^-_i$) flows. The two objective functions are:

- The maximization of the sum of the leaving flows ($\Sigma\, \Phi^+_i\, x_i$)
- The minimization of the sum of the entering flows ($\Sigma\, \Phi^-_i\, x_i$).

Hence, the bi-objective IP model has the following form:

$$\max \Sigma\, \Phi^+_i\, x_i \quad \min \Sigma\, \Phi^-_i\, x_i$$

$$\text{Subject to} \qquad x_i \in S \qquad (1)$$

$$x_i \in \{0,1\}$$

The dominated solutions (denoted with *D*) of this problem are those that are outranked by one of the “most preferred” solutions:

$\forall d \in D \;\; \exists\, p \in P \;\; | \;\; (\Sigma\, \Phi^{+}_{i}\, x_i)_p \geq (\Sigma\, \Phi^{+}_{i}\, x_i)_d \;\; \wedge \;\; (\Sigma\, \Phi^{-}_{i}\, x_i)_p \leq (\Sigma\, \Phi^{-}_{i}\, x_i)_d$

with at least one strict inequality

By the definition of Pareto optimality and of outranking relationship according to PROMETHEE I, the Pareto optimal solutions of this bi-objective problem are the “most preferred” solutions that are candidate for selection (denoted with *P*).

The different Pareto optimal solutions indicate different combinations of selected alternatives. If they are more than one, it means that either indifferences or incomparability exist among them.

Indifference : the situation where two or more Pareto optimal solutions (different combinations of $x_i$) have identical objective functions’ values.

Incomparability : the situation where solution A is better than B in one objective function and worse in the other one.

**When more alternatives are present in the grey set (as it is usually the case) the selection among them, also respecting the segmentation constraints, becomes a complex task that needs a systematic approach.**

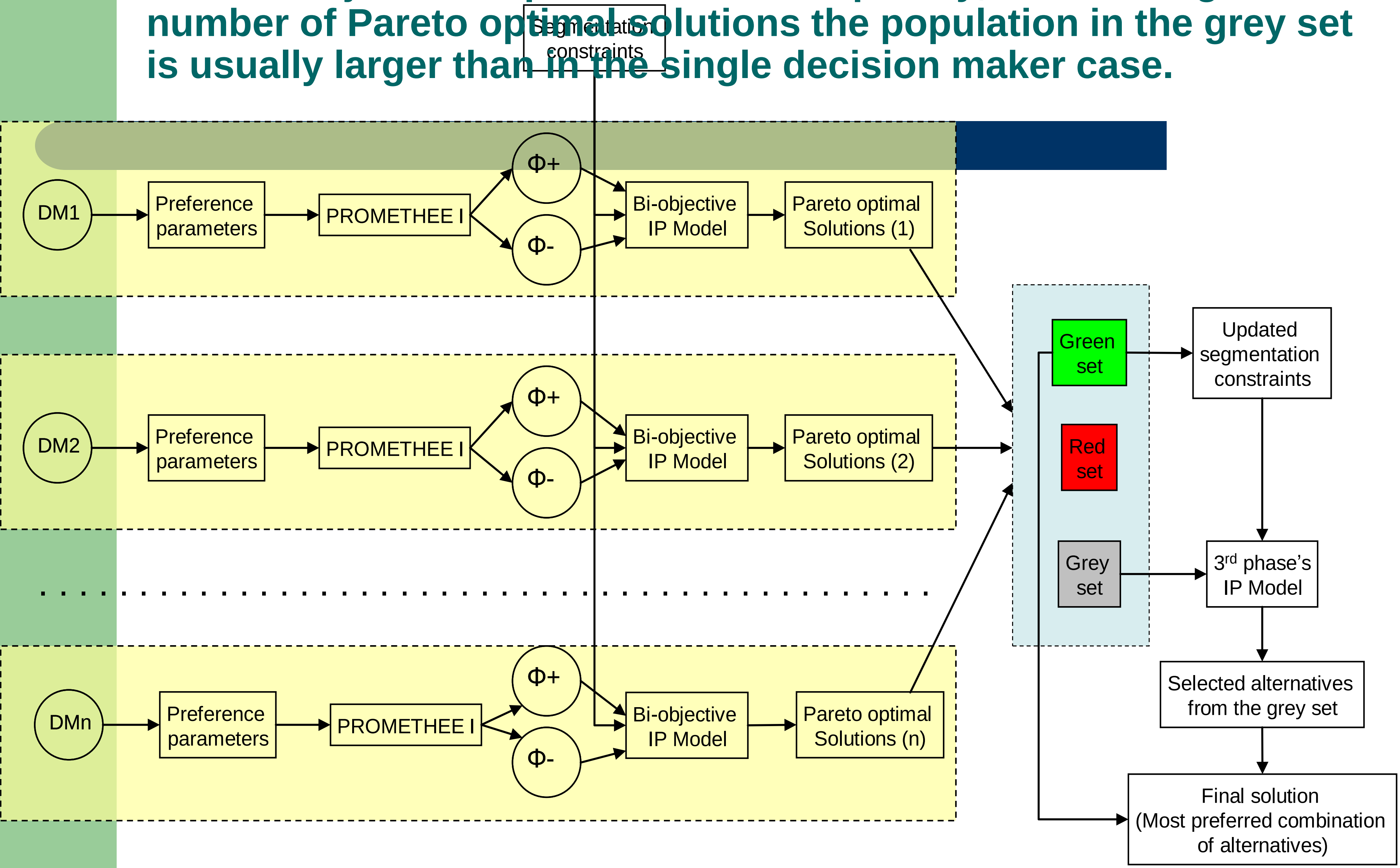
In order to accomplish this task an IP model is formulated which involves as decision variables only the alternatives of the grey set (the green and the red set alternatives have already been determined in the previous phase) and has the following form:

$$\max \Sigma\, n_j\, x_j \quad \text{subject to } x_j \in S',\ x_j \in \{0,1\}$$

where $n_j$ is the number of appearances of the j-th alternative in the Pareto optimal solutions of the bi-objective IP problem, $x_j$ is the binary decision variable indicating if the j-th alternative from the grey set is selected by the 3rd phase's IP model.

The feasible region *S'* is defined by the segmentation constraints that involve only the alternatives of the grey set, taking into account the status of the alternatives in the green and the red set.

**Group decision making context: each decision maker using their own preference parameters so we consider the Pareto optimal solutions from all the *n* bi-objective IP problems. Consequently, due to the greater number of Pareto optimal solutions the population in the grey set is usually larger than in the single decision maker case.**



# Evaluation and PROMETHEE parameters of business ideas out of AUA research activities

| | TRL | Inno added value | Responding to need | Clarity of business proposal | Competitive advantage | Expected benefit vs development effort | Clarity of Business scheme | Coverage of required skills | Degree of commitment |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 8 | 4 | 4 | 3 | 3 | 4 | 3 | 4 | 4 |
| 2 | 5 | 3 | 3 | 3 | 4 | 4 | 3 | 4 | 4 |
| 3 | 7 | 4 | 3 | 3 | 3 | 3 | 2 | 2 | 3 |
| 4 | 6 | 4 | 4 | 3 | 3 | 2 | 2 | 2 | 2 |
| 5 | 9 | 4 | 4 | 4 | 3 | 4 | 3 | 3 | 4 |
| 6 | 7 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 2 |
| 7 | 8 | 3 | 4 | 4 | 3 | 4 | 4 | 4 | 4 |
| 40 | 7 | 4 | 3 | 4 | 3 | 2 | 2 | 4 | 3 |
| direction | max | max | max | max | max | max | max | max | max |
| type | 5 | 4 | 4 | 2 | 2 | 2 | 2 | 2 | 2 |
| q (or s) | 1,000 | 0,500 | 0,500 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 |
| p | 2,000 | 1,000 | 1,000 | | | | | | |
| weight | 11% | 11% | 11% | 11% | 11% | 11% | 11% | 11% | 11% |

# conventional vs. outranking

Business expectations