PROMETHEE

METHODS

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Multicriteria Decision Aid with Visual PROMETHEE

- **PROMETHEE & GAIA** methods
- **Visual PROMETHEE** software

Thessaloniki 2015

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Decisions

- Personal decisions
  - Choose a restaurant tonight
  - Choose a university
  - Purchase a new phone, a new car, …
- Business decisions
  - Develop a new product
  - Choose a computer system
  - Investments, strategies, project management, …
- Political decisions
  - Join the EU…
  - Build a new hospital
  - Regional investment, taxes, …

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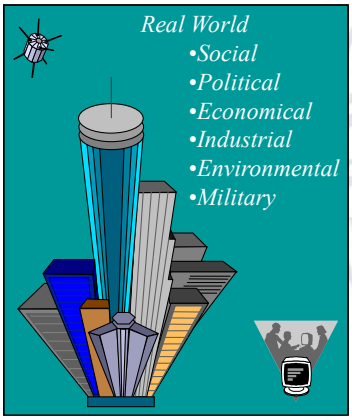
Beautiful Greece…

Beautiful Belgium…

Decision making

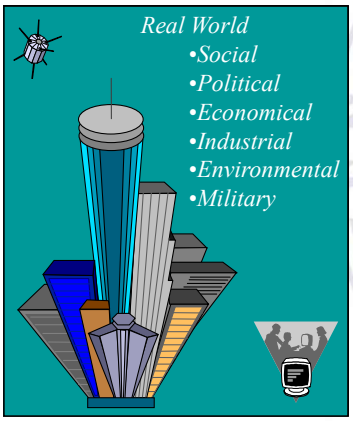


- Describe,
- Understand,
- Manage.

2 Approaches :

- Qualitative approach,
- Quantitative approach.

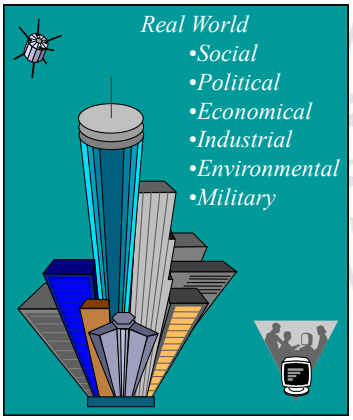
Decision aid



Quantitative model

- Possible decisions?
- How to compare them?
- Preferences, Objectives?

Decision aid



Quantitative model

- Approximation to real world!

➢ Decision Aid.

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Quantitative model?

- Describe possible decisions (actions)?
  - List, variables, …
- Objective? Best decision? Best choice?
  - Minimize costs?
  - Maximize profit?
  - Maximize quality?
  - Minimize impacts?
- Optimization models?

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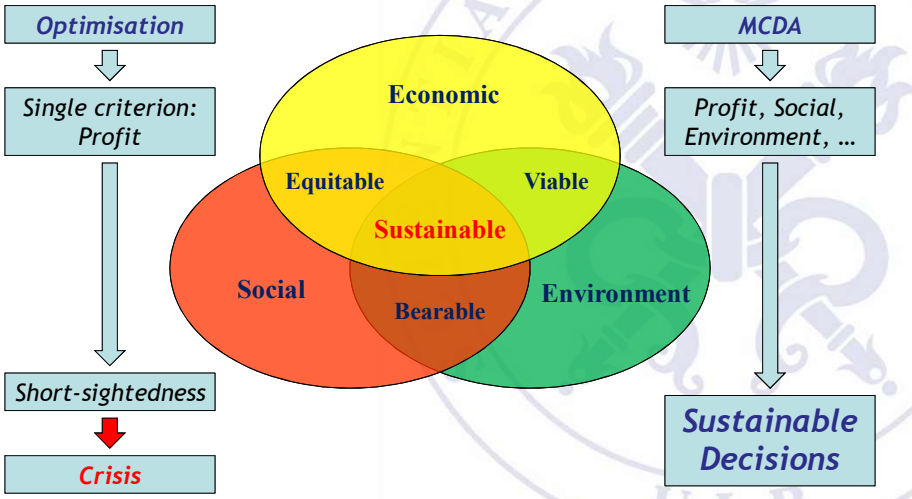
MCDA vs Optimisation



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Some Decision or Evaluation Problems

- Locating a new plant, a new shop, ...
- Human resources management.
- Purchasing equipment.
- Assessing the quality of suppliers.
- Evaluating projects.
- Selecting an investment strategy.

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Multicriteria table

- Actions:
  - Possible decisions,
  - items to evaluate.
- Criteria:
  - quantitative,
  - qualitative.

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Multicriteria table

	Crit. 1 (/20)	Crit. 2 (rating)	Crit. 3 (qual.)	Crit. 4 (Y/N)	…
Action 1	18	135	G	Yes	…
Action 2	9	147	B	Yes	…
Action 3	15	129	VG	No	…
Action 4	12	146	VB	?	…
Action 5	7	121	G	Yes	…
…	…	…	…	…	…

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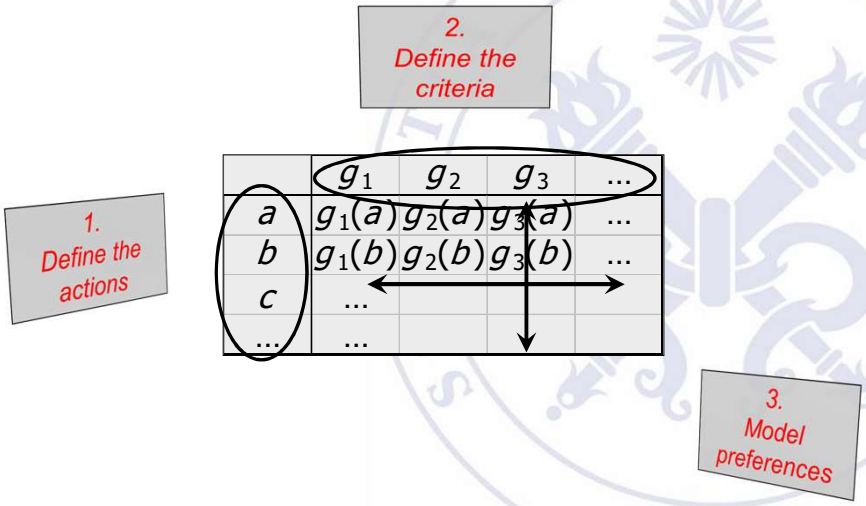
Plant location

	Investment (M€)	Costs (k€)	Environm. (impact)	…
Site 1	18	135	G	…
Site 2	9	147	B	…
Site 3	15	129	VG	…
Site 4	12	146	VB	…
Site 5	7	121	G	…
…	…	…	…	…

Purchase options

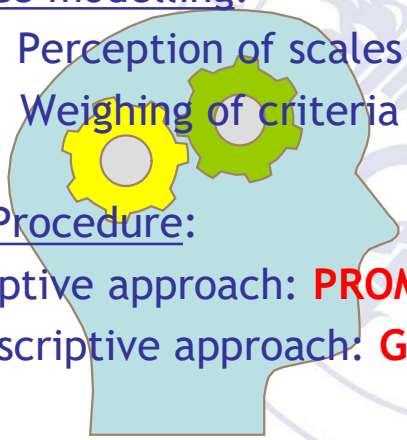
	Price (€)	Reliability (days)	Maintenance (estimate)	…
Product A	18	135	G	…
Product B	9	147	B	…
Product C	15	129	VG	…
Product D	12	146	VB	…
Product E	7	121	G	…
…	…	…	…	…

Modeling… 1… 2… 3…



Decision aid methods

- Preference modelling:
  - Perception of scales
  - Weighing of criteria
- Analysis Procedure:
  - Prescriptive approach: **PROMETHEE**
  - Descriptive approach: **GAIA**



Why PROMETHEE?

- Proven methodology
  - 30 years development
  - Over 1200 published scientific papers
- « Simplicity »
- Visual tools
- Sensitivity analysis tools
- Interactivity
- **Visual PROMETHEE** software

Principles of the PROMETHEE methods

- Preference modeling:
  - Preference functions
  - Weighing of the criteria
- Pairwise comparison of the actions:
  - Outranking
  - Prudent (partial ranking)
  - Partially compensatory approach
    - Advantage over weighted sum and utility functions

A simple example

The purchase of a new car

Objectives:

- Economy (price),
- Usage (fuel consumption),
- Performance (power),
- Space,
- Comfort.

Multicriteria table

Cars	Price	Power	Consumpt.	Space	Comfort
Tourism A	26 000 $	75	8,0	average	average
Sport	29 000 $	110	9,0	very bad	bad
Tourism B	25 500 $	85	7,0	good	average
Luxury 1	38 000 $	90	8,5	good	very good
Economic	15 000 $	50	7,5	bad	very bad
Luxury 2	35 000 $	85	9,0	very good	good

- Best buy?
- Best compromise?
- Priorities of the buyer?

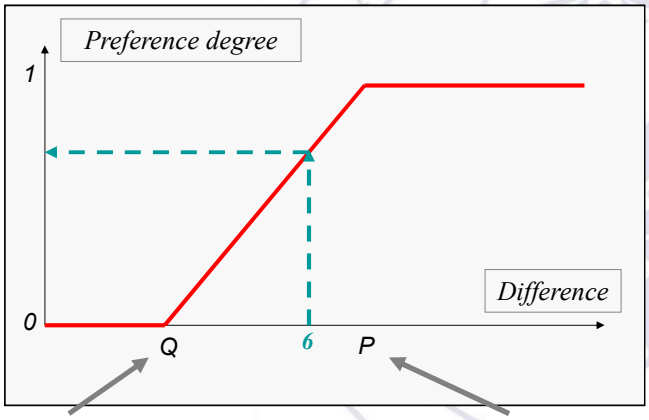
Preference modelling

- Preference functions:
  - Quantitative criteria
  - Qualitative criteria
- Weighing of the criteria:
  - Equal weights (to start…)

Comparison of 2 actions

	Crit. 1 (/20)	Crit. 2 (rating)	Crit. 3 (qual.)	Crit. 4 (Y/N)	...
Action 1	18	135	G	Yes	...
Action 2	9	147	*Difference = 6*		...
Action 3	15	129	VG	No	...
Action 4	12	146	VB	?	...
Action 5	7	121	G	Yes	...
...	...	...	...	...	...

Preference function

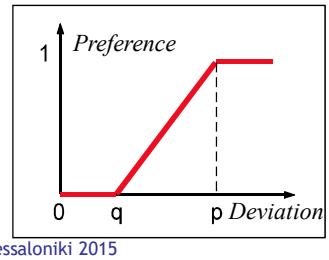


Indifference threshold Linear *Preference threshold*

PROMETHEE

Pref (Eco.,Lux.) *Pref (Lux.,Eco.)*

		Economic		Luxury 1			Wght
1,0	**-23000**	15000	*Price*	38000		0,0	*1/5*
0,0		50	*Power*	90	**+40**	**1,0**	*1/5*
0,5	**-1,0**	7,5	*Fuel*	8,5		0,0	*1/5*
0,0		B	*Space*	G	**+2**	**0,5**	*1/5*
0,0		VB	*Comfort*	VG	**+4**	**1,0**	*1/5*

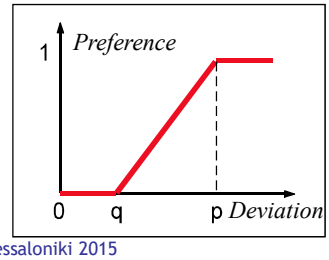


- *Pref (Eco.,Lux.) = 0,3*
  = (1 + 0 + 0,5 + 0 + 0) / 5
- *Pref (Lux.,Eco.) = 0,5*
  = (0 + 1 + 0 + 0,5 + 1) / 5

PROMETHEE

Pref (Eco.,Lux.) *Pref (Lux.,Eco.)*

		Economic		Luxury 1			Wght
1,0	**-23000**	15000	*Price*	38000		0,0	*1/5*
0,0		50	*Power*	90	**+40**	**1,0**	*1/5*
0,5	**-1,0**	7,5	*Fuel*	8,5		0,0	*1/5*
0,0		B	*Space*	G	**+2**	**0,5**	*1/5*
0,0		VB	*Comfort*	VG	**+4**	**1,0**	*1/5*

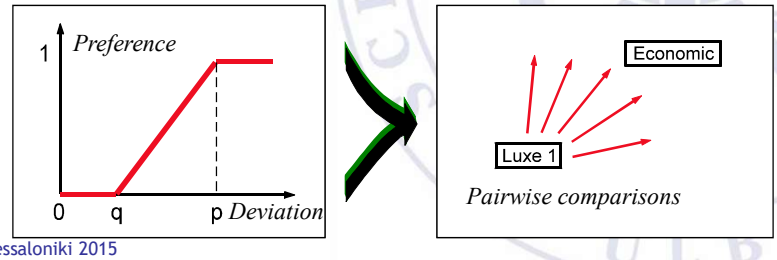


- *Pref (Eco.,Lux.) = 0,43*
  = (2 x 1 + 0 + 2 x 0,5 + 0 + 0) / 7
- *Pref (Lux.,Eco.) = 0,36*
  = (0 + 1 + 0 + 0,5 + 1) / 7

PROMETHEE

Pref (Eco.,Lux.) *Pref (Lux.,Eco.)*

		Economic		Luxury 1		
1,0	**-23000**	15000	*Price*	38000		0,0
0,0		50	*Power*	90	**+40**	**1,0**
0,5	**-1,0**	7,5	*Fuel*	8,5		0,0
0,0		B	*Space*	G	**+2**	**0,5**
0,0		VB	*Comfort*	VG	**+4**	**1,0**



Computation of preference flows

$\pi(a,b)$	*Tour.A*	*Sport*	*Tour.B*	*Lux.*1	*Econ.*	*Lux.*2	$\phi^+(a)$
Tour.A	0,00	0,34	0,00	0,21	0,26	0,22	0,21
Sport	0,20	0,00	0,16	0,24	0,30	0,24	0,23
Tour.B	0,15	0,55	0,00	0,32	0,45	0,33	0,36
*Lux.*1	0,18	0,45	0,10	0,00	0,50	0,15	0,28
Econ.	0,20	0,34	0,14	0,30	0,00	0,35	0,27
*Lux.*2	0,24	0,30	0,10	0,04	0,60	0,00	0,26
$\phi^-(a)$	0,19	0,40	0,10	0,22	0,42	0,26	
$\phi(a)$	0,02	-0,17	0,26	0,06	-0,15	0,00	

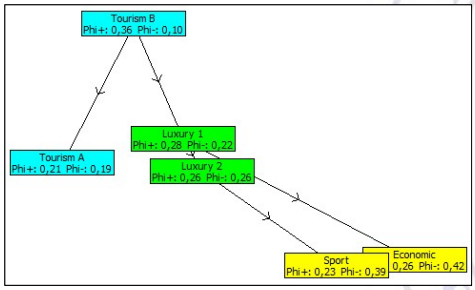
Preference Flows

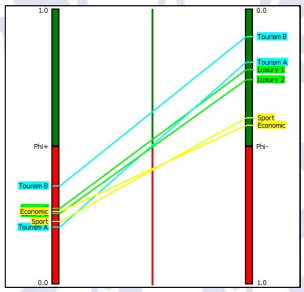
- Relative scores computed for the actions.
- Leaving (+) and entering (–) flows:
  - Strength: $0 \leq \phi^+ \leq 1$
  - Weakness: $0 \leq \phi^- \leq 1$
- Net flow:
  - Balance: $-1 \leq \phi = \phi^+ - \phi^- \leq +1$
- Unicriterion net flows:
  - Standardized scores for each criterion:

$$\text{criterion } f_j \quad \Rightarrow \quad -1 \leq \phi_j \leq +1$$

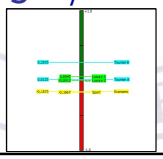
PROMETHEE I & II

- PROMETHEE I : partial ranking - ϕ^+, ϕ^-

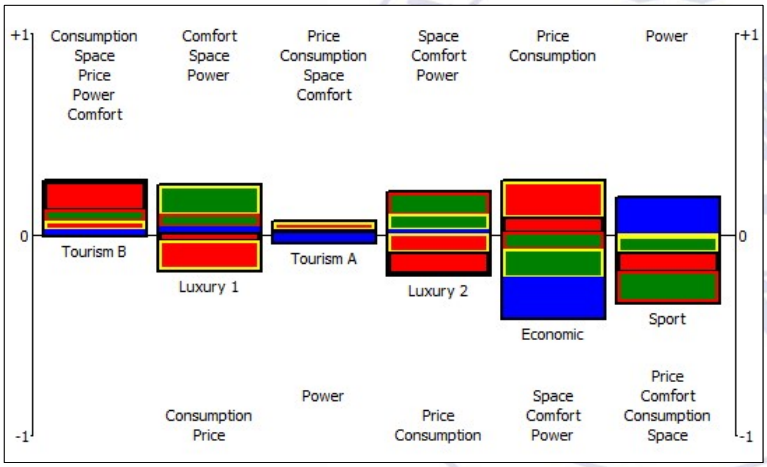




- PROMETHEE II : complete ranking - ϕ



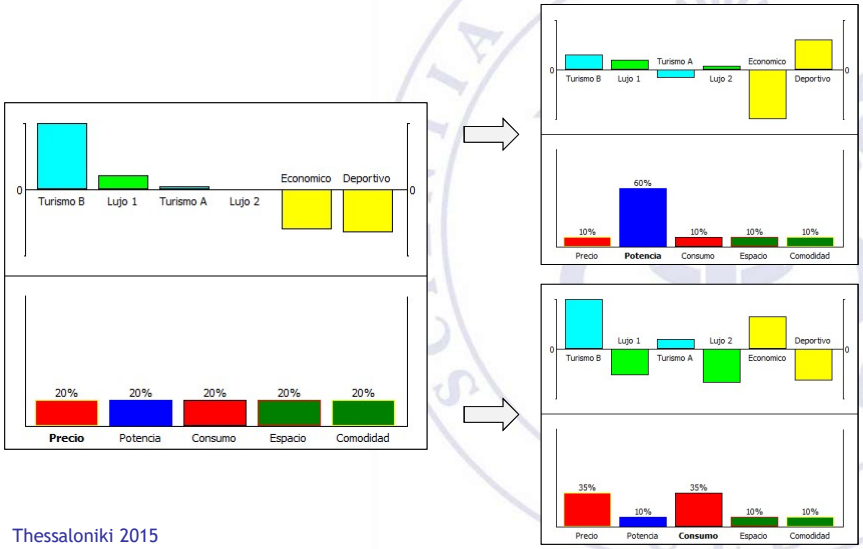
PROMETHEE Rainbow



Sensitivity Analysis with PROMETHEE

- Criteria weights ↔ PROMETHEE ranking.
- Interactive weight sensitivity analysis: « Walking Weights ».
- Robustness with respect to weight values?
  - Weight stability intervals.
  - Visual weight stability intervals.

Walking Weights



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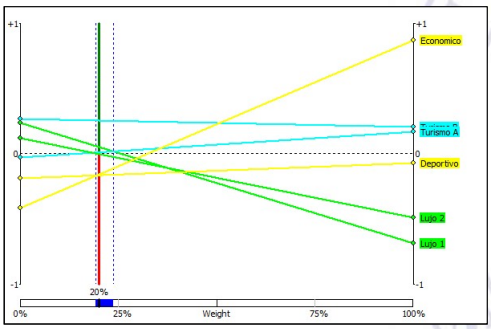
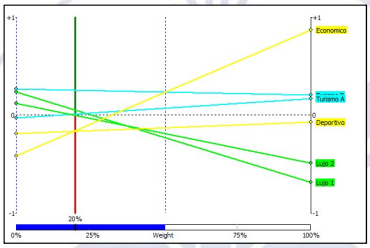
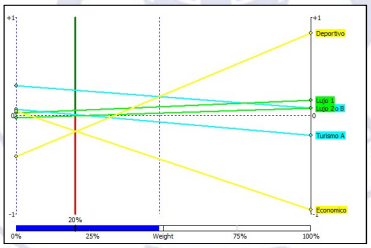
Visual Stability Intervals



VSI for « Price » (level 6):
[19.20% , 23.70%]



VSI for « Price » (level 1): [0.00% , 50.68%]



VSI for « Power » (level 1): [0.00% , 48.65%]

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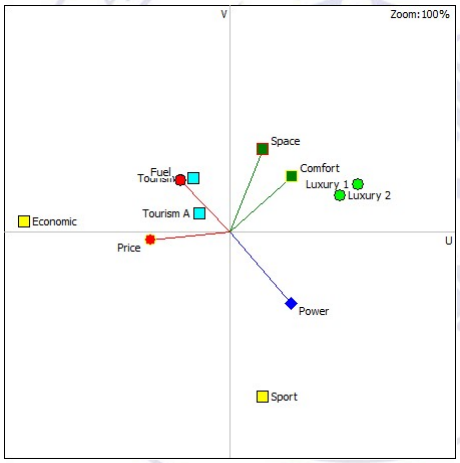
GAIA

- Visual descriptive analysis.
- Better understanding:
  - Conflicting criteria.
  - Action profiles.
  - Possible compromise solutions.
- Reducing the multicriteria dimension:
  - Principal components analysis.

GAIA

- Discover conflicts among criteria.
- Identify potential compromises.
- Help to fix priorities.



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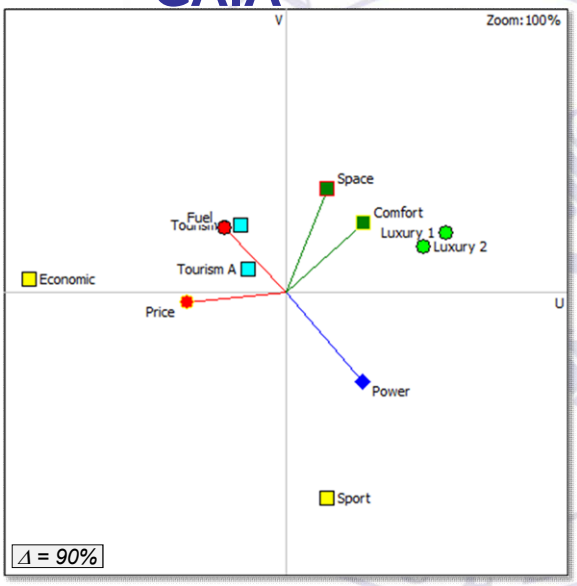
GAIA

- *Actions: points*
- *Criteria: axes*



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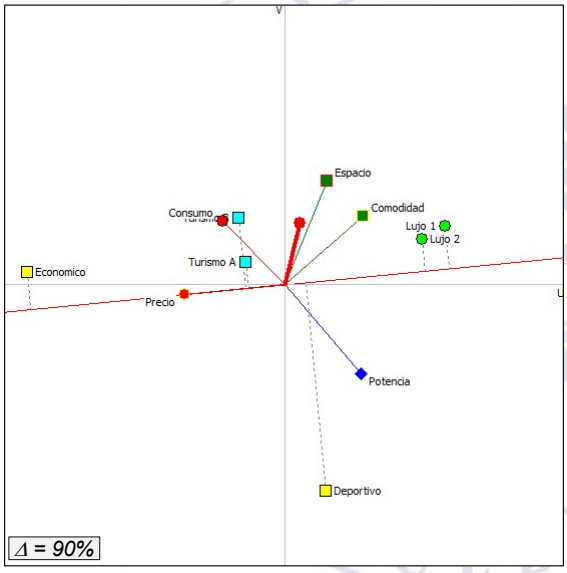
GAIA

Price

- *Economic: 15 k€*
- *Tourism: 25,5-26 k€*
- *Sport: 29 k€*
- *Luxury: 35-38 k€*



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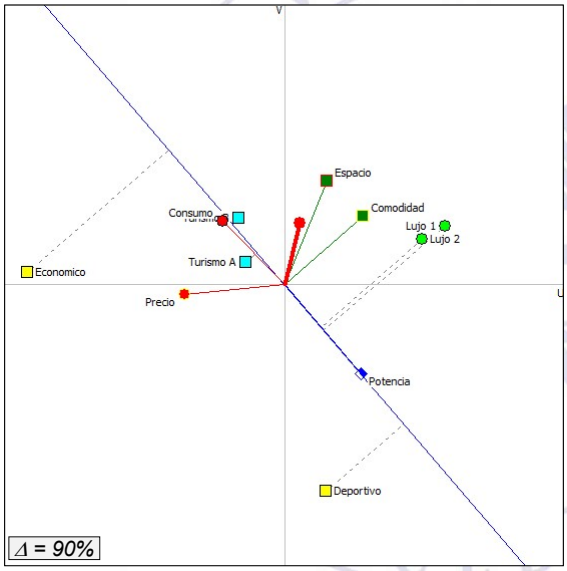
GAIA



Power

- *Sport: 110 kW*
- *Luxury: 85-90 kW*
- *Tourism: 75-85 kW*
- *Economic: 50 kW*

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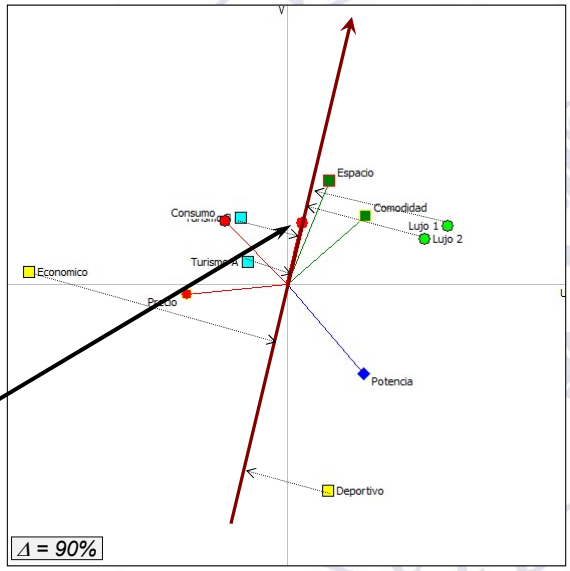
GAIA



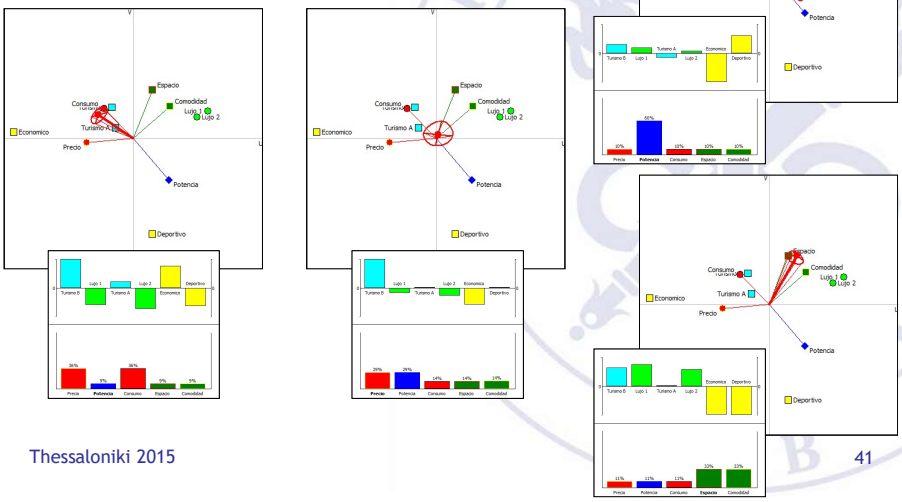
PROMETHEE II !

- *Tourism B : 0,26*
- *Luxury 1 : 0,06*
- *Tourism A : 0,02*
- *Luxury 2 : 0,00*
- *Economic : -0,15*
- *Sport : -0,17*

GAIA-Brain

20 years old

35 years old



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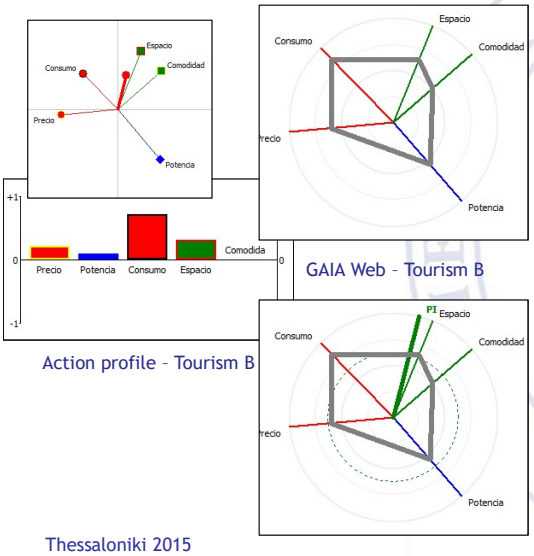
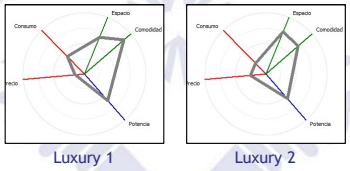
GAIA Webs



Action profile – Tourism B

GAIA Web – Tourism B



Luxury 1

Luxury 2

Tourism A

Tourism B

Sport

Economic

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One or several stakeholders ?

- Single stakeholder:
  - One actor (decision maker)
  - One multicriteria table and one preference structure
- Multiple stakeholders:
  - Several actors (including decision maker(s))
  - Several multicriteria tables and preference structures
  - Search for consensus

Multi-scenarios model

- Scenarios:
  - Points of view,
  - Hypotheses, …
- Evaluations:
  - 'Objective' criteria: common evaluations.
  - 'Subjective' criteria: specific evaluations for each scenario.
- Specific preference structures :
  - Weights, preference thresholds.

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Multi-scenarios model

- Adaptation of **PROMETHEE**:
  - Individual rankings
  - Global (group) ranking with possible weighing of the scenarios
- Adaptation of **GAIA**:
  - Three different analyses:
    - **GAIA**-Criteria
    - **GAIA**-Scenarios
    - **GAIA**-Unicriterion

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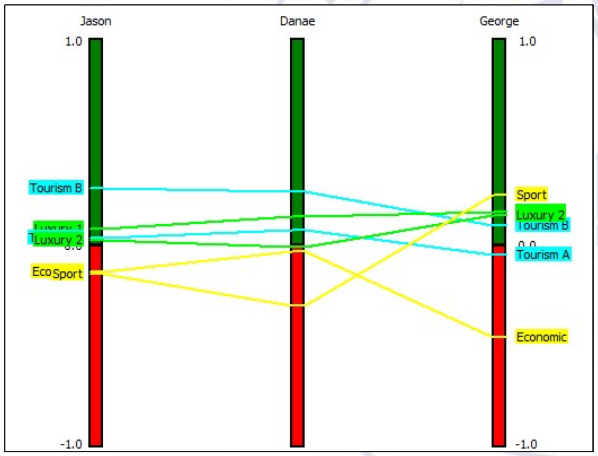
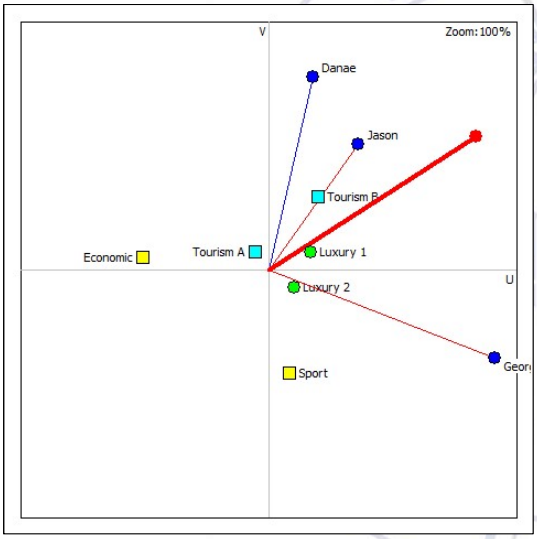
Example

- A Greek family
- Three actors (“decision makers”):
  - Jason (dad),
  - Danae (mom),
  - George (the kid).
- Three scenarios.
- Three multicriteria tables:
  - Different weights.
  - Subjective evaluation of comfort.

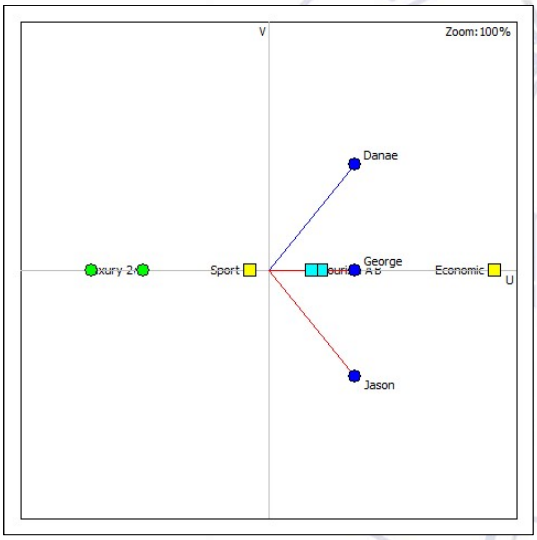
Individual PROMETHEE rankings



GDSS-GAIA: Scenarios

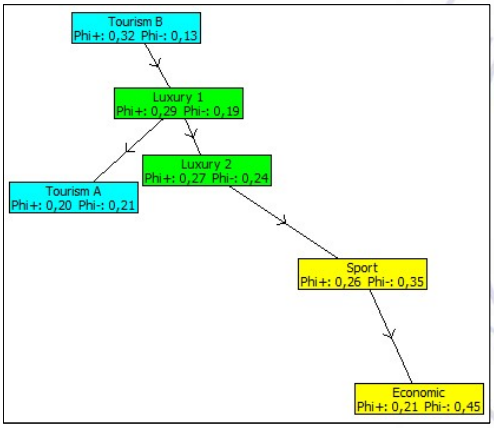


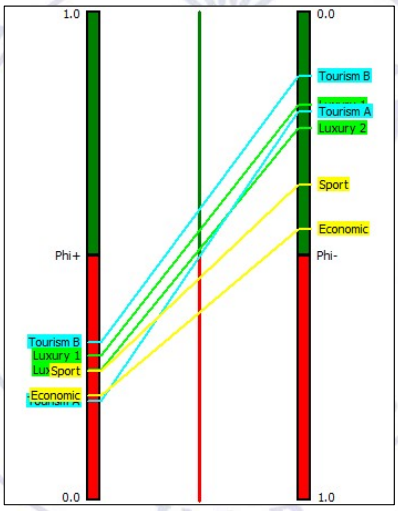
GDSS-GAIA: Criterion Price



GDSS-GAIA: Criterion Comfort

« Family » (group) ranking

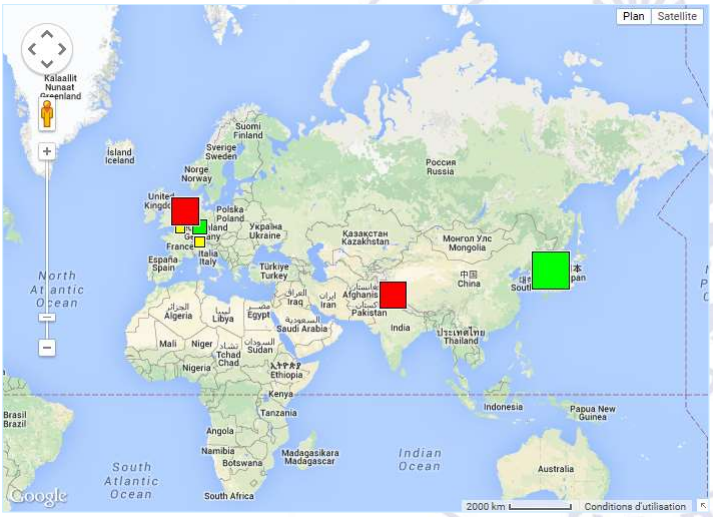




Other PROMETHEE tools

- PROMETHEE V
  - Portfolio selection under constraints
- PROMETHEE Sort
- Bank Adviser
- PROMETHEE Efficiency Analysis
  - Input/output model
- …

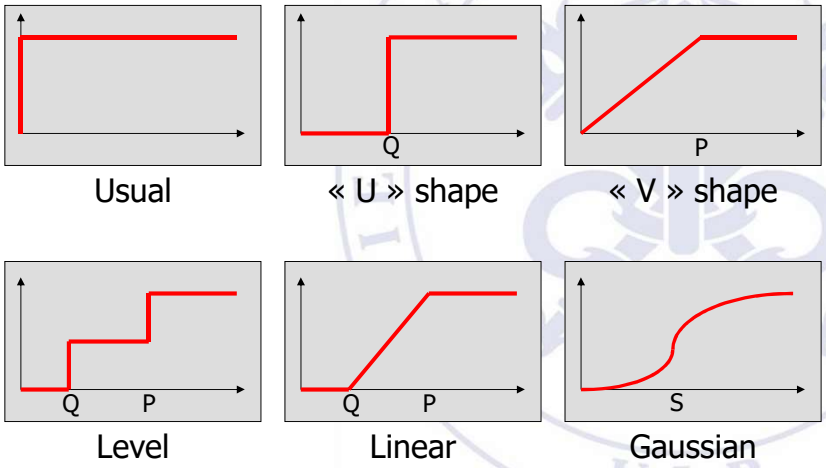
Google Maps interface



Steps for using PROMETHEE

1. Define the actions (list)
2. Define the criteria
   - Quantitative
   - Qualitative (scale)
3. For each criterion:
   - Choose the right type of preference function
   - Set the appropriate thresholds
4. Set the weights of the criteria

Preference functions
(as in Visual PROMETHEE software)



Preference functions

- For continuous quantitative criteria (e.g. cost, price, power):
  - V-shape (no indifference threshold)
  - Linear
- For qualitative or discrete quantitative criteria (e.g. « very good to very bad », number of USB ports):
  - Usual (no thresholds)
  - Level

Visual PROMETHEE

WWW.PROMETHEE-GAIA.NET

- **Visual PROMETHEE** software:
  - **Free Academic Edition**
  - **Business Edition**
- http://biblio.promethee-gaia.net :
  - Over 1200 references
- **Visual PROMETHEE** Manual (PDF or ebook)
- Services: Training, Coaching, Free seminars
- http://blog.promethee-gaia.net
- http://www.promethee-days.com May 2016
- LinkedIn group, Twitter, ResearchGate, …

Some stats…

- First paper published in 1982 by J-P. Brans.
- Over 1200 published papers as of today.
- 75 papers published by 128 Greek authors, from 1989 to 2015
  (worldwide #3, after Belgium and China)
- Main fields of application:
  - Environment
  - Industry
  - Public sector

ULB

Forthcoming…

- **PROMETHEE *Days* 2016**
  - Montréal, May 2-4
  - With **Optimization Days 2016** conference
  - Theoretical and applied papers
- **PROMETHEE *Academy* 2016**
  - Montréal, April 29-30
  - 2-day course
  - Methodology
  - Practicals