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Multicriteria Decision Aid with Visual PROMETHEE

- Multicriteria decision aid
- PROMETHEE & GAIA methods
- Visual PROMETHEE software

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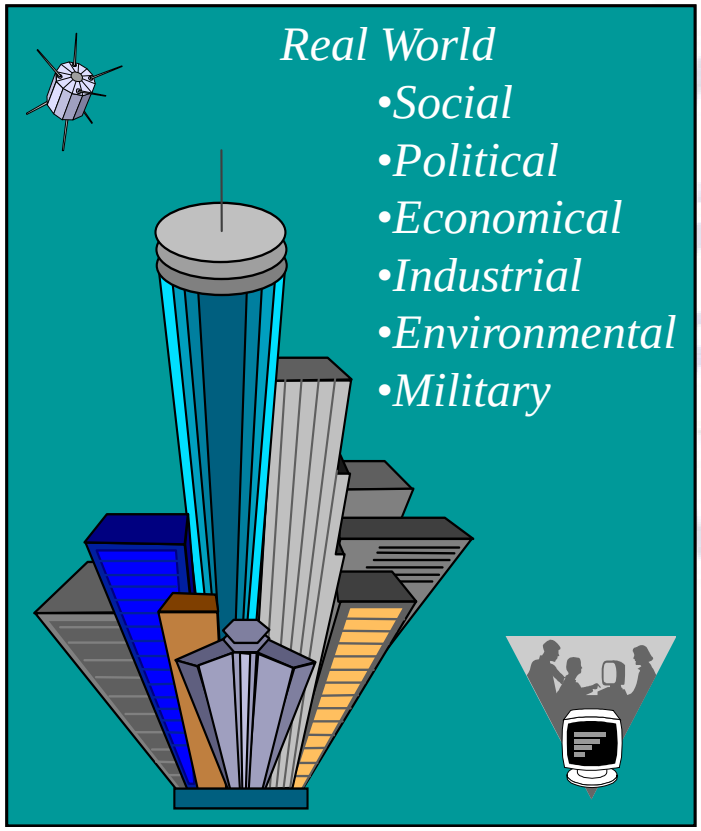
Course summary

1. Unicriterion vs. multicriteria models.
2. Multicriteria modeling: Basic concepts.
3. Multi-attribute utility theory (aggregation) vs. outranking methods.
4. PROMETHEE & GAIA methods.
5. Visual PROMETHEE software.
6. Practicals.

Decision making

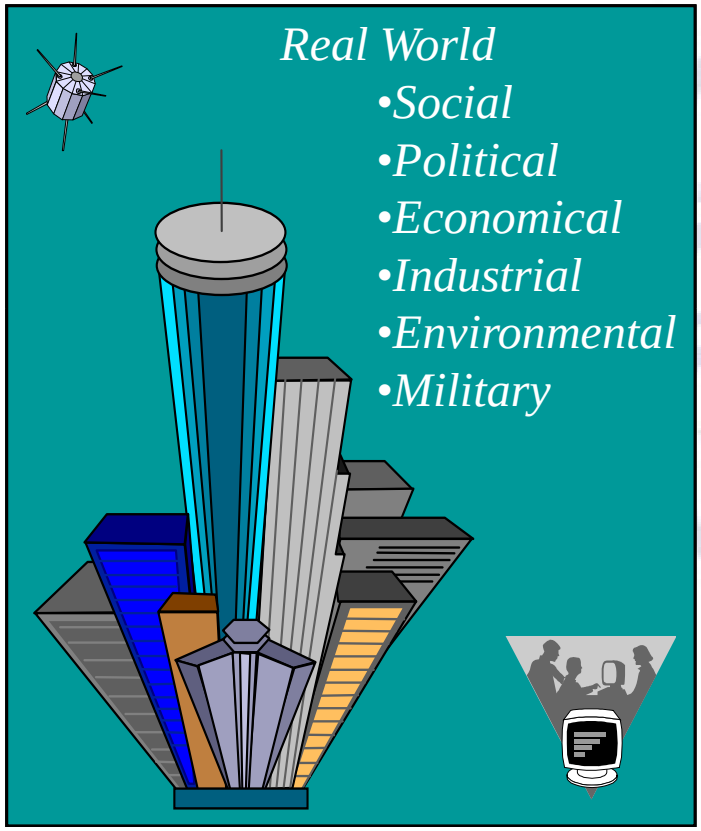


- Describe,
- Understand,
- Manage.

2 Approaches :

- Qualitative approach,
- Quantitative approach.

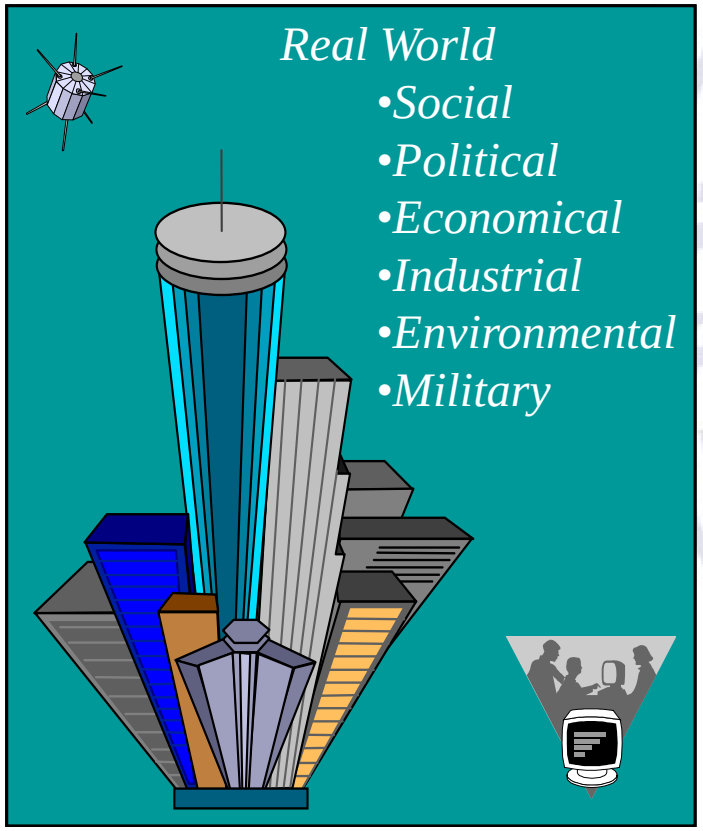
Decision aid



Quantitative model

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

Decision aid



Quantitative model

- Approximation to real world!
- ➢ Decision Aid.

Quantitative model?

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

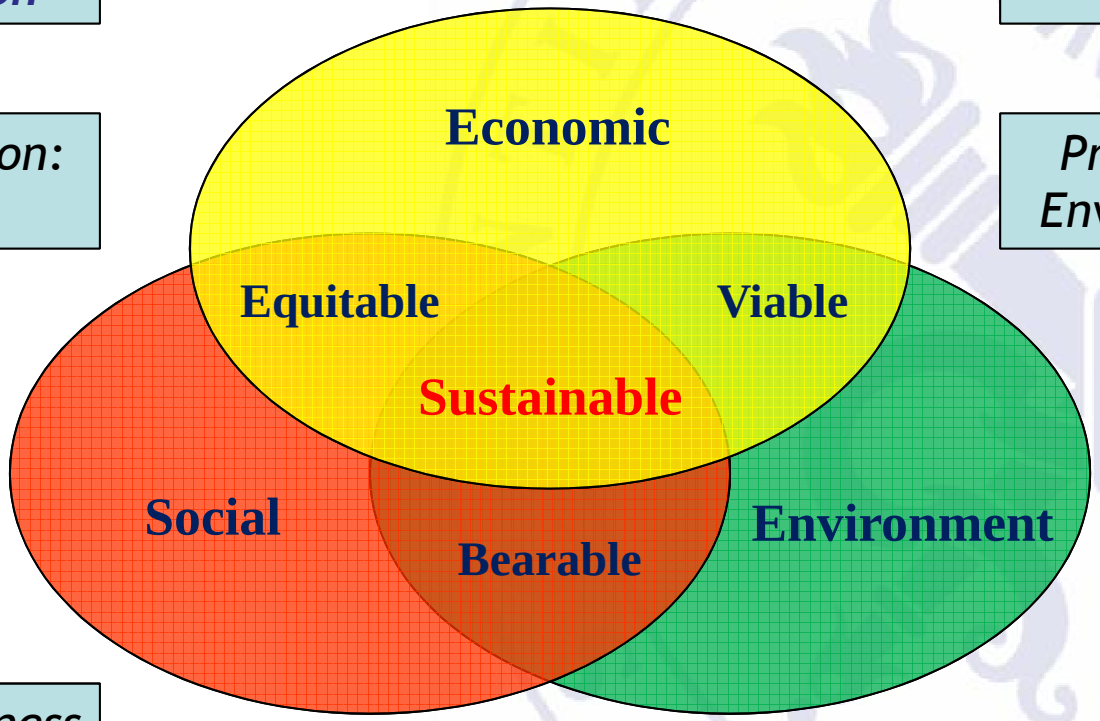
MCDA vs Optimisation

Optimisation

Single criterion: Profit

Short-sightedness

Crisis



MCDA

Profit, Social, Environment, …

Sustainable Decisions

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.

Unicriterion vs multicriteria model

- Unicriterion model:

$$\text{Optimise}\{g(a) \mid a \in A\}$$

  - Mathematically well-stated:
    - Optimal solution,
    - Complete ranking of the actions.
  - Socio-economically ill-stated:
    - Single criterion? Not realistic.
    - Notion of criterion: perception thresholds, …

Unicriterion vs multicriteria model

- Multicriteria model:

$$\text{Optimise}\{g_1(a), g_2(a), \ldots, g_k(a) \mid a \in A\}$$

  - Mathematically ill-stated:
    - No optimal solution,
    - No mathematical meaning.
  - Socio-economically well-stated:
    - Closer to real world decision problem,
    - Search for a compromise solution.

Multicriteria table

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

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	…
…	…	…	…	…	…

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	…
…	…	…	…	…

A simple example

The purchase of a car

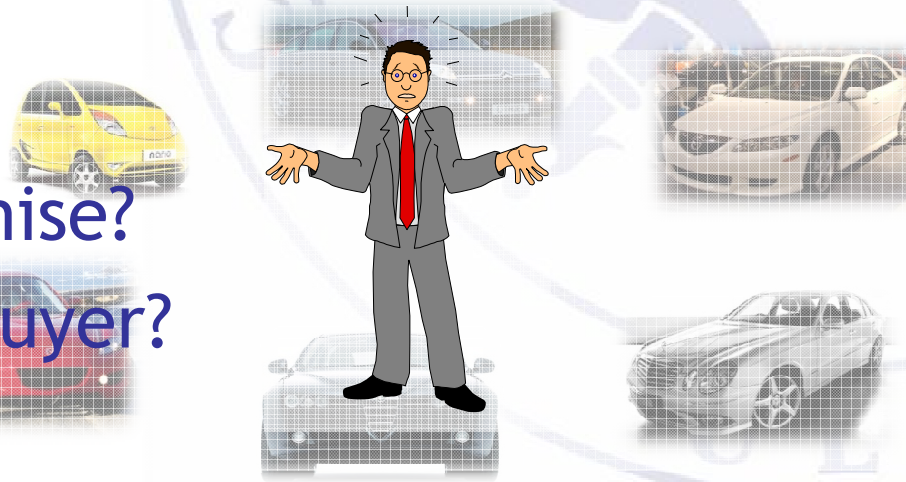
Objectives:

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

Multicriteria table

Coches	Precio	Poder	Consumo	Habitabil.	Comodidad
Turismo A	26.000 €	75	8,0	A	A
Deportivo	29.000 €	110	9,0	VB	B
Turismo B	25.500 €	85	7,0	G	A
Lujo 1	38.000 €	90	8,5	G	VG
Economico	15.000 €	50	7,5	B	VB
Lujo 2	35.000 €	85	9,0	VG	G

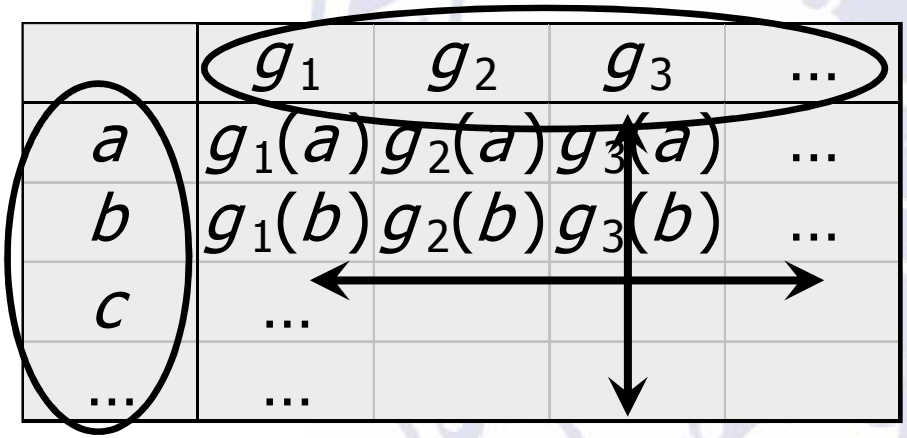
- Best buy?
- Best compromise?
- Priorities of buyer?



Modeling… 1… 2… 3…

2. Define the criteria

1. Define the actions



3. Model the preferences

1. Defining the actions

- Definition : Let A the set of actions. A can be defined:
  - **in extension**:
    by enumeration of its elements.
    ➔ relatively small number of actions.
  - **in comprehension**:
    by constraints on a set of decision variables.
    (Cf. linear programming)
    ➔ large number or infinity of actions.

Some properties of the set of actions

A can be:

- **stable**: a priori defined, doesn't evolve.
- **evolutive**: can evolve during the procedure.

- **globalised**: mutually exclusive elements.
- **fragmented**: combinations of actions are considered.

2. Defining the criteria

- Definition:
  function g defined on A, taking its values in a totally ordered set, and representing an objective of the decision-maker.
- Consistent family of criteria:
  - Include all aspects of the decision problem, all the objectives of the decision-maker,
  - Avoid redundancies.

Qualitative criteria

- Qualitative scales:
  - Maximum 9 levels (7 ± 2) to ensure a consistent evaluation.
  - Presence of a neutral level?
  - Examples:
    - Very good, Good, Average, Bad, Very bad
    - Yes, No
    - ++, +, 0, -, --
    - ++, +, -, --
- Underlying numerical scale (coding).

3. Modeling preferences

- Problem:

  How to compare two actions a and b to each other?

- A first model: 3 possible results:
  1. Preference: aPb or bPa
  2. Indifference: aIb
  3. Incomparability: aRb

Traditional preference structure (unicriterion)

- Optimisation of a function g on A

$$\forall a,b \in A: \begin{cases} aPb & \Leftrightarrow & g(a) > g(b) \\ aIb & \Leftrightarrow & g(a) = g(b) \end{cases}$$

- Consequences:

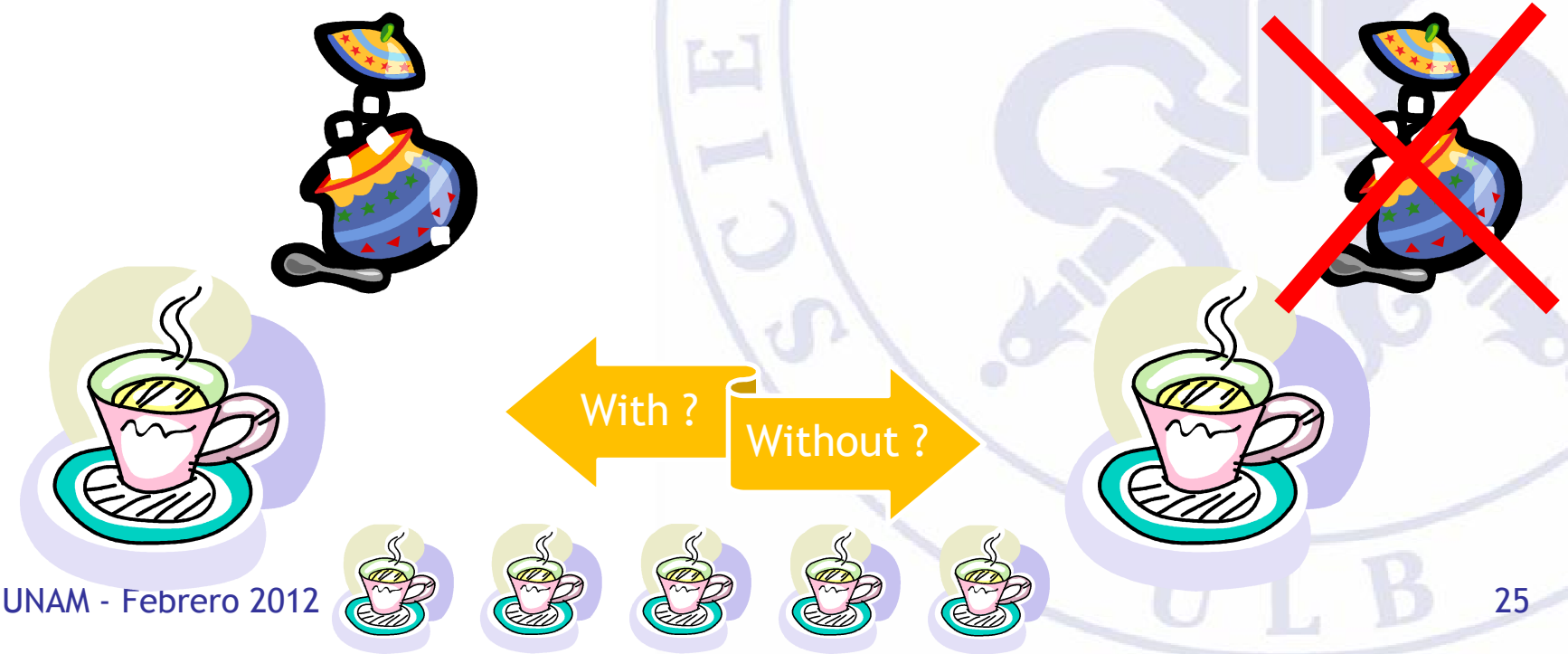
R is empty
P is transitive
I is transitive

- Complete ranking.

The notion of indifference threshold

- Problem: Indifference can be intransitive.

  Cf. Coffee cup paradox (Luce, 1956)



The notion of indifference threshold

- Problem: Indifference can be intransitive.

  Cf. Coffee cup paradox (Luce, 1956)

- Introduction of an indifference threshold:

$$\forall a,b \in A: \begin{cases} aPb & \Leftrightarrow \quad g(a) > g(b) + q \\ aIb & \Leftrightarrow \quad \left| g(a) - g(b) \right| \leq q \end{cases}$$

- Quasi-order : P is transitive, but not I.

Other preference structures

- Variable indifference threshold
  $\Rightarrow$ Interval order.
- Preference + indifference thresholds
  $\Rightarrow$ Pseudo-order.
- Models including incomparability
  $\Rightarrow$ Partial orders.
- Valued preference structures.

Problematics

	g_1	g_2	g_3	…
a	$g_1(a)$	$g_2(a)$	$g_3(a)$	…
b	$g_1(b)$	$g_2(b)$	$g_3(b)$	…
c	…			
…	…			

Evaluations

- n actions
- k criteria

α - choice: determine a subset of actions (the « best ones »).

β - sorting: sort actions in predefined categories.

γ - ranking: rank from the best to the worst action.

δ - description: describe actions and their consequences.

Dominance and efficiency

- « Objective ».
- Based on a unanimity principle:

$$a \text{ dominates } b \Leftrightarrow g_h(a) \geq g_h(b) \ \forall \ h$$

- Efficiency: a is efficient if it is not dominated by any other action.
- Problems:
  - Dominance is poor (few dominances),
  - Many actions are efficient.

Objections to dominance

I	g_1	g_2
a	100	100
b	20	30

- *a* efficient
- *a* preferred to *b*

II	g_1	g_2
a	100	30
b	20	100

- *a* and *b* efficient
- *a* and *b* incomp.

III	g_1	g_2
a	100	99
b	20	100

- *a* and *b* efficient
- *a* preferred to *b*

IV	g_1	g_2
a	100	99
b	99	100

- *a* and *b* efficient
- *a* and *b* indifferent

V	g_1	g_2
a	100	100
b	99	99

- *a* efficient
- *a* and *b* indifferent

Some characteristics
for a good multicriteria method

- Take into account **deviations** between evaluations.
- Take **scale** effects into account.
- Build either a **partial** (P,I,R) or a **complete** (P,I) ranking of the actions.
- Stay sufficiently **simple**:
  - **no** black box,
  - **no** technical parameters.

A common approach:
The weighted sum

Criteria

Actions or Decisions

	g_1	g_2	g_3	...
a	$g_1(a)$	$g_2(a)$	$g_3(a)$	...
b	$g_1(b)$	$g_2(b)$	$g_3(b)$	...
c	...			
...	...			
	w_1	w_2	w_3	...

Weights of the criteria

A common approach:
The weighted sum

- Global value for a :

$$V(a) = w_1\, g_1(a) + w_2\, g_2(a) + \ldots$$

- a is preferred to b if:

$$V(a) > V(b)$$

(if all criteria are to maximise)

Weighted sum:
Example 1

	g_1	g_2	g_3	g_4	g_5
a	100	100	100	100	55
b	85	85	85	85	100
	1/5	1/5	1/5	1/5	1/5

- V(*a*) = 91 V(*b*) = 88
- Total and uncontrolled compensation of weaknesses by strengthes.

Weighted sum:
Example 2

	g_1	g_2
a	100	0
b	0	100
c	50	50
d	50	50
	1/2	1/2

- V(a) = V(b) = V(c) = V(d) = 50
- Elimination of conflicts – Loss of information.

Weighted sum:
Example 3

"Profit is approximately 2 times more important than time savings;
0.7 for profit and 0.3 for time savings."

	g_1 (BF)	g_2 (min)
a	60	60
b	48	70
	0.7	0.3

V(a) = 60
V(b) = 54.6

a is ranked 1st.

Weighted sum:
Example 3

"Profit is approximately 2 times more important than time savings;
0.7 for profit and 0.3 for time savings."

	g_1 (FF)	g_2 (min)
a	10	60
b	8	70
	0.7	0.3

V(a) = 25
V(b) = 26.6

b is ranked 1st!

Weighted sum:
Example 3

	g_1 (BF)	g_2 (min)
a	60	60
b	48	70
	0.7	0.3

V(a) = 60
V(b) = 54.6

a is ranked 1st.

	g_1 (FF)	g_2 (min)
a	10	60
b	8	70
	0.7	0.3

V(a) = 25
V(b) = 26.6

b is ranked 1st.

→ *Significance of the "weights" !* ←

Multicriteria decision aid

- Multiattribute utility theory.
- Outranking methods.
- Interactive methods.
- Multiobjective programming.
- …

Since 1970, numerous developments: conferences, papers, books, applications, software...

Multiattribute utility (MAUT)

- Single synthesis criterion (aggregation).

$$U(a) = U(g_1(a), g_2(a), \ldots, g_k(a))$$

- Existence?
- Construction?
- Mathematical form?

➔ additive?

$$U(a) = \sum_{j=1}^{k} U_j\left(g_j(a)\right)$$

Multiattribute utility (MAUT)

- Mode of construction :
  - direct,
  - indirect.
- Information intensive for the decision maker. (quantity of information vs reliability?).
- Not flexible (sensitivity analyses).
- Far away from the original decision problem structure:

multicriteria $\rightarrow$ unicriterion

Outranking methods

- Majority principle
  (vs unanimity for dominance).
- Pairwise comparison of actions.
- Closer to the decision problem.
- ELECTRE methods (1968-).
- PROMETHEE & GAIA methods (1982-).

Different approaches

Outranking

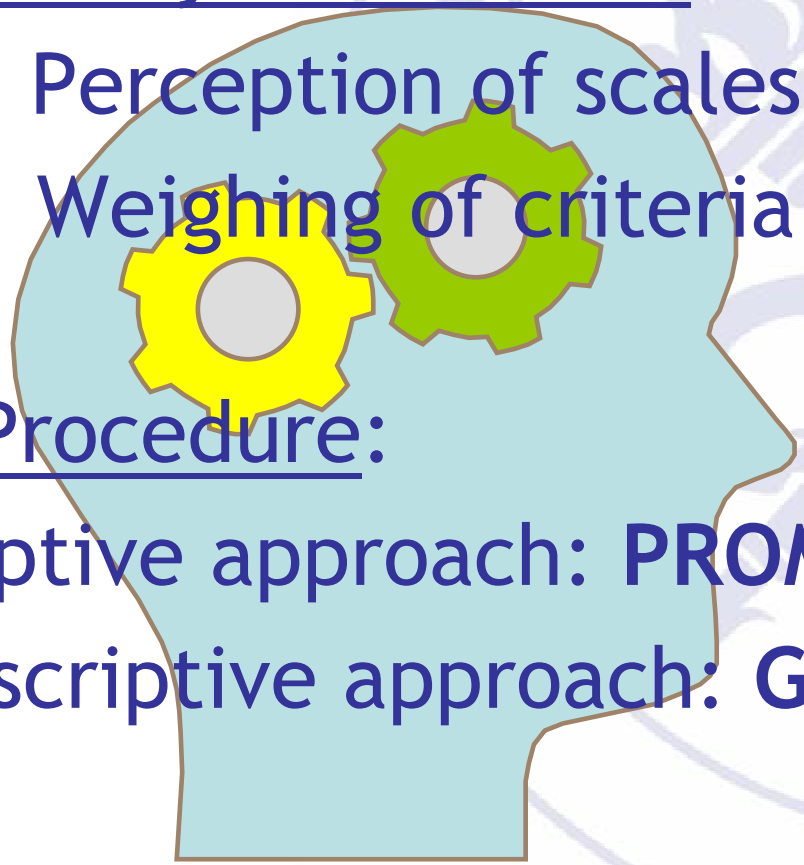
	Unicriterion approach	Weighted sum MAUT	Pairwise comparisons
Foundation	Mathematical	Economical	Economical
Compensation between criteria	-	Total	Limited
Scales	-	Linked to weigths of criteria	Taken into account
Conflict detection	-	No	Yes

Decision aid methods

- Supplementary information:

  Perception of scales

  Weighing of criteria



- Analysis Procedure:

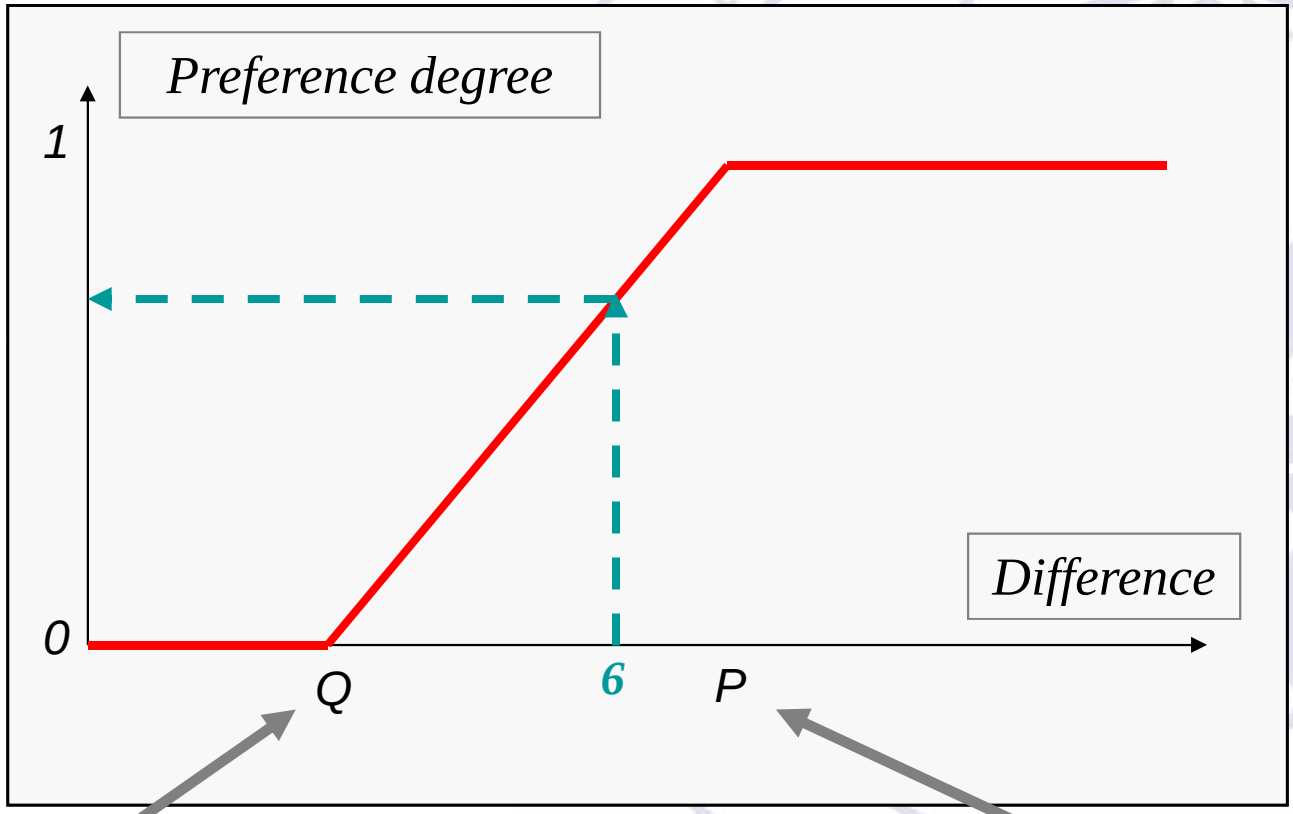
  Prescriptive approach: **PROMETHEE**

  Descriptive approach: **GAIA**

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

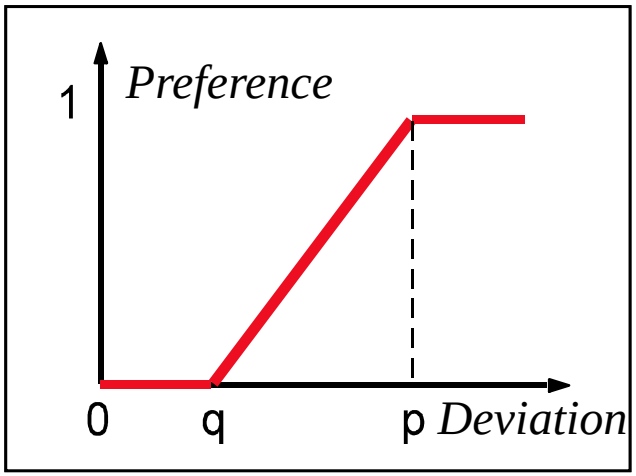
Linear

Preference threshold

PROMETHEE

Pref (Eco.,Lujo) ***Pref (Lujo,Eco.)***

		Economico		Lujo 1			Wght
1,0	**-23000**	15000	*Precio*	38000		0,0	*1/5*
0,0		50	*Potencia*	90	**+40**	**1,0**	*1/5*
0,5	**-1,0**	7,5	*Consumo*	8,5		0,0	*1/5*
0,0		B	*Espacio*	G	**+2**	**0,5**	*1/5*
0,0		VB	*Comodidad*	VG	**+4**	**1,0**	*1/5*



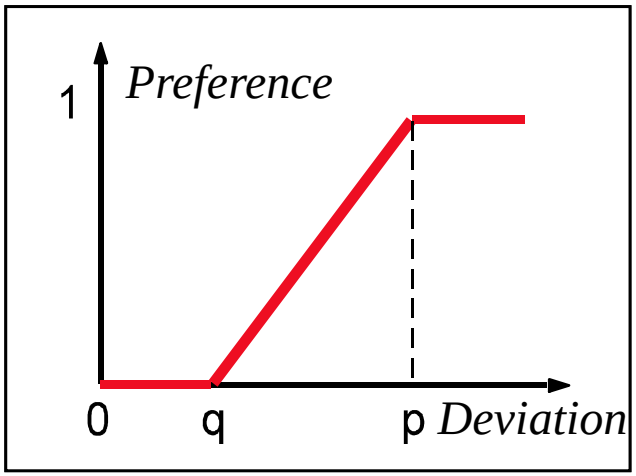
- *Pref (Eco.,Lujo) = 0,3*
  = (1 + 0 + 0,5 + 0 + 0) / 5
- *Pref (Lujo,Eco.) = 0,5*
  = (0 + 1 + 0 + 0,5 + 1) / 5

PROMETHEE

Pref (Eco.,Lujo)

Pref (Lujo,Eco.)

		Economico		Lujo 1			Wght
1,0	**-23000**	15000	*Precio*	38000		0,0	*2/7*
0,0		50	*Potencia*	90	**+40**	**1,0**	*1/7*
0,5	**-1,0**	7,5	*Consumo*	8,5		0,0	*2/7*
0,0		B	*Espacio*	G	**+2**	**0,5**	*1/7*
0,0		VB	*Comodidad*	VG	**+4**	**1,0**	*1/7*



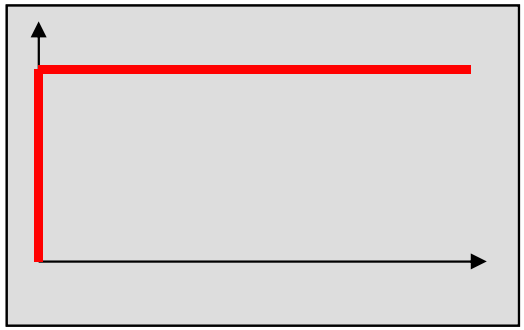
- *Pref (Eco.,Lujo) = 0,43*
  = (2 x 1 + 0 + 2 x 0,5 + 0 + 0) / 7
- *Pref (Lujo,Eco.) = 0,36*
  = (0 + 1 + 0 + 0,5 + 1) / 7

Pairwise comparisons

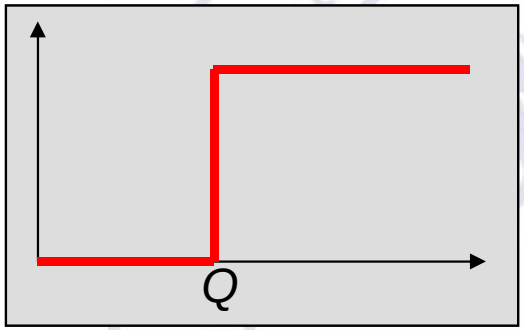
- For each criterion g_j :
  - Preference function P_j
  - Weight w_j
- Multicriteria preference degree of a over b :

$$\pi(a,b) = \sum_{j=1}^{k} w_j \, P_j(a,b)$$

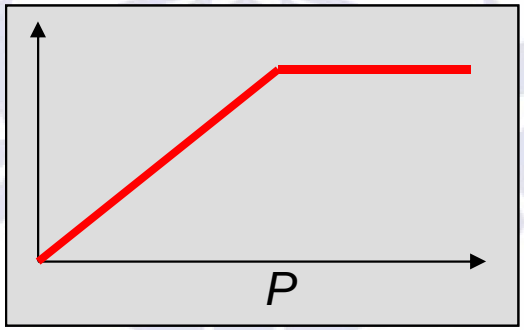
Preference functions
(as in PROMETHEE software)



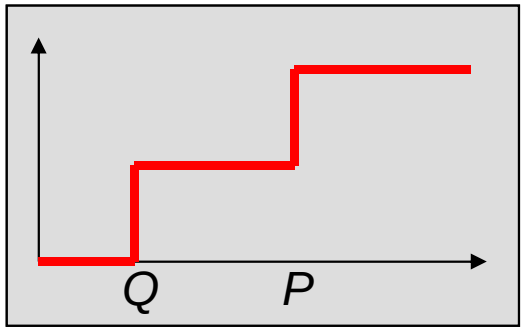
Usual



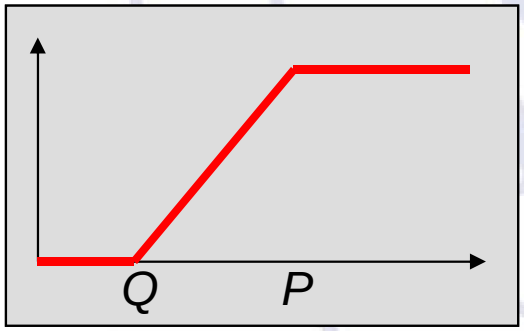
U-shape



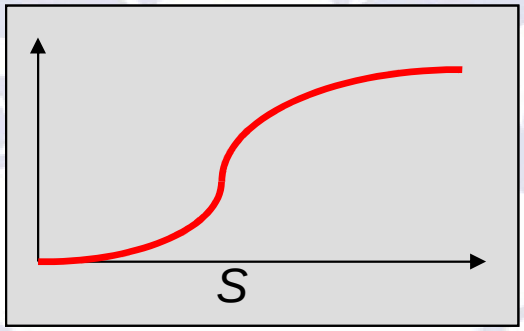
V-shape



Level



Linear



Gaussian

Preference functions Checklist

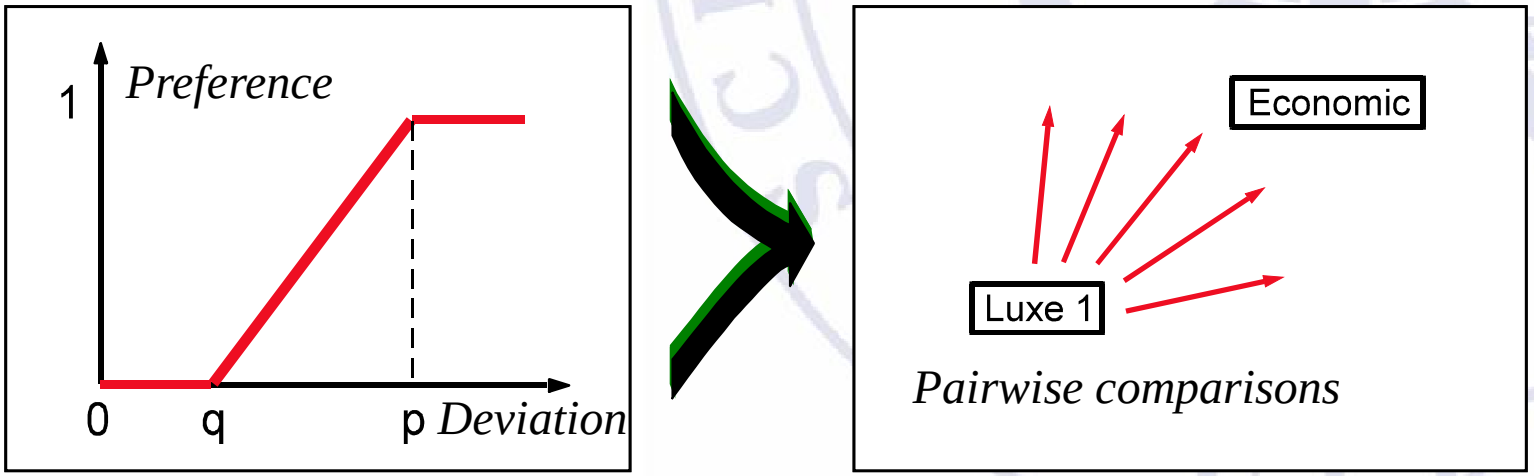
- Quantitative criterion:
  - Indifference threshold $\rightarrow$ Linear.
  - No indifference threshold $\rightarrow$ V-shape.
- Qualitative criterion:
  - Few very different levels $\rightarrow$ Usual.
  - More differentiate levels $\rightarrow$ Level.

PROMETHEE

Pref (Eco.,Lux.)

Pref (Lux.,Eco.)

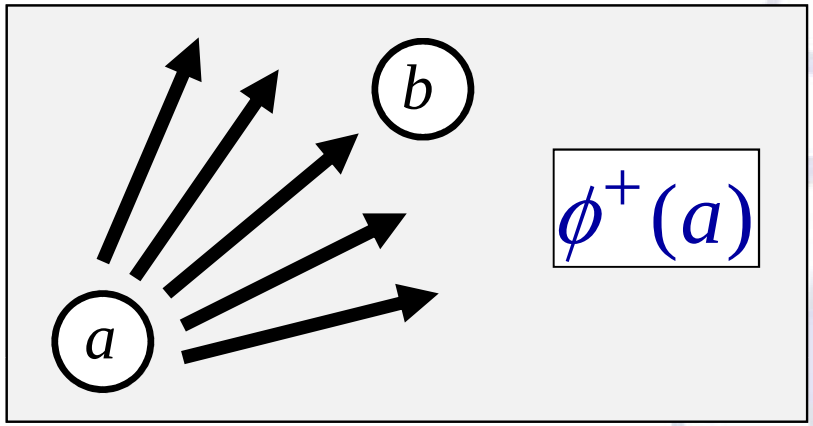
		Economico		Lujo 1		
1,0	**-23000**	15000	*Price*	38000		0,0
0,0		50	*Power*	90	**+40**	**1,0**
0,5	**-1,0**	7,5	*Consumpt.*	8,5		0,0
0,0		B	*Space*	G	**+2**	**0,5**
0,0		VB	*Comfort*	VG	**+4**	**1,0**

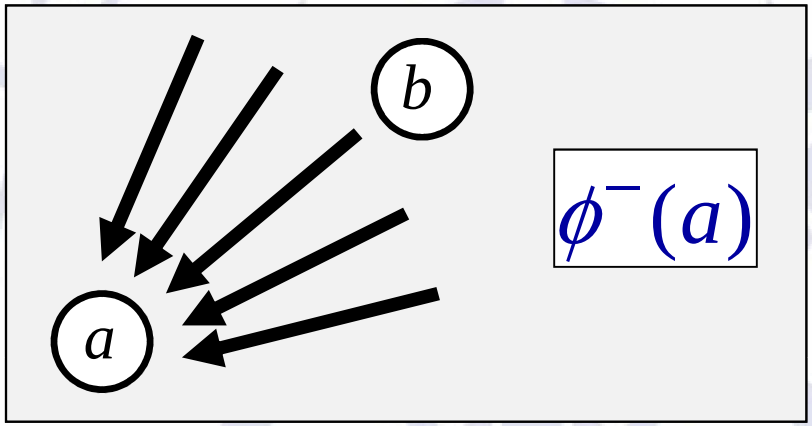


Computation of preference flows

$\pi(a,b)$	*Tur.A*	*Dep.*	*Tur.B*	*Lujo*1	*Econ.*	*Lujo*2	$\phi^{+}(a)$
Tur.A	0,00	0,34	0,00	0,21	0,26	0,22	0,21
Dep.	0,20	0,00	0,16	0,24	0,30	0,24	0,23
Tur.B	0,15	0,55	0,00	0,32	0,45	0,33	0,36
*Lujo*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
*Lujo*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





- Leaving flow: (strength)
- Entering flow: (weakness)
- Net flow:

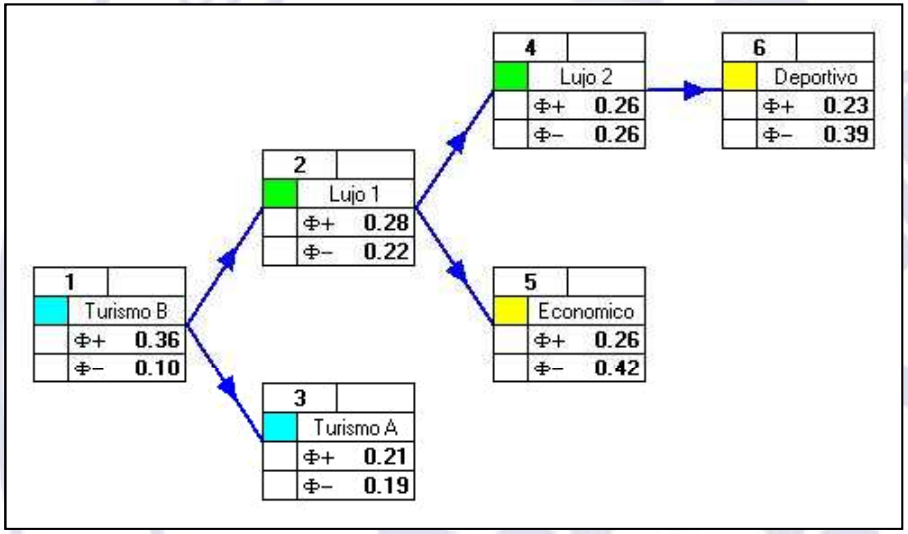
$$\phi^+(a) = \frac{1}{n-1} \sum_{b \in A} \pi(a,b)$$

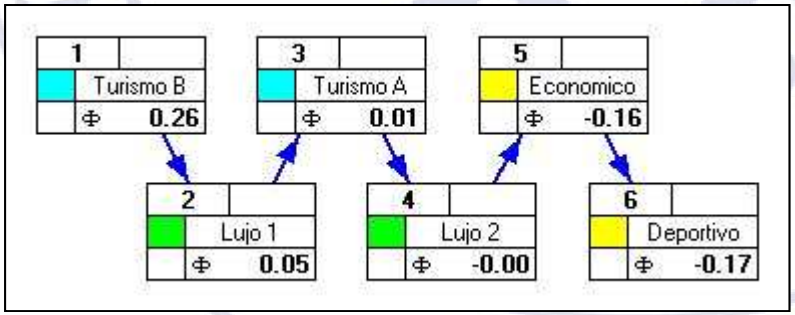
$$\phi^-(a) = \frac{1}{n-1} \sum_{b \in A} \pi(b,a)$$

$$\phi(a) = \phi^+(a) - \phi^-(a)$$

PROMETHEE

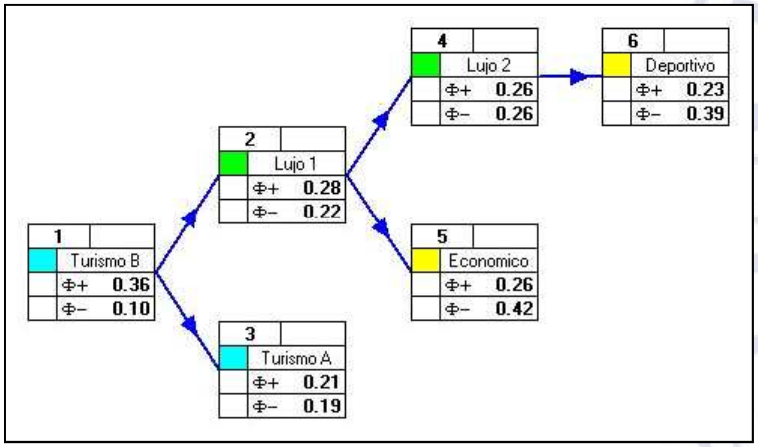
- Rank decisions from the best to the worst ones.
- Identify best compromise solutions.

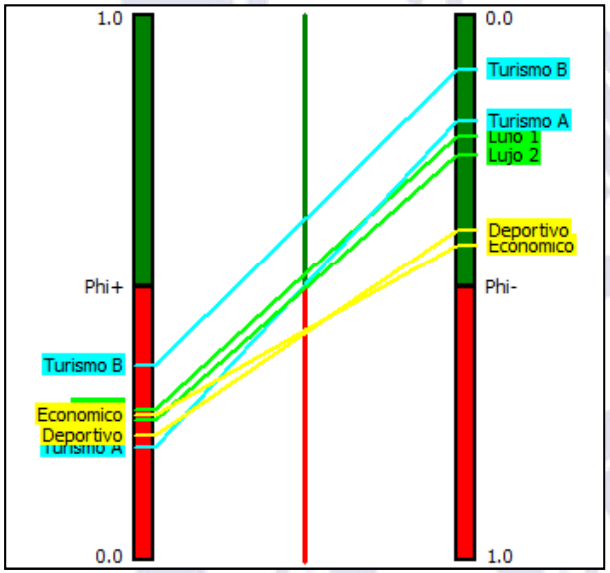




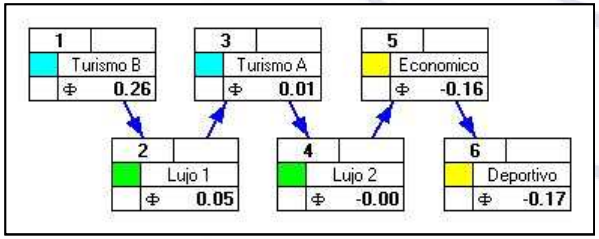
PROMETHEE I & II

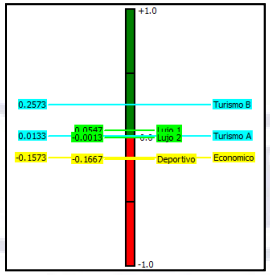
- PROMETHEE I : partial ranking – ϕ^+, ϕ^-



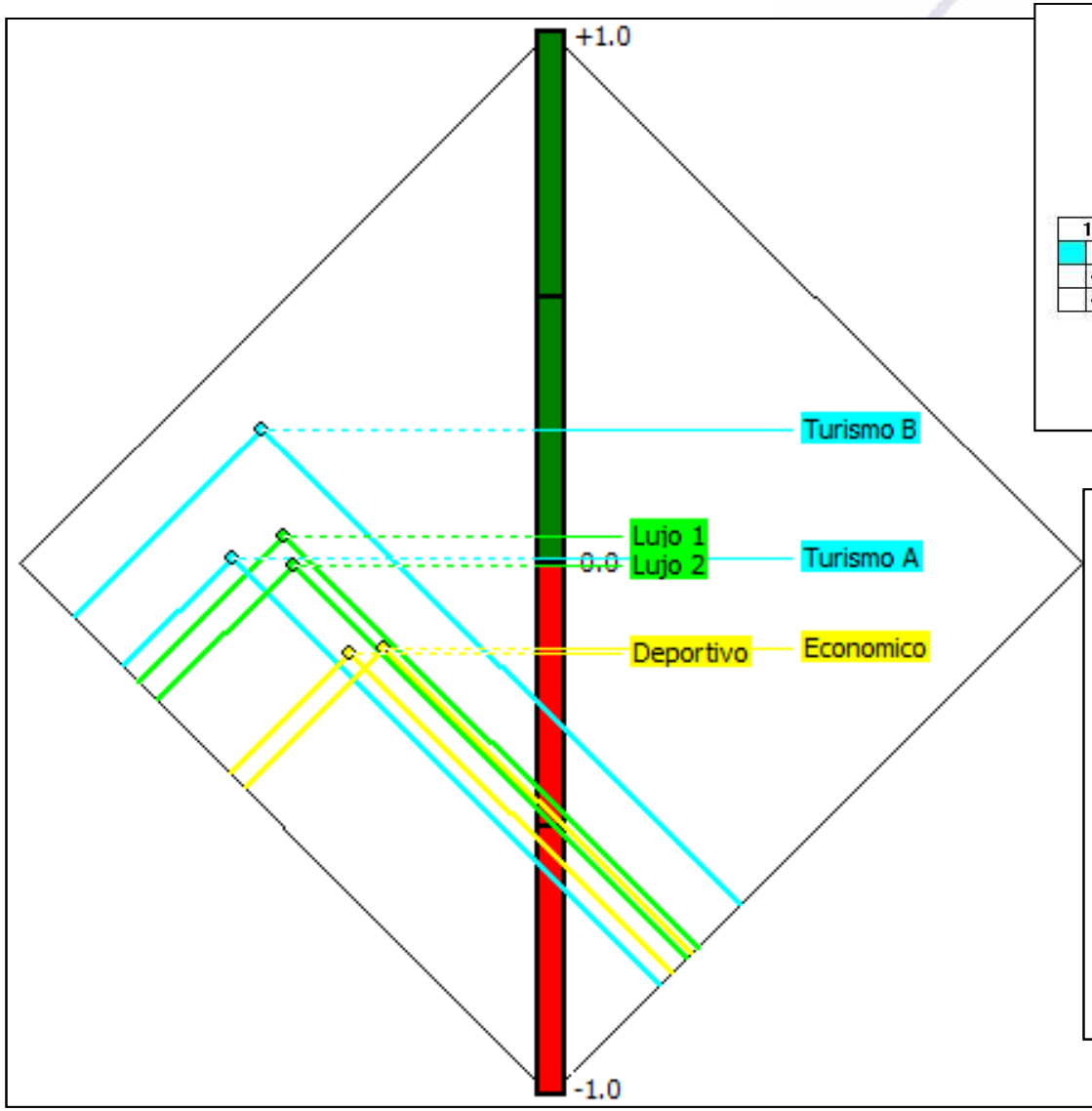


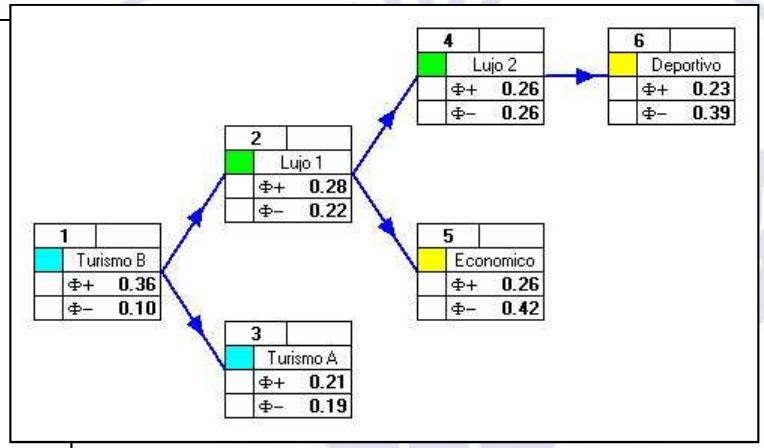
- PROMETHEE II : complete ranking – ϕ

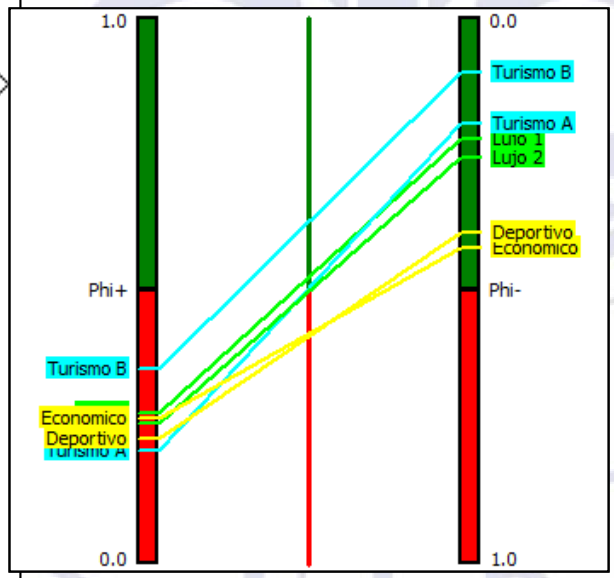




PROMETHEE I Diamond



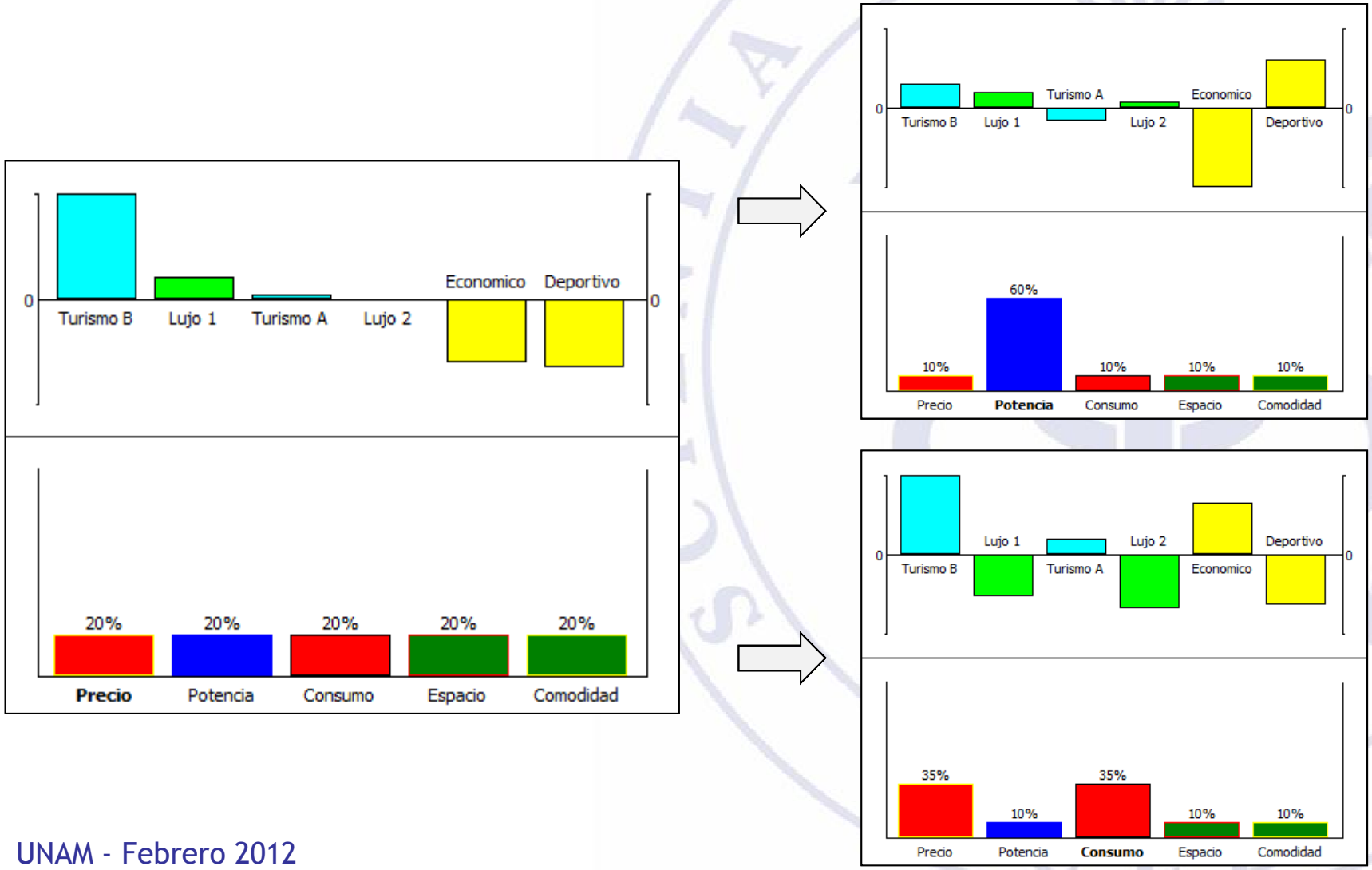




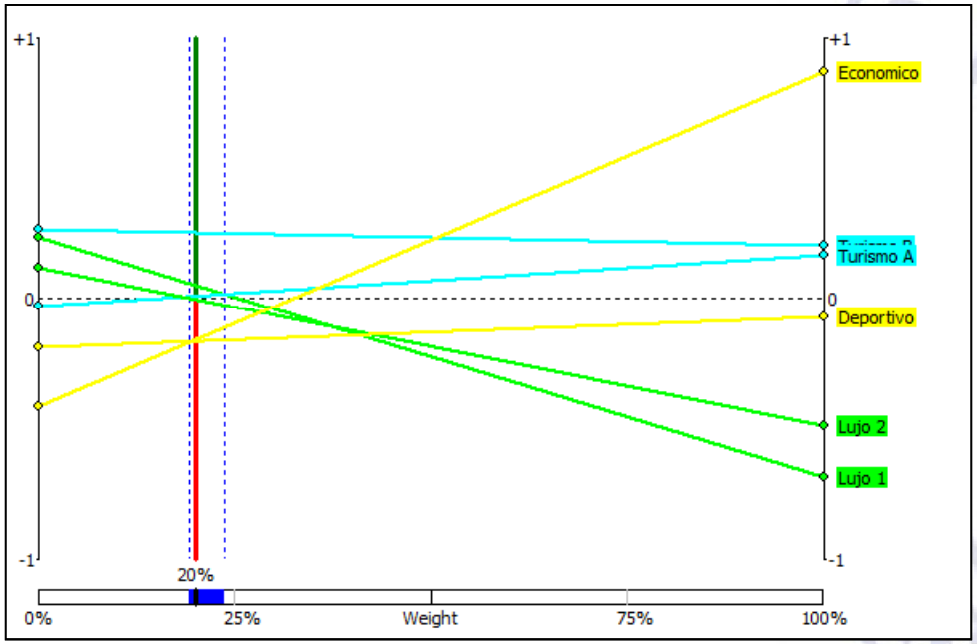
Sensitivity Analysis with PROMETHEE

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

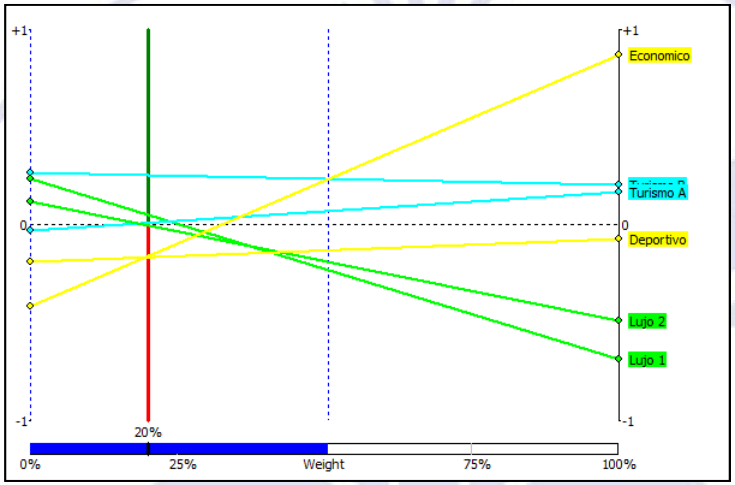
Walking Weights



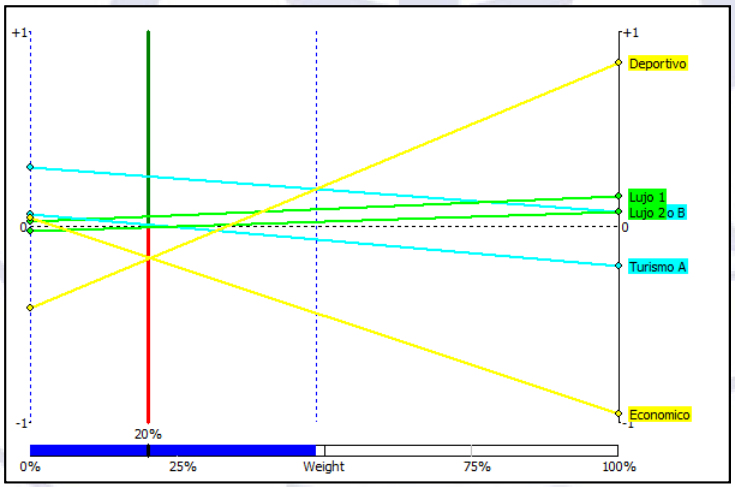
Visual Stability Intervals



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



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



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

Limits of a ranking method

- Robustness of the ranking?
- « Blind » sensitivity analysis.
- Closely ranked actions can have quite different profiles.
- Origin of incomparabilities?

➢ Usefulness of a complementary descriptive approach.

Properties of the net flow

- Net flow is centered: $\sum_{a \in A} \phi(a) = 0$

- Unicriterion net flows:

$$\phi(a) = \sum_{j=1}^{k} w_j \cdot \phi_j(a)$$

with

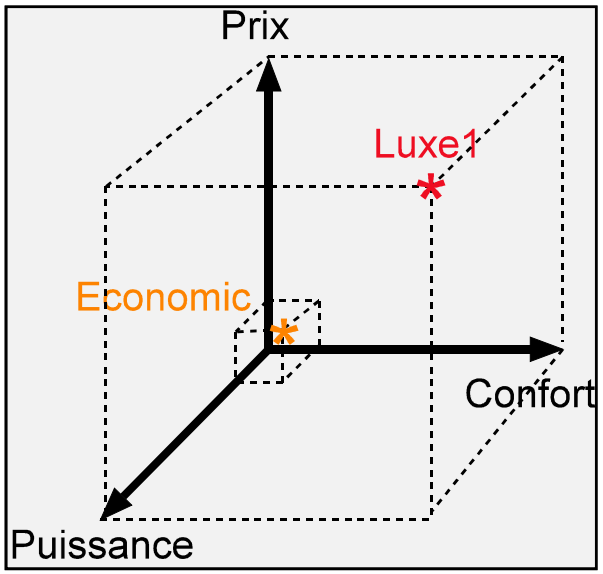
$$\phi_j(a) = \frac{1}{n-1} \sum_{b \in A} \left[P_j(a,b) - P_j(b,a) \right]$$

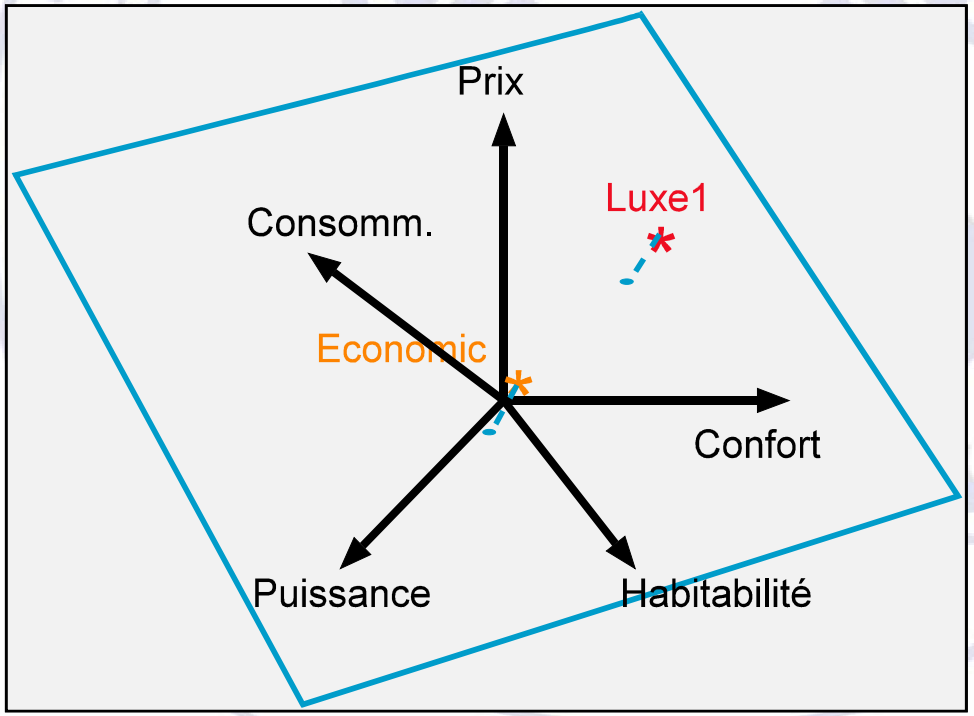
GAIA

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

GAIA

1. *Computation of unicriterion net flows (normalization)*
2. *Projection on a plane:*

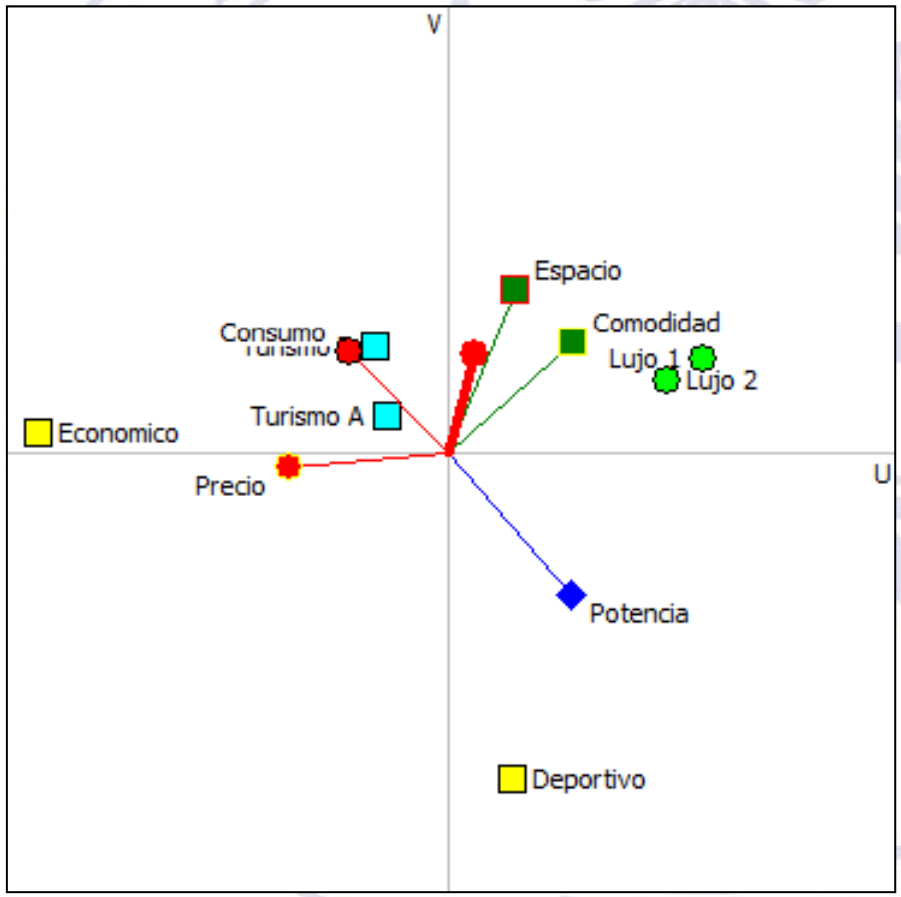




- Graphical representation.
- 5 dimensions!

GAIA

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



GAIA

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

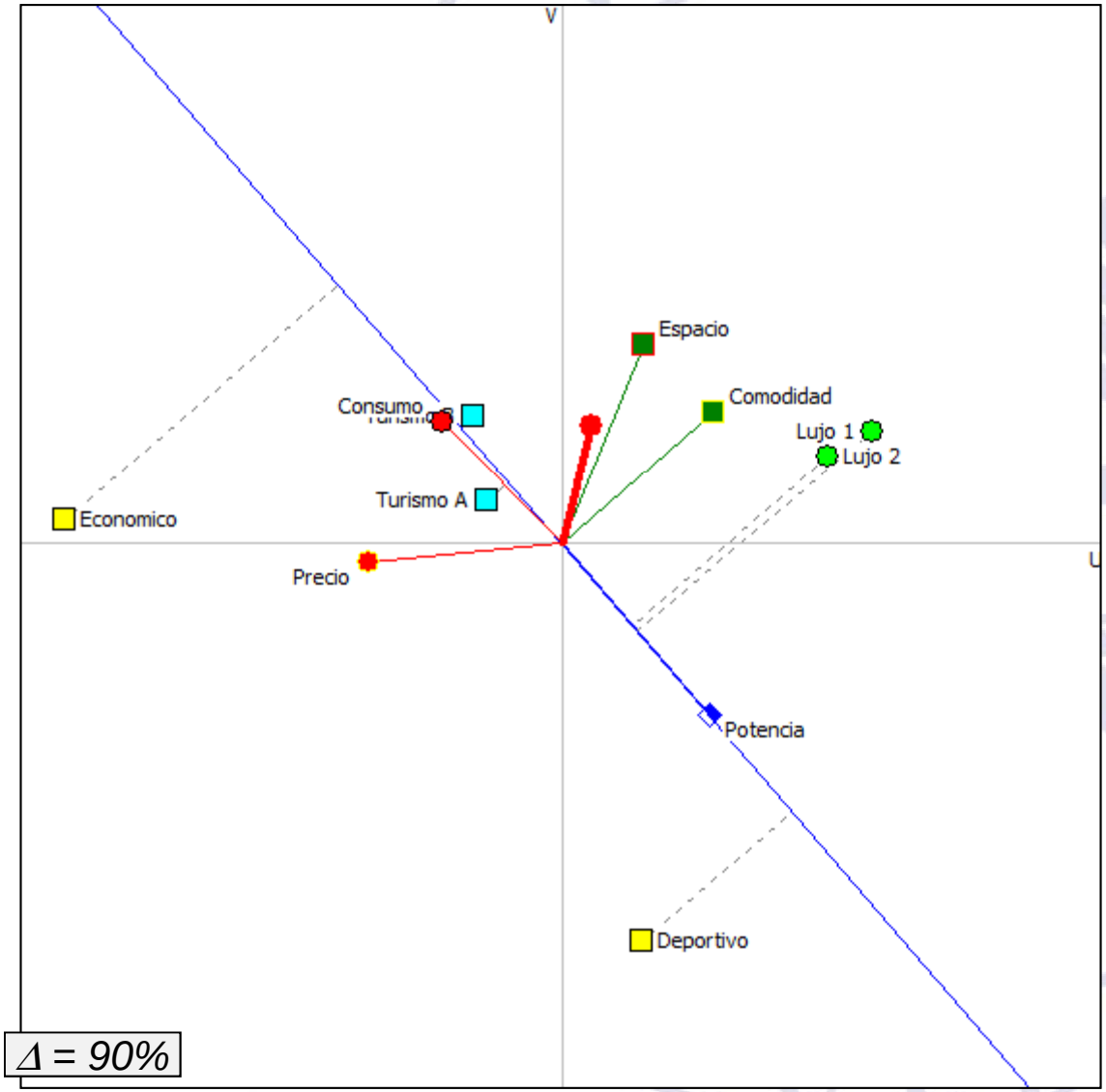
GAIA

Precio

- *Economico: 15 k€*
- *Turismo: 25,5-26 k€*
- *Deportivo: 29 k€*
- *Lujo: 35-38 k€*

$\Delta = 90\%$

GAIA

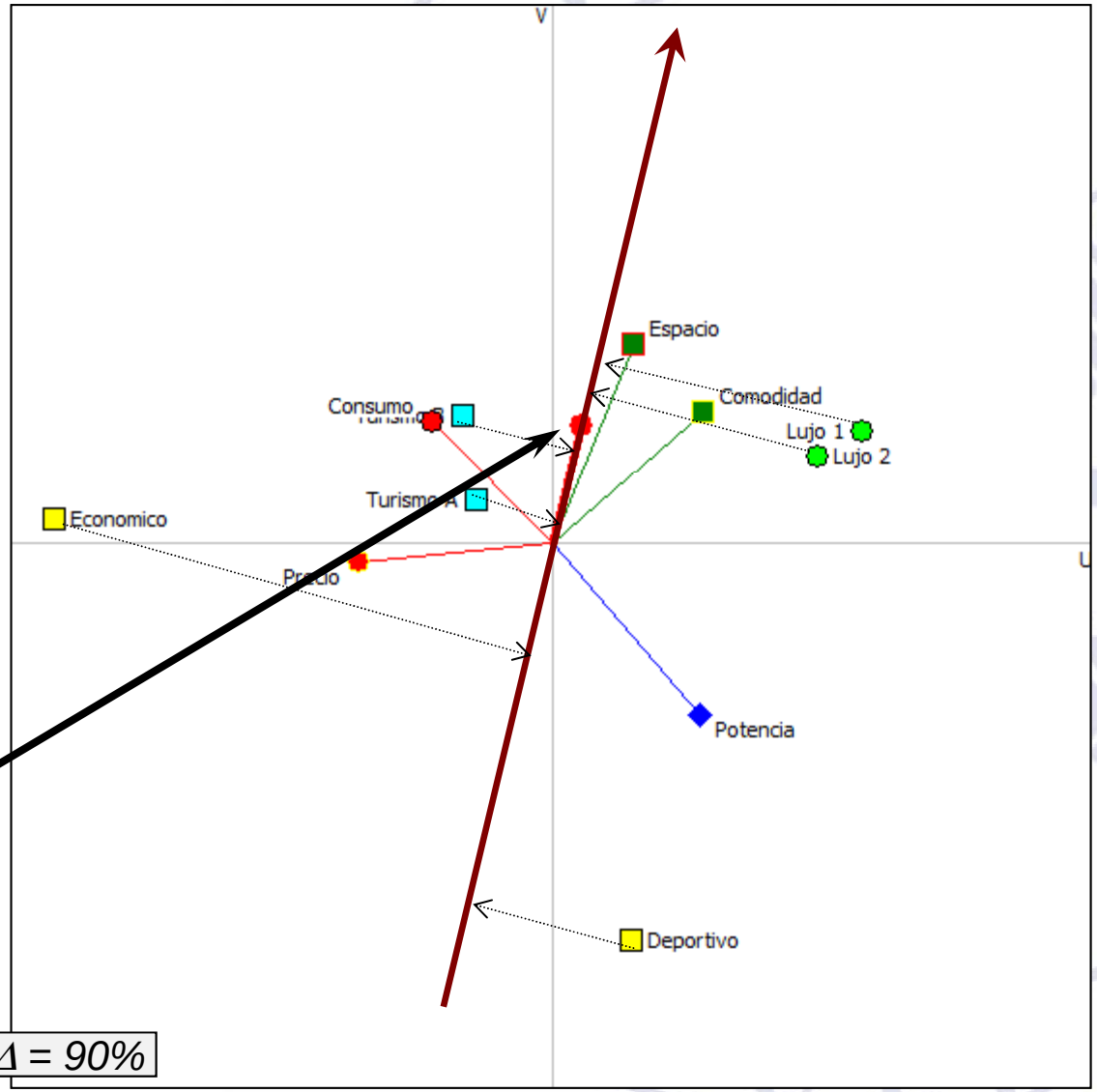


Potencia

- *Deportivo: 110 kW*
- *Lujo: 85-90 kW*
- *Turismo: 75-85 kW*
- *Economico: 50 kW*

$\Delta = 90\%$

GAIA



PROMETHEE II !

- *Turismo B : 0,26*
- *Lujo 1 : 0,06*
- *Turismo A : 0,02*
- *Lujo 2 : 0,00*
- *Economico : -0,15*
- *Deportivo : -0,17*

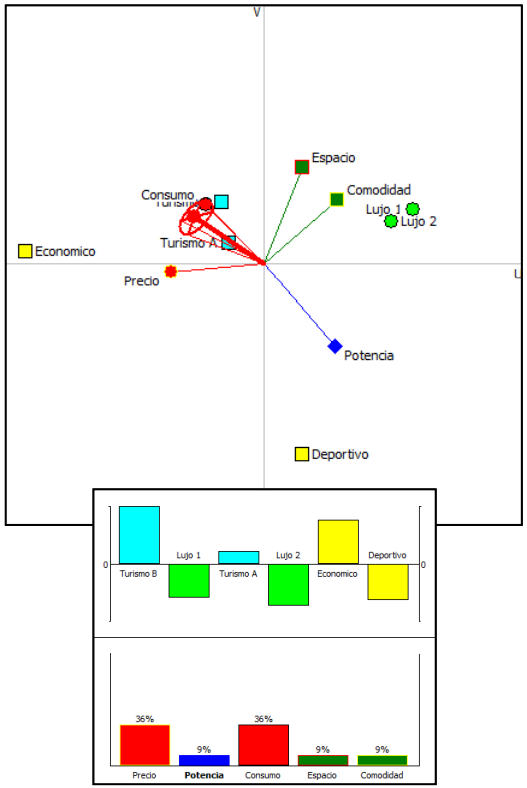
Sensitivity Analysis with GAIA

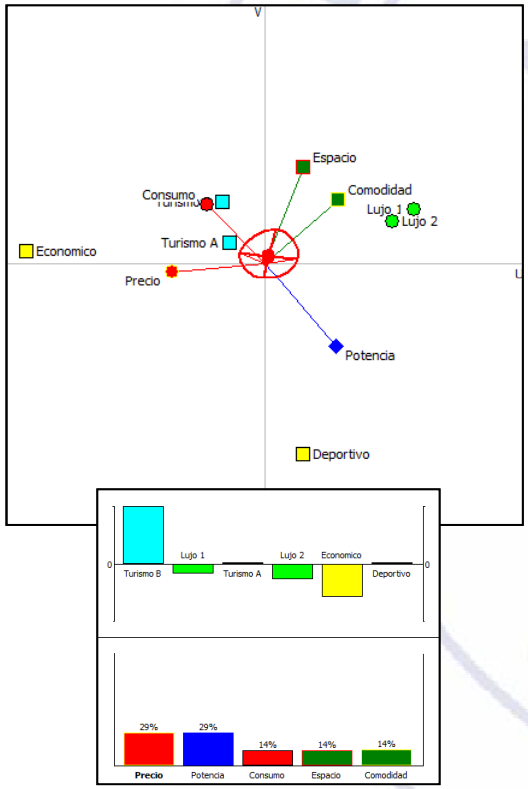
- Criteria weights $\leftrightarrow$ Decision axis position.
- Interactive weight sensitivity analysis: « Walking Weights ».
- Robustness with respect to weight values?
  - Decision maker « brain » (PROMETHEE VI).
  - Area determined by the tip of the decision axis when criteria weights are changed within predefined percentages.

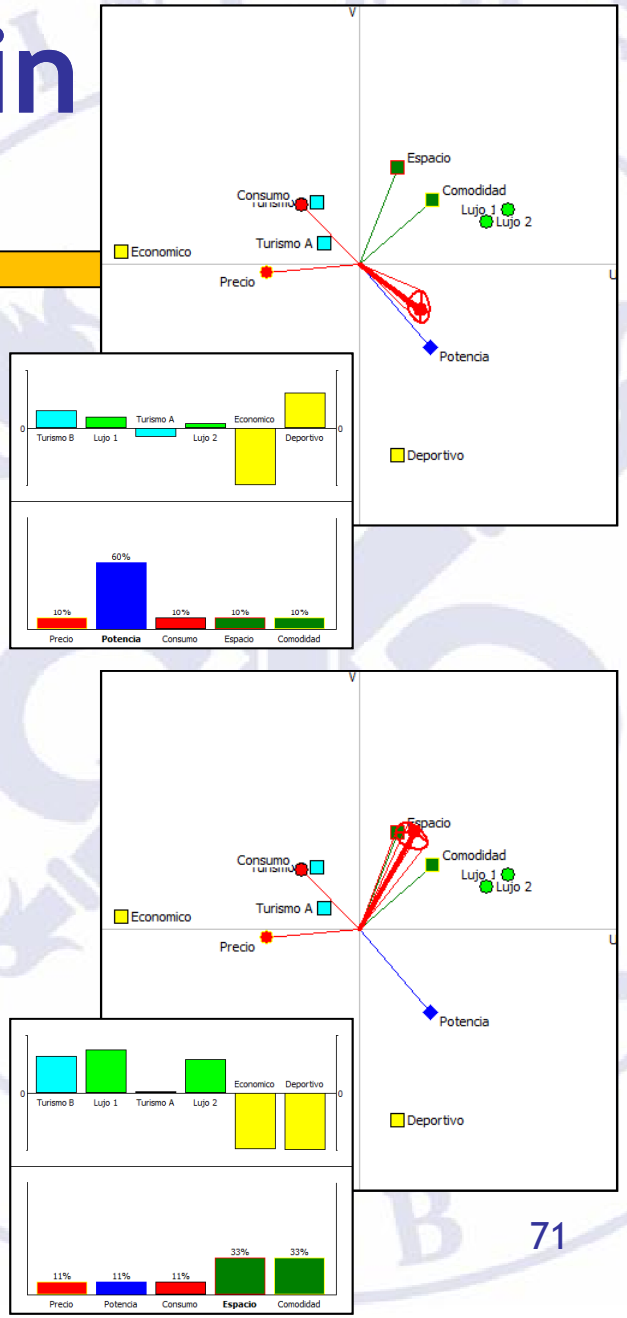
GAIA-Brain

20 years old

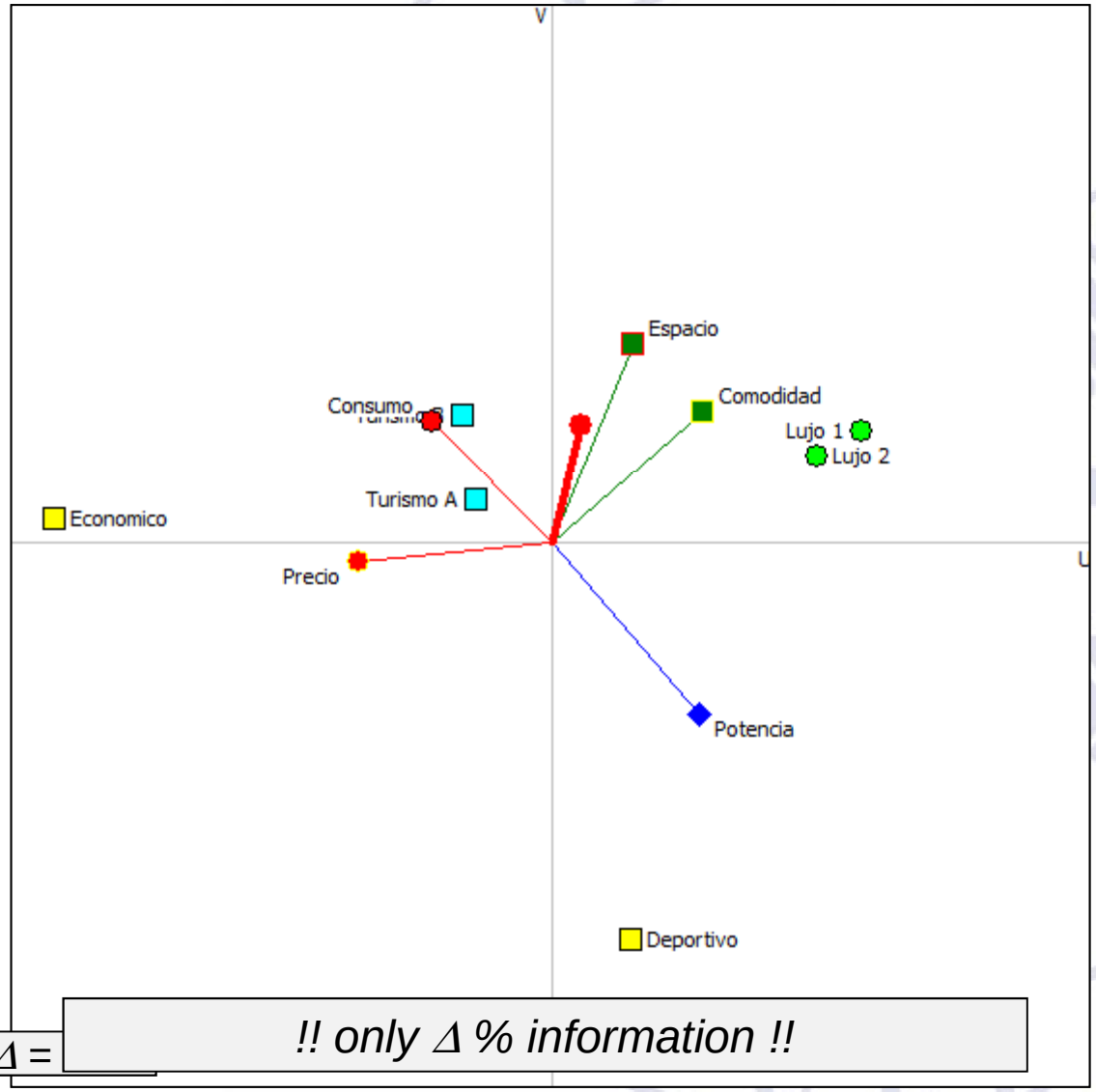
35 years old







GAIA



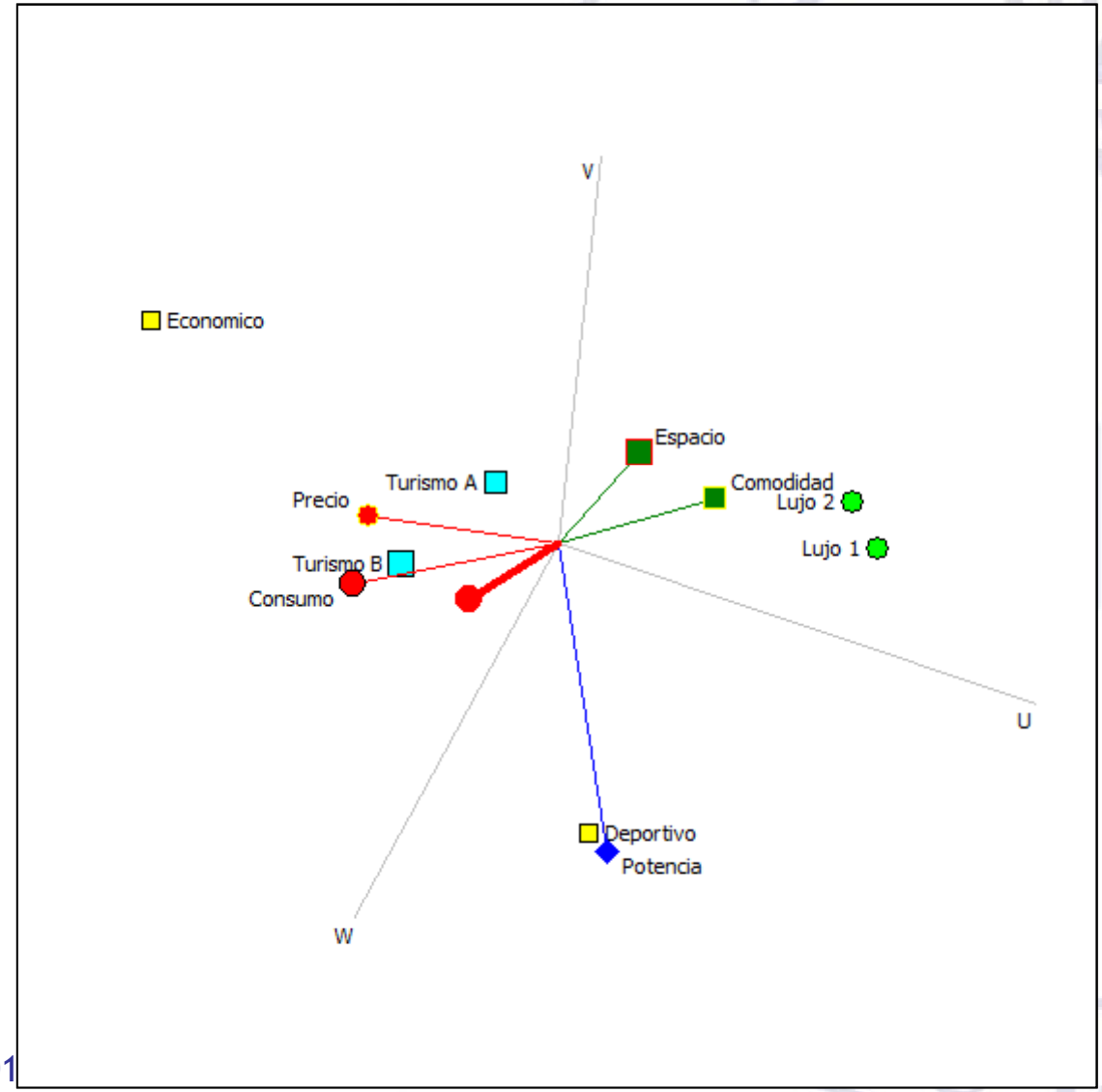
- *Actions: points*
- *Criteria: axes*
- *Decision axis*

!! only Δ % information !!

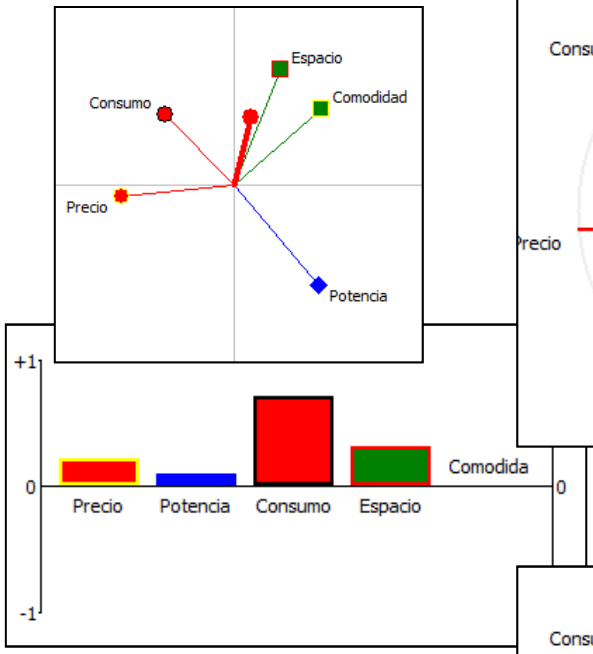
Enhancing GAIA

- Limits of GAIA:
  - Imperfect view of the multicriteria data (Δ%).
  - Potential distortion of the action profiles.
  - Non-optimal representation of the decision axis (weights) and distortion of the PROMETHEE II ranking (especially when the decision axis is shorter).
- New« GAIA-type » views:
  - GAIA 3D
  - GAIA Webs
  - GAIA-Stick
  - GAIA-Criterion

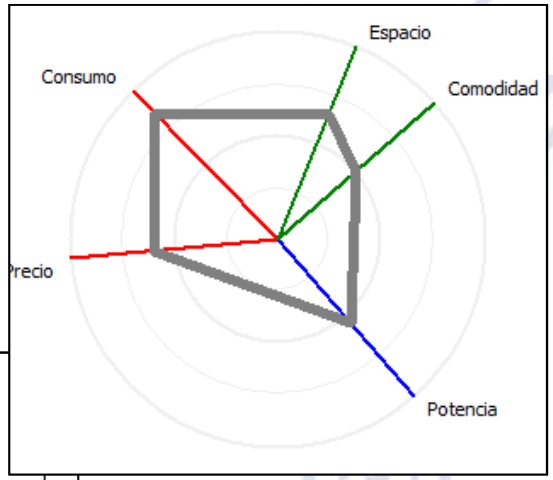
GAIA 3D


V
Economico
Espacio
Turismo A
Precio
Comodidad
Lujo 2
Lujo 1
Turismo B
Consumo
U
Deportivo
Potencia
W

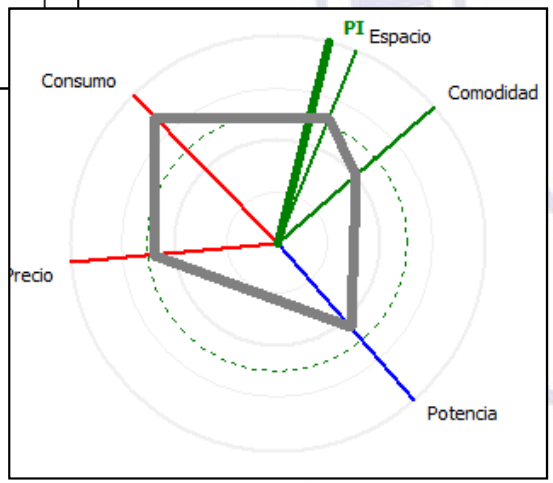
GAIA Webs

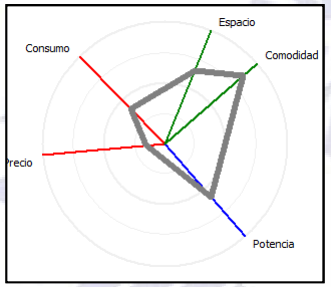


Action profile – Turismo B

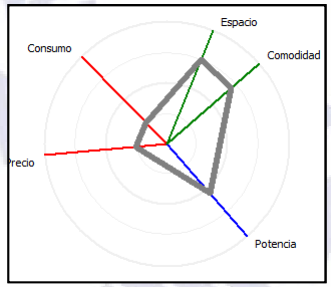


GAIA Web – Turismo B

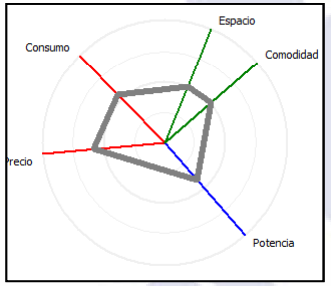




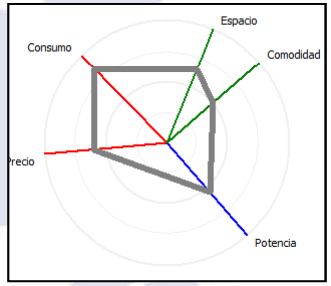
Lujo 1



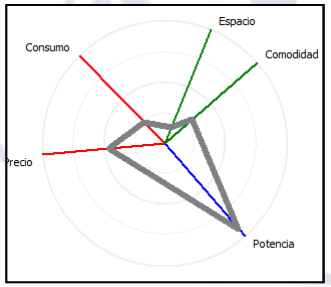
Lujo 2



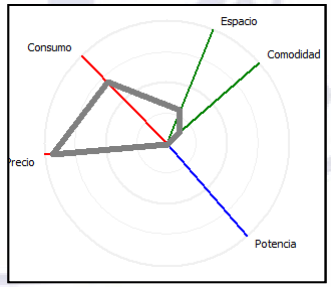
Turismo A



Turismo B



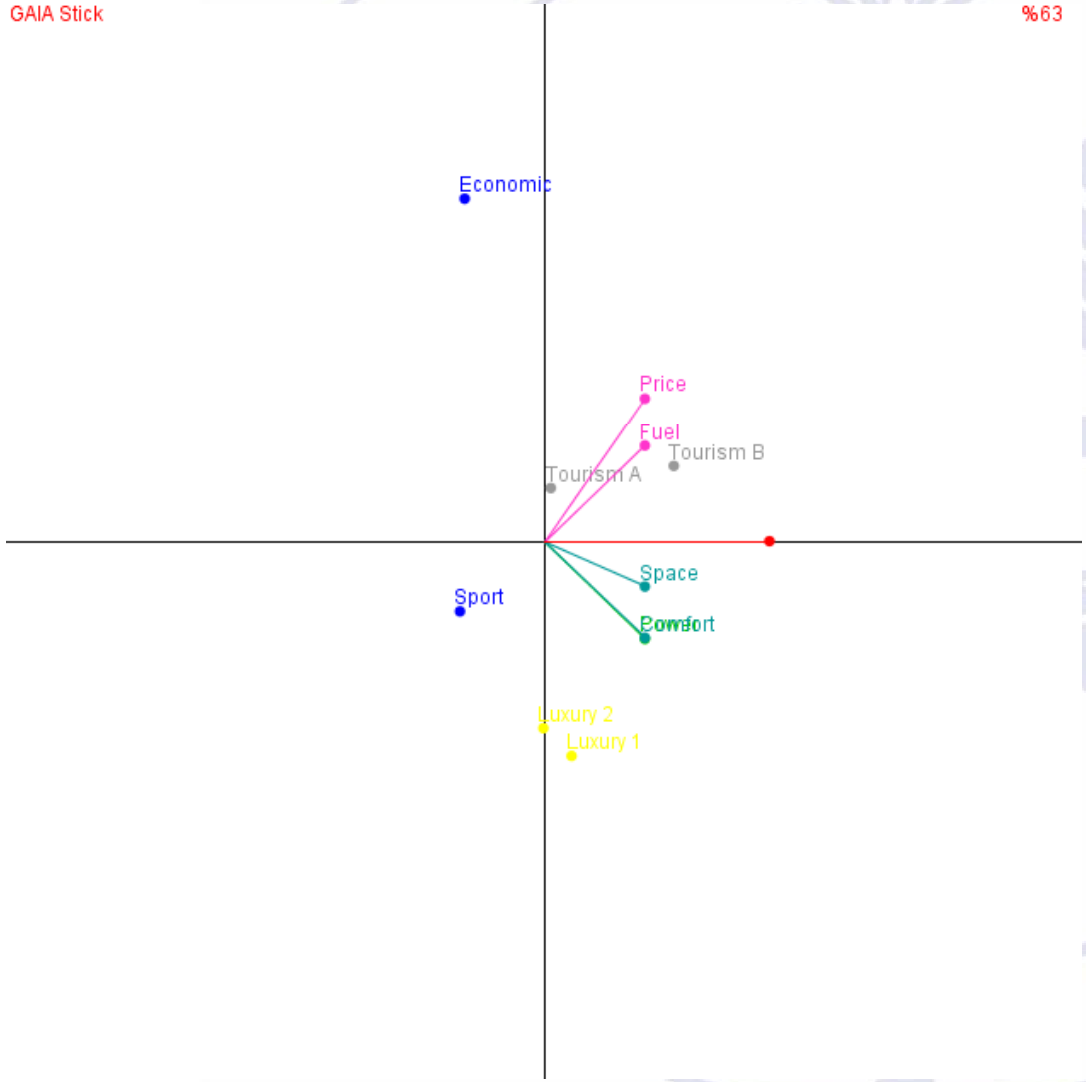
Deportes



Economico

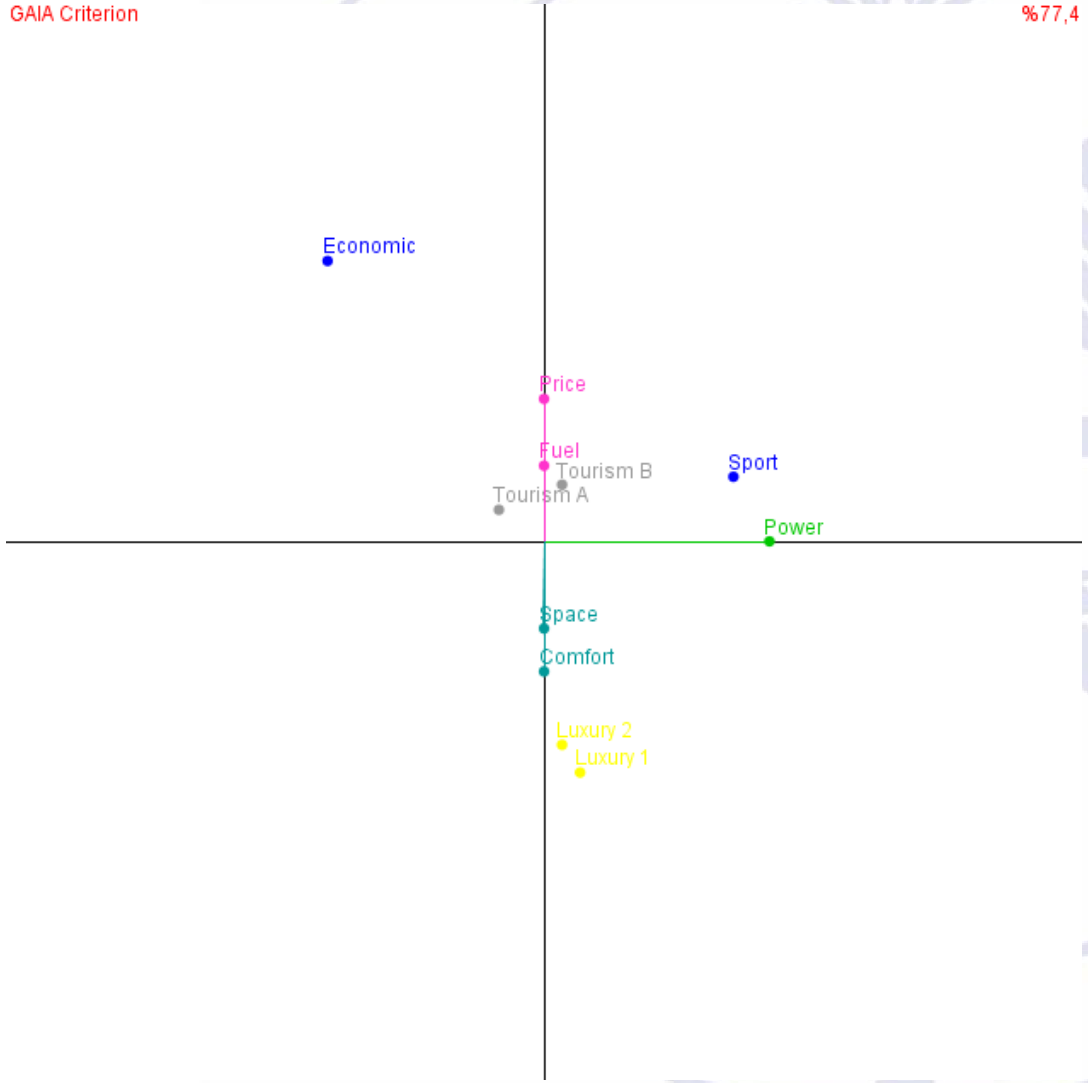
GAIA-Stick

- *Horizontal axis:*
  - *PROMETHEE II net flow.*
- *Vertical axis:*
  - *Most conflicting criteria.*
  - *Incomparabilities.*



GAIA-Criterion

- *Horizontal axis:*
  - *Selected criterion unicriterion net flow.*
- *Vertical axis:*
  - *Most conflicting other criteria.*



PROMETHEE & GAIA methods

- PROMETHEE : prescriptive approach
  - Partial ranking (prudent)
    - PROMETHEE I
  - Complete ranking (rating)
    - PROMETHEE II
- GAIA : descriptive approach
  - Identification of conflicts among criteria.
  - Profiles of actions – Clustering.
  - Assess priorities, sensitivity analysis (decision axis).

Example 2 : Plant location

- Actions: 5 potential sites
- Criteria:
  - g_1 : Cost (investment)
  - g_2 : Cost (operations)
  - g_3 : Employment
  - g_4 : Transportation
  - g_5 : Environmental impact
  - g_6 : Social impact

Evaluation table

Tutorial2

	Investment	Operations	Employment	Transportation	Environment	Social
Min/Max	Minimize	Minimize	Minimize	Maximize	Minimize	Minimize
Weight	25.0000	15.0000	20.0000	20.0000	10.0000	10.0000
Preference Functi	Linear	Linear	Linear	Level	Level	Level
Indiference Thres	5.00 %	5.00 %	5.00 %	0.5000	0.5000	0.5000
Preference Thres	25.00 %	25.00 %	10.00 %	1.5000	1.5000	1.5000
Gaussian Thresh	-	-	-	-	-	-
Threshold Unit	Percent	Percent	Percent	Absolute	Absolute	Absolute
Unit	M$	M$	workers	5-point	Impact	Impact
Site 1	74.0000	12.0000	175.0000	Average	High	Low
Site 2	86.0000	9.0000	170.0000	Good	Low	Very Low
Site 3	89.0000	7.0000	145.0000	Very Good	Very Low	Moderate
Site 4	115.0000	8.0000	95.0000	Bad	Low	High
Site 5	128.0000	10.0000	110.0000	Good	Moderate	Very Low

Industrial | Political | Environment | Social

- Criteria to minimize or maximize.
- Different scales.
- Quantitative or qualitative criteria.

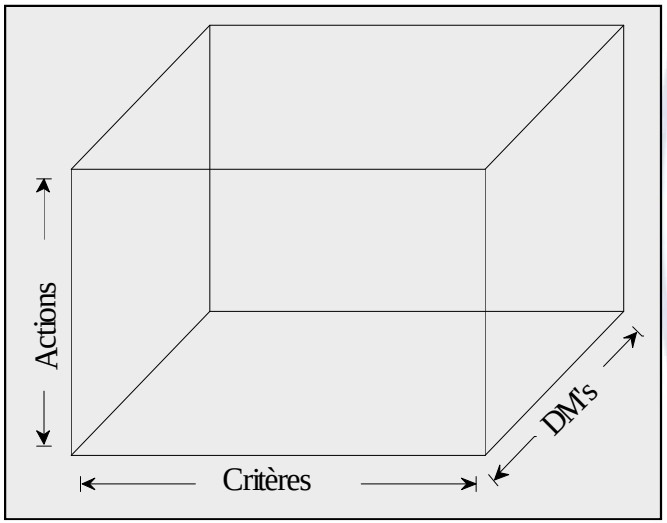
Single- and Multi-decision maker decision problems

- Single-decision maker :
  - Single stakeholder (decision maker).
  - Single evaluation table and preference structure.
- Multi-decision maker:
  - Multiple stakeholders (including decision maker(s)).
  - Multiple evaluation tables and preference structures.
  - Looking for a consensus solution.

Example 2

- Four stakeholders ("decision makers"):
  - Industrial (actual decision maker),
  - Political authorities (regional),
  - Environmental protection groups,
  - Workers unions (social).
- Four multicriteria tables.

Multicriteria matrix



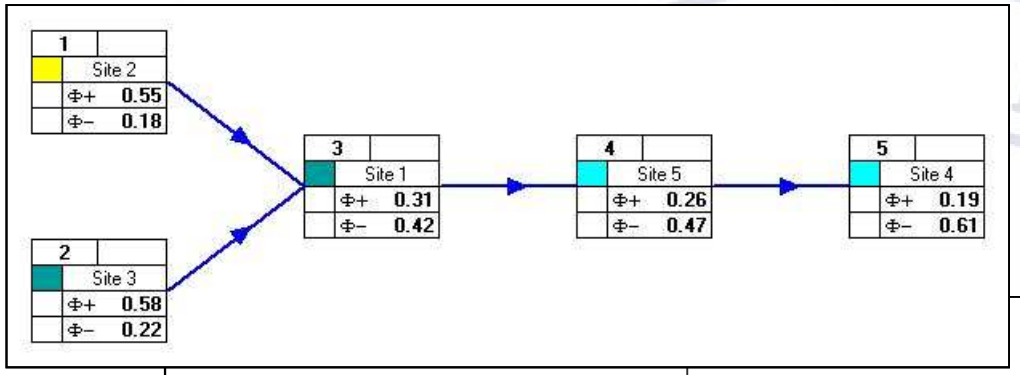
- Adapt multicriteria methods to multi-decision maker problems.
- Analyze conflicts among decision makers.
- Help to achieve consensus solution.

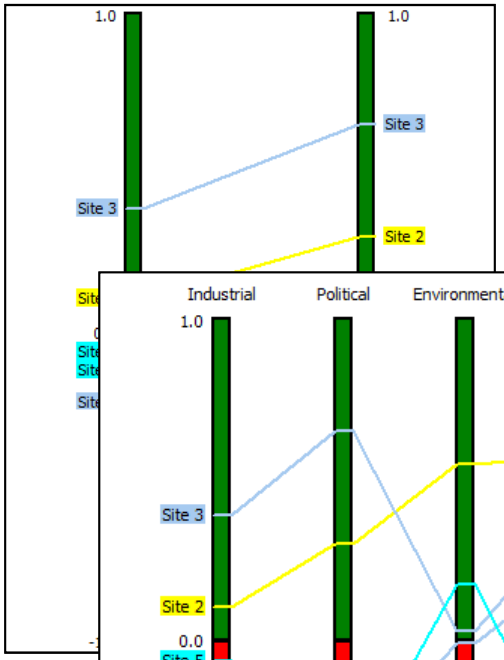
Multi-scenarios model

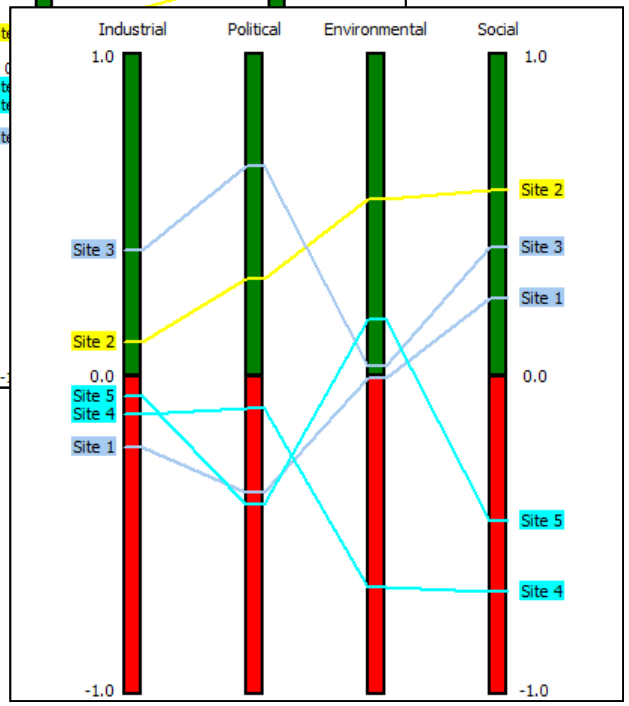
- Scenarios:
  - Points of view,
  - Hypotheses, …
- Evaluations:
  - ‘Objective’ criteria: common evaluations.
  - ‘Subjective’ criteria: specific evaluations for each scenario.
- Specific preference structures :
  - Weights, preference thresholds.

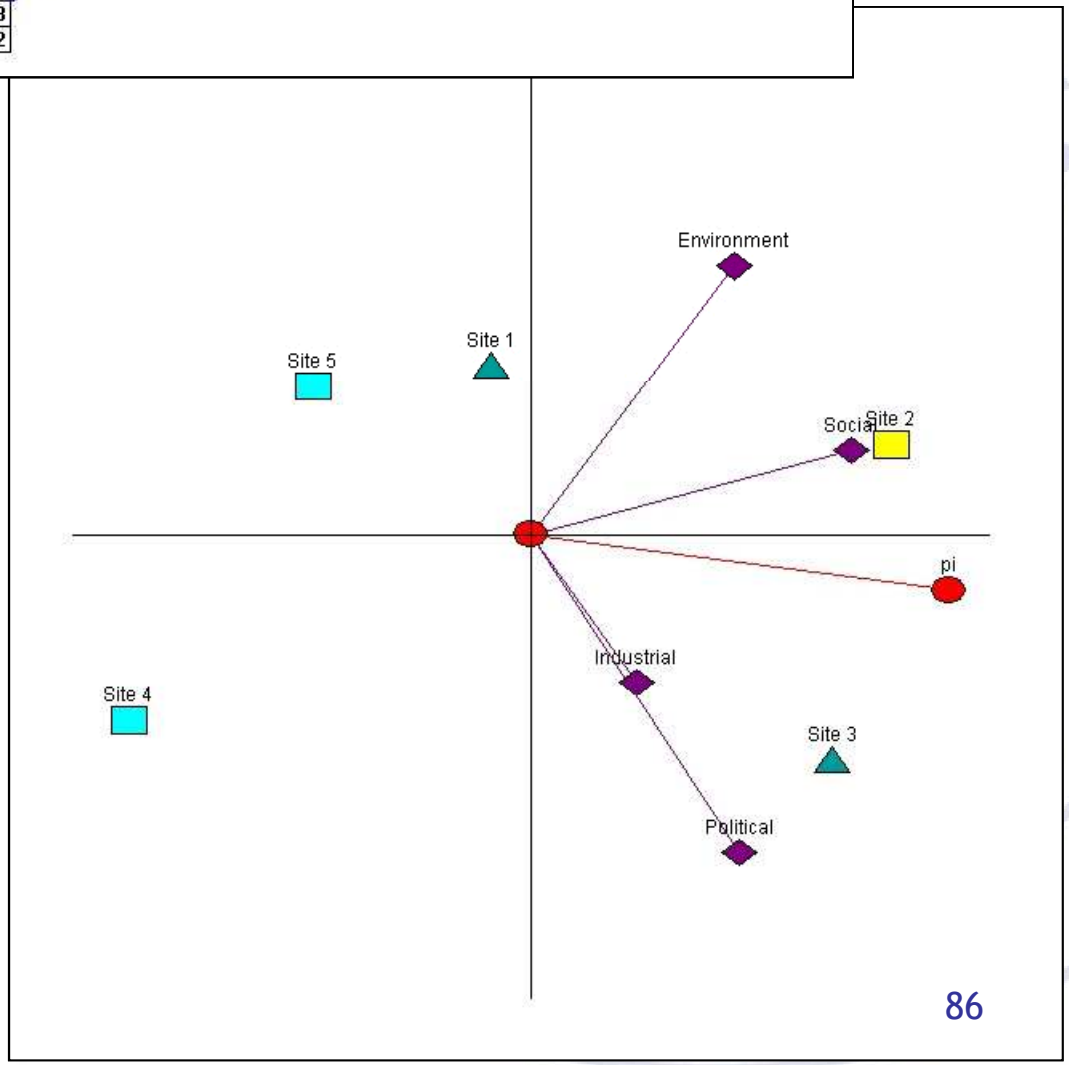
Multi-scenarios model

- Adaptation of PROMETHEE:
  - Individual rankings.
  - Global (group) rankings taking into account a possible weighing of the scenarios.
- Adaptation of GAIA:
  - Two distinct analyses.


1
Site 2
Φ+ 0.55
Φ− 0.18
2
Site 3
Φ+ 0.58
Φ− 0.22
3
Site 1
Φ+ 0.31
Φ− 0.42
4
Site 5
Φ+ 0.26
Φ− 0.47
5
Site 4
Φ+ 0.19
Φ− 0.61


1.0
1.0
Site 3
Site 2


Industrial
Political
Environmental
Social
1.0
1.0
Site 3
Site 2
0.0
Site 5
Site 4
Site 1
Site 2
Site 3
Site 1
0.0
Site 5
Site 4
-1.0
-1.0


Environment
Site 5
Site 1
Social
Site 2
pi
Industrial
Site 4
Site 3
Political

PROMETHEE Software

- Decision Lab 2000
- D-Sight
- Visual PROMETHEE
  - beta version, close to 1.0 release.
  - 2-level simple hierarchical criteria structure.
  - Visual representations:
    - PROMETHEE I Diamond,
    - GAIA-Stick,
    - GAIA-Criterion, …

Decision Lab 2000
PROMETHEE & GAIA software

- Data management:
  - Qualitative scales,
  - Missing values,
  - Categories of actions or criteria.
- PROMETHEE I et II
- GAIA
- Sensitivity analysis tools:
  - Walking weights,
  - Weight stability intervals.
- Multiple scenarios (GDSS)

Visual PROMETHEE

WWW.PROMETHEE-GAIA.NET

- 2 level simple hierarchical criteria structure.
- New visual tools:
  - PROMETHEE rankings and Diamond,
  - Visual Weight Stability Intervals,
  - Decision-maker's Brain (PROMETHEE VI),
  - GAIA-3D,
  - GAIA-Webs and PROMap GIS integration,
  - Performance (input-output) analysis, …

PROMap

- *Google Maps* integration:

Further developments

- Imperfect information:
  - Uncertainty (probabilistic evaluations, …)
  - Imprecision (fuzzy numbers, …)
- Enhanced GAIA analysis:
  - GAIA-stick
  - GAIA-criterion
- Group decision:
  - Multi-DM GAIA views (criteria, actions)

Some applications at ULB

- Financial evaluation of companies.
- Quality assessment of suppliers.
- Electricity production planning at Electrabel.
- Regional planning.
- Evaluation of urban waste management systems.
- Environmental applications.
- Therapeutical choice.
- ...