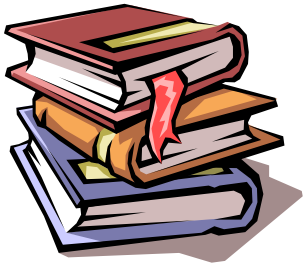
# The Absolute Measurement in AHP/ANP

*(The Rating Mode and its Need for Thresholds)*

**ISAHP - 2024**



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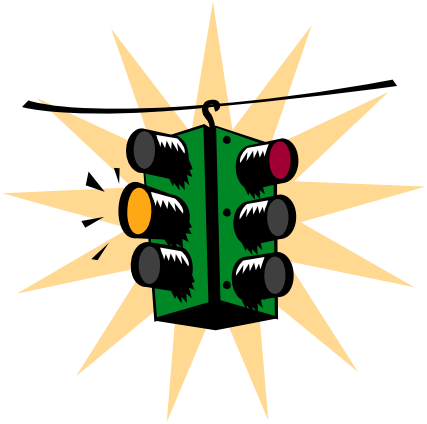


# Agenda

**Introduction: Some Reference of Projects with Rating**

**Relative or Absolute Measurement in AHP/ANP?**

**About Scales**

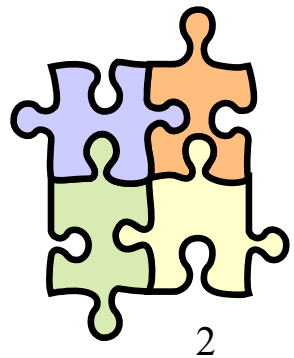
**About Thresholds**

**How Should Look The Results?**

**Is The Decision Final?**

**The 5 Steps Summary**

**Conclusions**

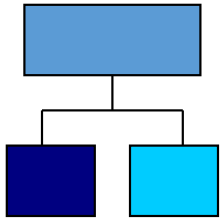


# List of Some Projects with Rating Mode Applications

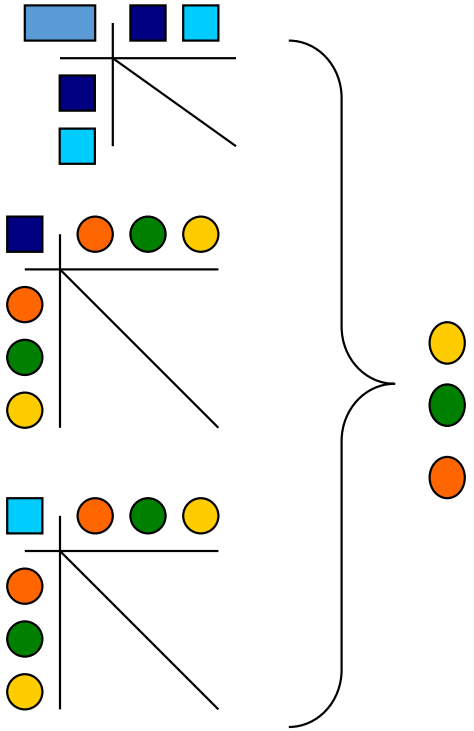
| Year | Project details (Client and short description) |
|---|---|
| 2024 | IDB (Interamerican Developing Bank). Developing an operative application to prioritize a projects portfolio (Part II) |
| In Continuum | MEDICAL SAPIENS SpA. Developing Medical Support Software applying EAI (Ethic Artificial Intelligence). |
| 2022 | IDB (Interamerican Developing Bank). Developing an operative application to prioritize a projects portfolio (Part I). |
| 2022 – 2023 | CORFO. A multicriteria application for developing an I+D project. A web platform for shiftwork optimization process |
| 2022 – 2023 | SECRETARY OF TRANSPORTATION. Developing a Guide to evaluate urban transportation projects |
| 2022 | ECONAP – MOP (Ministry of Public Construction). Project: "New Methodologies for Rating Hydraulic Projects". |
| 2020 – 2021 | MINISTRY OD HOUSING AND URBANISM. Developing a multicriteria index to evaluate the quality of urban planning projects. |
| 2019 – 2020 | MINISTRY OF SOCIAL DEVELOPMENT AND FAMILY. Developing a multicriteria index method to prioritize a project portfolio. |
| 2019 – 2020 | OFFICE OF NATIONAL EMERGENCY Part III. Guide of a Multicriteria Evaluation Model for Disaster Risk Management |
| 2018 – 2019 | GIZ Society. Build the strategy and the global index to measure the degree of criticality of public highway projects |
| 2018 | OFFICE OF NATIONAL EMERGENCY Part II. Construction of a Multicriteria Guide for Disaster Risk Management |
| 2018 | CHILEAN COMMISSION OF NUCLEAR ENERGY. Analysis of the evolution alternatives of nuclear energy in Chile in next 20 years. |
| 2017–2018 | UNITED NATION. Part II. Methodological Guide for construction and facilitation assessment of disaster risk. |
| 2017–2018 | OFFICE OF NATIONAL EMERGENCY Part I. Application of a multi-criteria Evaluation model for Disaster Risk Management |
| 2017 | UNITED NATION Part I. Construction and facilitation of multicriteria models (AHP) for the assessment of risk disasters. |
| 2017 | SUPERINTENDENCY OF PENSION. Part II. Application of a multicriteria workload assessment model in the company. |
| 2017 | Building a Multi-criteria model (AHP) to measure the level of risk of entry to the environmental assessment evaluation system |
| 2016 | OFFICE OF NATIONAL EMERGENCY (Regionals): Multicriteria modeling workshops for territorial planning (risk of disasters). |
| 2015–2016 | REGIONAL GOVERNMENT OF ARAUCANIA: Computer system for the evaluation of investment portfolios. |
| 2015 | REGIONAL GOVERNMENT OF VALPARAISO. Second Workshop for prioritization of the project portfolio. |
| 2014 | REGIONAL GOVERNMENT OF VALPARAISO . First Workshop for prioritization of the project portfolio. |
| 2013 | MINISTERY OF NATIONAL GOODS. Planning and Measurement workshop, dedicated to the territorial planning instruments |
| 2012 | REGIONAL GOVERNMENT OF VALPARAISO: Elaboration and Measurement of Indicators for regional planning instruments |
| 2011–2012 | MINERA LOS PELAMBRES. Implementation of the decision system of investment under the RSE (Corporate Social Responsibility). |
| 2011–2012 | SUBSECRETARY OF DEFENSE. Analysis of the strategic degree of defense companies. |
| 2011 | SUBSECRETARY OF DEFENSE. Workshop: Decision making and investment portfolios with AHP. (Analysis of Investment projects). |

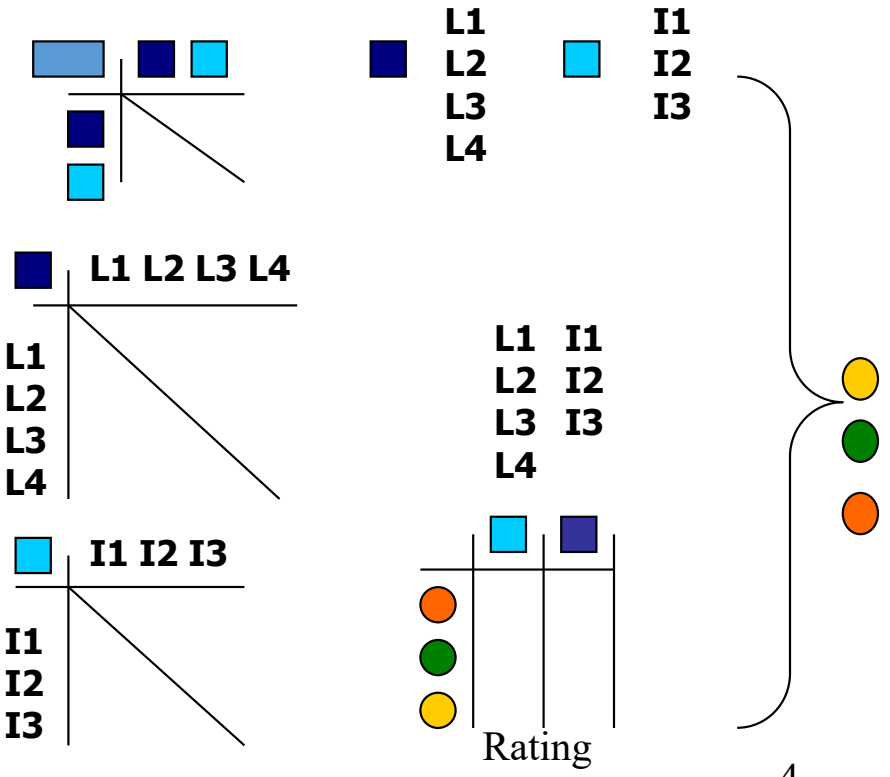
# Relative or Absolute AHP?

**Relative AHP :**
**Compare alternatives against each other for every terminal criterion**



**Absolute AHP :**
**Build intensity scales for terminal criteria and directly assess each alternative's behavior on each scale**



# Relative or Absolute ? …

**Relative / Absolute AHP generate relative / absolute metric for the alternatives.**
**Difference in the process only related to handling of alternatives**

## Relative Measurement

**Most known AHP metric**
**Able to capture some feedback between alternatives and terminal criteria**
**Naturally allows rank reversal, but may be preserved when desired**
**Less steps**
**Oriented to "how different/close" alternatives are between themselves**
**Results are dependent upon the set of alternatives**
**Hard to handle numerous alternatives (>7), even if regrouped w/pivots**

## Absolute Measurement

**Less known AHP metric. Closer to indicator usage in analysis.**
**Always preserves ranks.**
**Need to define and handle intensity scales. Highly dependent on our knowledge about the terminal criteria levels.**
**Able to measure many alternatives simultaneously.**
**Able to respond to how good the alternatives are, through the definition of thresholds.**
**Able to create standards for measures.**
**Easy to understand from operational use.**

# Relative or Absolute ? …

## Use Relative Measurement if :

- There is some level of feedback between alternatives
- Need to allow for rank reversal
- The set of alternatives does not exceed 6 or 7
- One shot type of decision
- You have the complete set of alternatives

## Use Absolute Measurement if :

- No rank reversal/feedback considerations
- Need / have intensity scales for technical criteria
- Experts are available to build metric from known scales
- Need to consider number of any alternatives (10 – 500…)
- Repetitive type of decision
- Don’t have a complete set of alternatives
- Need to know how good the alternatives are: set minimum acceptance levels by criterion or for the entire problem (Local & Global Thresholds).

# About scales

Each terminal criterion, indicator or driver needs its own scale where levels are to be well defined

Scales are represented using ideal mode (maximum norm). Thus, the top level is always associated to 1.

Considerations:

In a risks model, if it is no info about the criterion the corresponding value is 1.

In a benefits model, If it is no info the corresponding value is 0.

Null level = no presence of the criterion in the alternative is defined with 0 *(when correspond).*

# About scales

## Example of an absolute ratio scale coming from an ordinal scale of intensities for Lahar stream:

### 1. Describe each level of the scale in terms of its intensity

**Levels description**

Area of **very high** risk of being affected by lahar during the eruption and originated by the main crater.

Area of **high** risk of being affected by lahars during the eruption and originating from the main crater.

Area of **moderate** danger to be affected by lahars coming from the main crater or adventitious.

Area of **low** danger, they could be affected by large eruptions that occur during periods of greater snow accumulation.

**No Info** Avaliable for evaluation on this criterion

Direction of the scale.
Since it is a Threat scale, the higher the intensity the greater the threat.

### 2. Every intensity can be classified with a short name according its description

| Intensity | Description |
|---|---|
| **Very High** | Area of **very high** risk of being affected by lahar during the eruption and originated by the main crater. |
| **High** | Area of **high** risk of being affected by lahars during the eruption and originating from the main crater. |
| **Moderate** | Area of **moderate** danger to be affected by lahars coming from the main crater or adventitious. |
| **Low** | Area of **low** danger, they could be affected by large eruptions that occur during periods of greater snow accumulation. |
| **No Info** | No info avaliable for evaluation |

No information/Not applicable.
A good practice is to add a separate level that makes it easier to evaluate a location or project when there is no information or it does not apply to the scale

### 3. Weight every intensity level through a pair comparisons matrix

| Intensity | Description | Value |
|---|---|---|
| **Very High** | Area of **very high** risk of being affected by lahar during the eruption and originated by the main crater. | **1** |
| **High** | Area of **high** risk of being affected by lahars during the eruption and originating from the main crater. | **0,5693** |
| **Moderate** | Area of **moderate** danger to be affected by lahars coming from the main crater or adventitious. | **0,1903** |
| **Low** | Area of **low** danger, they could be affected by large eruptions that occur during periods of greater snow accumulation. | **0,0915** |
| **No Info** | No info avaliable for evaluation | **1** |

Intensity values.
They must correspond and be consistent with the intensity classification, that is, the higher the intensity value, the higher the classification.

# About scales

**Scale for measuring the degree of Hazard due to Lahars stream**

| Intensity | Description | Value |
|---|---|---|
| **Very High** | Area with a very high risk of being affected by lahar during the eruption and originated by the main crater. | **1** |
| **High** | Area with high risk of being affected by lahars during the eruption and originating from the main crater. | **0,5693** |
| **Moderate** | Area of moderate danger to be affected by lahars coming from the main crater or adventitious | **0,1903** |
| **Low** | Less dangerous areas could be affected by large eruptions that occur during periods of greater snow accumulation. | **0,0915** |
| **No Info** | No info available to evaluate the degree of Hazard. | **1** |

Ordinal ➔ Cardinal

The result (last column on the right) is the normalized eigenvector, which corresponds to the priority vector and reflects the preference ratio between the different intensity levels of the scale, thus constituting an absolute ratio scale, that is, the Very High level is exactly 1.757 (1/0.5693) times the High level and the latter 2.992 (0.5693/0.1903) times the Moderate level, all of which are dimensionless.

This priority vector is also called a *transformation function*, because it can transform ordinal scales into cardinal scales.*

# About scales

Tips for defining that a terminal criterion can be considered an indicator.

1. Is the name or definition of the criterion still abstract or general? If so, it is necessary to break down the criterion into sub-criteria that explain it.

   Some examples of general names: hazards of the area, deterioration of the area, level of vulnerability, quality of services, access to services, development of the region, etc..

2. Does the name or definition of the criterion already speak of measurements or can it be categorized? If so, the terminal criterion can already be considered an indicator.

   Some examples of specific names: lahar flow, building height, quality of construction materials, access to basic services, level of education, crimes per 100,000 inhabitants, etc..

# About scales

## Tips for building a scale

The indicator or driver must be able to be qualified by intensities, that is, the attributes or characteristics of the alternatives to be evaluated can be differentiated.

For example:

- Height of construction [1 floor, 2 floors, 3 floors] or [< 3m; 3 to 3.9m; 4 to 5.9m; > 6m]
- Distance to the coast [< 30m, 30 to 49m, 50 to 69m, > 70m]
- Access to satellite telephony [has access, not has access]

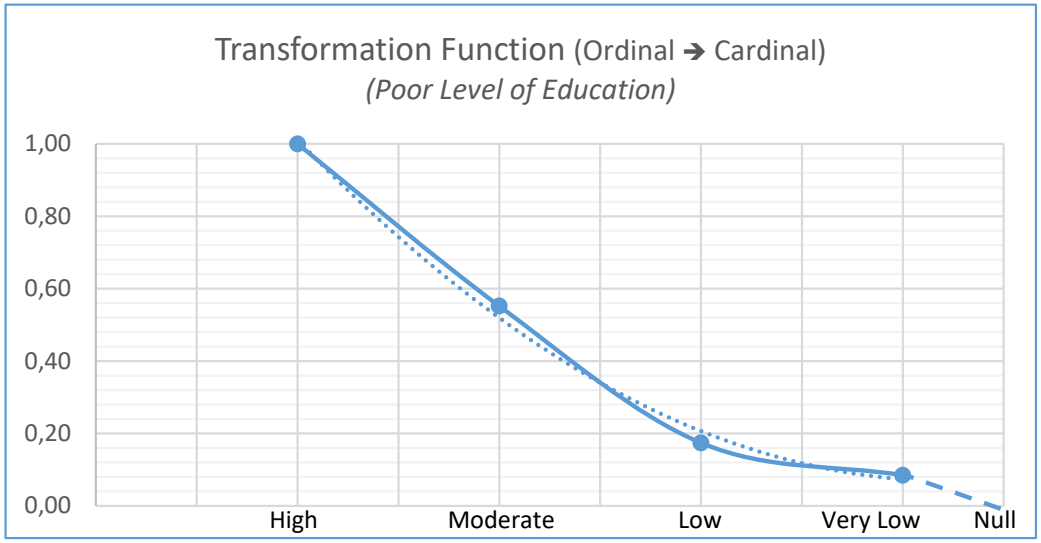
The last scale the indicator is defined in two levels as a binary scale (0, 1).

The more levels the indicator has, the more precise the evaluations of the alternatives will be and thus, the differentiation between them is improved (and better thresholds can be built as we will see later).

# About scales

**Transformation function::** Transforming an Ordinal Scale to a Cardinal One

## Driver: Poor Level of Education




| Poor Level of Education | High | Moderate | Low | Very Low | Priority Vector |
|---|---|---|---|---|---|
| High | 1 | 2 | 7 | 9 | 1 |
| Moderate | 1/2 | 1 | 4 | 6 | 0.5524 |
| Low | 1/7 | 1/4 | 1 | 3 | 0.1736 |
| Very Low | 1/9 | 1/6 | 1/3 | 1 | 0.0847 |

Ordinal ⟹ Cardinal

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Level | High | Moderate | Low | Very Low | Null | No Info |
| Value | 1,0 | 0,5524 | 0,1736 | 0,0847 | 0,0 | 1,0 |

# About Thresholds

Once all the scales are done and the alternatives evaluated, some questions arise about how to interpret the results:

- The result is **good or bad**? (*is the risk too high? or benefit too low?)*
- There is a way to **classify** its level of risk or benefit?
- What about its **performance**?

Also:

- Can we **improve** its classification and performance efficiently?

# About Thresholds

## There are Local and Global thresholds

**Local Thresholds (LT):**

A local threshold represents the **frontier** or tipping point between two consecutive levels of the scale.

It helps us to locally **classify** the alternative in a rigorous and precise way.

For a Risks Model:

$$LTj = \frac{2 * L(i) * L(i+1)}{L(i) + L(i+1)}$$

For a Benefits Model:

$$LTj = \frac{L(i)^2 + L(i+1)^2}{L(i) + L(i+1)}$$

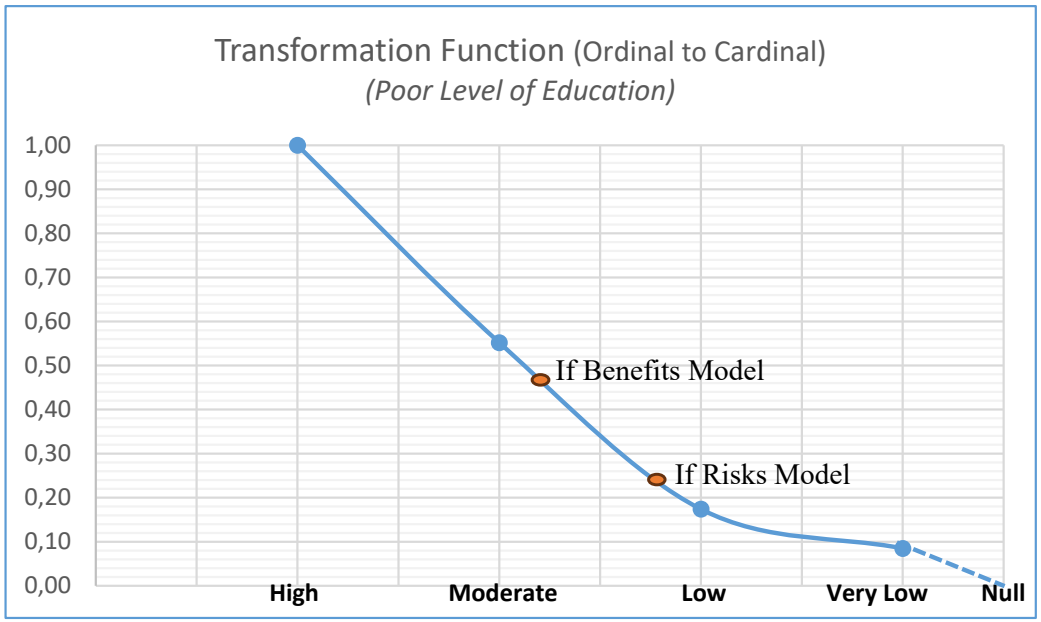
*Normally: L(i) = Low ; L(i+1)= Moderate*

*The LT will be as good as the scale from which it come!*

*Garuti, C.; Mu, E.*
*A Rate of Change and Center of Gravity Approach to Calculating Composite Indicator Thresholds: Moving from an Empirical to a Theoretical Perspective. Mathematics **2024**, 12, 2019. https://doi.org/10.3390/math12132019*

# About Thresholds

## Example for a LT Calculation:




| Bajo Nivel de Educación | High | Moderate | Low | Very Low | Priority Vector |
|---|---|---|---|---|---|
| High | 1 | 2 | 7 | 9 | 1 |
| Moderate | 1/2 | 1 | 4 | 6 | 0.5524 |
| Low | 1/7 | 1/4 | 1 | 3 | 0.1736 |
| Very Low | 1/9 | 1/6 | 1/3 | 1 | 0.0847 |

Ordinal → Cardinal

Ratio of change for M/B = .5524/.1736 = **3.182 < 4**

*Thus, the expert is willing to accept a little more risk*

$$LT = 2ML/(M + L) = 2*.5524*.1736/(.5524+.1736) = \mathbf{0.2642} \quad \textit{(If Risks Model)}$$

$$LT = (M^2 + L^2)/(M + L) = (.5524^2 + .1736^2)/(.5524 + .1736) = \mathbf{0.4618} \quad \textit{(If Benefits Model)}$$


*Garuti, C.; Mu, E.*
*A Rate of Change and Center of Gravity Approach to Calculating Composite Indicator Thresholds: Moving from an Empirical to a Theoretical Perspective. Mathematics **2024**, 12, 2019. https://doi.org/10.3390/math12132019*

# About Thresholds

## Never try any of these (*please*):

- Average the levels: (M+B)/2 = 0.3630. The average is a **bad proxy** for both models, risks and benefits.
- Trisecting the dataset (1/3 is low; 1/3 is moderate ;1/3 is High) as thresholds of the dataset.
- Average the Max and Min values from the dataset as a threshold of the dataset.
- Average & standard deviations (left and right) from the dataset as thresholds of the dataset.

## Some Hints & Tips for Thresholds

- Always take consecutive levels to calculate the local threshold *(the experts should select those levels)*
- For binary variables take 0 for LT in a Risks model and 1 in a Benefits model.
- For lack of data /information take 1 for LT in a Risks model and 0 in a Benefits model.

# About Thresholds

**There are Local and Global thresholds**

## Global Threshold (GT):

Once all the LT have been calculated, it is posible to calculate the global thereshold (GT):

$$GT = \sum_i (LT_i * WG_i) \quad i = 1 \text{ to n° of drivers or indicators}$$

GT = Global Threshold of the model

$LT_i$ = Local Threshold of driver "i" (terminal criterion)

$WG_i$ = Global weight of driver "i" (terminal criterion)

*Garuti, C.; Mu, E.*
*A Rate of Change and Center of Gravity Approach to Calculating Composite Indicator Thresholds: Moving from an Empirical to a Theoretical Perspective. Mathematics **2024**, 12, 2019. https://doi.org/10.3390/math12132019*

# About Thresholds

Example for a GT Calculation: *(just 5 variables)*

| Drivers (terminal criteria) | (M/B)i | LTi | WGi | GTi = LTi*WGi |
|---|---|---|---|---|
| Exposition to emission sources | 1.777 | 0.2999 | 0.5288 | 0.1586 |
| Exposition to hazards contaminants. Binary Variable (acceptability Norm) | 0 | 0 | 0.1454 | 0 |
| Exposition to noises | 1.777 | 0.2999 | 0.1604 | 0.0481 |
| Exposition to micro garbage landing | 3.633 | 0.2494 | 0.1654 | 0.0413 |
| Sum | - | - | 1.0 | **0.2480** |

➔ Maximum Tolerable Risk = 0.2480 (24.8%)

**Conclusion:** If an alternative (Project or cell of territory) have a level risk that exceed the value 0.2480 (24.8%), then its risk is excessive and (technically) should not be accepted as a tolerable risk for the territory.

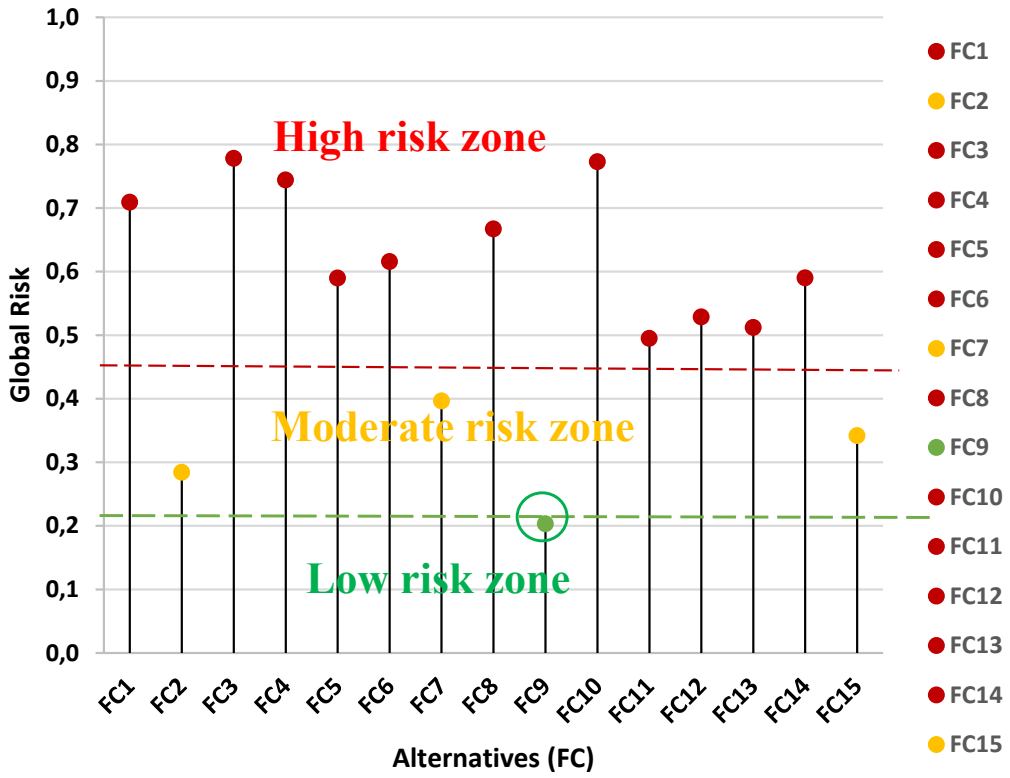
*(Correction measures are needed!)*

# How should look the results?

At the end of the rating process with its corresponding local an global thresholds calculation the results should look like this:

High GT = 0.448 (44.8%)
Moderate GT = 0.208 (24.8%)

**≤ 0,448 High risk zone ≤ 1**
**0.208 ≤ Moderate risk zone < 0,448**
**0 ≤ Low risk zone < 0,208**




| Alternative | Global Risk |
|---|---|
| FC1 | 0,709 |
| FC2 | 0,284 |
| FC3 | 0,778 |
| FC4 | 0,744 |
| FC5 | 0,590 |
| FC6 | 0,616 |
| FC7 | 0,397 |
| FC8 | 0,667 |
| FC9 | 0,203 |
| FC10 | 0,773 |
| FC11 | 0,495 |
| FC12 | 0,529 |
| FC13 | 0,512 |
| FC14 | 0,590 |
| FC15 | 0,342 |

**Conclusions:**

The alternative FC9 belongs to the low risk zone, thus FC9 has a low global risk level.

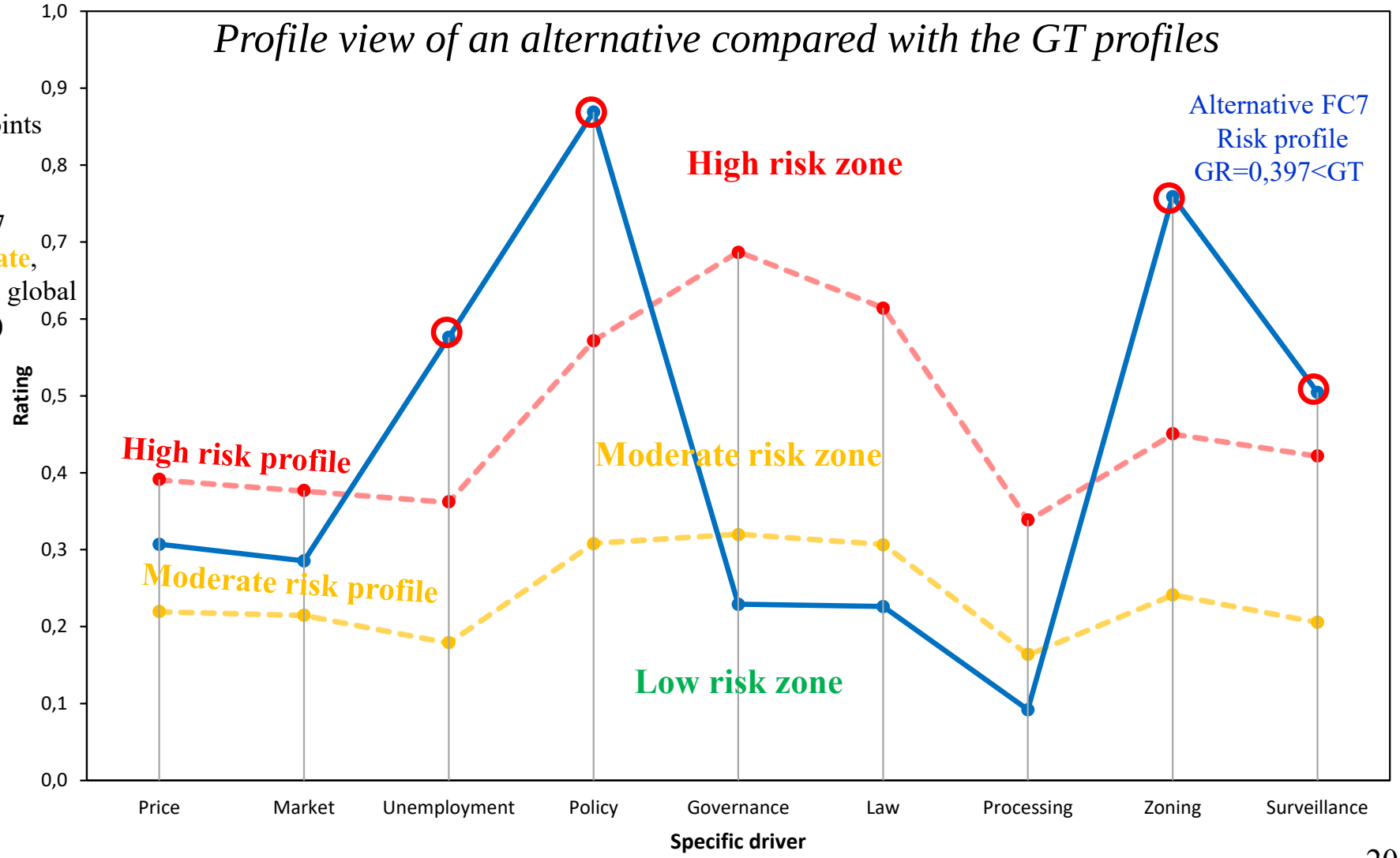
The alternatives FC2, FC7 and FC15 belongs to the moderate risk zone, thus they have a tolerable global risk level but they must be under regular inspection. The rest of the alternatives belongs to the high risk zone (they have a non tolerable risk level) and they need inmediate action.

# How should look the results?

At the end of the rating process with its corresponding thresholds calculation the results should look like this:

Identify crucial points (red circles).

GR=0.397 => FC7 classify as **moderate**, thus an acceptable global risk (0.397<0.448)



# Is the decision final?

## Compatibility index *G* to determine possible compensations in the profile of an alternative.

Beside to classify the alternatives compared with GT, there is also info in the alternative profile in terms of its behavior.

The Compensation or Offset Issue:

There is an interesting question about the degree of offsetting or compensation between drivers. Indeed, *sometimes may happen unacceptable compensations between drivers (especially in the risks models).*

Continuing the last example in a risk model:

GT = 0.448 (44.8%)
GV(FC7) = 0.397 (39,7%)

Thus, the alternative FC7 in global terms is aceptable since GV(FC7) < GT

**BUT…**

# Is the decision final?

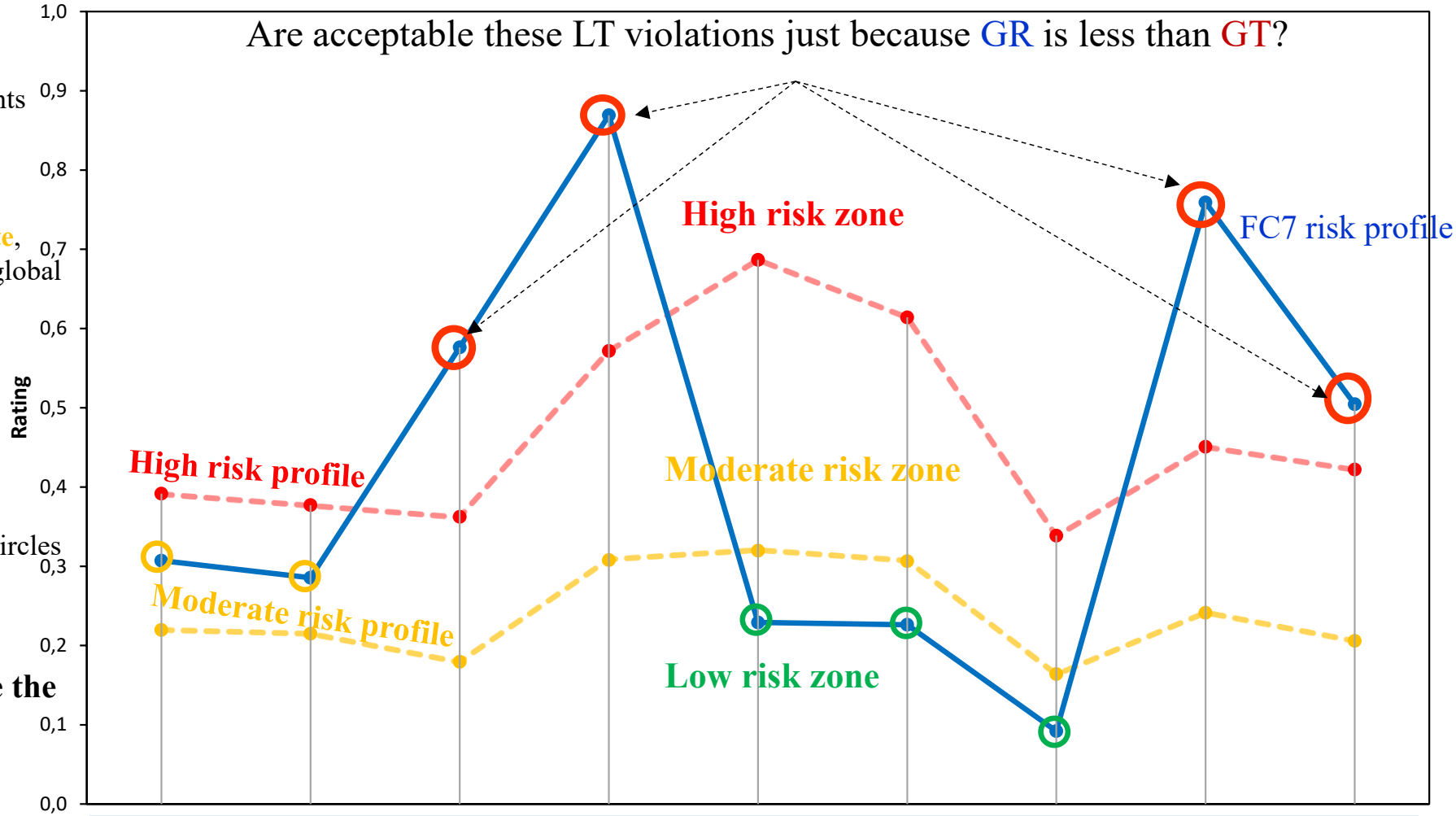
## What About Compensations? (Offsettings)

Identify crucial points (red circles).

GR=0.397 => FC7 classify as **moderate**, thus an acceptable global risk (0.397<0.448)

**But, what about Compensations**? (green and yellow circles offseting reds).

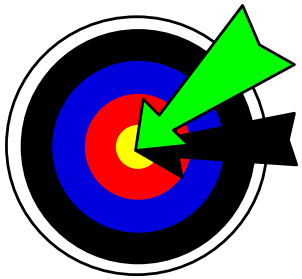
**How to measure the quality of this offseting effect?**




(Tip)

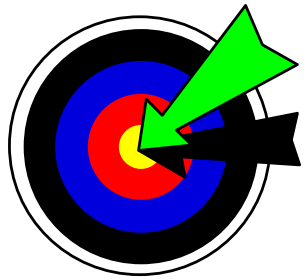
Measure *G* between the alternative and the moderate risk profile

# 5 Steps Summary



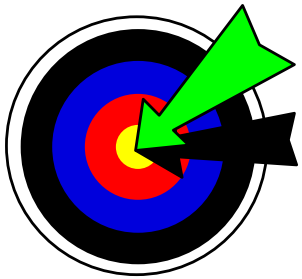
1. **Build a cardinal scale for every indicator of the model.**
2. **Calculate the Local Threshold (LT) to each scale using CGRC Method.**
3. **Calculate the Global Threshold (GT) combining all the LT as a weighted sum *(just like AHP/ANP does).***
4. **Compare the alternatives result with GT value and classify the alternative *(good, bad, acceptable, unacceptable tolerable, etc..)***
5. **Check possible compensations *(applying compatibility index G).***

# Conclusions About Scales



- The complexity of the problems to be solved normally leads to the use of a **large number of variables and indicators**, aimed at analyzing the available alternatives.
- These indicators and scales must be **specific to the problem**, regardless of its qualitative or quantitative nature.
- AHP/ANP provides a **mechanism for constructing measures and cardinal scales** for all types of intensity scales (qualitative or quantitative). Only scales that constitute measures possess the arithmetic properties necessary to integrate results from and to other methods and, e.g., to perform sensitivity analyses.
- Technological development has filled us with figures and data. The challenge is to determine the relevant variables of a problem and **find the data necessary to evaluate the alternatives** within the context of the problem.
- Numbers are important, but **knowledge is even more important**. Numbers alone can be totally invalid, useless or irrelevant..

# Final Conclusions



**The AHP Rating mode (the absolute measurement mode) is very powerful mode of measurement, suitable for many real life problems.**

**To use AHP/ANP rating mode requires clear understanding of the drivers of the problem and the presence of experts to build the scales.**

**Classification of alternatives is a necessary condition for the decision makers in order to assist their management process. Thus, the thresholds calculation become a necessary complement to the rating process.**