RETHINKING THE RISK MATRIX

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Agenda

- Criticizing the risk measure
- Criticizing the consequent risk matrix
- re-thinking that measure as expected value justified in a long term “manager’s” perspective
- re-thinking a new measure justified in a “citizen’s” perspective

The risk measure as P·L

- The risk measure R is commonly accepted as

$$R = P \cdot L$$

  - being P the probability of an adverse event and
  - L the loss incurred as consequence of that event

Typical Risk Matrix (diag shape)

LIKELIHOOD	CONSEQUENCES				
	Insignificant	Significant	Moderate	Severe	Extremely severe
Almost certain	High	High	High	Very high	Very high
Likely	Medium	Medium	High	High	Very high
Possible	Medium	Medium	High	High	High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium

‘highest-lowest’ and ‘highest-lowest’ corners:
‘extremely severe’ consequence / ‘low’ or ‘very low’ probability and
very likely events / low consequences

Risk according to the "AND" logic

- even an 'extremely severe' consequence is generally reduced to a 'medium risk' evaluation if a 'low' or 'very low' probability has been attributed to the event
- Specularly, very likely events, characterized by low consequences, could be undervalued.
- Only events with high probability AND high severity lead to an extremely high risk evaluation

Cox L. A. Jr. (2008) "What's wrong with risk matrices?", *Risk Analysis*

Link between risk matrix and risk measure

- If it is possible to quantify the consequences as a Loss and normalize it in a [0, 1] interval
  - Therefore
    - Loss = 0 no consequences
    - Loss = 1 catastrophic consequences

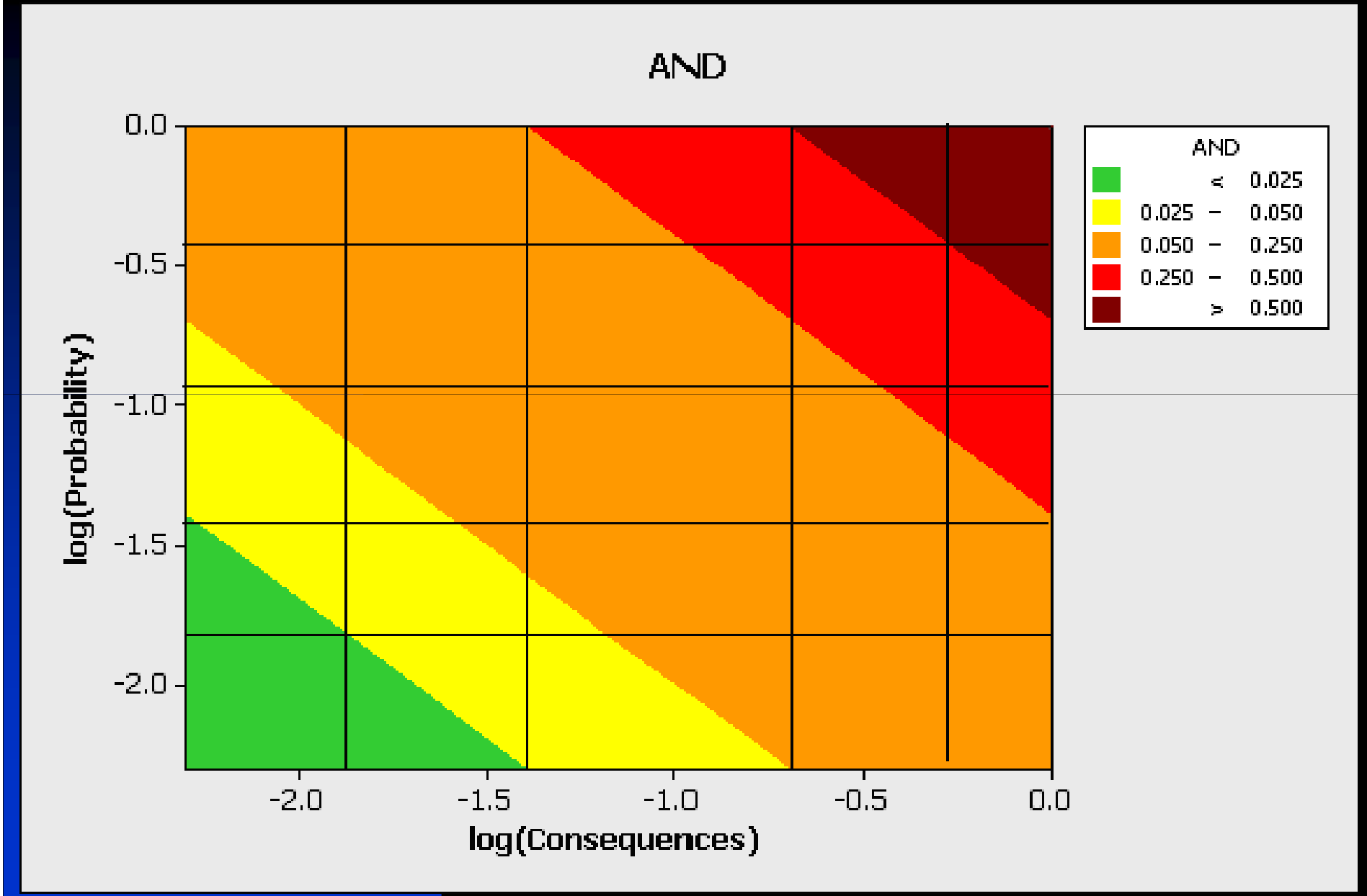
- Taking the logarithm from

$$\text{Risk} = \text{Probability} \times \text{Loss}$$

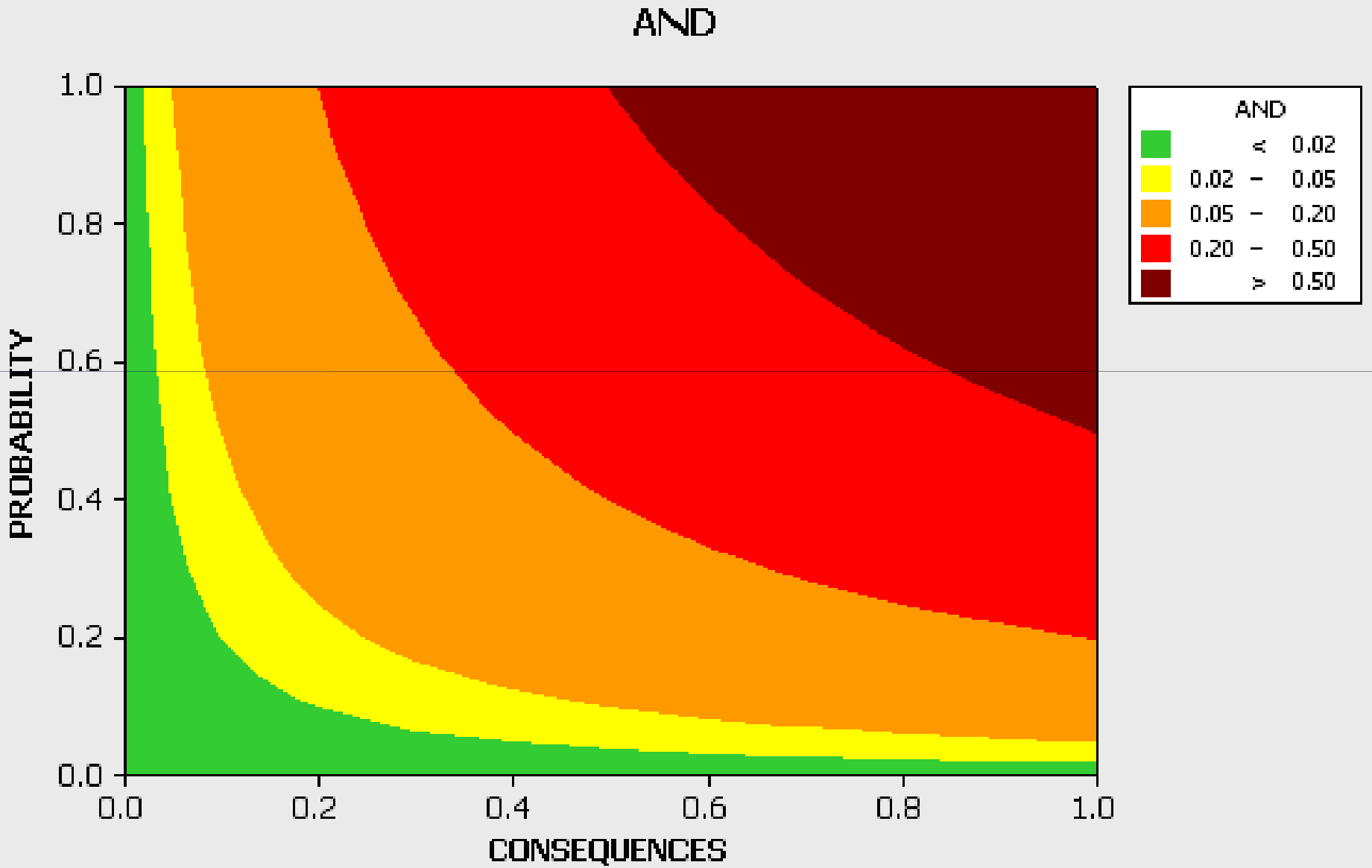
follows

$$\text{Log}(\text{Risk}) = \text{Log}(\text{Probability}) + \text{Log}(\text{Loss})$$

Risk measure $R = P \cdot L$ on bi-logarithmic scale



The risk measure on natural scale



Risk Measure

The drawbacks of such measure become obvious when $R = P \cdot L$ is plotted on natural scale axes:

- it is possible to reduce the risk level by appropriately reducing the probability of the event;
- very likely events do not entail high risk if their consequences are not severe;
- only likely AND severe events lead to extreme risk.

The risk as expected cost (long-term mean)

- The measure of Risk as Probability times Loss is universally accepted, but not always adopted
  - For instance in the insurance contracts. In order to avoid the individual risk the person accept to pay a price higher than that foreseen by the mathematical expectation.

- The measure of Risk can be also viewed as an expected cost (long-term mean),
  - therefore it is acceptable only when “the mean is meaningful”, for instance when we handle amortizable figures.
  - In fact Risk is appropriately seen as an expected cost when it is possible to ‘amortize’ an issue over several units (time, persons).

The risk as expected cost (manager's perspective)

the measure of Risk as a mean loss is in agreement with the manager's perspective,

i.e. a long term perspective,

in which a today's high cost can be amortized

by several tomorrow's low costs.

This vision should never be used when

non-replaceable elements are involved,

like human (or living) beings,

non-renewable environmental resources, and so on.

The concept of Probability in Risk measure in positive events

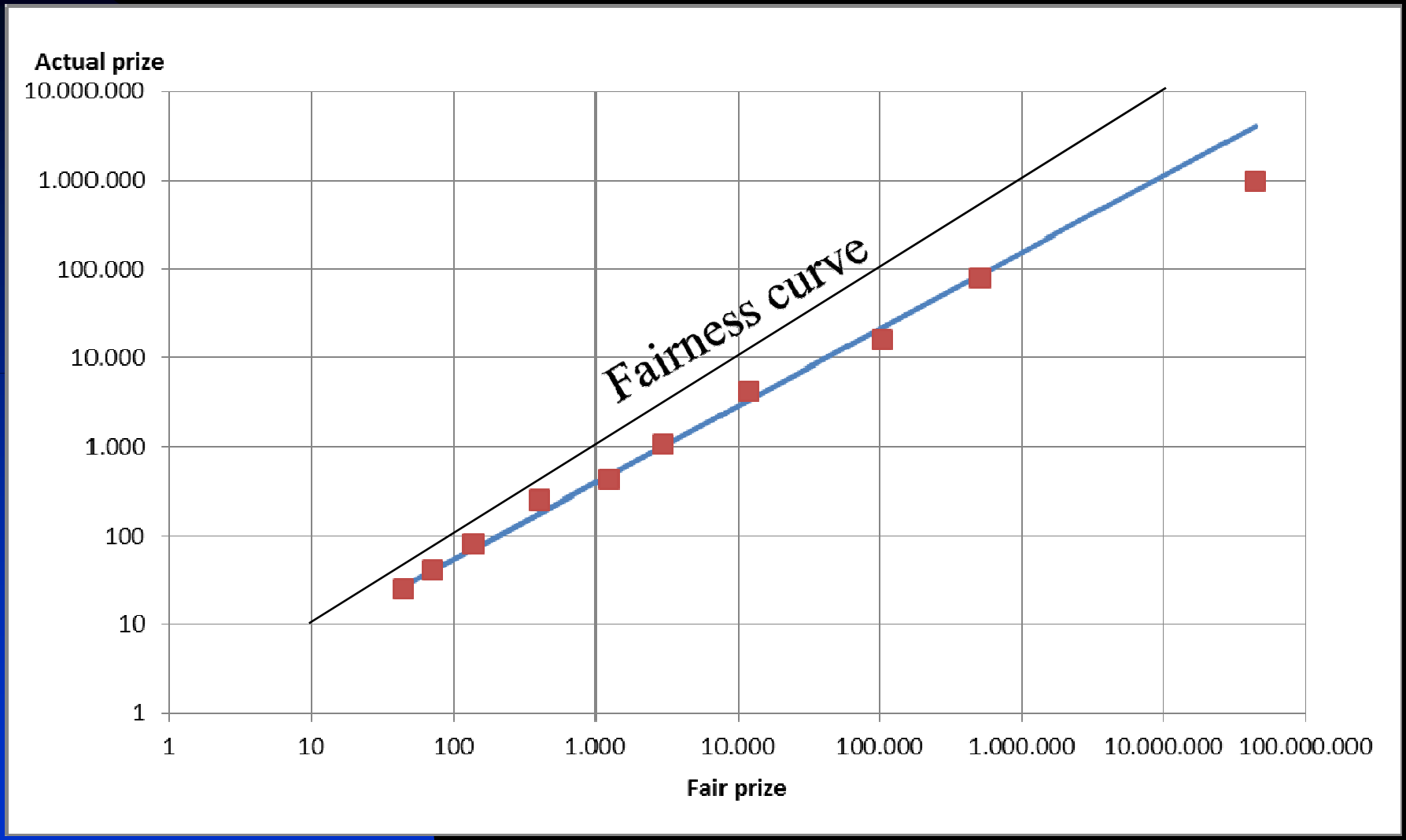
Another example of how probability can be assessed so differently from what the frequentist theory describes, particularly for very low probability values, is in the case of **lotteries**.

Italian “Lotto” game, comparing the ‘fair’ prize (corresponding to the ‘expected gain’) and the actual prize, really paid.

This ratio (unfairness ratio) is not constant, but increases for decreasing probability.

People is satisfied with prizes lower than the fair ones to have access to an attractive “game”.

Actual prize vs. fair prize in Italian "Lotto" (log-log scale graph)



Partial conclusions

There is considerable discrepancy of the manager's logic
and the logic of the individual user,
    this discrepancy is increasing as decreasing probability
This effect is observed both in 'negative' and in 'positive' risk,
i.e. for negative and for positive events.

An alternative measure of Risk (OR logic)

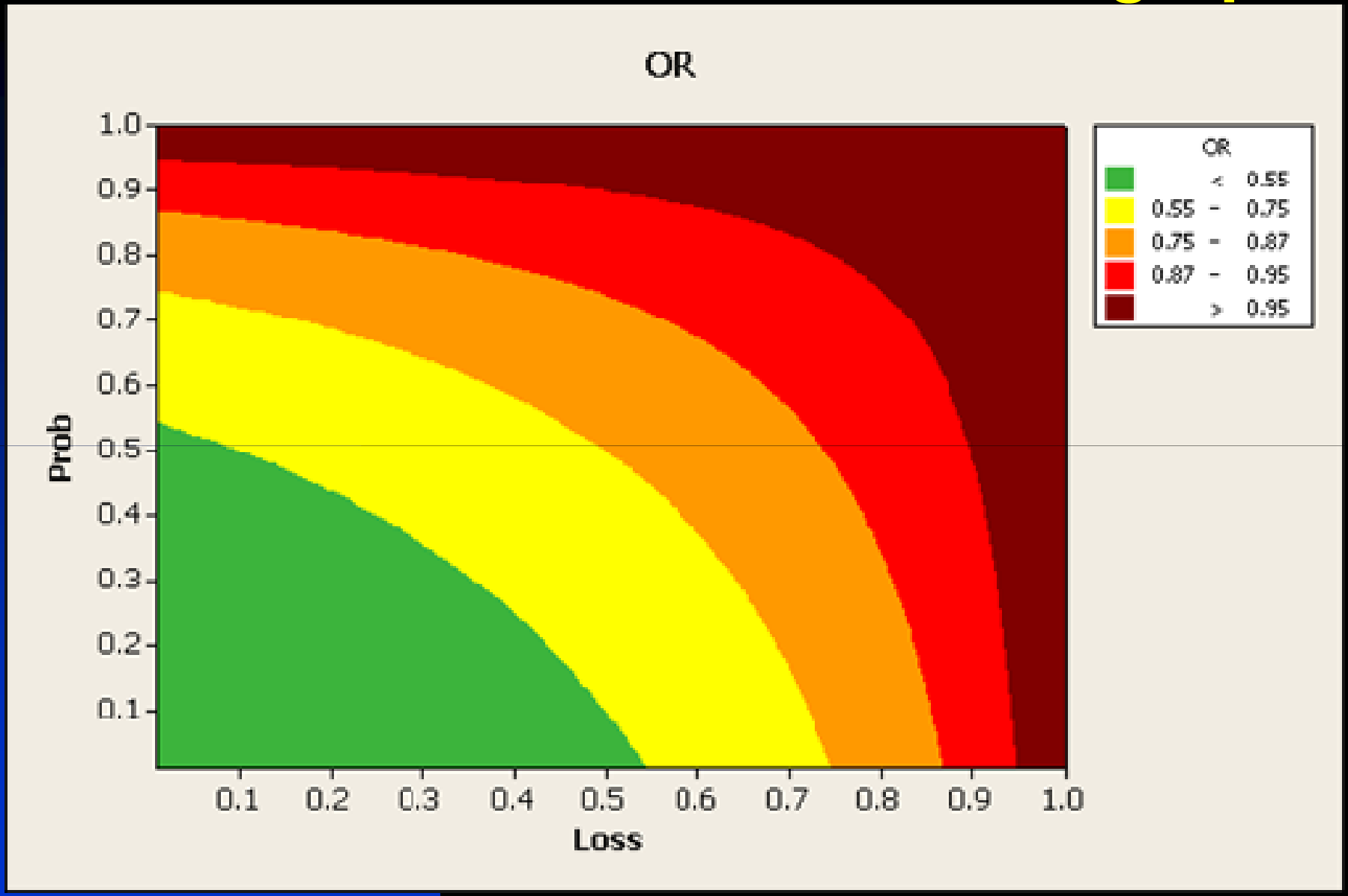
We define ‘Safeguard’ as:

$$Safeguard = Improbability \cdot Saving$$

$$Safeguard = (1 - Probability) \cdot (1 - Loss)$$

$$Risk = (1 - Safeguard) = 1 - [(1 - Probability) \cdot (1 - Loss)]$$

The alternative measure of Risk graph



An alternative measure of Risk

$$Risk = 1 - [(1 - Probability) \cdot (1 - Loss)]$$

The advantages of the new measure of Risk are evident:

- very frequent events must be evaluated as highly risky, even if their consequences are not severe;

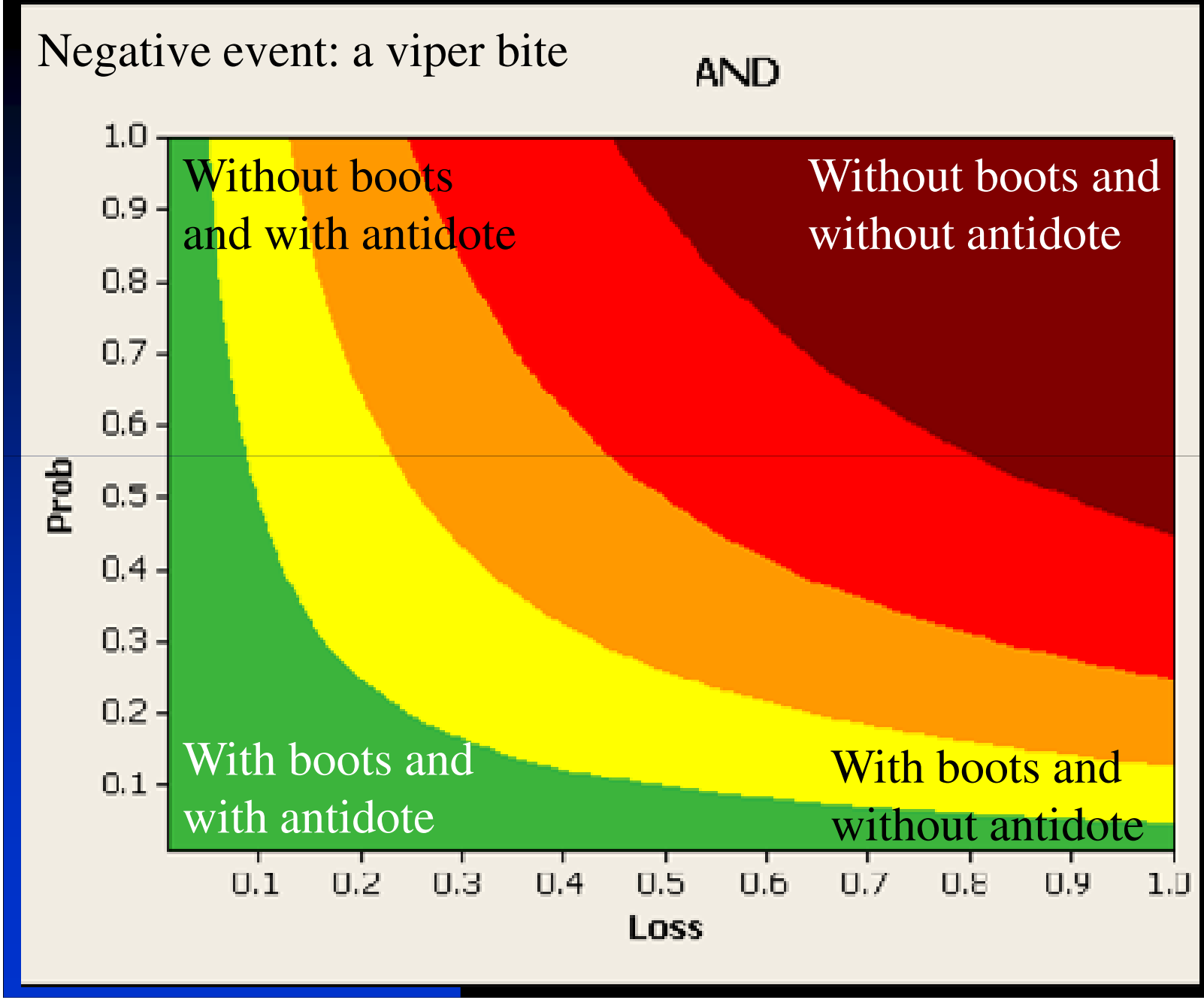
- events with catastrophic consequences may never be associated to an acceptable level of Risk, even when their probability is judged as negligible;

- it is sufficient the presence of high severity of consequences (*Loss*) OR high probability of the negative event to lead to a high evaluation of Risk.

An alternative measure of Risk

- The last property is in line with the precautionary principle.
- We are compelled to reduce both severity and probability (whenever possible) to have an activity that can be declared SAFE;
- this is a path towards a real continuous improvement process that cannot be stopped when one or another of the two terms is minimized.

An illustrative example: a walk in the countryside



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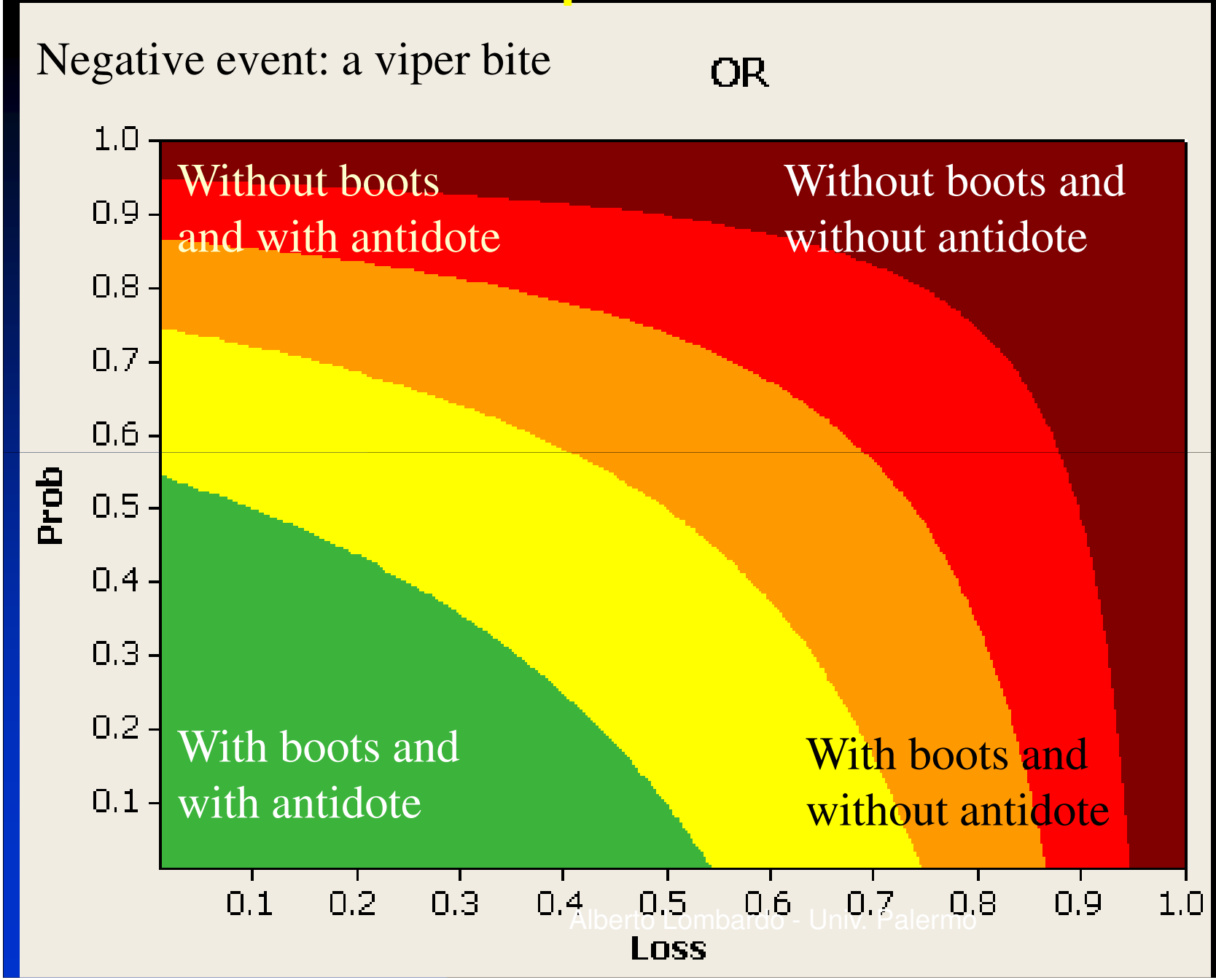

The new Risk Matrix

LIKELIHOOD	CONSEQUENCE				
	Insignificant	Minor	Moderate	Major	Extreme
Almost certain	Extreme	Extreme	Extreme	Extreme	Extreme
Likely	High	High	High	High	Extreme
Possible	Medium	Medium	High	High	Extreme
Unlikely	Low	Medium	Medium	High	Extreme
Rare	Low	Low	Medium	High	Extreme