ICQSS 2011

14th QMOD conference on Quality and Service Sciences

From Learn*Ability* and Innov*Ability* to Sustain*Ability*

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Welcome message

It is an honour for us to welcome you to the 14th QMOD/ICQSS conference. The aim of the Conference is to focus on the three key themes of **LearnAbility, InnovAbility and SustainAbility**, all of which are necessary in today's business environments, which are constantly evolving towards higher complexity. All three key concepts indicate the importance of meta competencies in terms of our capability to learn (learnability), capability to innovate (innovability) and capability to sustain (sustainability). It is our belief that these meta competencies will become increasingly important in the coming years. Among the many issues which challenge modern management theories and practices are:The hyper competition, the increasing importance of intangible assets, cultural and ethnic diversity, the focus on quality of life, gender, organisational ecology, environmental sustainability, corporate social responsibility and risk management.

The QMOD conference has become one of the largest scientific conferences within the research fields of Quality, Service, Organisational Development and related research areas. The yearly QMOD conference is also proven to be a major forum where academics as well as practitioners from all around the world have the opportunity to exchange their knowledge and experiences and thereby built a **'QMOD Community'**. Through this forum, we can discuss and share our research and experiences in order to be able to draw a more accurate picture of organisational and business realities, and thereby to improve our diagnosing capabilities of current problems and improvement opportunities.

We take this opportunity through this written welcome to express our recognition of the effort and work put in by all those people who have made it possible to organise **QMOD 2011**: we pay tribute to the Scientific Committee who have assured the quality of the accepted papers, to the members of the organising committee for their keen motivation and to all the people who have directly or indirectly influenced the smooth progress towards the conference.

Finally, we would like to express much gratitude to all of the authors for contributing their papers. We hope you will find the conference schedule we have prepared interesting and worthwhile, and we encourage you to enjoy the delights offered to us by San Sebastian, our host city.

Donostia – San Sebastián, August 2011

QMOD Organising Committee

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Rethinking the risk matrix

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Key words: Risk matrix, Risk sustainability, Managerial perspective, Social perspective

Introduction

Any decision under uncertain conditions imposes to evaluate the 'risk' related to the possible consequences. Such evaluation can be absolute or relative. However, in both cases a quantitative indicator is needed to take into account all factors involved in the 'risk'. In the first case (absolute evaluation), it is necessary to express such indicator as a measure in monetary, material or human terms (cost, number of causalities, etc.). Also in the second case (relative evaluation), this assignment is necessary but it looks less critical, because a proportional error in the definition of the measure will be neutralized.

In both cases above, the definition of risk and its measure are often confused.

In an ideal world we would like that the negative consequences (*Loss*) be null or minimal. This should be the goal of the improvement work, in technology and human sciences. Any 'measure' that clouds this aim or deflects from this path, has inside something wrong.

Since the consequences are usually 'possible', the definition – or, better, the measure – of risk is inevitably associated with the concept of probability.

Unfortunately, as we will see in this note, even if the consequences are correctly evaluated and the probability is a well-established measure, an 'inappropriate' mix of the two can lead to a 'risky' evaluation of risk. This idea will be described in Section 2 and Section 3 and further clarified by an illustrative example in Section 4.

The Risk Matrix

Pioneer work on establishing a common definition of Risk was started in the early 60' with Wood (1964), where risk is defined as an objective state differing from the concept of uncertainty, more related to a subjective state. Many papers have studied the relation between the perception of probability in comparison with the rational computation. This link between risk and perception of risk has been object of further studies, see e.g. Weber and Milliman (1987). They also discuss the influence of posing a question concerning a consequence either in positive (gain) or in negative (loss) way.

As for the measure of risk, a milestone work was due to Kaplan and Garrick (1981) where, in place of a simple univariate measure of risk, a more complex definition including scenarios and risk curves was proposed.

However, despite more complex definitions, in the practice of risk management, the tool generally adopted to classify risk levels is the so called *Risk Matrix*. The risk matrix has two dimensions, likelihood and severity, both usually classified on five levels. The risk level, reported on each cell of the matrix, can be usually classified on three-five levels. The risk matrix reported in Table 17 is just an example. Slight modifications can be found depending on the specific risk analysis context.

Table 17. Risk matrix

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

In several articles such matrix has been sometimes criticized. In particular, Smith *et al*. (2009), have experimentally demonstrated for instance that […'*Human subjects exaggerate the influence of losses when the losses occur to their personal wealth*'…]. (We suppose that an opposite effect could occur when impersonal decisions regarding the general health, must be taken). In addition, these Authors showed that when probability is very low or very high a biasing effect occurs, deflecting its evaluation towards medium levels.

The risk matrix shows that the risk level depends on the probability of occurrence of the 'negative event' and the severity of the possible consequences. The 'very high' risk level is reserved only to the cases where both factors are at high or the highest level (the three purple cells in the top right corner of the Table).

According to us, the attention should not only be devoted to the 'highest-highest' and 'lowest-lowest' corners, leading to obvious evaluations, but mainly to the other two corners.

In fact, in those cases 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.
The relationship between the risk matrix and its analytical definition has been already noted by Cox (2008).

The analytical measure of Risk

Usually, Risk is analytically measured by using the following formula:

$$Risk = Probability \cdot Loss \quad (1)$$

Whenever it is possible to quantify the consequences as a *Loss* and normalize it in a [0, 1] interval, the contour plot of this function in log-log scale is presented in Figure 1. With an opportune choice of axes scales and contour levels, it is evident that the formula (1) can be assumed as the theoretical basis of the above mentioned risk matrix reported in Table 17.

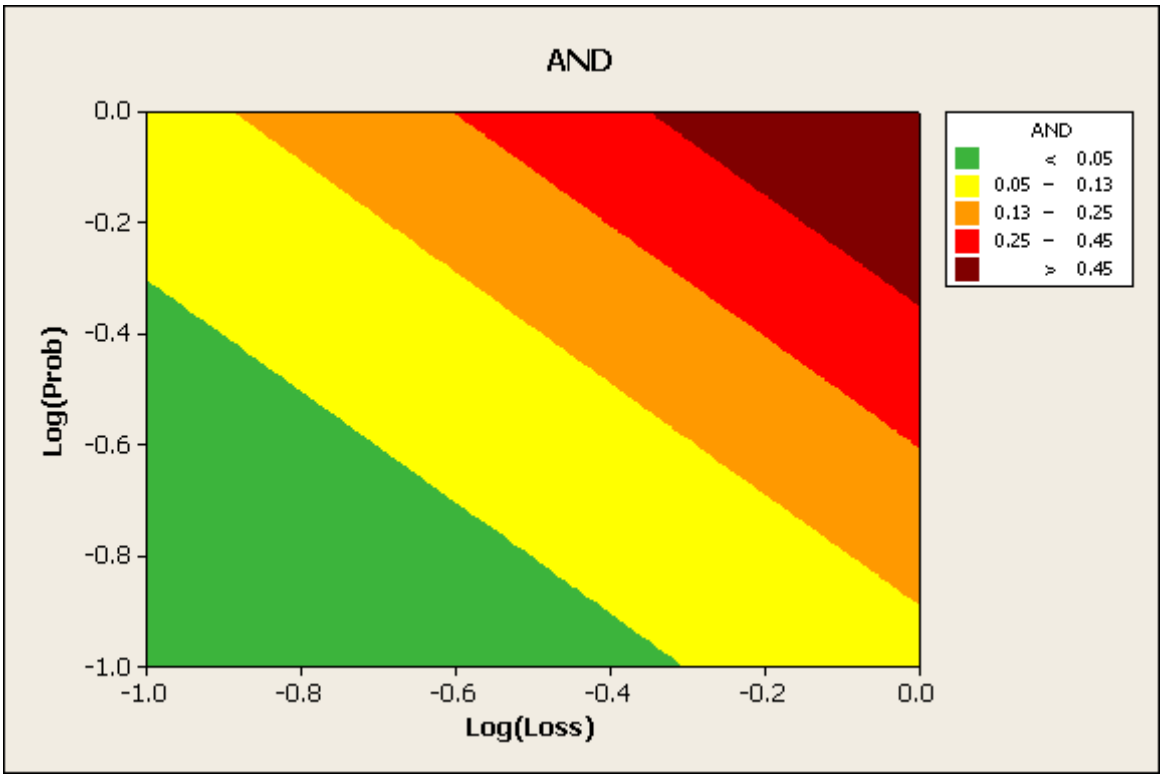


Figure 1. Contour plot of the function *Probability*·*Loss* in log-log scales.

Range, number of levels and their limits can be arbitrarily assigned. For the plot in Figure 1, we chose them in order to obtain a picture similar to that in Table 1.

The measure of risk stated by (1) is based on the logical operator "AND". The main aspects of such measure are the following:

- 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 drawbacks of such measure become obvious when the function (1) is plotted on natural scale axes, see Figure 2.

In this Figure limits are chosen in order to obtain five zones covering same area. Those limits are the same chosen in Figure 1.

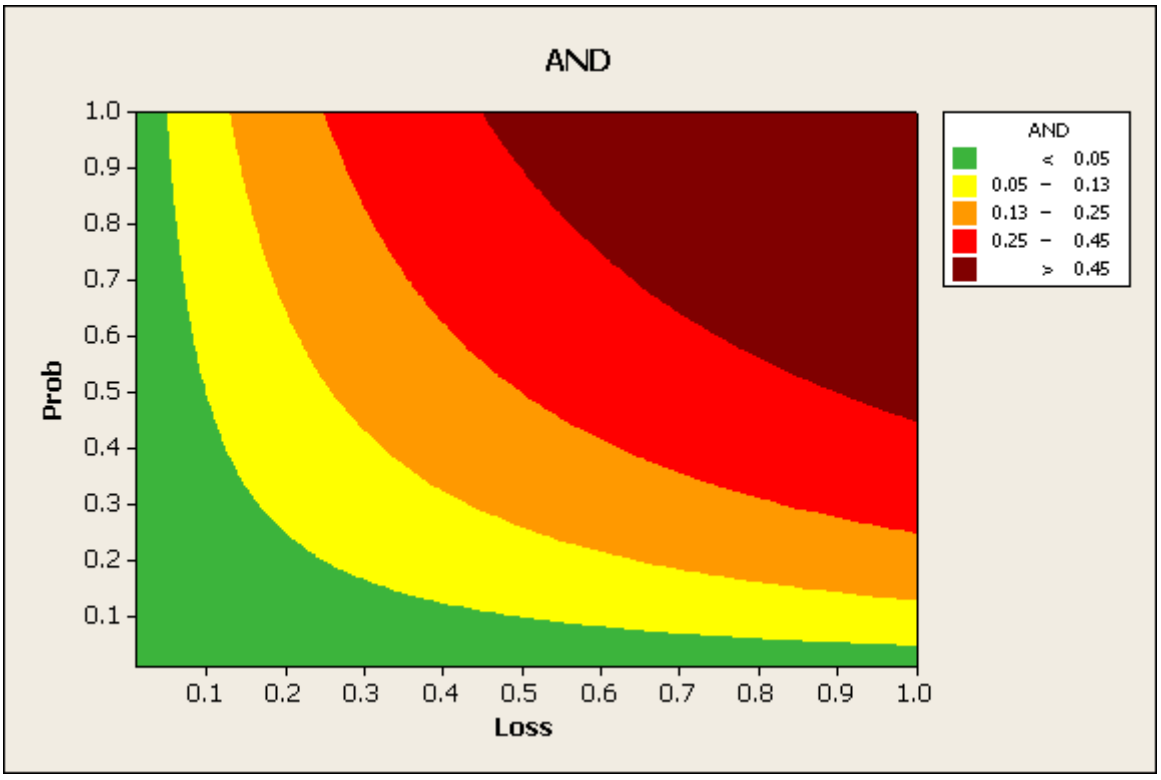


Figure 2. Contour plot of the function *Probability*·*Loss* in natural scale axes

The concept of Probability in Risk measure

The measure of Risk as *Probability* times *Loss* is universally accepted, but not always adopted. There are many cases diverging from this measure. A typical example of disagreement of everyday behavior from a probabilistic point of view concerns the choice of means of transport. Nobody of us will drive a car if we would consider the probability and the severity of consequences of an accident. In this case, since the probability is very low, people seem to not exactly understand what does unlikely mean.

This behavior is not only typical of human beings. Experiments carried out in aquariums showed that, until the ratio predatory/preys is low, fishes do not exhibit visible anxiousness.

Many examples can show the attitude of human beings, who are used to live in a dangerous environment, but are not paralyzed by fear. This attitude can lead individuals to afford high risks, but can allow species to survive.

What does Risk mean according to the "AND" logic? Particularly, what does "probability" mean?

A typical probabilistic statement is: 'This event has a probability to occur once in a thousand years'. What does it mean? How many years we are now from the last occurrence?

This question is meaningless in a Poissonian world (remind the so called memory-less process) where the probability does not increase or decrease over time. The 'event' could either occur now or we should wait for more than expected.

The measure of Risk (1) 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).

For example, saying "10% probability of paying a cost C" means that we expect 10 occurrences of the negative event out of 100 times, so we divide $10 \cdot C$ by 100.

Another example: when using 100 bulbs in a row, it makes sense to sum up the lifetimes of each of them and to divide by 100 to estimate the mean life. In such a case, one long-life bulb can counter-balance several short-life bulbs. Conversely if it is necessary to use only one bulb, it is better to refer to the probability to reach an assigned time horizon. In a very asymmetrical distribution, as the Exponential one, governing memoryless processes, the probability of having an element with life-time less than the mean is the 62.3%. It means that we approximately expect that 2 bulbs out of 3 will fail before their mean life. For systems that can be modeled as "renewal processes" the mean lifetime can be used as a valid criterion, otherwise when a very high reliability is required, it is necessary to take into account more conservative percentiles.

In conclusion we think that 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.

An alternative measure of Risk

Doubtless, the mean is a very simple and attractive way to summarize variable quantities. Moreover the product *Probability* times *Loss* is very easy and manageable. Therefore, we wish to express a new measure of Risk that is as simple as the previous one, but avoiding the drawbacks discussed above.

We may define 'Safeguard' as the complement to one of the Risk and as the product of 'improbability' times 'saving', therefore:

$$Risk = (1 - Safeguard) = 1 - [(1 - Probability) \cdot (1 - Loss)] \quad (2)$$

The contour plot of the function (2) in natural scale axes is presented in Figure 3, using the same number of levels and limits of Figure 2.

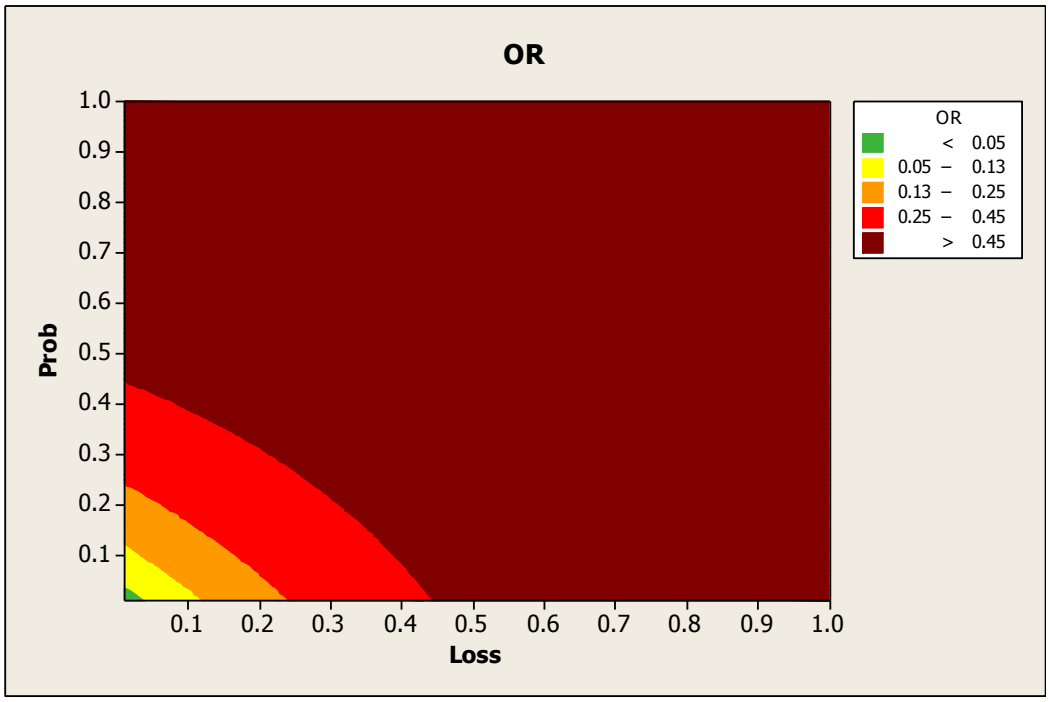
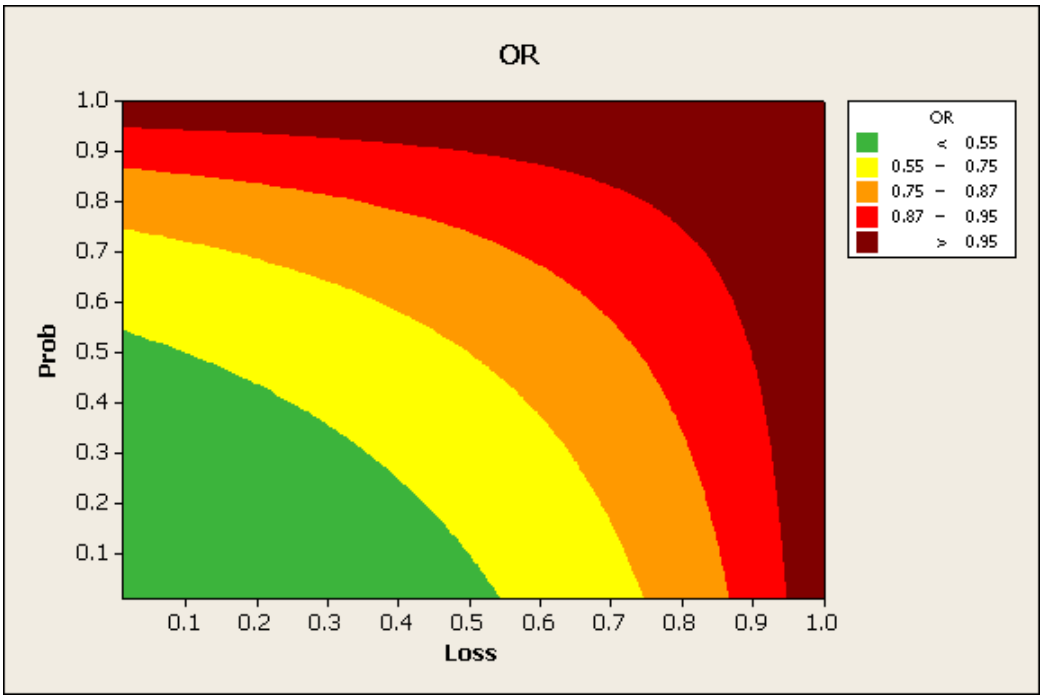


Figure 3. Contour plot of the Risk function expressed in (2)

By opportune rescaling, in order to obtain five almost equispaced zones, limits have to be changed. Hence Figure (4).



However any rescaling does only affect an absolute evaluation of risk, but not a relative evaluation, i.e. when comparing different alternative scenarios.
The advantages of the measure of Risk expressed by (2) are evident.
In fact:

- 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.

The last property is in line with the precautionary principle.

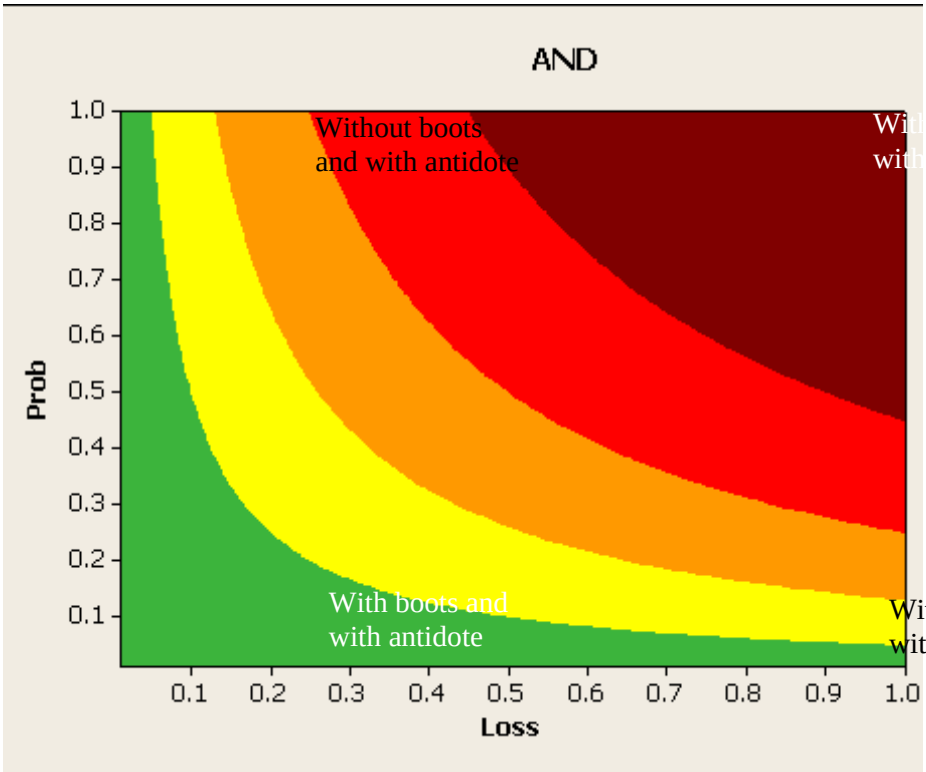
We are compelled to reduce both severity and probability (whenever possible) to have an activity that can be declared SAFE; this is a path towards a real continuous improvement process that cannot be stopped when one or another of the two terms is minimized.

An illustrative example

To clarify the difference on applying the two investigated measures, 'AND' and 'OR', we use an illustrative example: a walk in the countryside.
A possible danger when walking in the countryside is a viper bite. The consequences of the viper bite can be minimized using an antidote, while the probability of being bitten can be minimized by using boots.

According to the traditional ‘AND’ logic a very risky action is committed only when not using boots and not bringing an antidote. While it seems sufficient, for reducing the risk level to an “acceptable” one, to adopt just one precaution.

Conversely, according to the ‘OR’ logic here proposed, this is excluded. Not bringing an antidote OR not using boots keeps the level of risk at high levels. Only bringing antidote and using boots implies a low risk.



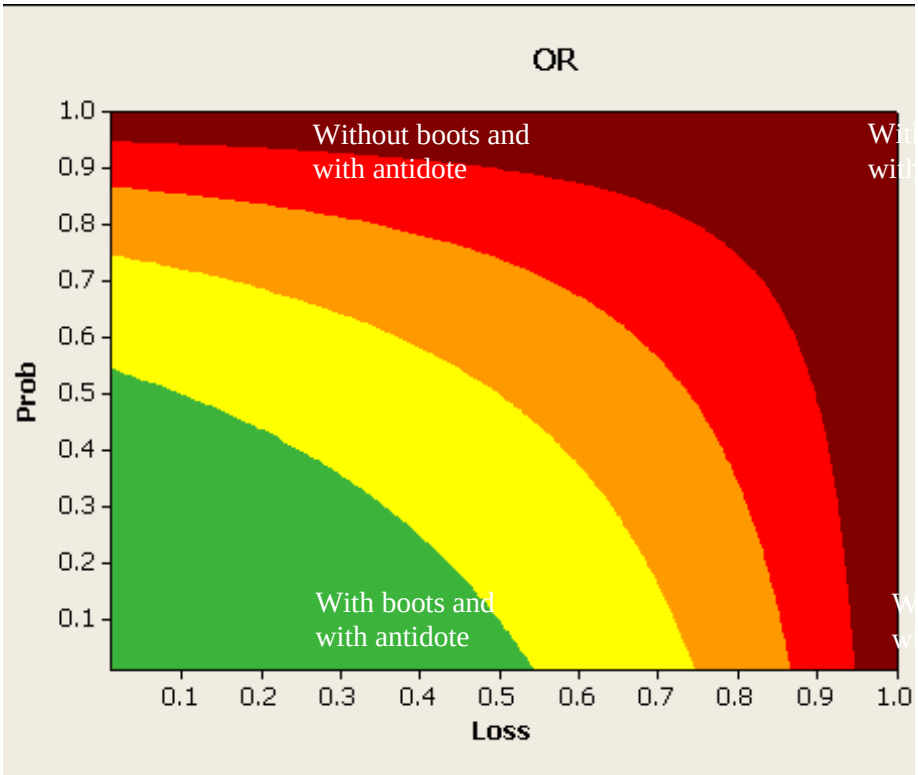


Figure 4. Comparison of the Risk logics AND (Figure a) and OR (Figure b), through an illustrative example.

Conclusions

The 'AND' logic, directly deriving from the measure of Risk as 'expected consequence', i.e. the product of *Probability* times *Loss* is a simple and effective measure that can be used (and it is used) to give managers the ability to assess the risk level of an activity and then to rank possible alternatives. This logic, also expressed through a traditional Risk matrix, where both *Probability* and *Loss* are discretized in e.g. five levels, in our opinion may be appropriate only for central values of the two factors.

Also in the corners low-probability/low-loss, and high-probability/high-loss, the assessments are fairly obvious and do not show weaknesses.

However, when we consider the two other corners, such definition of risk has big drawbacks.

The first reason is that often low probabilities are not perceived or interpreted correctly. The second reason is that some phenomena are not amortizable. The AND logic can be defined as the "manager's logic", where it is possible to dilute a potentially catastrophic event, which can very rarely occur, over a high number of other, lucky or successful, cases. This logic often presides over the decisions of Authorities and it is far from those who actually pay the real losses.
The alternative logic and consequent measure of Risk, that we have proposed here, privileges the perspective of citizens, who are unable to offset the consequences of a catastrophic event that could invest them, and therefore must seek to avoid in any way actions that could lead to disasters, albeit with low probability.

As a last reflection, consider the insurance contracts. The basis of their attractiveness lies in the fact that they match the AND manager's logic used by the company having the possibility of amortizing adverse events over large numbers, with the OR citizen's logic who prefer to pay a fee (although higher than the expected loss), rather than afford an enormous expense even very unlikely.

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