From *Risk Management* towards *Uncertainty Management*

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INTRODUCTION

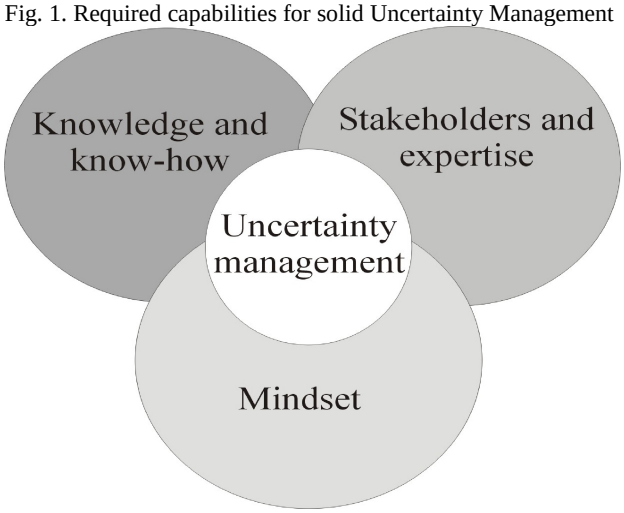
Risks are defined by ISO 31000:2009 (Risk Management) as 'the effect of uncertainties on achieving objectives' (ISO, 2009). Our world can indeed not be perfectly predicted and life and businesses are always and permanently exposed to uncertainties, which have an influence on the fact whether objectives will be reached or not. The only certainty there is about risks, is that they are characterized with uncertainty. All other features result from assumptions and interpretations.
The ISO definition implies that risks are two-faced: we call them negative risks if the outcome is negative and positive risks if the outcome is positive, although the same risks are envisioned.
Because risks cannot be eliminated, organizations should manage them in a way trying to minimize the negative outcomes and attempting to optimize the positive outcomes. Such management is called Risk Management (RM) and contains, amongst others, a process of risk identification, -evaluation, -mitigation and -transfer (insurance) aiming at being in control of all existing risks, whether they are known or not, and whether they are positive or negative. Risk Management has been developed over time and within many sectors in order to meet diverse needs. The adoption of consistent processes within a comprehensive framework can help to ensure that risk is managed effectively, efficiently and coherently across an organization. However, in current industrial practice, risk management is only focused on negative risks, and only on avoiding losses, instead of simultaneously avoiding losses and producing gains. This is mainly due to the fact that companies tend to consider 'risk managers' as 'negative risk managers', for historical reasons: risk managers have been appointed in organizations mainly due to legislative reasons or due to incidents and accidents that happened within firms, and hence the only risks that needed to be managed were possible negative consequences.

Nonetheless, a variety of approaches exists to tackle and manage negative and positive risks in one go. Most of these approaches are focused on certain domains. This implies that the management approaches are not applicable in all circumstances, on all levels and for all situations and organizations. The most well-known examples of approaches (sometimes inspired by total quality management and/or financial risk management) include EFQM (Van Nuland et al., 1999), ERM (Chapman, 2007), The Balanced Scorecard (Kaplan and Norton, 1996), lean management (King, 2009), Corporate Sigma (El-Homsi and Slutsky, 2010), etc. To take all aspects of risks into account and to take optimal decisions, risks should thus be viewed from a holistic viewpoint, meaning that all relevant stakeholders and experts should be involved in the risk management process, and that all possible knowledge and know-how should be present.

The best available 'classic viewpoint' of risk management is one of (narrow) thinking of purely organizational risk management, and taking different domains within the company into account, integrating them to take decisions for maximizing the positive side of risks and minimizing the negative side of risks. The process for taking decisions in organizations should however be much more holistic than this. Risks are characterized by internal as well as external uncertainties. Hence, all these uncertainties and their possible outcome(s) should be anticipated, that is, identified and mapped, for every risk, and by different types of experts and stakeholders. If this can be achieved, the most optimal decisions can be taken. The end-goal is to use all the right people and means at the right time, to manage all existing risks in the best possible way, whether the risks are positive or negative, or whether they are known or not. After all, a part of risk management is "thinking about the unthinkable".

To manage uncertainties efficiently, a composite of 3 building blocks (knowledge and know-how, stakeholders and expertise, and mindset) can be conceptualized, as illustrated in Figure 1.

Fig. 1. Required capabilities for solid Uncertainty Management



For each of the building blocks, needed by an organization to efficiently perform uncertainty management, some recommendations can be suggested. To deal with the knowledge and know-how needs, cognition should be present in the organization about past, present and (e.g. scenario-based) future data and information, and about risk taking-, risk averting-, and risk neutral items. Furthermore, the organization should collect info on laws and regulations, rules and guidelines, and best practices and ideas, and it should gather it on the procedural, technological and people's domains. To address the stakeholders and expertise building block, involvement should be considered from different organizations, authorities and academia, as well as from other stakeholders (clients, personnel, pressure groups, media, surrounding communities, etc.), and from different types of disciplines (engineers, medical people, sociologists, risk experts, psychologists, etc.), and used where deemed interesting. The mindset building block indicates that some principles should be followed for adequate uncertainty management: circular-, non-linear-, and long-term thinking, law of iterated expectations, scenario building, and the uncertainty principle, and operational, tactic, and strategic thinking. All these requirements should be approached with an open mind. Section 4 of this Chapter explains these principles to a greater extent.

The risk management discipline (or rather the uncertainty management discipline) can be compared with the mathematics discipline: both disciplines are commonly regarded as 'auxiliary science' domains, helping other 'true sciences' to get everything right. In case of mathematics, true sciences indicate physics, chemistry, bio-chemistry, and the alike: without mathematics, these domains would not be able to make exact predictions, conclusions, recommendations, etc. The same holds for risk/uncertainty management: without this discipline, applied physics, industrial chemistry, applied bio-chemistry, etc., lead to sub-optimal results and achieving objectives will be hampered. Hence, mathematics is needed for correct laws in physics, chemistry, etc., and risk management is required for optimized applications in physics, chemistry, etc. Bearing this in mind, it should be noted that although (negative) risk management has proved to be extremely important the past decades to save lives and/or to avoid illnesses and injuries in all kinds of organizations, major and minor accidents as well as occupational illnesses are still very much present in current industrial practice. Hence, there is still room for largely improving (negative) risk management and it can be made much more effective. How this can be theoretically achieved, and at the same time improved by taking advance of the opportunities of risks will be explained hereafter.

UNCERTAINTY TYPES

Roughly, three types of uncertainties can be distinguished: uncertainties where a lot of historical data is available (type I), uncertainties where little or extremely little historical data is available (type II), and uncertainties where no historical data is available (type III). From the viewpoint of negative risks, consequences of type I uncertainties mainly relate to individual employees (e.g. most work related accidents), the outcome of type II uncertainties may affect a company or large parts thereof (e.g. large explosions, internal domino effects, for this sort of accidents the reader is referred to Lees (1996), Wells (1997), Kletz (1999 and 2003), Atherton and Gil (2008), Reniers (2010)), and type III uncertainties for example have an unprecedented and unseen impact upon the organization and society.

Thus, whereas type I negative risks lead to most work-related accidents such as falling, little fires, slipping, etc., type II negative risks can result in catastrophes with major consequences and often with multiple fatalities. Type II accidents do occur on a (semi-)regular basis in a worldwide perspective, and large fires, large releases, explosions, toxic clouds, etc. belong to this class of accidents. Type III negative risks may transpire into 'true disasters' in terms of the loss of lives and/or in terms of economic devastation. These accidents often become part of the collective memory of humankind. Examples include disasters such as Seveso (Italy, 1976), Bhopal (India, 1985), Tchernobyl (USSR, 1986), Piper Alpha (North Sea, 1988), 9/11 terrorist attacks (USA, 2001), and more recently Deepwater Horizon (Gulf of Mexico, 2010) and Fukuchima (Japan, 2011).

For preventing type I risks turning into accidents, risk management techniques and –practices are widely available. The interested reader is e.g. referred to Greenberg and Cramer (1991) and/or CCPS (1992). Statistical and mathematical models based on past accidents can be used to predict possible future type I accidents, indicating the prevention measures that need to be taken to prevent such accidents.

Type II uncertainties and related accidents are much more difficult to predict. They cannot be predicted via commonly used mathematical models since the frequency with which these events happen, is too low and the available information is not enough to be investigated via e.g. regular statistics. The errors of probability estimates are simply too large to be able to use such probabilities (Taleb, 2007). Hence, managing such risks is based on the scarce data that are available and on extrapolations, assumptions and expert opinions (see e.g. Casal, 2008). Such risks are also investigated via available risk management techniques and –practices, but these techniques should be used with much more caution, since the uncertainties are much higher for these types of risks than for type I risks. Accidents related to type II uncertainties can be referred to as 'fractal accidents', since a lot of risks (and latent causes) are present which never turn into large-scale accidents due to adequate risk management, but very few risks are present that turn into accidents with huge consequences. In other words, these risks can be regarded as fractal and following a power law. In simple terms, the large majority of fractal accidents have minor consequences, but a very small fraction of fractal accidents leads to huge consequences. Such accidents are characterized by fractal 'sudden variation' (following a power law and its accompanying exponent), and not by Gaussian variation. Hence, highly specific mathematical models should be employed for determining relative risks.

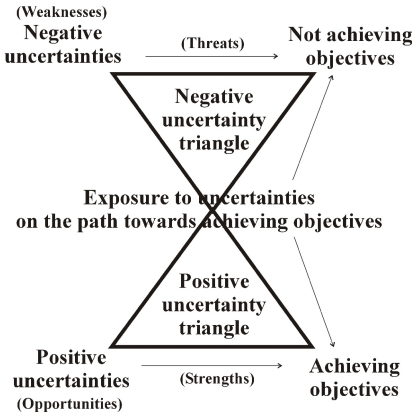
The third type of uncertainties are extremely high, and their related accidents are simply impossible to predict. No information is available about them and they only happen extremely rarely, as a result of a number of simultaneously occurring circumstances. They are the result of pure coincidence and they cannot be predicted by past events in any way, they can only be predicted or conceived by imagination. Such accidents can also be called 'black swan accidents' (Taleb, 2007). Such events can truly only be described by 'the unthinkable' (which does not mean that they cannot be thought of, but merely that people are not capable of (or mentally ready to) realizing that such event really may take place). Physicist Richard Feynman's dissenting opinion in the Rogers Commission Report offers the perfect perspective: by NASA's risk management protocols, perhaps among the most sophisticated work on risk, the failure rate for the space shuttle orbiter was determined to be one in 125,000. Feynman used a common-sense approach, asking scientists and engineers the approximate failure rate for an unmanned rocket. He came up with a failure rate of between 2% and 4%. With two failures – Challenger and Columbia – in the 135 missions, Feynman's back-of-the-envelope calculation was by far the more accurate (Balmert, 2010).

RISKS SEEN AS UNCERTAINTIES FOR MAKING DECISIONS

Risk means different things to different people at different times. However, as already mentioned, one element characterizing risk is the notion of uncertainty. That is, for the omniscient or omnipotent the risk concept would be incomprehensible. The future of events, handlings, circumstances, etc. cannot be perfectly predicted. Unexpected things happen and cause unexpected events. In business context, these events can have positive or negative consequences for an organization.

On the one hand, to enhance innovation and to induce changes having positive consequences for business, many firms have specific departments (for example Research & Development or Marketing & Prospection departments) and specific R&D-, marketing-, or innovation managers. On the other hand, to improve safety records and to reduce unwanted events having negative consequences, companies have (operational) risk managers (and a risk management department). By dividing these two important domains having possibly an impact on the organization's future, companies fail to seize the opportunity to treat both future-related domains as one 'department of uncertainty' and to integrate the disciplines and knowledge domains for both positive and negative risks. Analogous to the Risk Sandglass from Reniers (2011), an 'Uncertainty Sandglass' can be drafted, and the well-known SWOT analysis technique can be related to the concept. Figure 2 displays the Uncertainty Sandglass, with Strengths, Weaknesses, Opportunities and Threats situated within the concept.

Fig. 2. The Uncertainty Sandglass



As probably known by most readers, SWOT is an abbreviation for Strengths, Weaknesses, Opportunities and Threats. A SWOT analysis is a strategic planning method involving specifying the envisioned objectives of e.g. a business venture or a project and identifying the internal and external factors that are favorable and unfavorable to achieve those objectives. In relation with the Uncertainty Sandglass, the different parts of a SWOT analysis are indicated in Figure 3. Using the principles of a SWOT analysis (that is, identifying positive as well as negative uncertainties) has the advantage that risk managers (or rather *uncertainty managers*) close the gap between line management and corporate- or top management regarding taking decisions on existing uncertainties in the organization. By not only focusing on the negative side of risks (weaknesses and threats), but by also emphasizing the positive side of risks (strengths and opportunities), an approach is adopted by the uncertainty manager which is easily understandable by top management.

The most influential research into how people manage risk and uncertainty has been conducted by Kahneman and Tversky, two psychologists. One of their most interesting findings is the asymmetry between the way people make decisions involving gains and decisions involving losses. Their research results include that when the choice involves losses, people are risk-seekers, whereas when the choice involves gains, people are risk-averse. In other words, people tend to not gamble with certain gains, but they tend to gamble with uncertain losses. Other research results indicate inconsistency with the assumptions of rational behavior and people being loss-averse, rather than risk-averse. People are apparently perfectly willing to choose a gamble when they consider it appropriate, and they not so much hate uncertainty, they hate losing. Losses are likely to provoke intense, irrational, and abiding risk-aversion, due to the fact that people are much more sensitive to negative than to positive stimuli.
These results from human psychology and human decision making have important repercussions on risk decision making in companies, especially concerning negative risks. Operational risk managers and middle- or top management tend to gamble with uncertain losses, possibly leading to major accidents. They often fail to recognize the huge hypothetical benefits resulting from prevention. Reniers and Audenaert (2009) however indicate that accident avoidance benefits, that is, the prevention of accidents result in avoidance of a number of direct and indirect costs and thus create hypothetical benefits. Such benefits resulting from non-occurring accidents can be quite substantial, expressed in monetary terms.

Hence, due to the inconsistent understanding and meaning of the risk concept by people and due to irrational risk decision making, it is essential that 'risks' should be regarded as 'uncertainties' in companies. By treating uncertainties instead of risks, and by taking all possible knowledge and all stakeholders into account, large potential losses and small potential losses and at the same time large potential gains and small potential gains can be linked, and decisions can be taken in a more consistent way. The less uncertainty there is concerning the possible consequences of a decision, the more it is possible to make adequate and good decisions. This is typically the case for type I risks, and much less the case for type II risks. One should always try to avoid type III risks with possibly huge negative consequences.

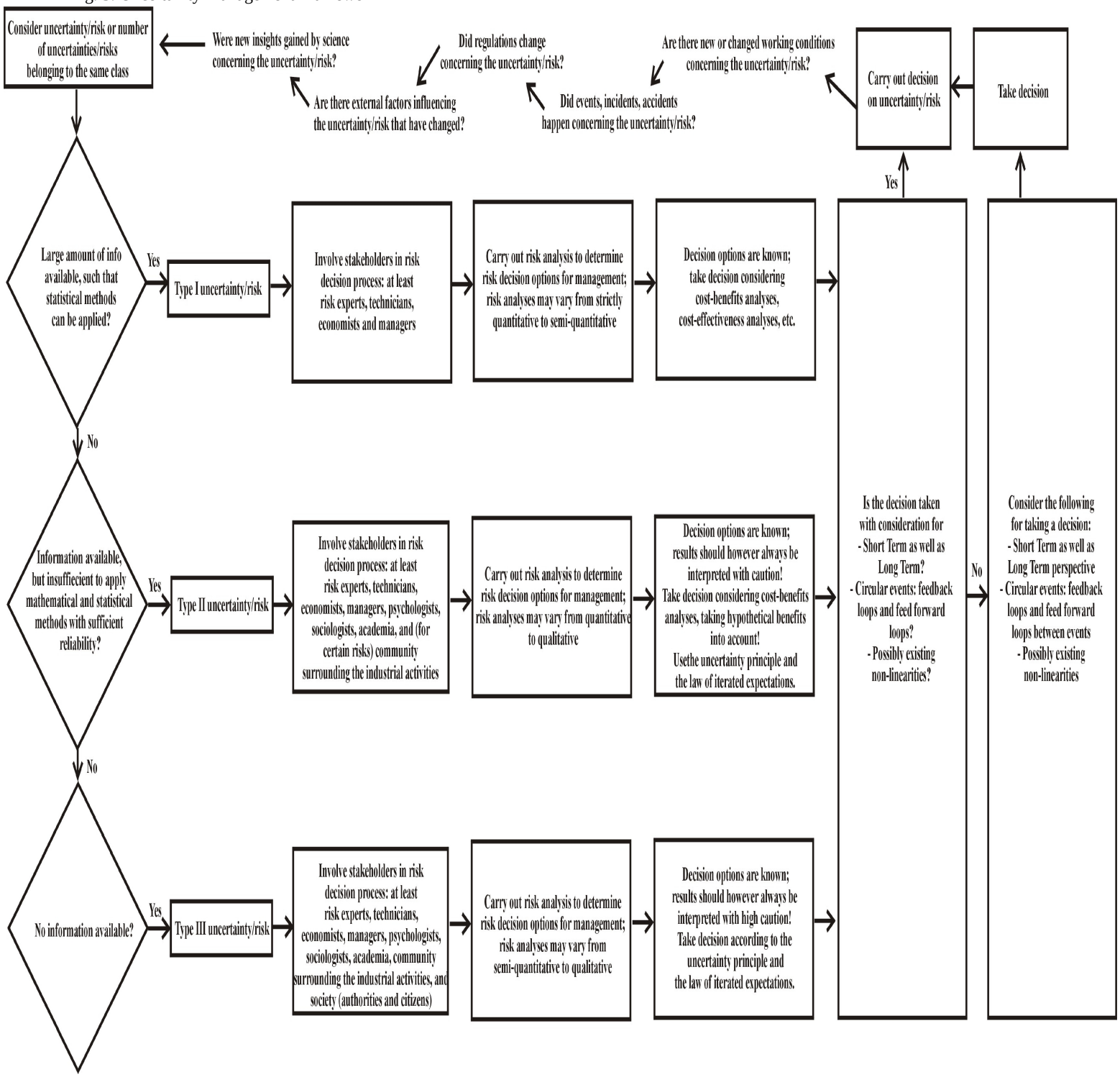
DEVELOPING A FRAMEWORK FOR UNCERTAINTY MANAGEMENT

On the surface, risk management in an organization seems to be all about avoiding any type of unwanted event. All undesired happenings, either with large consequences or with a minor outcome, or with high or low likelihood, are treated by the risk management department within a company on the same psychological level. But as we will argue hereafter, this psychological level, and thus the management decisions taken, should be different for different types of risks.

It is obvious that, taking the positive side of risks into account, a decision-maker can be risk-taking in the case where a lot of historical data is available, since he has some knowledge from past events in this area and since the possible negative outcomes (which are never extremely severe in this case) can be predicted quite accurately by using scientific models, statistical methods, etc., since sufficient information is available. Hence, making profits in this type I area follows from taking positive risks and keeping the negative sides of these risks well under control. Profits are tangible and follow from investment choices, production decisions and risk management strategies (amongst others).
However, a decision-maker must be very careful to be risk-taking (for making profits) in the fractal or the black swan area, since the possible negative consequences in these areas are possibly very high. Actually, making 'profits' in the fractal and the black swan areas follows from averting risks: profits in these areas are intangible and hypothetical. Non-occurring accidents (and their accompanying costs) resulting from risk averting behaviour of a decision-maker, should be regarded as a true and large hypothetical benefit in these areas. Besides classic industrial sectors with the possibility of major accidents such as the chemical industry or the nuclear industry, also the banking sector can be used as an example. One should for example be cautious taking risks in an economic growth period for making huge profits (which is possible in the type II and III areas), since in the event that a worldwide economic crisis occurs (as has been the case in 2008 for example), financial disaster may strike. Hence, non-occurring huge financial losses in a bank (which might be realized in the case of a sudden global economic crisis) as the result of careful risk management (aimed at making profits in the type I area) in the economic prosperous period, should be regarded as true and huge hypothetical gains in the fractal and black swan areas.

Hence, decisions to take risks, or indeed to avert them, depend on the character of the risks (that is, the type of the risks) and their accompanying uncertainties and objectives. Moreover, hypothetical (short term and long term) benefits should be taken into account when taking decisions concerning type II and III uncertainties and risks.
A Framework for Uncertainty Management is suggested in Figure 3 to meet with all the aforementioned goals.

Fig. 3. Uncertainty Management Framework



The uncertainty management framework first considers the different types of risk depending on the amount of data and information which is available. For the different types of risks, different sets of stakeholders are involved; the more uncertainty there is, the more stakeholders need to be involved, since not only the know-how to deal with risk analysis techniques is required, but also open-mindedness, the willingness to collaborate, and viewpoints from other, non-purely technological disciplines, can make the difference to make good or poor decisions. In the next step of the Framework, risk analyses are carried out. A risk analysis method which can for example be used for all three types, is scenario building. Scenario building is well known and much used by risk experts. Scenarios are drafted based on past events or by imagining future events using a variety of available techniques such as risk analysis techniques, the Delphi method, etc. Scenarios lead to a better understanding of possible futures, and what can be done to prevent some of the possible unwanted futures, and/or to enhance the emergence of possible wanted futures. It should be noted that the more information is available, the less uncertainty there is, and the more quantitative character the used risk analysis can have. With no or extremely little data available, quantitative analyses should be avoided. At the best, semi-quantitative analyses might be employed for high uncertainties, and the results should always be treated and interpreted with much caution.

When the decision options are known, some further principles should be followed when taking decisions: at least the law of iterated expectations and the uncertainty principle. The law of iterated expectations simply states that if an event (e.g. an accident) can be expected somewhere in the future *with a certain probability*, then the event can also be expected at present. Following this principle implies that measures should be taken for preventing some events, among them some of the fractal and black swan events, as if they might happen now. The uncertainty principle (following reasoning according to the precautionary principle (Rio Declaration on Environment and Development, 1992)) states that it is not because a cause-consequence relationship between any two variables cannot be proven, that such a relationship does not exist, in other words, unknown complicated relationships (characterizing any complex phenomenon) should not be disregarded, whether the consequences are desired or undesired.

In the last step before carrying out the decision, a decision-maker should reflect on several important systemic principles. It is therefore recommended that every decision is approached by thinking in the long term, thinking circular, and thinking non-linear. Long-term oriented indicates that risk decisions should not only be taking short- and medium term into account, but also the (very) long term, thus leading to more sustainable risk decisions. Circular thinking and non-linear thinking are concepts used in systems thinking (Senge, 1990; Senge *et al.*, 1994; Byran *et al.*, 2006). System thinkers see wholes that function rather than input-output transformers; they also see the parts of the whole and the relationships among them; they see patterns of change rather than static snapshots. Positive and negative feedback loops exist between events. These feedbacks are not necessarily linear, meaning that one should think in terms of 'changes of A and B in the same or opposite direction', rather than 'a pre-defined increase or decrease of B due to a specific increase or decrease of A'. Such an approach guarantees more profound and well-considered decisions.

When decisions have been taken, the decision-maker should regularly monitor whether no changes have occurred concerning the decision. If this was the case, the risk/uncertainty should be subject to the risk decision process again.

Summarizing, this Framework aims to obtain objective and consistent results, for the different existing types of uncertainties. Assessments which are subject to small uncertainties should be treated differently from assessments subject to large uncertainties, in a way that under different assumptions and/or the use of other analysts, the decision options and –results concerning any uncertainty or risk should not be different. Solutions and decisions should only depend – or partially depend – on probabilities and probability estimates under certain conditions and circumstances. As Aven (2010) already suggests, risk assessments need to provide a much broader risk picture than is typically the case today. Separate uncertainty analyses should be carried out, extending the traditional probability-based analyses.

The Framework is generic in its application, indicating that any uncertainty/risk can be tackled by it, and recognizing the negative as well as positive consequences of risks. In general terms, the negative side of risks should always be minimized and the positive side should always be maximized. This Framework recognizes that this is not always the best solution leading to optimal decisions, and addresses the need to sometimes 'balance' negative and positive consequences rather than opt for one or the other, to be able to ensure long-term success of – and long-term profits within – any organization.

CONCLUSIONS

Company management should be aware that uncertainties and risks should not be rooted out, and that they should not be considered as some kind of evil that detracts from managers' abilities to manage with control in an organization. Uncertainty – and thus risk – should be recognized by company decision makers as two-faced, creating obstacles for the organization in generating profits and ensuring consistent performance, as well as presenting opportunities for improvement and innovation. Moreover, different levels of uncertainty require different stakeholders, different levels of quantitativeness of risk analysis techniques, different principles to be followed, etc. The Framework for Uncertainty Management which was elaborated in this

article takes this into account and offers decision makers within companies the possibility not only to manage (negative) risks, but to manage uncertainties. Such an approach leads to better risk decision making and long-term organisational success.

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