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Risk and uncertainty in project management decision-making

Karolina Koleczko
Bond University

RISK AND UNCERTAINTY IN PROJECT MANAGEMENT DECISION-MAKING

KAROLINA KOLECZKO

ABSTRACT

Today, managing for risk and uncertainty are cornerstones of the project manager's role. It is common practice for practitioners to use the terms risk and uncertainty interchangeably which can be unhelpful when managing long-term and complex projects, minimising adverse impacts and taking advantage of upside opportunities that may develop. However, the literature points to important differences in practices to measure, cost, mitigate and manage project risk and deal with future uncertainty which suggests that the distinction may warrant greater understanding at the project level.

Contemporary project management requires practitioners to understand a great deal about the risk profile of a project and manage in conditions of uncertainty. This is especially the case with long-term infrastructure projects. Managers also need to understand a client's risk appetite, carry out risk-weighted measurement of costs, and make decisions about those risks that can be absorbed with reasonable confidence, and those that should be transferred. Additionally, the manager is required to prepare risk mitigation and management strategies and anticipate future uncertainty in the form of externalities that threaten project outcomes.

This paper distinguishes between risk and uncertainty in the project management context and examines how the distinction influences decision-making in contemporary project management with particular focus on probability and judgement. It also argues that project managers should consider a wider set of variables when considering the impacts of risks and unpredictable future events including the behavioural responses of agents, the role of ownership and control, and the complex relationship between bounded rationality, experience and judgement.

KEYWORDS:
Risk & Uncertainty, Bounded Rationality, Project Management.

BACKGROUND

In order to obtain their objectives for projects, project managers must be prepared to take risks and face uncertainties. Evidently, there are no shortages of risks and uncertainties to challenge a project manager's ability to manage a project. New technologies, competition, globalisation, and innovations in products and processes will influence an even more complex and dynamic decision-making environment (Csiszar, 2008).

The capability of project managers to identify, assess, and manage for risk and uncertainty is necessary for effective decision making, as the potential returns from those decisions are weighed against the costs associated with bearing and managing them. Risk and uncertainty have real impact on project returns, stakeholder cash flow and shareholder value, and it is therefore fundamental that the project manager has the capacity to manage both (Csiszar, 2008; Rodger & Petch, 1999).

At their most basic level, risk and uncertainty are fundamentally multifunctional and multidisciplinary concepts, applicable in accounting as much as in finance, marketing, operations, human resource management and organisational design. Risk and Uncertainty influence all that a project manager must do in order to succeed. Additionally, risk and uncertainty involves concepts from other disciplines such as engineering, mathematics, sociology, psychology and human behaviours (Csiszar, 2008).

Studies in risk and uncertainty have not been limited to theoretical studies only, but have easy confluence with more practical interests. Many industries, for instance, have tried to implement risk management process, but not all have succeeded for example, in capital markets, predicting business cycles & economic forecasting). Managing risk and uncertainties presents one of the most challenging subjects for both academics and practitioners alike. Risk and uncertainty are, after all, not entirely new subjects, however as a tool in business, uncertainty and risk analysis has historically lacked sound use. This is surprising, considering that many business decisions are

based on a figure that has been calculated from analysis of some kind. A number on its own is only half the picture; to fully understand the result it is necessary to have an estimate of the probability that the expectation will be realised (Rodger & Petch, 1999).

It is frequently the case in project appraisals that considerable effort goes into forecasting future values, but very little time is spent understanding the uncertainty around that value. It is common practice for practitioners to use both risk and uncertainty interchangeably. However, the distinction between both is important, to understand and create management strategies to minimise, monitor, and control the probability and/or impact of unfortunate events or to maximise the realisation of opportunities (Rodger & Petch, 1999). The following sections of this paper will discuss the distinction between risk and uncertainty, and its significance to contemporary project management and decision making.

RISK

Consider the following illustrative definition of a project: an endeavour in which human, material and financial resources are organised in a novel way, to undertake a unique scope of work of given specification, within constraints of cost and time, so as to achieve unitary, beneficial change through the delivery of quantified and qualitative objectives (Turner, 1992). In this day and age, successful project outcomes are contingent upon robust risk management practices that support the realisation of project objectives and future benefits in the most sustainable and economically efficient manner. As mentioned, undertaking efficient risk analysis will not only aid in the success of a project, but it allows the project management team to identify risks that are likely to produce an outcome at variance to expectation (Rodger & Petch, 1999). In other words, the probability of a risk event can be estimated on the evidence of past precedent. Uncertainty, which will be examined later in this paper, cannot be ascertained.

In project management, risk is the measure of the probability and consequence of not achieving a defined project goal. It is of common opinion that most people agree that risk involves a notion of uncertainty. Yet, when considering risk, the consequences or damage associated with the event occurring must also be taken into account. To evaluate risk is not always a simple task, since the probability of occurrence and the consequence of occurrence are usually not directly measurable parameters and must be estimated by judgement, statistical, or other procedures. In broad terms, as either the probability or consequence increases, so does the risk. Both the probability and consequence must be considered in risk management (Kerzner, 2009).

To understand the importance of risk, a better understanding of project management is required. Project management, a discipline of planning, organising, securing, and managing resources to achieve specific predetermined expectations, faces various challenges. Primarily, the challenge is to achieve all project goals and objectives while honouring the preconceived parameters such as scope, time, specification, quality and budget matters within the control and authority of the project manager (Kerzner, 2008). To achieve this, it necessitates both a practical risk management methodology that promotes the early identification and escalation of project related risks (and opportunities), and a portfolio approach that ensures that risks are managed in an integrated and cost effective manner across the whole portfolio of project activities. Together, these enable more informed decision making, and strengthen management agility in the face of uncertainty and change. Thus, the importance of risk to project management can be illustrated in the difference between bringing in cost on budget, achieving a revenue or profit objective, succeeding or failing as an enterprise, and maintaining credibility in the eyes of stakeholders (Rodger & Petch, 1999).

In the case of project management, all commercial and professional activity is a gamble on the future. Accordingly, risk requires both science and judgement to identify the probability of risk. Probability theory, a branch of mathematics concerned with the analysis of random phenomena (Bernstein, 1998), states that the outcome of a random event cannot be determined before it occurs; it may though be any one of several possible outcomes. Friedman argued that human beings can attach probabilities to every conceivable event. In the classical theory of decision making, under conditions of risk, the utility of each outcome is weighted by its probability of occurrence (Tversky & Fox, 1995). Science and judgement continues through to risk measurement, where probability of occurrence and impact are weighted and decisions are made concerning placement of mechanisms for mitigating and managing risk. Ensuring that risk does not produce outcomes beyond the expectations of managers, expected utility theory was developed to understand and explain attitudes toward risk, namely, risk aversion and risk seeking, especially concerning the process of decision making. Theoretical constructs in risk have been studied for over a century (Bernstein, 1998) to better understand its effects in practical application.

PROBABILITY

Probability theory is a major instrument for forecasting, but the quality of information that forms the basis of probability estimates will ultimately dictate the quality and accuracy of expected outcomes (Kerzner, 2009). When complete knowledge of the future or even of the past is

impossible to achieve, how comprehensive and accurate is the information that is to be utilised? As previously mentioned, the theory of risk has been studied for centuries, yet the development of a forecasting tool for real life project management situations has not advanced very far. Probability utilises historical event observations to predict future occurrence (Regan, 2011). It is a complex task to make decisions about future events in conditions of uncertainty. As stated by Jacob Bernoulli, only in rare cases does life replicate games of chance, for which we can determine the probability of an outcome before an event occurs – a *priori*. In most cases, we have to estimate probabilities from what happened after the fact – a *posteriori*. Jacob Bernoulli's theorem for calculating probabilities a posteriori, known as the Law of Large Numbers, notes that there will always be a possibility that the observed result will differ from the true average by a larger amount than the specified bound (Bernstein, 1998). This observation saw John Maynard Keynes and Warren Buffet playing it smart on the stock market at different times in the 20th Century, by creating buffers as *margins of safety* in order to compensate for imprecision and absorb 'the effect of miscalculations or worse than average luck' (Walsh, 2007). This form of value investment concentrates on ex ante downside risks prior to investing by seeking to ensure a sufficient margin of safety in respect to any potential purchase.

Probability is commonly used as a method of quantitative risk analyses. In project management, quantitative risk analysis outputs can be used in a variety of ways, including but not restricted to developing (Kerzner, 2009) prioritized risk lists; probabilistic cost estimates at completion per project phase and probabilistic schedule estimates for key milestones to help the project manager allocate reserve accordingly; probabilistic estimates of meeting desired technical performance parameters and validating technical performance of key components; and estimates of the probability of meeting cost, technical performance, and schedule objectives. It is crucial to produce accurate quantitative risk analysis results which can be achieved by developing an accurate model structure and incorporating accurate probability information. In the case of project risk management, Kerzner (2009) stated that there is often insufficient attention given to each of these items, and the outcome can be inaccurate. Thus, it is important that the design of the model be carefully developed and validated before any output is used for decision making. If the outcomes cannot be represented by one or more point values (i.e. decision tree approach), then probability distributions should be used. The quantitative stochastic analytical approach process is a methodology that incorporates a model structure and probability distributions. When applied to risk management, this process can create a series of probability distributions for potential risks which are randomly sampled. The process continues by transforming these numbers into useful information that reflects quantification of the associated cost, technical performance or schedule risks. It is important to note that for the stochastic analytical approach and other quantitative risk analysis methods, if information is not carefully obtained and accurate, the results can be misleading, if not erroneous (Kerzner, 2009).

Probability in practice was also examined by Keynes in his General Theory, which explored how periodic informational cascades can compromise efficiency of investment decisions, but also that investors cannot be the rational actors of classical theory because a cold calculation of expected outcomes is simply not possible. Keynes observed that there are some events for which 'there is no scientific basis on which to form any calculable probability whatever'. He was noted stating that, 'the outstanding fact is the extreme precariousness of the basis of knowledge on which our estimates of prospective yield have to be made. Our knowledge of the factors which will govern the yield of an investment some years hence is usually very slight and often negligible...' (Walsh, 2007). Yet, the Bayesian system provides a process in which new information is used to revise probabilities based on old information or, in the language of the statisticians, to compare posterior probability with the priors (Bernstein, 1998). Jacob Bernoulli has provided an agenda for debating the managing of risk through the use of his three requisite assumptions: full information, independent trials, and the relevance of quantitative valuation. The relevance of these assumptions is critical in determining how successfully we can apply measurement and information to predict and make judgements about the future (Bernstein, 1998).

JUDGEMENT

In managing for risk, the project manager must rely upon sound judgement and the use of the appropriate tools. The decision about how best to deal with risk is based in part upon the project manager's tolerance for risk, along with contractual requirements, stakeholder preference, and so forth (Kerzner, 2009). Decision-making falls into three categories: certainty, risk and uncertainty. Jacob Bernoulli declared that probability is the degree of certainty and differs from absolute certainty as the part differs from the whole. A condition of moral certainty exists when we are almost completely certain (Bernstein, 1998). This data is drawn from sufficient observations. The appropriate test here is that the sample observations are independent and outcomes are assumed to represent a balance of probabilities (Regan, 2011). Decision making under certainty implies that we know with 100 per cent accuracy what the states of nature (outcomes) will be and what the expected payoffs will be for each state of nature. There will be one strategy that will produce larger gains or smaller losses than any other strategy for all the states of

nature, irrespective of which state of nature exists under certainty. However, with decision making under risk, there is not usually one strategy that dominates for all the states of nature over which we have no control. In a realistic situation, higher profits are usually accompanied by higher risks and therefore high probable losses (Kerzner, 2009). When there does not exist a dominant strategy, a probability must be assigned to the occurrence of each state of nature, as discussed previously in this paper.

In the early days of project management on many commercial programs, the majority of project decisions heavily favoured cost and schedule. This favouritism occurred because we knew more about cost and scheduling than we did about technical risks. In this digital age where technological advancements are made every year, to aid with decision making, technological forecasting is being utilised on many projects. For projects with a time duration of less than one year, it is typically assumed that the environment is known and stable, particularly the technological environment. For projects over a year or so in length, obsolescence forecasting must be considered. Kerzner (2009) states that computer technology doubles in performance about every two years and engineering technology is said to double every three or so years. Given the rapid change inherent with technology, forecasting allows project managers to make decisions regarding scope planning on long term projects without expecting somewhat uncertain engineering changes resulting from technology improvements.

It has been stated by economist Robert Shiller, that 'elaborate quantitative analysis may sometimes be an attempt to clothe mere hunches in a cloak of intellectual respectability'. He continues to point out that institutional investors often do not feel that they have the authority to make decisions in accordance with their own best judgements, which are often intuitive that they must have reasons for what they do, reasons that could be justified to a committee (Walsh, 2007). Thus risk management processes had been developed and implemented where risk information is to be made readily available to key decision-makers. Kerzner (2009) states that the risk management process should be designed to do more than just identify potential risks; it must also include a formal planning activity, analysis to estimate the probability and predict the impact on the project of identified risks, a risk response strategy for selected risks, and the ability to monitor and control the progress in reducing these selected risks to the desired level. A common view is that risk management provides decision makers with a rational process to validate their choices.

UNCERTAINTY

Uncertainty is a condition of project management, as we use assumptions and expectations in defining and realising the outcome of the project (Kerzner, 2009). Knight (1921), noted that there are two types of uncertainty. The first, measureable probability as discussed previously, Knight labelled 'risk', and the second, unquantifiable ambiguity, or uncertainty. In project management, risk can be assigned a probability value, whereas uncertainty is completely immeasurable (Regan, 2011). It is critical to note this distinction, as risk is concerned with objective probabilities, whereas uncertainty requires consideration of subjective probabilities (Rutherford, 1995).

Modern views of uncertainty assert that it is based not only on randomness but also on beliefs and behaviour. Cultural norms and other informal institutions of society have an observable effect on decision makers (Rutherford, 1995). Uncertainty is a condition of insufficient knowledge and, influenced by uncertainty, project managers can experience unpredictable periods of 'whim or sentiment or chance' and fall prey to 'purely irrational waves of optimism or depression'. 'Animal spirits', the 'spontaneous urge to action rather than inaction', as defined by Keynes, and inherent behavioural psychology embolden individuals and allow them to make decisions in the face of uncertainty (Walsh, 2007). Accounts of how people perceive and respond to uncertainty are basically grounded in psychology (Smithson, 2008). The problem faced by project managers is recognising which risk management approach is appropriate for the particular project at hand. There are few guides to inform the project manager in decision making under uncertainty. Managers are left with intuition and experience to guide their decision-making. Still to this day, studies (Meyer et. al., 2001) categorise risk as a 'type' of uncertainty. Therefore, to adequately discuss the influence of uncertainty on project management, we need to understand human responses to uncertainty.

Attitudes towards risk can be applied to understanding decision making under uncertainty, although this approach does not take into account human response to uncertainty. Risk is measureable and outcomes can be estimated and a contingent style of management can be adopted to manage the imprecision with forecasting. If a project manager were to attempt to apply a purely rational approach when anticipating uncertainties, they would be rendered immobile by the daunting 'what ifs' of an unforeseeable future. Keynes' paradox of *Buridan's Ass* illustrates why 'the necessity for action and for decision compels us as practical men to overlook the awkward fact that a uniquely correct valuation of an asset or event shrouded by uncertainty is impossible' (Walsh, 2007). Keynes believed that decision makers will resort to less analytical factors when assessing opportunities: *'to avoid being in the position of Buridan's Ass, we fall back on motives which are not 'rational' in the sense of being concerned with the evaluation of consequences, but are*

decided by habit, instinct, preferences, desire, will etc...' When something cannot be measured, what else can the decision maker fall back on? Here we can examine the psychology of uncertainty and its effect on decision making in project management.

Much of the study of decision making is concerned with the assessment of two attributes: the desirability of possible outcomes, the likelihood of occurrence, and the probability of achieving expected outcomes. Economists often criticise psychological research for its tendency to generate lists of errors and biases (Kahneman, 2003), yet it provides a basis to suggest that when evaluating a decision-makers response to uncertainty, various influential human factors may be taken into account. This can be illustrated in three situations: bounded rationality, incomplete contracts, and risk appetite.

Bounded rationality recognises that it is impossible to comprehend and analyse all of the possibly relevant information while making choices. It proposes an idea that in decision-making, rationality of individuals is limited by their formal training, experience, skill, the cognitive limitation of their minds, and the finite amount of time they have to make a decision (Elster, 1983). A further component is peer group pressures and the decision making that takes place in a group context, as opposed to individual (Flyvbjerg et al., 2006). The influence that peers and tendencies toward a consensus view suggest that decision making by groups may not be optimal. Bounded rationality can also be attributed to informal institutions of society including cultural norms and social capital (Flyvbjerg, 2005). These institutions are widely shared standard operating procedures (SOP) that facilitate decision making along with other various techniques and habits developed to cope with the complexity of the unknown. Herbert Simon proposed the notion of bounded rationality as an alternative basis for the mathematical modelling of decision making, as used in economics and related disciplines; it complements rationality as optimisation, which views decision-making as a fully rational process of finding an optimal choice given the information available (Elster, 1983).

Contract theory employs the notion of a complete contract, which is understood to be a contract that specifies the legal consequences of every possible state of the world (Maskin, 2001). Recent developments known as the theory of incomplete contracts, established by Oliver Hart and his co-authors, study the incentive effects of parties' inability to write complete contingent contracts, e.g. concerning relationship-specific investments. As it would be impossibly complex and costly for the parties to make an agreement to make their contract complete (Bolton & Dewatripont, 2005), the law provides default rules which fill in the

gaps in the actual agreement of the parties. Therefore an incomplete contract can be defined as a contract that does not address all future contingencies (Hart in Palgrave 2nd ed. 4/177). It is worth noting that the response to uncertainty in incomplete contracts and complete contracts will be different. Decision making in incomplete long term contracts is generally determined as events occur with the use of robust decision-making and alternative dispute resolution procedures. For example, a decision made at a point in a contract may be subject to different incentives than another point in time in that contract. This argument suggests that incomplete contracts give rise to the need for changes with built in mechanisms to compensate for uncertainty with the added benefit of flexibility.

The response of a decision-maker in core activities will be very different in areas where there is little understanding of the financial consequences of particular events (Kahneman, 2011). The advantage of decision making affecting core business activities is a better understanding of potential outcomes, lessons learned of previous experience and access to past solutions.

An orthodox view stated by Smithson (2008) states that there are typically three traditional views of human responses to uncertainty:

1. *The knowledge seeker,*
2. *The certainty maximiser,* and
3. *The intuitive statistician-economist.*

These are used to underpin most psychological approaches. We can take a further examination and explore how people manage in an uncertain world; within these views there are three uncertainty constructs that need to be examined, namely probability, delay and lack of clarity. It is also important to highlight an important link between uncertainty and emotion. This leads on to the literature of Keynes who examines the differences in orientation to ignorance and uncertainty and that of Tversky and Kahneman (1972, 1979, 1981) who stress the importance of reason-based choice, whereby individuals actively seek to generate, understand, and justify their decisions.

The first view rarely found in the project management environment is the 'knowledge seeker' which supports the individual who seeks new information and experience; is open to full and honest communication; can tolerate uncertainty and even ignorance in the short run in order to gain knowledge, and is not defensive about prior beliefs. This approach would seem idealistic in terms of developing current dependable data to base forecasting, because the process and the outcomes appear too great an investment. As stated previously in this paper, project managers often do not feel that they have the authority to make decisions in accordance with their own best judgements while faced with uncertainty, as they believe they must have justifiable, hard fact reasons for the bases of their decisions.

The second view presented by Smithson (2008), of the 'certainty maximiser', focuses on the debilitating consequences of uncertainty, unpredictability and uncontrollability for the affective, cognitive and physiological capabilities of the decision maker. Studies into this view (Gudykunst & Nishida, 2001; Berger & Calabrese, 1975) have proposed that anxiety is the emotional equivalent to uncertainty and that people are motivated to reduce uncertainty. This notion gives thought to Keynes' concept of 'animal spirits', and whether decision makers are urged to action rather than inaction to reduce the inherent psychological feelings of anxiety that are elevated as a consequence to the presence of uncertainty. Keynes summarised, '...a large proportion of our positive activities depend on spontaneous optimism rather than mathematical expectation, whether moral or hedonistic or economic. Probably most of our decisions to do something positive, the full consequences of which will be drawn out over many days to come, can only be taken as a result of animal spirits...and not as the outcome of weighted average or quantitative benefits multiplied by quantitative probabilities' (Walsh, 2007).

The third view, that of the 'intuitive statistician-economist', originates from perception and cognitive psychology and psychophysics, and reflects information processing models of cognition. This view typically represents common responses in project management to risk, as it is primarily concerned with criteria for rationality in judgement and choice, yet can present a restrictive process in which to deal with uncertainty. The dominate normative viewpoints, which have a lot in common with neo-classical economics, are probability theory and a view that humans as hedonic rent seekers, or in the case of project management, focussed solely on seeking profit and avoiding loss (Smithson, 2008). 'Rational' decision-makers order their preferences for outcomes and quantify those preferences into 'utilities' (net benefits/costs). This 'maximising subjective expected utility' continues by combining the probabilities and utilities to select the option whose outcomes, on average, are expected to deliver the greatest utility. Given that these elaborate models appear restrictive, much of the research (Kahneman & Tversky, 1982; Tversky & Fox, 1995) on this view has focused on judgemental and decisional errors, in the form of deviations from this rational methodology.

Many of the perspectives that have been discussed also take the position that while there may be objective uncertainties (risk), generally subjective uncertainty is more important for understanding how people, especially in project management, make judgements

and choices. Smithson (2008) notes that to date, there are three uncertainty constructs that have dominated the literature. The foremost construct, most relevant to project management, is probability or randomness. As noted, much of the behavioural decision literature treats probability as synonymous with uncertainty, yet both Knight and Keynes would argue that probability theory is utilised to measure risk but not uncertainty. So where does that leave us if most judgements under uncertainty are commonly assessed according to how well they conform to the rules of probability theory? Perhaps this leads us to the uncertainty construct of absence or lack of clarity in information. There were early attempts by Keynes (1921) to develop descriptive as well as prescriptive frameworks for decision-making when probabilities are unknown. Literature on risk perception and valuation provides an indication that individuals actually behave as if there are different kinds of uncertainty. Decision-makers do not evaluate risk on a single yardstick, however employ several dimensions.

An important conclusion to be drawn from decision-making under uncertainty, is the risk that the project manager wishes to incur. There are various criteria (i.e. Hurxicz, Wald, Savage and Laplace) that any strategy can be chosen by, depending on how much money the project manager can afford to lose and what risks they are willing to take (Kerzner, 2009). In the end, the difference between risk and uncertainty is that under risk, there are assigned specific probabilities, and under uncertainty, meaningful assignments of specific probabilities are not possible and decision-makers are left with making judgements based on information at hand, intuition, their knowledge of the project and its characteristics, and their attitudes and beliefs regarding the project. Tversky and Kahneman support this notion as their studies suggest, that people do not act as if they were the value-maximisers, rather they are claimed to be, by more rationally based theories. Individuals function as problem-solvers who creatively construct their choices and resolve complex problems which require trade-offs between values and goals; like so, preferences are created, rather than stimulated, within the process and context of choice itself (McDermott, 2001).

CONCLUSION

The classical theory of decision under risk and uncertainty combines the principle of mathematical expectation with the assumption of decreasing marginal utility, which jointly imply risk aversion (Tversky & Wakker, 1995). Through countless studies and theoretical analyses, each has attempted to explain risk attitudes that are inconsistent with expected utility. All have approached the problem utilising theoretical frameworks based on mathematical principles, yet it is crucial decision-making, and the human response to uncertainty is examined from a psychological standpoint. It is important to understand that the cognitive sciences have educated economists to pay attention to what people actually do instead of what they would do if they behaved rationally. An aim of this paper was to discuss risk and uncertainty and the importance of this distinction to contemporary project management. A particular focus was on how this distinction influences decision making.

The paper began by addressing the fact that many practitioners use the terms risk and uncertainty interchangeably, and various studies categorise risk as a type of uncertainty. But why is the difference significant to project management? This question led to the work of Tversky and Kahneman who demonstrated that people's attitudes toward risks concerning gains may be quite different from their attitudes toward risks concerning losses. Their conclusion was not that people's behaviour is irrational, but rather that it is important for analysts to recognise the asymmetry of human choices under different conditions, such as certainty and uncertainty (Bernstein 1996). Since project management is a discipline that is faced with various conditions throughout the life of each project, identifying these is critical, as it informs the project manager in their decision making. Keynes and Knight (1921) stated that as a general rule, risk is measurable using probability theory but uncertainty is not. This notion has been studied for over a century, in particular the theoretical constructs of risk, to better understand its effect in practical application. As a result, research, strategies and theories have been developed to deal with risk; above all probability has been largely used as a method of quantitative risk analyses in project management. In practice, probability is a serious instrument for forecasting, yet the quality of information that forms the basis of probability estimates will ultimately dictate the quality and accuracy.

When dealing with risk, project managers must rely upon sound judgement and the use of various methods and tools to guide their decision. Decision-making under conditions of risk where there are assigned estimated probabilities and predicted impacts for each identified risk, enables management strategies to be developed as a response including monitoring and controlling the risk mitigation to reduce these risks to the desired level. Uncertainty on the other hand, is immeasurable and it has been observed that people do not behave rationally when faced with uncertainty. Although people use reasoning to make decisions, their reasoning is often clouded by bias, cultural influences and emotion, and by incorrect interpretation of mathematical probabilities.

This paper examines various human responses to uncertainty and how each of three significant

views would influence decision making in project management. Comparison was made to Keynes' notion of 'animal spirits', suggesting that inherent behavioural psychology emboldens individuals and allows them to make decisions in the presence of uncertainty when rational mathematical methodologies are not an option. Today, risk management is a key part of overall project management. By discerning the distinction between risk and uncertainty, project managers are forced to consider project conditions and how they will respond differently to each by developing suitable plans of action to prevent potential risks from becoming problems and by understanding the human factors inherent in the behavioural psychology of decision making when assessing opportunities (profit/loss) under uncertainty. There is a strong behavioural side to the study of risk and uncertainty in project management that puts the decision makers at the core of risk and uncertainty, and that this area of work is much less researched and less well understood. Managing risk and uncertainty is both a process and a function that requires rigorous thinking and research to comprehend the substance, likelihood, and consequences brought about by different sets of risk and uncertainties.

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KAROLINA KOLECZKO

Karolina Koleczko - Project Engineer, Johnstaff Karolina Koleczko is a postgraduate student at the Institute of Sustainable Development at Bond University. She has degrees in project management, architecture and design. Her research interests are in behavioural economics with a particular focus on the link between bounded rationality and decision making under conditions of uncertainty and when managing risk.