

The Threat-Opportunity Risk Matrix Paradox – should we continue to use common-practice risk analysis methods? ¹

Martin Hopkinson

The idea of using risk analysis to sort project risks into prioritised rank order is a feature of the most widely used sources of guidance in the field of project management. In the forms of practice that are in the most common use ^{1,2}, risks are treated as being potential events with a probability and impact that can be used to determine a prioritisation index. Typically, this analysis is performed with aid of a Probability-Impact Matrix (PIM). Alternatively, risks might be ranked by basing the ranking index on the product of probability and impact.

It has also become widely accepted that the risk management process should address opportunities (beneficial outcomes of risks) as well as threats ³. This paper identifies a paradox that occurs when this approach is combined with a risk prioritisation process that uses either a PIM or the assumption that Risk value = Probability x Impact. In seeking to resolve the causes of this paradox, it identifies and challenges assumptions that frame the use of these techniques. In doing so, it discusses insights with the potential to identify improvements upon common practice.

Previous authors have been critical of the use of PIMs for risk analysis. For example, Cox ⁴ has identified numerous mathematical defects with the technique, including conditions under which its results are worse than useless, whilst Chapman and Ward have described the PIM as a tool that needs scrapping ⁵. The discussion at the end of this paper therefore explores the implications of another paradox: the continued widespread use of a technique known to have numerous faults.

The Threat Opportunity Risk Matrix Paradox

A project manager identifies the following three threats as being significant risks:

- Threat A – Probability 70%, Impact \$100K (value = 70% x \$100K = \$70K)
- Threat B – Probability 50%, Impact \$100K (value = 50% x \$100K = \$50K)
- Threat C – Probability 30%, Impact \$100K (value = 30% x \$100K = \$30K)

Each of these risks concerns the probability of an event, which should it occur, would result in a \$100K cost increase. The risks are listed in the prioritisation order ABC, as determined by the calculation Risk Value (V) = Probability (P) x Impact (I).

However, suppose the project sponsor ⁶, when presented with these risks, decides to take the prudent approach of including the full impact of their effects within the budget. The project budget would be increased by \$300K and the three risks would become opportunities, each with a

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potential saving of \$100k and a probability equal to the chance that the threat might not occur. Hence:

- Threat A would become Opportunity A: Probability 30%, Impact -\$100K (value = 30% x -\$100K = -\$30K)
- Threat B would become Opportunity B: Probability 50%, Impact -\$100K (value = 50% x -\$100K = -\$50K)
- Threat C would become Opportunity C: Probability 70%, Impact -\$100K (value = 70% x -\$100K = -\$70K)

The nature of the associated risk event and actions in the risk register would have remained unchanged. Despite this, the risk prioritisation order, determined by the size of deviation from baseline would have been reversed to CBA. This is the paradox. Can both prioritisation orders be correct? And if not, which, if either, is?

The paradox can also be illustrated with a prioritisation process that employs a 5x5 PIM. Suppose a risk impact of \$100K is classified as being High and that risk probabilities are classified in accordance with Table 1, which is based on the illustrative example of probability classification boundaries detailed in the PMI Practice Standard for Project Risk Management.

Probability	Classification
61% - 99%	Very High (VHI)
41% - 60%	High (HI)
21% - 40%	Medium (MED)
11% - 20%	Low (LO)
1% - 10%	Very Low (VLO)

Table 1: Example of the classification of project risk probabilities

Figure 1 shows how the three threats/opportunities A, B and C would be mapped onto a mirror-imaged PIM as illustrated by the same PMI Standard. This illustrates how using the PIM prioritisation technique can also reverse the prioritisation order.

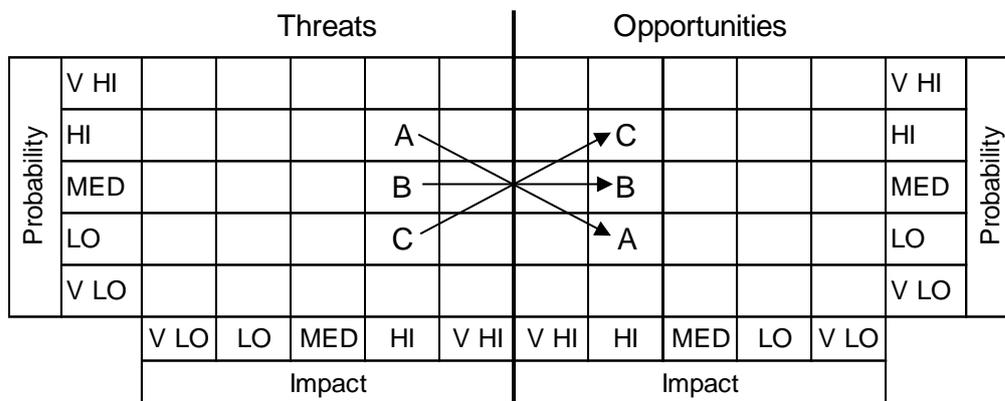


Figure 1: Mapping of Threat/Opportunities A, B and C to a PIM

Risk assessment assumptions that frame the paradox

The approaches to risk prioritisation used in the paradox are frequently used in common practice. However, both techniques are framed by a number of assumptions that sources of professional guidance typically fail to acknowledge⁷. In the case of the paradox there are at least eight assumptions:

1. It is risks that should be prioritised, not risk-related actions or decisions.
2. Risks should be quantified with reference to a deterministic baseline.
3. Expected value or a proxy such as the use of a PIM should be the preferred measure when prioritising cost risks.
4. All risks should be identified as events for the purposes of analysis.
5. Probability and impact are the only attributes of risks relevant to prioritisation.
6. Project estimates for risk probability can be treated as being objective.
7. Threats and opportunities can be compared using the same technique.
8. The outcome of each risk is independent of the outcome of the others.

The following sections challenge the first three of these assumptions in turn and discuss insights that arise. The discussion section that follows touches on the other five assumptions and addresses the question as to whether or not project risk management processes that use common practice techniques can be improved upon.

Should risks be prioritised, rather than risk-related actions or decisions?

The Association for Project Management (APM) guide *Prioritising Project Risks*⁸ identifies twelve attributes of risks that might be relevant to prioritising risks, depending upon the context of risk analysis. Probability and impact are just two of the twelve. One of the others is:

- Response effectiveness – the degree to which identified risk responses can be expected to influence the risk’s outcome.

As a simple example of how response effectiveness might contribute towards risk prioritisation decisions we can consider how the three risks A, B and C might be assessed if the impact of the associated event can be reduced to zero in turn by taking a different action i.e. risk response and if each of these actions would cost \$40K. The expected value of taking such actions can be calculated as shown in the decision trees in Figure 2, which shows the calculation for Risk A, first as a threat and then as an opportunity.

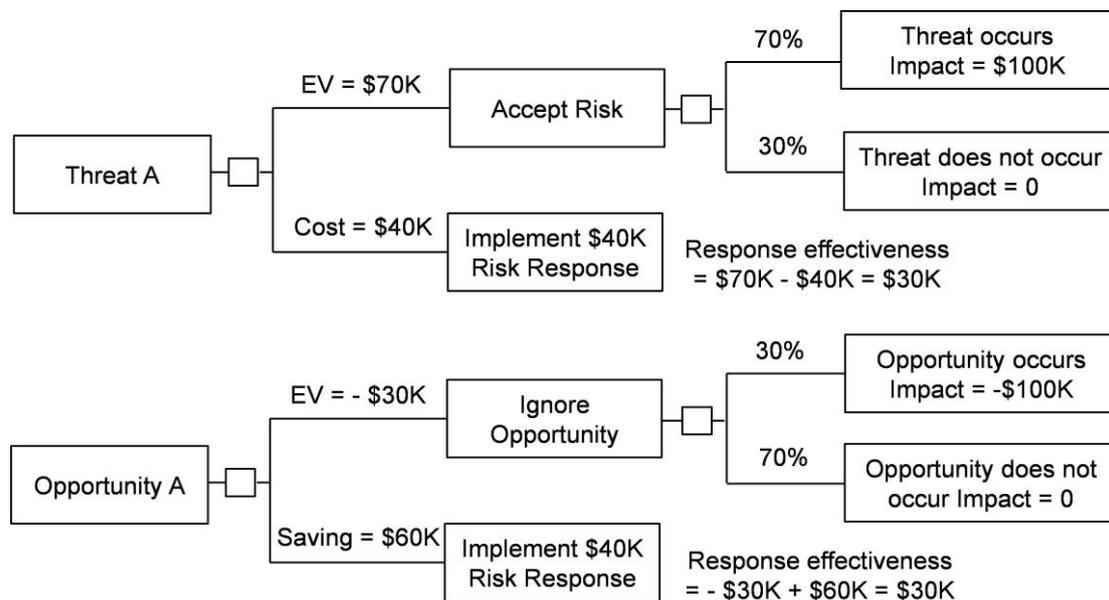


Figure 2: Decision trees for evaluating response effectiveness

Table 2 shows the results of the response effectiveness calculation the risks A, B and C estimated as both threats and opportunities.

	Probability	Impact	Response Cost	Post-response Risk Value	Response Effectiveness
Threat A	70%	\$100K	\$40K	0	\$30K
Opportunity A	30%	-\$100K	\$40K	-\$100K	\$30K
Threat B	50%	\$100K	\$40K	0	\$10K
Opportunity B	50%	-\$100K	\$40K	-\$100K	\$10K
Threat C	30%	\$100K	\$40K	0	-\$10K
Opportunity C	70%	-\$100K	\$40K	-\$100K	-\$10K

Table 2: Response Effectiveness Results for Risks A, B and C

Table 2 illustrates how risk responsiveness has the same value regardless of whether or not the associated risk is assessed as being a threat or an opportunity. This would be true of any equivalent

calculation of risk response effectiveness no matter what the associated probability, impact, response cost or post response risk value. This is because the nature of the risk event and associated risk response are unaltered by the movement of the cost baseline against which they are assessed.

Table 2 also shows that, in this example, the threats and opportunities have the same priority order ABC when ranked by response effectiveness. Indeed, Risk C would usually be given no priority at all given that, on average, implementing the response would be counterproductive. This can be contrasted with the prioritisation orders produced by the Expected Value and PIM techniques, which accorded C as being the risk of greatest priority when assessed as an opportunity.

The characteristics of Risk C provide a clue as to why the risk prioritisation paradox occurs: in the case of high probability threats and low probability opportunities, there exists a greater potential for identifying risk responses that add value. In contrast, the potential value of acting on low probability threats and high probability opportunities is relatively low. The reason for the latter may be counterintuitive but amounts to the fact that, by the way in which they are conceptualised, such opportunities are likely to occur regardless of further action.

This section of the paper is based on a simple example of decision analysis. However, it is sufficient to illustrate how insights arising from decision analysis can differ from those obtained by simple risk analysis techniques. Although decision analysis and risk analysis are related fields such differences are often overlooked. As a result, many project risk practitioners lack experience in the use of decision analysis techniques. Given that these techniques are focussed on how the outcomes of risk can be influenced by action, this would seem to be a lost opportunity.

Should Risks be quantified with reference to a deterministic baseline?

When using the expected value or PIM techniques for risk assessment the deterministic baseline used for quantifying risk is typically derived from a project plan. However, this practice may place a counterproductive constraint on the risk management process. If risks must be quantified relative to planned objectives, risk analysis cannot be conducted until the project plan has achieved an appropriate level of definition. This delays the point at which risk analysis can commence. In contrast, professional guidance suggests that the project risk management process should commence at project inception; a point in time when there is typically no planning baseline. There is thus a need for risk analysis methods that are not dependent upon the prior existence of a deterministic plan.

An example of such a method is the Uncertainty-Importance Matrix (UIM) as described in the APM's *Prioritising Project Risks* and illustrated in Figure 3. Risks and issues can be mapped to a UIM regardless of the existence of an approved plan making it potentially useful, even from the point of project inception. For example, a UIM analysis might be used to prioritise project concept phase activities that reduce uncertainty and thus improve later planning choices.

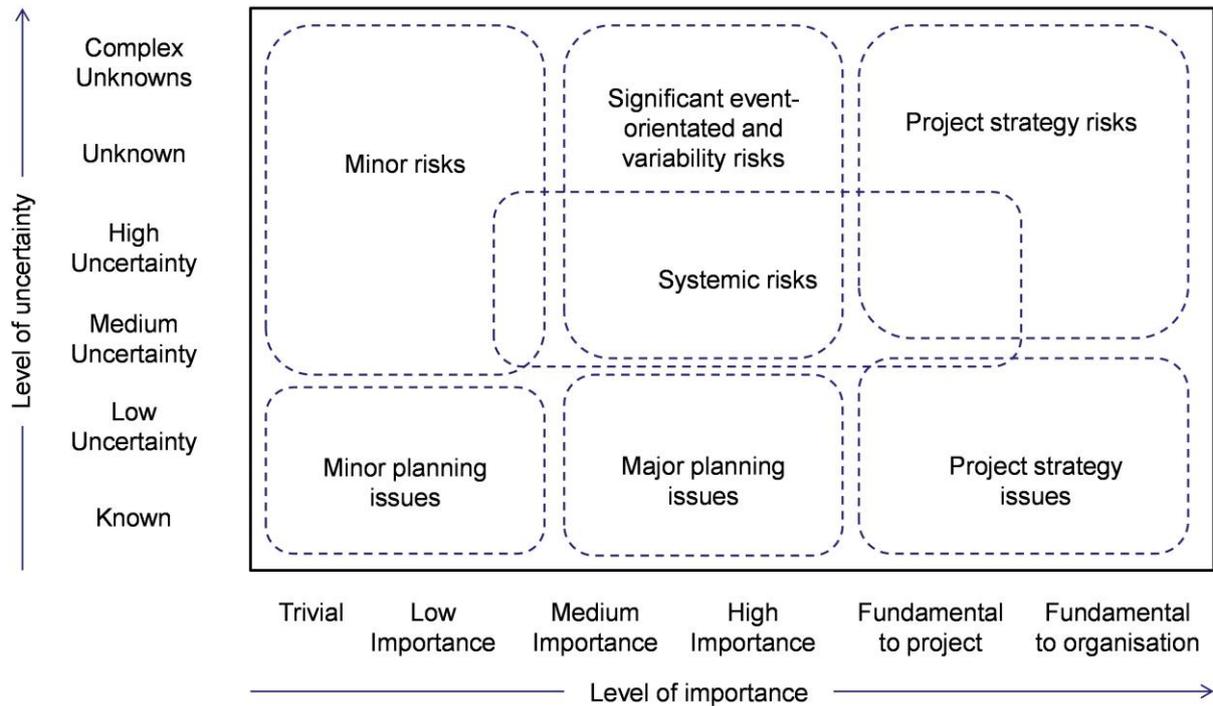


Figure 3 – Regions in a project uncertainty-importance matrix

The UIM is only designed to classify risks and issues on the basis of qualitative data. This is a significant constraint on its utility, making it increasingly inefficient as the definition and understanding of project matures to a level whereby quantitative techniques should be preferred. In contrast, the PIM is often supported as being a tool that is suitable for use with both quantitative and qualitative data. However, if the use of a quantitative analysis should be preferred, there are a number of other quantitative risk analysis techniques available. Some are rooted in a decision analysis approach and do not require the prior existence of a deterministic baseline.

Chapman and Ward’s risk efficiency principle⁹ is an example of a quantitative decision analysis technique that is not dependent on reference to a baseline. It can be illustrated by comparing the project cost forecasts produced by a risk analysis in Figure 4.

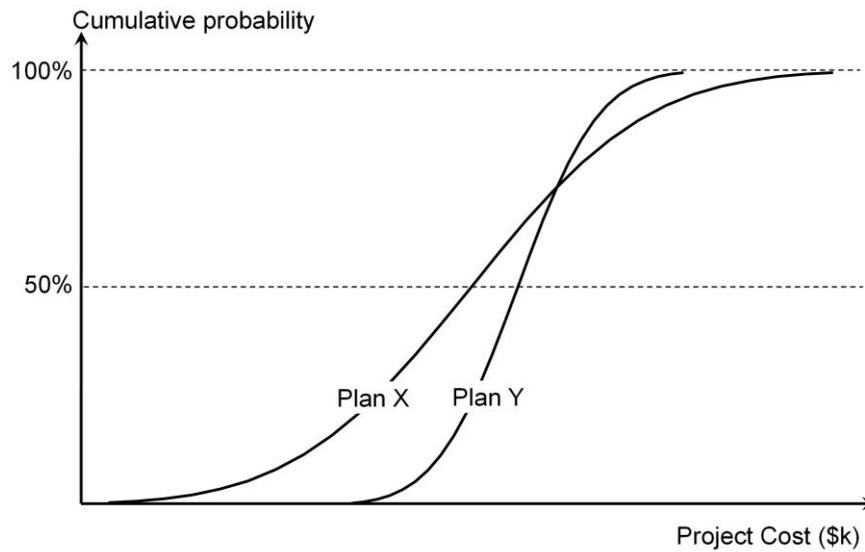


Figure 4 – Risk efficiency; comparing plans for the same project

Figure 4 shows the comparison of overall cost risk for the same project for two different project delivery plans. Plan X might be regarded as being higher risk in that its cost outcome is the more uncertain. However, it might also be the preferred option given that the mean cost is lower. If the organisation that owns the project aims to optimise overall cost across its project portfolio, Plan X would be identified as being the risk efficient choice. This is because variances in the outcomes of individual projects can be tolerated on the grounds of diversification.

However, the project decision making process might be altered if a risk forecast is compared to a deterministic objective. Figure 5 illustrates this by adding a “Maximum” cost tolerance objective to the curves shown in Figure 4.

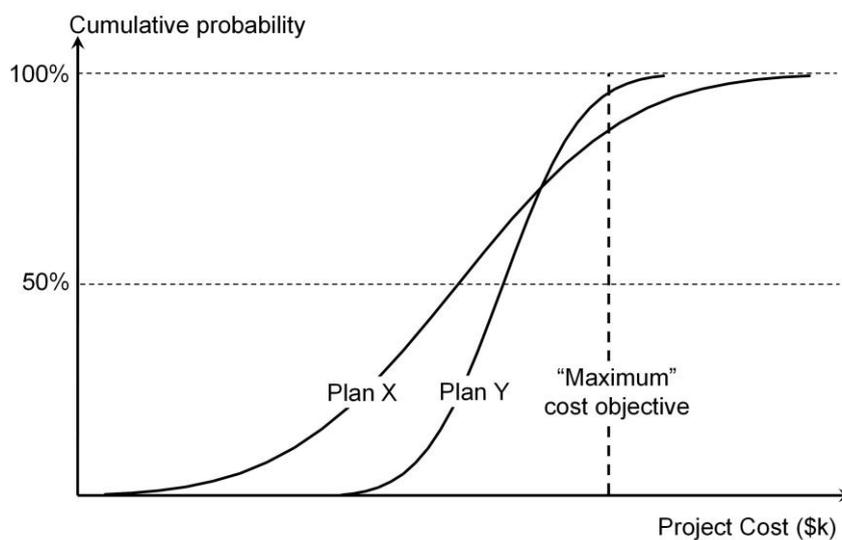


Figure 5 – Assessing plans against a deterministic cost objective

Figures 4 and 5 illustrate the potential for conflict between the aim of making risk efficient decisions and the practice assessing risk against deterministic objectives. Whilst Plan X would be the risk efficient choice, Plan Y offers the greater probability of being delivered within the approved maximum cost. An organisation might thus select Plan Y even though it was the more costly option on average.

The practice of managing both projects and their associated risks against deterministic objectives is widespread. Whilst it may make processes easier to understand and operate, it can also lead to process constraints and dysfunction. These effects often remain unrecognised. However, given that they exist, it would be wrong to argue that risks should always be estimated and assessed with reference to fixed objectives defined in a baseline.

Should the preferred measure for prioritising cost risks be based on expected values or the use of a PIM?

The Association for Project Management’s (APM) Guide Prioritising Project Risks describes a wide range of different risk prioritisation techniques and the various risk modelling contexts in which they can be used. Expected Value and the PIM are but just two of the techniques described. Some of these techniques are discussed in other sections of this paper. For the purposes of this section, it can be noted that one of the simple alternative techniques suggested by the APM guide is the use of standard deviation (σ) or variance (σ^2). These are measures of spread or variability in the probability distributions defined by risk estimates and can thus be interpreted as representing the magnitude of uncertainty.

If we consider the paradox example, we can compare the standard deviations of Risks A, B and C. They are summarised in Table 3.

Threats	Prob (%)	Impact (\$k)	Expected Value (\$k)	Standard Deviation (\$k)	Opportunities	Prob (%)	Impact (\$k)	Expected Value (\$k)	Standard Deviation (\$k)
Risk A (Threat)	30%	100	30	45.83	Opportunity A	70%	-100	-70	45.83
Risk B (Threat)	50%	100	50	50.00	Opportunity B	50%	-100	-50	50.00
Risk C (Threat)	70%	100	70	45.83	Opportunity C	30%	-100	-30	45.83

Table 3 – Mean values and Standard Deviations of Risks A, B and C

Table 3 shows that Risk B has the highest standard deviation. On this basis, it might be argued that risk B should be treated as being the more significant. Since the standard deviations of Risks A and C are equal, the prioritisation order would be:

- Risk B (higher priority)
- Risk A and Risk C (equal priority)

More generally, Figure 6 shows how the standard deviations of risks with an impact of \$100K vary with probability.

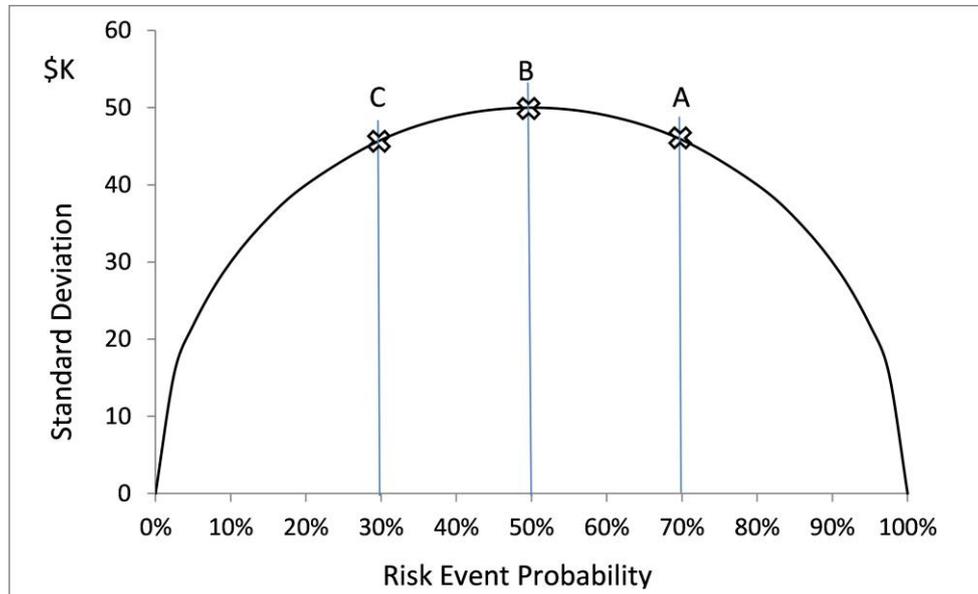


Figure 6 – Standard deviations of a \$100K risk as a function of probability

Figure 6 shows that when risk impacts are estimated with single point values, the maximum standard deviation occurs at a probability of 50%: the probability at which the risk outcome is least certain. As a cost risk's probability rises towards 50%, its standard deviation increases. Beyond this, however its standard deviation decreases, until becoming zero at a probability of 100%. If risks are measured on the basis of their effect on uncertainty, this result is logical in that a probability 100% of an event occurring at a fixed cost represents conditions of certainty i.e. there is no risk.

In contrast expected value calculations produce a self-contradictory result. 100% probability results in the highest expected value – yet the lack of uncertainty implies that there is no risk. Project processes often address this problem by treating 100% events as being issues rather than risks. However, this approach raises the question of how to treat potential events with probabilities approaching 100%: at what level of probability does an event switch from being a high risk to not being a risk at all? It also treats events with a 100% probability but significantly uncertain impact as not being risks.

Most risk management standards and guides use a concept of uncertainty to define what they mean by risk. For example, two of the most influential risk definitions are:

- *Risk is the effect of uncertainty on objectives* (ISO31000)
- *A project risk is an uncertain event or condition that, if it occurs, has a positive or negative effect on a project's objectives* (PMI)

These definitions imply that uncertainty is a common attribute of all risks and provides a justification for using variances or standard deviations to assess risks. However, both definitions also stress the importance of the effect on objectives. It is open to question as to what this means. For example, does it mean that risks should be assessed in dimensions e.g. cost, time and product in which objectives are set, or is it intended to mean, more specifically, that risks should be assessed using a baseline against which outcomes can be measured objectively?

Finally, it can be noted that variances and standard deviations can be calculated without reference to a baseline estimate and that the resultant prioritisation orders are the same regardless of whether the risks have been identified being threats or opportunities. From amongst the techniques identified in this paper the PIM and expected value calculations are the only ones that lack this property. This illustrates how the threat-opportunity risk matrix paradox is a consequence of estimating risks from a deterministic baseline.

Discussion

The risk analysis presented in this paper for Risks A, B and C can be criticised reasonably as being simplistic. However, these examples are not untypical of common practice. Many projects use a slightly more sophisticated approach for risk estimation e.g. by making three point estimates for impact. However most still identify and estimate risks as unconnected events and map each risk to a single location in a PIM. Many either fail to identify and assess risks whose nature lies in the variability of outcome across a continuous range, or attempt to force fit them into PIM/event-orientated construct.

Designing a project risk management process around the conceptualisation of all risks as being events so as to use techniques such as the PIM is a feature of common practice. However, as Chapman and Ward have observed, common practice is not necessarily best practice. Hubbard describes risk analysis based on basic scoring schemes as being worse than useless or no better than astrology¹⁰. Whilst acknowledging that all risk analysis techniques have faults, he identifies probabilistic modelling as being the best available and that just as Newton was a starting point for Einstein, it may provide the best opportunity for continued improvement. The S-curves illustrating Chapman and Ward's risk efficiency principle in Figures 4 and 5 would typically be a product of the best available types of modelling to which Hubbard refers.

Common practice is usually supported by organisations that flow down requirements to use the same tools and techniques for all projects. Typically, the core tool is a risk register with a prioritisation process supported by the use of a PIM. The more sophisticated of these organisations also support quantitative modelling tools and techniques for forecasting project level risk using Monte Carlo simulation for the purposes of cost and/or schedule risk analysis. However the risks used for such modelling purposes are typically imported from the risk register. Hence, the analysis remains rooted in a single pass event-orientated approach to risk identification and assessment that is dependent upon the prior existence of a deterministic baseline.

However, any company and organisation that understands that such forms of common practice are not necessarily best practice faces a dilemma. There are many advantages to supporting a common practice approach. For example, when sharing information on multi-owned projects or producing risk reports within a contractual framework, the lack of a common approach would cause confusion. Even for the purposes of internal reporting, managers could become confused by reports produced using different analysis techniques for different projects. More generally, simplifications in the common practice approach help to clarify guidance for the majority of professionals working on projects, who are not risk specialists, in a way that is relatively easy to learn. The result is tension between the best practice ideals of skilled risk specialists and academics and the more limited but pragmatic common practice used by most organisations and companies.

In the meantime, the lack of alignment between common practice and what many experienced professionals understand to be better practice creates a dilemma for those that seek to improve their management of project risk by tailoring the use of analysis techniques on the basis of the needs of individual projects. Since every project is different it is illogical to expect that a single fixed process for managing the implications of uncertainty can provide an optimised approach for all projects during all stages in the project life cycle. Skilled project risk managers recognise this and would prefer to select their analysis tools and techniques to suit.

During my career, I have had the opportunity to discuss the limitations of common practice risk management with numerous risk management practitioners and academics. As a result, I know that those who are more experienced, have reflected critically on their own work, read widely on the subject or have an academic background usually understand the limitations of common practice. As a result, they are able to adapt their practice intelligently whilst working within the constraints of their organisations' tools and process. For example, they are able to design and use PIMs to produce analysis results that are better than useless and to avoid over-representing their significance. They also exploit the most useful properties of risk registers by focussing on matters such as risk ownership, and the development and implementation of effective risk response plans. Often, when selecting risks for detailed attention at risk reviews they take into account factors such as urgency (lead time to commence an effective response), lack of effective risk response plans and ambiguity of risk ownership. Many are able to develop coherent quantitative models that simulate interdependencies between risks or to incorporate decision analysis techniques into their practice. Some, though fewer, are also able accommodate a subjective approach to probability estimates or to exploit a multi-pass approach to the risk management process, as, for example, advocated by the APM PRAM Guide¹¹ or Chapman and Ward.

It is therefore often possible for the skilled project risk manager to make adaptations that improve the process whilst living within the constraints of common practice. For example, they might be able to use influence diagrams or decision analysis techniques to identify risk response actions maintained in the risk register. They could also use a top-down multi-pass approach to building cost or schedule risk analysis models. Some improvements might be made without the need to use any risk analysis tool or formal reporting process. For example, on a multi-owned project or a

project with a contractual hierarchy a risk manager might identify how the most significant financial consequences could manifest themselves and seek to use these insights to help the project team align contractual requirements with the abilities of the various parties to manage the risks involved.

However, there are at least two conditions to be satisfied before projects are able exploit the wider benefits of employing skilled project risk managers. First all risk managers as a professional group should seek to improve their understanding of best practice by using a range of sources, including the academic literature. They should be aware of and be able to use a wide range of tools and techniques including those related to decision analysis. Second, organisations should understand that common practice tools and techniques have significant limitations. Since the best results will not be obtained by dogmatically mandating a single system they should be prepared to act on insights developed by skilled risk managers using alternative techniques.

A good place to start for organisations and companies is to recognise that the PIM is a more flawed risk prioritisation and decision-making technique than most project management professionals realise. This does not mean that current risk register tools should be scrapped immediately. However, it does mean that managers should be wary of over-valuing all forms of PIM-based risk analysis. An enlightened management should, instead focus on the effectiveness of the processes used for making risk management decisions, and ensuring that the associated risk response plans are implemented as intended. In so doing they could also exploit the benefits of allowing skilled risk managers to make intelligent choices to use tools and techniques that are not necessarily identified as being a core component of a common-practice process.

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Martin Hopkinson is the Director of Risk Management Capability Limited and has 30 years' experience as a project manager, project risk management specialist and consultant. His experience has been gained across a wide variety of industries and engineering disciplines and includes multibillion-pound projects and programmes.

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