Article category: Risk

Project Risk Management

Part 3:
Modelling and Software Tools

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The previous two parts in this series considered the nature of project risk and the process of risk management. In this third and final article we will introduce a number of slightly more advanced concepts, all aimed at improving the management of project risk through better insight and modelling. We will cover the following topics: the relationship between project decisions and risk management, risk efficiency, information and control, methods to aggregate individual risks into overall project risk, and software tools. In conclusion, a number of further topics in project risk management will be mentioned.

Project decision-making and risk management

Consider a project manager who has to decide between a number of contending bids from subcontractors. Should he choose the low-price bid from a new and unknown company or the bid from a reputable contractor that is 20% more costly? Does the lower risk justify the higher price? Or should the 20% price premium rather be applied in another area of the project where there is significant risk? Another organisation agonises over the appointment of a project manager for an important project: should they choose the experienced external individual with an excellent track record but commanding a high salary, or should they give this opportunity to a promising but junior employee? Would the apparent cost saving of the internal appointment outweigh the higher risk involved with this choice?

These are two real and practical manifestations of everyday problems in risk management in a project environment. A decision must be made and this involves a tradeoff between risks and costs (or rewards). A specific choice of project strategy will by necessity have an impact on the level of risk. In a product development project context, for example, using an unknown technology could induce much higher risk than would otherwise be the case. So would deciding on a project plan that does not allow sufficient time for testing and integration. Decision-making allows us to select an optimum strategy under uncertainty (see Clemen [1], for example, for an introduction to decision making under uncertainty). Such a strategy will strive for an optimum balance between risks and rewards. This level may be achieved at different levels for different organisations, given the differences in risk tolerance that exist. Finding such a balance is one of the main objectives of risk management. Utility theory allows us to weigh the benefits of risk management with their costs and strive for an "optimal" level of risk reduction. A number of decision software packages are available that can aid in the decision making process. DPL™ (from Applied Decision Analysis in Menlo Park, California) is a prominent package with powerful tools for the modelling and analysis of complex decisions.

Risk efficiency

This concept concerns the efficiency with which resources are used to reduce risks. A plan (or strategy) is said to be risk efficient if the risk can only be reduced further by increasing the cost or (equivalently) if a reduction in cost will lead to an increase in risk.

This concept is illustrated in Figure 1. The horizontal axis represents the expected cost of the project while the vertical axis maps the overall level of risk. Each of the options A, B and C are risk efficient and together they define a risk efficient frontier. The set of points on the line form

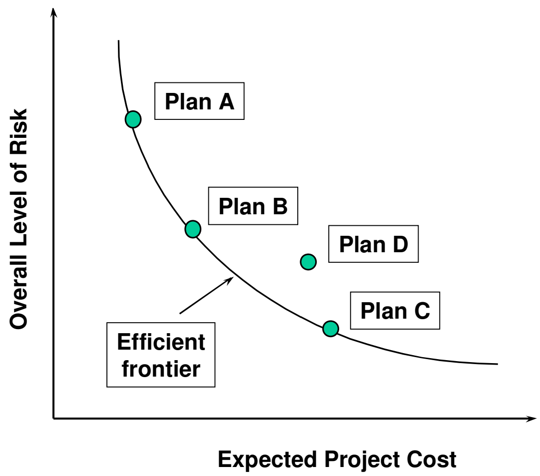

Figure 1: Risk Efficiency

the Pareto optimal set , i.e. for no point can risk or cost be reduced without increasing the other. Point D, however, represents an inefficient point where resources are wasted by not achieving the minimum possible level of risk for the money spent or, alternatively, by not achieving a lower cost for the same level of risk. Although Figure 1 is only a conceptual tool, it is very useful to illustrate the notion of risk efficiency and make the point that it is necessary to search for solutions that approach the frontier. It also illustrates the "decreasing returns" or non-linear nature of the relationship between cost and risk. We should seek risk efficiency in our projects, although there is of course no knowing if we are on the frontier or perhaps even close to it. Although we have only referred to the cost dimension, risk efficiency can also be extended to include time. We are often confronted with a limited budget and a fixed target date; in this context a project plan would be efficient if it involves the minimum risk for the money and time available.

Information and control

Information plays an important role in risk management. Having information about whether a particular risk will occur can be very valuable. So is information about the existence, likelihood and consequences of risks. The discipline of decision analysis allows us to determine the value of information about the outcome of a uncertain event (see Clemen [1]). This value assists us in determining how much we should pay for that information. This information-buying type of activity is an integral part of project management, although usually not called by that name. Performing a feasibility study on a number of product alternatives would be a good example: resources are spent to try and assess the future outcomes of each of the alternatives in order to choose the most promising one. Performing tests on product prototypes would be another example.

A further useful concept is that of the value of control. Here the concern is with the value that can be derived by exercising control over the outcome of an uncertain variable. It would clearly be very useful to control the occurrence of a risk event. Again, decision analysis allows us to put a value on such control. Achieving control over outcomes is exactly what project management is all about: we want to influence the outcome by exercising control through project management.

Risk aggregation

Projects usually have a substantial number of risks. Analysing these risks individually is useful, but tells us little about the overall project risk. We cannot assess the total project risk without "adding up" the individual risks in some way. Consider the following situation. A certain project consists of 20 activities, each of which has uncertain cost. There is therefore a cost risk associated with each activity. The problem now is to find the total project cost, which will also be uncertain (rather than a single-point value). Clearly this is of crucial importance – how else would we know what budget or financing we need, or whether we will make profit on a contract? Also, what level of contingency should we allow for?

Let us assume that each of the 20 costs can be described by a simple triangular distribution. This continuous distribution is often used in project risk management and is characterised by the upper limit, the lower limit, and the most likely value. Knowing the lower limits of the individual costs, we can find the lower limit for the total project cost by just adding them all up. Likewise for the upper limit. But how likely would each of these total values be? Let's say we chose the limits for each cost distribution such that there is a 5% chance of achieving them. Then the probability of obtaining a total cost equal to the sum of all the upper limits is $0,05^{20}$, which turns out to be 10^{27}. This is as good as zero – not of much use in understanding the total cost distribution. A more useful value would be the total "likely" cost. Or even better, the total cost distribution. But how do we find this? One approach would be to discretize each of the individual cost distributions and enumerate the complete probability tree resulting from this. If we used five discrete states for each cost variable and needed one second to add up one complete path through the tree, it would take us more than three million years to finish the job – clearly not an attractive prospect! And remember that this is only a simple 20-activity project; real projects typically run into hundreds of activities. We need a better solution.

The answer lies in sampling. If we wanted to find the distribution in height of the adult population, it is not necessary to measure everybody. We only need to measure a representative sample, and this will provide us with a very accurate approximation of the total distribution. Exactly the same approach can be used to add up risks. We take a random sample from each of the 20 costs, add these samples up and find a total cost point. We do this a few hundred times to find a corresponding number of total cost sample points. All that is then necessary is to count the number of points that fall in a particular cost interval, and we have a distribution (actually, a frequency histogram) for the total cost. Although there are billions of total cost points (for the discrete case) it turns out that less than a 1 000 sample points are usually more than enough to evolve a very accurate total cost distribution. We know a distribution is a good approximation if the expected value and standard deviation have converged to stable values and further samples provide no significant change.

Monte Carlo simulation

The above process is called Monte Carlo simulation. Fortunately, we do not have to do this by hand. Several software packages are available. Two well-known products are @RISK and Crystal Ball, both add-ins for spreadsheet programs (Excel and Lotus 1-2-3). Not only can they be used for cost simulation, but also, with a little ingenuity, for schedule simulation (see Grey [2] for a very useful and practical treatment of the topic). The past few years have also seen the introduction of risk simulation facilities for and with project planning packages, like Microsoft Project and Primavera. One can expect this to become a standard feature in project management software over the next few years.

The above example of the 20 cost activities produces a distribution which we can draw in cumulative form (see Figure 2). This is a useful graph; we can now easily answer questions like: what is the probability that the actual cost will exceed a certain target figure? This cumulative graph is also very useful for setting a total budget and deciding on a contingency budget. However, a word of caution is in order here. The above sampling method makes the implicit assumption that all the cost risks are independent, i.e. the actual cost of one activity has no influence on the actual cost of another activity. This is usually not true. In real life, there is often a dependence between activities. For example, if we overspend on one activity there may now be a good chance of overspend on other activity as well. Fortunately, it is easy to build this dependence (or correlation) into a Monte Carlo simulation. The effect is shown in Figure 2.

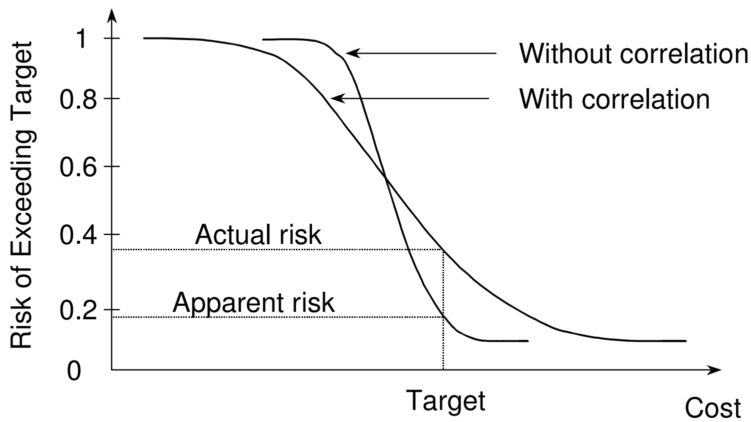

Figure 2: Cumulative Cost Distribution and the Effect of Correlation

Correlation tends to draw out the cumulative distribution and causes a substantial increase in risk. Whereas we might have thought that the chance of exceeding the target budget is only say 20%, correlation has increased this to around 40%. The conservative approach is to introduce correlation rather than not.

Conclusion and further topics

The objective of this series of articles was to provide a brief introduction to the topic of project risk management. There are a number of further important areas though that we did not touch on. Examples are: risk communication, risk allocation, organising for risk management, documentation, and the value of risk management. Interested readers are encouraged to consult the references given in the previous article.

Risk management has developed into an indispensable part of project management over the past few decades and holds significant promise for improving performance and profitability. No project should be without it! And remember: we need good management rather than good luck.

References

[1] Clemen, R.T., *Making Hard Decisions: An Introduction to Decision Analysis*, 2nd edition, Duxbury Press, 1996.

[2] Grey, S., *Practical Risk Assessment for Project Management*, John Wiley & Sons, Chichester, England, 1995.

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Back to top

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