White Paper 2024-01

How to Complement Statistical Quantitative Risk Analysis with Scenarios Approaches

Quantitative risk analysis on large complex projects is often performed using statistical tools based on Monte Carlo approaches, applied for cost and schedule. These approaches can be supplemented by scenario analysis, in which a number of risk and opportunity factors are combined in scenarios of different probabilities of occurrence. Reviewing the consistency of the outcomes of the two techniques will increase the resilience of the risk analysis result. In this White Paper we examine how scenario analysis can be deployed and how to use its results.

Preliminary methodological remarks

As a preliminary remark, all techniques described in this White Paper address known unknowns, i.e. how to measure the impact on the project of identified risks and uncertainties. Unknown-unknowns cannot be estimated using such quantitative techniques, since they are unknown by definition.

Scenario-based models are useful complements to the usual Monte Carlo approaches and allow to identify specific non-linear effects that may be difficult to apprehend otherwise.

Both scenario analysis and statistical risk analysis are the result of a modelling of the project. A model is a representation of an item that is simplified and generally geared towards a specific purpose. Therefore, the outcomes of those processes are various models of the project, that can be tested and updated using the models' key parameters and assumptions. The combination of a variety of models based on different sets of mechanisms and assumptions generally allows to better understand reality, as seen from multiple angles. This is the approach followed here.

Quantitative scenario versus statistical risk analysis

In statistical risk analysis, probability and impacts factors are determined for each line or activity, and they are combined using a statistical analysis based on Monte Carlo techniques. In addition to line-by-line variation, the influence of discrete risks can also be included in the model. In this case, unless correlation factors have been previously defined, the risk or opportunity on each line or activity is considered to be independent during the Monte Carlo simulation. This is a serious limitation of those techniques, because in reality, strong dependencies can exist between the risks or variations applicable to cost lines or schedule activities, for example in terms of available resources, general market conditions etc. (refer to White Paper 2012-11 'Take Risks, But Take Risks the Right Way' and 2015-10 'Monte Carlo Best Practices').

Another alternate approach is to define a limited number of scenarios combining a number of events. Those events need of course to remain physically compatible between each other within a single scenario, to ensure that the scenarios are indeed physically possible. Several scenarios of various probability can thus be built, each corresponding to compatible combination of events. Ideally, at least 2 quite different scenarios for each class of probability should be built to provide diversity in the scenario analysis. The analysis of the outcome of the scenarios will provide another estimate of the provision for risks that is required. The benefit of this approach is that interdependencies can indeed be factored in each scenario, contrary to the Monte Carlo approach. The drawback is that the choice of scenarios is limited to a couple and the assessment of their probability remains quite subjective and can be challenged. Scenario probability is hence generally limited to subjective categories such as 'possible, probable, remotely probable' and is often a matter of judgment.

Limit the complication of models

Models should generally remain of a limited complication for both Monte Carlo and scenarios: it is better to spend effort building multiple models based on major effects rather than trying to fiddle into building a too complicated model. In addition, it is known that limited complication (maximum a couple of hundred lines) is an essential factor for reliably comparing Monte Carlo models.

Examining the consistency between statistical and scenario-based approaches and iterate to obtain a consistent set of models

Since the two techniques model the project according to different approaches, the important issue is to check the consistency of the outcomes for similar class of probability. Consistency between the results provided by statistical analysis and scenario analysis will improve confidence in the risk analysis results, while inconsistencies will raise questions to be resolved.

In particular, non-linear effects such as 'cliff effects' (small variations of parameters leading to substantial changes of the outcome in terms of cost or schedule) or an accumulation of consequential impacts can be much easier identified and modelled in the scenario approach. They will generally not be identified in Monte Carlo analysis, possibly leading to a greater spread of outcomes for the scenarios.

Conversely, probabilistic schedule risk analysis can lead to identify unexpected alternate critical paths for the project due to statistical variation that become the actual drivers of the project and increase the importance of certain aspects of the project previously thought to be secondary. This may not be captured by scenario analysis and can be used to complement certain scenarios.

Combining diverse types of risk modelling is useful to improve confidence in contingency.

Therefore, there should be some iteration between the results of both Monte Carlo and scenario analysis in order to get to a relatively consistent set of models that should show the same order of magnitude in terms of contingency.

Updating the project risk models

It will be useful to update the models as the project definition progresses (for owners) or as the project execution progresses (both for owners and contractors), in order to assess the remaining schedule and cost contingency required in the project forecast. The limited complication of models will also make updates easier. At

each stage of the project, it will be useful to check the consistency between the various models and iterate to represent the main effects that can be expected.

Summary

Combining diverse types of risk modelling is useful to improve confidence in contingency. Scenario-based models are useful complements to the usual Monte Carlo approaches and allow to identify specific non-linear effects that may be difficult to apprehend otherwise. Ensuring consistency between the various types of models provides further analysis on possible impacts of risks and opportunities and therefore will enhance the reliability of the quantitative risk process, and thus this approach to combine different types of models is highly recommended.