PROJECT RISK MANAGEMENT - ADVANTAGES AND PITFALLS

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Abstract

Proper project decision-making requires that risk management and risk analysis techniques be applied in order to guide management in making better decisions. Cost estimates attempt to define projects as single point values whereas virtually all project variables are variable and may deviate from the values assumed in preparing the original estimate. The objective of this paper is to demonstrate why risk analysis is necessary, and how to determine the probability of having a cost overrun. Some pieces of risk analysis software will be described and range estimating will be demonstrated as an effective tool for reducing risk and for determining how much contingency to add to reduce residual risk to an acceptable level.

Keywords: risk, contingency, decision-making, cost overruns, Monte Carlo

Introduction

Risk Analysis is often performed using spreadsheets and random number generators, best case/worst case scenarios, or sensitivity analysis. While these approaches have some utility, if used with caution and if their limitations are recognized, it is far more practical, and in most cases requires less effort, to use Monte Carlo software approaches. With this software one can estimate cost overrun probability and the amount of contingency required to reduce the overrun probability to an acceptable level. The software also enables the project professional to explore alternate project scenarios quickly in order to determine the optimum solution for virtually any economic decision, something which is often not practical or feasible with manual methods. The software can provide an estimate of required contingency to avoid overruns at any desired probability level. It can identify the required contingency for each critical project item and it can identify those items within the estimate which contribute most significantly to project risk, as well as those which afford the greatest areas of opportunity.

Perhaps the most influential pioneer in the field of project risk analysis is Michael Curran, president of Decision Sciences Corporation in St. Louis, Missouri. Curran (1976, 1988, 1989, 1998) has written extensively on project risk analysis and range estimating approaches and developed the first major piece of software for project risk analysis, *Range Estimating Program for Personal Computers* (REP/PC). Curran's pioneering work began in 1964 and was prompted by an article in the *Harvard Business Review*, Jan/Feb 1964 issue entitled "Risk Analysis in Capital Investment" by David B. Hertz.

Curran recognized that, although Hertz never used the term, the article was about Monte Carlo Simulation and how it could be used to address key issues in the problem of capital planning. Monte Carlo Simulation techniques had come into prominence in the 1940s when they were used in game theory and were applied to answer a problem in particle physics in the Manhattan Project, i.e., the development of the atomic bomb. It wasn't long before other scientists and engineers realized the power of Monte Carlo and began applying it many ways. But in the Hertz article Curran saw that for the first time someone was suggesting its use in business practice. This made so much sense to Curran that in 1968 he formed Decision Sciences Corporation which has pioneered the field of project risk analysis in the United States.

The Fourth Variable

Curran observed that decision-makers generally use only three building blocks on which to base their decisions. One is *units*, i.e., units of service required or rendered, units constructed, square meters of building space, etc. Another building block is *currency*, in whatever way you count it-- Euros, dollars, yen, etc. The third is *time*, time to complete a project, time to construct a building, etc.

Decision-makers however often do not adequately consider a fourth variable, *risk*. What is risk? Here is the AACE International definition of risk:

> *Risk*: *The degree of dispersion of variability around the expected or "best" value which is estimated to exist for the economic variable in question, e.g., a quantitative measure of the upper and lower limits which are considered reasonable for the factor being estimated.*

While technically correct, this definition does not explain what decision-makers really need to understand. For decision-makers it is better to define risk with an example - an example in plain English.

> *Risk (Plain English Explanation): I think it will cost $1 million, but there's a chance that it might be a little higher or a little lower.*

This is what decision-makers want to know:

1. What is the probable cost?
2. What is the probability of the cost exceeding the estimate?
3. If it does exceed the estimate, how high can it go, i.e., what is the economic exposure if the project overruns?
4. If the cost underruns the estimate, how low can it go?

Answering those questions is what risk analysis is all about. Even if a project looks potentially very favorable, if the probability of the project succeeding is low or if the exposure is excessive, few managers will be willing to authorize the project.

When managers consider the first three of these variables -- units, currency, time -- they are dealing in the world of accounting. There is no uncertainty in accounting. It is precise. In accounting, if all of the rows and columns don't add up, you work day and night to correct things so that they will. You remove the uncertainty. That can’t be done in decision making. Uncertainty always exists. When you include probability in your discussions, it is no longer the world of accounting. It is the world of decision making and there is a vast difference.

The Monte Carlo Approach

To perform a risk analysis does not require extensive knowledge of statistics and probability theory. All that is needed is to understand two key issues:

1. The probability number can influence decisions
2. You can measure the variability of a quantity as a simple range. How low can the variable go and how high can it go?

Now when should a risk analysis be performed? Certainly it is not always appropriate but if there are multiple numerical uncertainties and these uncertainties cause concern, the use of risk analysis techniques is advisable.

The question often arises as to how a highly sophisticated technique like Monte Carlo simulation can possibly apply to projects for which much information is not precisely defined in advance. After all, Monte Carlo simulation was developed for very precise applications (like the atomic bomb) and, as such, generally requires great accuracy and precision in data inputs and well-defined probability density functions for the various variables. By comparison, cost and schedule information on engineering projects is rarely precise. Estimates are opinions of probable cost, not highly accurate answers.

The reason Monte Carlo approaches can be applied to engineering projects is that decision-makers don't expect precise answers. They generally are willing to accept variances of 5 to 10% when making decisions related to quantitative values involving risk. By comparison, in highly scientific fields, errors of this magnitude cannot be tolerated. Such is not the case in engineering and construction. It's a different world. Because it is a different world and because we are more tolerant of some error in engineering or construction projects, we can de-escalate the requirements for the user of Monte Carlo.

The risk analyst must understand that the primary concern in the minds of managers is how large the economic exposure is if the project is authorized. Few managers will accept a project with a low probability of success and a high exposure. Managers rarely are risk takers. They are risk averse.

Often the worst case scenario approach is used to estimate exposure. In this approach, all major variables are estimated at their most extreme unfavorable values and the exposure is calculated. The results are inevitably horrible. They are the theoretical worst case. They are so mathematically remote that at best they are useless; at worst they are misleading. Even in a highly risky project, not every variable will go to its unfavorable extreme value. Some variables will show little variance from the plan and others may deviate in the favorable direction. Therefore the actual exposure generally is much less than the worst case scenario. Monte Carlo Simulation can identify what the actual exposure really is and what the probability of success is.

If, for example, you have performed a risk analysis and told management that they have a 80% chance of success but that they have a 45% exposure, what does that mean? That means that the bottom line decision variable can erode by as much as 45% of the target value.

"*Why?*" will be the next question they'll ask. "*Why will it be that way?*" They will want to look at a ranked list of risks and opportunities so that they can search for controllables and can challenge the management team to come up with alternative strategies and tactics. These alternatives can then be tested in the Monte Carlo environment to arrive at an optimum solution.

Monte Carlo is not only a great tool for evaluating a current plan; it's a marvellous tool for evolving a better one.

Contingency

In any estimate or project plan the estimators always include an item at the end of the estimate for contingencies. A contingency allowance is necessary because uncertainty exists in the estimating data and assumptions. The costs cannot be defined precisely when the estimates are made. To account for this many companies tend to use an allowance of about 10% for contingencies in their estimates. In some cases, the 10% allowance is company policy. All their estimates include a 10% contingency. <u>This is totally fallacious</u>. The amount of contingency which is required is a function of the desired probability that the final project cost will not overrun the estimate. The higher the desired probability, the higher the contingency, and 10% is rarely the correct number. There is no logical reason to arbitrarily assume 10%.

With Monte Carlo analysis you are able to determine the correct amount of contingency. The amount of contingency needs to be balanced with the concept of confidence, i.e., confidence that you won't overrun your budget. If you want to have a lot of confidence, the contingency required will increase, and Monte Carlo analysis will define how much of an increase is required.

As mentioned earlier, an in-depth knowledge of statistics is not necessary in order to conduct risk analyses and range estimates using Monte Carlo techniques. There are a variety of PC-based software programs on the market for this purpose. Technically they are excellent, easy to apply, and answer all the key questions in the minds of decision-makers. That is, they answer the key questions <u>if</u> the analyst uses the software properly. That is a big **IF** because software documentation is not always adequate to explain how to apply it properly to the imprecise nature of project estimating information. If care is not taken and the software is not applied properly, the result can be understatement of the true exposure in the decision. In such cases, actual risk can be far greater than predicted. In effect, the risk analyst actually can induce risk.

Avoiding Risk Analyst Induced Risk

The key to performing a project risk analysis is in properly identifying those variables which can have a critical effect on the project outcome and in applying ranges to those variables, and only to those variables. It is human nature to assume, for example, that a very large item in a cost estimate is critical just because of its magnitude. That is not the case. An item is critical only if it could potentially change by enough to have a significant effect on the bottom line. The effect need not be negative. What matters is if the effect is significant and can cause a change in either the negative or positive direction.

Curran (1988) has demonstrated that in virtually all project estimates the uncertainty is concentrated in a select number of elements--typically fewer than 30. In most cases there are only 10 to 20 critical variables even though the estimate may have hundreds or thousands of variables. You must understand which variables are the critical ones. Unless you take the time and trouble to measure the uncertainty of each of them, and only them, and unless you take the time and trouble to combine those uncertainties into some bottom line uncertainty using a technique like Monte Carlo, you will never get to the right answer.

<u>*Not everything is important*</u>**.** Very few things are really important. This is called variously the Law of the *Significant Few and the Insignificant Many* or the *80/20 Rule*. Others refer to it as *Pareto's Law* after the noted Italian sociologist and economist Vilfredo Pareto. Long ago Pareto examined how wealth was distributed from country to country, concluding that in any given country a small percentage of the population would collectively account for most of the wealth. The fact of the matter is that this principle applies well beyond economics. It extends to almost all issues involving multiple variables in any area of investigation.

How then do you identify which variables are the critical ones? Quoting Curran (1988):

> *"...a <u>critical element</u> is one whose actual value can <u>vary</u> from its target, either favorably or unfavorably, by such a magnitude that the bottom line cost of the project would change by a amount greater than the <u>critical variance</u>..."*

Curran goes on to define critical variance empirically as "in the neighborhood of 0.5% in conceptual estimates and 0.2% in detailed estimates." He goes on to state that "If the bottom line measures profit rather than cost, the threshold values are approximately 5% and 2% respectively." Thus, for example, if a detailed estimate is $1,000,000, the critical variance is $2,000. Any variable which could cause the bottom line to change, up or down, by $2,000 or more would be defined as a critical variable.

It is very important to understand that the magnitude of a variable is not important. What is important is the effect of a change in the variable on the bottom line. Relatively small variables are often critical while very large variables may not be critical at all. Typically there will be only 10 to 20 critical variables, even in the largest projects with hundreds of variables to consider. In identifying the critical variables it is also necessary to link strongly related variables together, not to treat them separately. It is also necessary in the range estimate to apply ranges only to the variables which are identified as being critical. You must know when a variable is important and when it is not.

Conducting the Risk Analysis

Now, what are we going to do with the items which have been identified as being critical? Give them a range and make an estimate of the probability that each item can be accomplished within the original plan, i.e., for a cost item, the probability that it can be accomplished at a cost no greater than the originally estimated amount.

And how do we do that? The very best way is get everybody involved. Everyone who understands the critical variables should be there contributing to the process except for anyone who may have undue influence on the group. Don't include them because it will taint the results.

The process is not as time-consuming as it may appear. In many cases, good risk analyses can be performed in a matter of hours. If the process takes a long time, there is probably something going wrong. That's not to say there aren't cases where it will require a lengthy period of time to do a risk analysis. But in the normal course of events, that doesn’t occur. This should be a decision based upon the collective experience of the group of people who understand the variables.

If you only ask a very inexperienced manager to range a critical element, you inevitably will get a very big range. Lack of experience breeds excessive conservatism.

On the other hand, if you only ask the estimator or quantity surveyor who came up with the figure, you are going to get a narrow range. It is human nature to defend your estimate. To agree to a wide range is akin to admitting failure.

If you recognize these human weaknesses and structure the ranges properly using the collective experience of the group, you will learn:

1. The probability of having a cost overrun.
2. How large the overrun can be (the exposure).
3. What can be done to capitalize on opportunities and reduce risk

Most importantly, you will learn how much contingency to add to the estimate to reduce the residual risk to an acceptable level.

Available Risk Analysis Software

There are some excellent pieces of software for performing risk analysis. Three of the better known ones are REP/PC, @RISK, and Crystal Ball. These three software packages are listed as examples only. There are many others which may be suitable for any particular application.

Here are some of the characteristics of the three programs:

1. REP/PC, Decision Sciences Corp., St. Louis, MO - Stand-alone software. Input: ranges and probabilities.
2. @RISK, Palisade Corp., Newfield, NY - Spreadsheet based software. Input: Probability density functions.
3. CRYSTAL BALL, Decisioneering Corp., Denver, CO - Spreadsheet based software. Input: Probability density functions.

Of these, REP/PC has been preferred by many companies for engineering and construction work for many years. Unfortunately it is a DOS based system and is no longer available for licensing and, unless a license still exists, one of the other available packages must be used. However, the other packages, and many more which are available, are excellent if applied properly, but there are limitations to be considered with all of them. Failure to properly identify the critical variables, or to assume that some variables are critical when they are not, will yield an incorrect analysis and will understate risk. REP/PC has proprietary algorithms in the software to detect improperly identified critical variables. The other pieces of software do not protect you against this problem. You must follow the rules outlined earlier for identifying the critical variables. The software itself will not do this job for you.

REP/PC requires the ranges and probabilities for the critical variables as the input. As stated earlier it is a DOS program and is not available in a Windows version. That is not a serious limitation for versions of Windows up through Me which directly support DOS. However, if one possesses a license for REP/PC, later versions of Windows can still activate DOS through the Command prompt.

@RISK, CRYSTAL BALL and several other widely available programs are fully Windows compatible and link directly to Excel or other spreadsheet software but generally require that probability density functions be identified for each critical variable. This is generally not a problem in engineering and construction project work, however, because we are not dealing with rocket science. High precision is not required for the typical projects cost engineers, quantity surveyors, and project managers work on. If the probability density functions are undefined (as will usually be the case), a simple triangular distribution can generally be safely assumed for each critical variable. This assumption is sufficiently accurate for cost work.

Risk analysis is not difficult to perform properly, and the benefits in project planning are great. However, if it is not done properly, the results can be disastrous as the analysis can severely understate risk and lead to unsatisfactory conclusions about project viability.

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