Risk Determination in Projects. The Advantages and Disadvantages of Stochastic Methods

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Abstract: This paper is a comparative study about the principal stochastic methods that is used in Project Management. Risk determination is a must for every Project Manager worldwide, but the methods have, of course, advantages and disadvantages. Further, many Project Managers work with deterministic methods, but they see only the advantages or disadvantages of those methods. In Subject of this paper it is *Risk determination in projects. The advantages and disadvantages of stochastic methods*. Choosing the theme of this paper is not random, it continues a series of articles published for strengthen of scientific research in the Doctorate studies that I followed since 2005.

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1. Introduction

Primary organizational structures of traditional organizations - institutions and companies - are rigid systems, which record the failures in practice whenever the need arises to solve new problem in a short period. These linear organizational structures with hierarchical dependencies are designed to solve routine problems. To solve the tasks with unique character, so the tasks of the project, is necessary to extend the primary organizational structure in an organization with concepts of secondary organizational structure namely with project management.

According to the latest edition of the book on which the Project Management Institute (IPMA, 2009) organize the contest to obtain the title of a professional project manager, there are identified nine areas of expertise of the project manager areas which reflect, in fact, nine processes in structure of project management: integration management, scope management, time management, cost management, quality management, human resources management, communication management, risk management, acquisitions management (outsourcing management).

2. Risk Management in Projects

Risk management is an active process for reducing exposure and adverse consequences of future events that could lead to failure goals. Projects involve identification and assumption of multiple risks, related to this specific area. Conduct work under the direct elements of nature, the mobility of the production process, high duration of execution, large number of activities to be led and coordinated, the production process complexity, contractual relations between the many parties involved - often with diverging interests - are arguments in support of the earlier allegation.

We call “risk” the uncertainty associated with any result. Uncertainty may relate to the probability of occurrence of an event, or influence, or effect of an event if it occurs. The risk occurs when:

- occurrence of an event is certain, but the result is uncertain;
- the effect of an event is known, but the event occurrence is uncertain;
- the occurrence and effect are doubtful.

We call element of risk in a project any item that has a measurable probability to deviate from plan.

One element of the project, noted (a) may be considered risk element if is following two conditions simultaneously (Opran, C. et all, 2001, p. 52):

$$\begin{gathered} 0< P(a) < 1 \\ L(a)=0 \end{gathered} \qquad (1)$$

where:

P (a) = probability to produce event (a) and

L (a) = monetary evaluation of the event (a).

Risk analysis in projects

The main benefit of risk analysis it is constitute by possibility of assessment exposure to the risk (quantification) of a project, activity or phase. To quantify, the risks are defined as the product of the probability of occurrence of the event and the negative impact that would result from the event:

$$Er = Event \times Impact \qquad (2)$$

Risks should be assessed in advance. The first evaluation must take place before the start of the project. Then, identification of risks should be ongoing during the project. Project members that are familiar with it circumstances must have an active role in identifying and assessing project risks. This collective participation will facilitate the identification of risks, making quick decisions to solve problems and reach a consensus on the necessary measures.

An event is a problem that must be solved, while risk is a potential future problem that has not occurred yet. Mathematically, the risk may be manifested by the percentage of occurrence probability. If the occurrence probability of the problem aims to 0%, then the risk will be ignored. Conversely, if the probability of occurrence of the problem is over 50% then the risk becomes a constraint that must be taken into account.

All projects have a degree of uncertainty because of associated assumptions and environment in which they are executed. Thus, although the risks cannot be completely eliminated, many of them can be anticipated and solved in a timely manner.

The purpose of risk analysis is to identify risk factors for the project and to develop a plan for risk management to minimize the probability of risk materialization.

Estimation and risks evaluation

Estimation is a quality evaluation that sets probability of risk occurrence and impact, measuring the probability and impact of each risk, classify into risk categories, and finding a common basis for classification risk tables - matrix of probability/impact, decision trees and series of distributions, Monte Carlo and Latin Hypercube curves, trend reports and risk register.

Evaluation is determining of acceptability degree for each risk and the needed actions for risks manage and need including risks minimization that contains identifying remedial actions, risk separation (only monitoring is required), developing action plans for those risks who can materialize, despite measures for minimize it.

Avoiding risk means eliminating the requirement that cause the problem. For example, if part of a project associated with a high degree of risk, then that whole part of the project is removed or replaced with another. Risks associated with a supplier can be avoided if it’s choosing another supplier. This is a very effective way to eliminate risk, but may be applied only in certain situations.

The simplest method of quantification of risk is the expected value (VA), which is calculated as the product of occurrence probabilities of certain events and their effects:

$$VA(a) = P(a) \times E(a) \qquad (3)$$

where:

VA (a) = the expected event (a);

P (a) = probability of event (a) occurrence;

E (a) = the occurrence of the phenomenon (a).

Stochastic Methods Used in Project Management

The main methods used in project management for analysis, monitoring and evaluation of risks are CPM - Critical Path Management, PERT - Program Evaluation and Review Technique, and statistical analysis Monte Carlo and Latin Hypercube.

PERT is probabilistic, which allows to calculating risk in completing of a project. CPM is deterministic, relying on single estimate of duration. Both CPM and PERT allow to use artificial activities (which do not consume resources and time) to determine the logic of the project. PERT is used especially in projects where the risk of having large differences in estimating duration is high.

Further we will present briefly only probabilistic methods, the CPM do not belong to this category, and finally we will describe the main advantages and disadvantages obtained by applying these methods.

PERT-Program Evaluation and Review Technique

PERT (estimating in three-point), is a management tool for planning and control. PERT uses three estimating sample (optimistic, most likely, and pessimistic). From these estimates may be deduce the duration of the project. In many cases, PERT networks are built from end to start, because the project end date is the most important key to the whole project.

Building PERT network we can determine the relevant time for the project. One aspect which should take into account when calculating the duration of the project is loading degree which it's taking into account.

We must keep in mind that team members may be sick, are entitled to holiday leave, and benefit, like any employee, to the legal holidays.

In network building must be established if the event represents the beginning or end of an activity.

In the PERT method each activity required three estimates:

d_o=duration most optimistic

d_e=duration of the most likely

d_p= duration of most pessimistic

Starting from these quantities, it's calculated the probable duration of each activity, based on statistics and start from the premise that errors it fall within the normal distribution curve.

$$DE = \frac{d_o + 4d_e + d_p}{6} \qquad (4)$$

where:

DE is the estimated duration.

This calculation is repeated for all activities of the network. The results are used to determining probability that the project be completed within the time scheduled. If the network is more than one hundred activities, using of computer becomes imperative, which takes the hardworking of this laborious calculations and produce results in time, for do the necessary measures.

Some experts do not accept the use of a normal distribution curve to predict the distribution of estimation errors. It is well known that estimates are often more optimistic than pessimistic. This trend may be offset by using an asymmetric distribution curve (or misplaced). As an example, it is used the following variation on the formula above:

$$DE = \frac{d_o + 3d_e + 2d_p}{6} \qquad (5)$$

Whatever is the statistical basis, PERT will generate the critical path in the same way as any other method of network analysis. The focus is moving, in this case, from cost-time and determining of critical path to a statistical approach, able to indicate the likelihood of project completion date set.

Although many users talk about their networks as PERT type, the term is often used improperly, in most cases was a classic analysis of critical road, with simple estimates of time, which is the most widely used.

Example: Suppose you have an *F* phase of a project *P*. *F* has four sub-phases SF1, SF2, SF3, and SF4 have estimated the following times:

Table no. 1 PERT analysis for *F* task of *P* project

Phase / Sub phase	d_o	d_e	d_p	**PERT1**	**PERT2**
F	50	74	116	77,0	84
SF1	10	15	25	15,8	17,5
SF2	8	13	19	13,2	14,2
SF3	2	6	12	6,3	7,3
SF4	30	40	60	41,7	45,0

The calculation of the estimate PERT1 we consider for calculating formula no. 4, and for PERT2 formula no. 5. Observe that the estimation of asymmetric distribution PERT2 is almost 10 percent more pessimistic than PERT1.

3. Monte Carlo Analysis

To overcome the challenges associated with the PERT method, Monte Carlo simulation can be used as an alternative. Monte Carlo is a mathematical method used in the analysis of risk in many areas and is used to estimate the distribution of potential outcomes based on probabilistic input links.

Statistical-mathematical analysis Monte Carlo is a class of computer algorithms that rely on computerized repeat, random, of samples for analysis results. Monte Carlo method has been used mainly to simulate the physical and mathematical systems.

Because it is based on random repeated or pseudo-random of a large number of inputs, Monte Carlo method is used mainly help by a computer when it is impracticable or impossible to calculate exact results through a determinant algorithm. Monte Carlo simulation was used especially in studying systems with a high degree of freedom of data, such as fluid mechanics, cellular structures etc. Recently, Monte Carlo analysis is used in estimating of the risk in business.

Latin Hypercube Analysis

Statistical-mathematical method Latin Hypercube was developed to generate a distribution of plausible parameters collection values within multidimensional distribution. The method is applied in the unreliable analysis.

In the context of statistics, a grid square containing sample position is a *Latin square* if and only if there is only once sample per row or column. *Latin hypercube* is a generalization of this concept to arbitrary values of dimensions, whereby each single value is in the proper axis (axe-aliened) hyper-plane what it contains.

When populating a function with *n* variables, the limit of each variable is divided into *m* probabilistic intervals. M points corresponding to values are placed so as to satisfy the Latin Hypercube – must be kept in mind that forces us that *m* be identical for each *n* variables. Also must be noted that this scheme does not require multiple values from multiple dimensions (variables), this "independence" is one of the great advantages of this scheme of values. Another advantage is that random values can be considered one by one, reminding us what values we were late.

Values collected for Latin Hypercube can actually improve Monte Carlo simulation, by choosing inputs more efficient. While the methodology for collecting of Monte Carlo method agree the random choice of domain values, Latin Hypercube collecting data from the whole area more systematically.

Monte Carlo simulation or Latin Hypercube has proven an effective methodology for the analysis of programming projects which contain uncertainties.

Each statistical-mathematical simulation has specific functionality; however, some issues are common for all. Firstly it entitles the user to: assign different statistical distributions including, of course, distributions specific for the project (activities duration, costs, etc.); perform Monte Carlo simulations and to export results in various formats. For example we can use frequency or cumulative diagrams of the probabilities or histograms to see the chance that project be completed in a given period. We can also calculate the criticising index or the probability that the projection of one of activities "lie" in a project.

We can generate a sensitive analysis or calculate how sensitive are the results of the project (projection duration, costs, risk, deadline etc.) based on irresolutely input dates (action duration, deadline etc.). The sensitive analysis results can be incorporated in graphics. Actions that are listed at the above on graph have the potential to affect the project duration the most.

Simulation tools can provide opportunities like: conditional disintegration or probabilities. An example of disintegration is when the user defined as a 40% chance that the activity A succeeds to B and 60% that C succeeds to B. Another example of conditional disintegration is when the user defines that activity A will be followed by activity B if the duration of A activity is equal to or greater than a certain value.

Classical Monte Carlo simulation has a number of limitations. The statistical of the project dates as activities duration, can be obtained on the basis of historical dates and in many cases they are usable. For example, a project manager usually known as a specify activity of construction work will take between 1 and 3 days and can be defined by normal distribution. However, in some cases, particularly in research projects, this information cannot be obtained and using Monte Carlo simulation we cannot improve estimates.

It is also very important to constantly check the performance of the project and to change the input data and associated distributions using performance measurement data. Another problem associated with the Monte Carlo simulation is that if a project "slide", project manager, usually carried out several actions to redress. It is difficult to define prognosis and response to a Monte Carlo simulation.

To defeat these challenges, was developed Event Chain Methodology (Event chain methodology) as the extension of classical methods of Monte Carlo simulation.

Uncertainty of the projects can be defined as a set of risks or probabilistic events (the list of risks) that may be designated to activities, resources and project scheduling. Several events may occur in the middle of work, and lead to delays in work, restarting, or stopping them etc. Events can cause other events and generate chain events. Project managers can monitor these events, determine the critical risks - which affect the project's most - and they can mitigate. Event Chain Methodology allows performing quantitative risk analysis combining project schedule with the lists of risks.

4 The Advantages and Disadvantages of Stochastic Methods in Project Management

Using stochastic analysis in project management can be beneficial for project managers who are overburden in the estimation of the duration or cost phases of the project, or even of the whole project.

The main advantages of using these methods have resulted in minimizing risk. Thus:

1. Probabilistic analysis can estimate the project completion date. By using their combined CPM and estimates like "bottom-up" or "top-down" a trained project manager can estimate and determine completion of a project;

2. If a customer requires a deadline for a project, the analysis may determine the chances that the project be completed by that date. In such situations should take into account the possibility of erroneous estimate data, so the pessimistic methods being useful to us;

3. A big advantage of project managers is that, using the methods described above can cause the flexibility of projects that are major differences between the and optimistic and pessimistic estimates. In this sense, if a project manager is forced to modify the programming accomplished initially, probabilistic methods can help to determine which phases of the project are more flexible and may change without risk.

4. Probabilistic methods help project managers to consummate programming and project activities. By estimating the duration of using probabilistic methods and standard deviation formula, project managers can schedule the start and end actions accurately. And this is a big advantage, especially in complex projects, where ever the start and finish are not clear from the outset.

Of course like any method, methods described above have disadvantages. Further, we enumerate a number of these disadvantages:

1. One of the most important factors in the probabilistic analysis is to establish accurate baseline data. Thus the optimal, the probable and the pessimistic duration become critical, whereas all the above using triangular-based data. Clearly, provision of inaccurate initial samples will compromise the outcome of reviews and of course the standard deviation, that are imminent result changing the time required for each project.

2. Probabilistic analyses require more time and certainly a lot of work. Where we have a simple project for a few tens of tasks, necessary time for forecasting stochastic of course using software tools, is in the order of days or weeks. When we talk about complex projects, that containing hundreds or thousands activities, the situation is complicated, adding the terms necessary modelling activities in each part is a mistake for any project. This argument leads invariably at affirmation that probabilistic modelling in large projects is ineffective and should not be used. The situation is not like that. In large projects, the project manager and team are very well prepared to estimate correctly, without the need for probabilistic modelling, operations and activities of most project components so that just the area of high risk involves stochastic modelling.

3. Probabilistic analyses are not practical. This argument shows that the second biggest drawback of probabilistic methods applied to projects. Because all methods require at least three sample of duration in the same task, and because methods listed require knowledge-statistical and mathematical, analysis presented are rarely used in practice.

4. One of the biggest disadvantages of the methods listed above is that the duration resulting from the calculations is more accurate or underestimated than correct estimating or overestimated. Underestimation of time can cause huge problems in project management. Late project is not the only problem that could

arise in case of underestimate one of activities, this will be resulting inevitably at overcome by supplementing resources budgets.

5. Conclusion

The question to ask is if we can overcome the disadvantages described above, and of course if we can use the methods listed in any project regardless of size? The answer is definitely yes, if we prove the precise initial estimates, where we use estimates in the scenarios of risk and of course if double the probabilistic methods with the classical deterministic mentioned above. Also prove to be patience and perseverance, which will obviously be rewarded by the accuracy of estimates, in which case the benefits of the methods listed above will overcome their disadvantages.

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