THE ASSESSMENT OF RISKS THAT THREATEN A PROJECT

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Abstract
A project consists of a number of interrelated tasks whose aim is to produce a specific result. A project risk analysis consists of analyzing schedule, cost risk, quality of the final product etc. A cost risk analysis consists of looking at the various costs associated with a project, their uncertainties and any risks or opportunities that may affect these costs. The distributions of cost are added up in a risk analysis to determine the uncertainty in the total cost of the project. A schedule risk analysis looks at the time required to complete the various tasks associated with a project, and the interrelationship between these tasks.
In this paper we want to study the various risks associated with the project. We start this study with the assumption that a project's cost and duration are linked together and also cost elements and schedule durations are correlated. The normal uncertainties in the cost items are modeled by continuous distributions like the Pert or triangular distribution. For project schedule modeling the most flexible environment is spreadsheet. We are interested in building blocks that typically make up a schedule risk analysis (also a cost risk analysis) and then show how these elements are combined to produce a realistic model. In the same time we want implement software tools for run Monte Carlo simulations on standard project planning applications.

Keywords: *feedback loops, cascading risks, portfolios of risks, sensitivity analysis, Monte Carlo simulations, critical path analysis, ModelRisk software*

Introduction

A project consists of a number of interrelated tasks, whose aim is to produce a certain result. Typically, a risk analysis on the achievement of a project implies the analysis of the risk regarding the plan of the project and its cost. In some cases the analysis may also include other aspects, such as for instance the quality of the final product. Risk may be defined as the possibility of the emergence of an event that affects the achievement of technical or cost objectives, or of project terms. The risk is aleatory, unpredictable, may be favorable, yet most of the times is unfavorable and thus, under these circumstances the analysis and prevention of risks should be an utmost preoccupation for project managers.

In this paper one intends to identify the risks that may appear during the execution of a project, as well as to identify techniques and methodologies of dealing with these risks. Since the risk is usually tackled statistically and since the statistical results are better only if the statistical distributions used are closer to the distribution of real data, one emphasized here the creation of new statistical distributions that would fulfill this requirement.

With this aim in view the team leaded by the author of this article created a library of programs, named ***DistriRisk*** which is based on the following four methods of creating new distributions: **the composition method, the „Rejection Sampling" (RS) method, the „Importance Resampling" (IR) method** and **the Metropolis – Hastings (MH) algorithm.** Using the random generation of numbers, one also created a program for the generation of beta distribution, applicable in the Monte Carlo method. All these new distributions are to be included in the pack of programs ModelRisk developed by the company VOSE Consulting with its European headquarters in Belgium.

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This paper also suggests another way to calculate the cost of a project by applying the central limit theorem. Since the ordinance of a project is a simulation based on a privileged scenario for each task, we hereby suggest the use of the Monte-Carlo method, which allows the exploitation of several ordinances, combining different scenarios for the tasks of the project, and leading to a probabilistic analysis of certain information, such as the duration of the project or the probability for a task to be difficult to achieve.

In the future we intend to develop a sampling algorithm based on **the Latin hypercube** method, which will provide a sampling method that **seems** to be random but **guarantees** the reproduction of the input distribution with greater efficiency that the one provided by the Monte Carlo method.

Once this methodology is certified, we will try together with the specialists of the company VOSE Consulting to tackle the quantitative calculation of risk, as well as the possibility to model it, so as to evaluate as many projects as possible.

The risks of a project

The risks corresponding to the main stages of a project are the following: the analysis of the needs, preparing the project and the execution of a project.

The analysis of the needs. There are four categories of risks that should be taken into account before launching a project: - the risk of competition; - the risk of market (the commercial situation);- commercial risks (the manufacture of the product, the relation cost / quality); - technological risks.

The factors that may increase the risk could be the following: - the inexistence or the incomplete previous research in the field of the project; - a need formulated in a wrong way; - functions or restrictions unspecified by the user; - functions, whose complexity is inadequately assessed when analyzing need, one also noticing an under-estimate of the level of difficulty that requires expensive resources; - non-negotiable functions, imposing thus highly restrictive objectives from a technical point of view or when it comes to price or terms, choosing some functional performances without being in fact imposed by the needs; - not knowing norms and regulations imposed on certain products.

Preparing the project. These analyses and conception considerations exert an important effect in the stage of the execution of the project. *In the second stage the following risks may be mentioned:*

- various flaws and constant hesitations in the first version of the project, to which one may add an incomplete and less competent technical documentation;
- under-estimating the complexity of the methods and conception procedures (programs, automatization microcontrollers), which leads to too little time spent for the learning of working techniques;
- difficulties in defining and planning the stages mentioned in the program;
- the wrong assessment of the availability and performance of resources used; generally, there is the tendency to over - estimate performances and to under-dimension costs, being too optimist in what regards the terms;
- if we also take into consideration the subcontracting of certain stages to specialized companies, the dimensioning of the performances of resources is an extremely laborious and risky action;
- the generation of conflicts in using available resources. The resources are limited and most of the times they should be used simultaneously in various activities. Under these circumstances, neglecting critical activities may lead to delay.

The execution of the project. The risks here are related to various flaws in the identification and analysis of critical information (delayed diagnosis, wrong diagnosis, improper answers).

According to the method AMDEC (the analysis of the defecting ways and their effects) a rational perception of the risk is done according to the following typology:

- identifying the flaws and weak points before they occur may be more or less precise and tardy, depending on the case.

A controlled procedure in a favorable organizational context may generate good results. Practically, *a good piece of information* travels *in a favorable moment* towards *a responsible actor;*

- the diagnosis of the cause – there are statistical methods which may provide data, according to which one may decide ensuring measures against diagnosis errors*;*

- prognosticated analysis of effect – appears when the effect is not yet evident or will be achieved on long term, and cannot be yet mentioned.

Emphasizing a risk in the management of a project

A project is defined by price objectives, performance objectives and terms objectives. Each category of objectives has its own risk issues, which make up the object of specific research:

- *The analysis of the risk to exceed the cost of the project* is usually done during its execution, appealing to techniques of financial and accounting control; the analysis of this type of risks may be also done in the stage of defining the project, appealing to the qualitative risk analysis.

- *The analysis of the risk of the failure to comply with performances* is an issue for technicians and its approach should focus on the technical fields to which it is related. Becoming aware of certain technical risks may be facilitated by the qualitative risk analysis.

- *The analysis of the risk of the failure to comply with terms*; its insufficiencies lead to its completion by approaching the risk from a qualitative point of view.

- *The quantitative approach* does not provide the decisive factor with information meant to guide one in action, this being oriented towards the quantification of the dispersion of results for an objective such as duration or price.

- *The qualitative approach* – the intuition of the leader, as well as good knowledge of the company and its environment have always played an essential role. A formal approach structures the reason with the help of control lists, which allow a fast and significant diagnosis.

This emphasis of the risk may be done either when defining the project (or the in-depth periodic re-examination of the project), as well as during the execution of the project, even if one does not use the same methods.

The quantitative risk analysis

The risk specific to this category is the failure to comply with terms and with the initially allocated budget.

A. The quantitative approach of the risk of not complying with terms.

The quantitative approach of the risk is done in a classical way, using statistical distributions. Of course, nowadays there simulation methods that are far richer in possibilities and information. This thing is a result of the use of computing techniques and implies highly sophisticated software.

The statistical methods[1] used for the management of the working time is based on the two classical distributions, i.e.:

- the empirical statistical distribution;
- the theoretical statistical distribution (beta, normal, triangular etc.).

Usually distributive methods are used. *These are based on the following principles*:

- the duration of each task in a project is considered random;
- one uses especially the Beta statistical distribution;

[1] Creangă Camelia**,** Darabonț Doru, Ionescu Dan, Kovacs Ștefan, *Metodologii pentru aprecierea riscului la locul de muncă – ARLM*; The Office for documentary information for industry, research and management (*Oficiul de informare documentară pentru industrie, cercetare, management – ICTCM*), București, 2001, p. 134

- one determines the parameters of this distribution starting from the extreme values A and B that the duration of the execution may take, and from the most probable value M_0 of the duration of execution.

Therefore one should come up with answers to the following three questions:

1. Which is the minimum duration (time)? – parameter A;
2. Which is the maximum duration (time)? – parameter B;
3. Which is the most probable duration (time)? – parameter M_0.

Once the parameters A, B, and M_0 are known, one may calculate the average mean and the variation of this random duration (time):

$$E(t) = \frac{A + B + 4M_0}{6}; \quad V(t) = \left(\frac{B - A}{6}\right)^2$$

- one determines the critical path of the project placed in a concrete situation, after which making use of the average times, one emphasizes the critical stages that cannot be delayed;

- the duration of the project is considered to be the sum of the durations (times) of the tasks of the critical path previously identified. This is a simplifying hypothesis;

- we use the central limit theorem in order to approximate the law of distribution of the probability of the project's execution schedule, using the approximation with continuity corrections for the Beta distribution. In other words we do, with the help of the corrections mentioned above, the normal approximation for the Beta distribution, with which the distribution of the project's execution schedule was configured;

- knowing the law of the probability distribution of the execution schedule of a project allows the calculation of trust intervals or of the probability for a schedule to be exceeded.

In order to generate a random variable with beta distribution we shall use two independent generations for the random variables with gama distribution, as can be noticed in the source code of the program that implements this generating way:

```
program rndbeta
    write(*,20)
 20 format(' ','introduce values for ix, iy, alpha, beta, n')
 read(*,*) ix, iy, alpha, beta, n
    do 100 i = 1, n
            ix = ix + i
            do 200 j = 1, n
                      iy = iy + j
                                call betarnd (ix,iy,alpha,beta,rn)
                                write(*,*) ix, iy, rn
 200                  Continue
 100 Continue
 end
    subroutine betarnd(ix,iy,alpha,beta,rn)
c Input: ix, iy - seeds
c alpha : form parameter
c beta : scala parameter
c Output: rn
 call gammarnd(ix,iy,alpha,1.0,rn1)
    call gammarnd(ix,iy,beta ,1.0,rn2)
    rn = rn1 / (rn1+rn2)
```

```
      return
      end
subroutine gammarnd(ix,iy,alpha,beta,rn)
c Input: ix, iy - seeds
c alpha : form parameter
c beta : scala parameter
c Output: rn
 rn = 0.0
      Do 1 i = 1, nint(alpha)
 call exprnd(ix,iy,beta,rn1)
 1    rn = rn + rn1
      return
      end
subroutine exprnd(ix,iy,beta,rn)
c Input: ix, iy - seeds
c beta: parameter
c Output: rn
 call urnd(ix,iy,rn1)
      rn = -beta * log(rn1)
      return
      end
subroutine urnd(ix,iy,rn)
 1    kx = ix / 53668
      ix = 40014 * (ix – kx * 53668) – kx * 12211
      if(ix .lt. 0) ix = ix + 2147483563
      ky = iy / 52774
      iy = 40692 * (iy – ky * 52774) – ky * 3791
      if(iy .lt. 0) iy = iy + 2147483399
      rn = ix - iy
      if(rn .lt. 1.) rn = rn + 2147483562
      rn = rn * 4.656613e-10
      if(rn .le. 0.) go to 1
      return
      end
```

ix and iy are the seeds, whereas rn is a random number between 0 and 1.

B. The analysis by simulation, using the Monte Carlo method [2]

The Monte Carlo method starts from the so-called "what – if" scenarios. The "what – if" scenarios are based on **the deterministic modeling**. This type of modeling implies the use of a single "well guessed" estimation for each variable, with the purpose of determining the results (effects) of the model. In practice, one varies the parameters of the model, thus slightly modifying the "well guessed" estimations, in order to determine the degree to which the effects **in reality** vary from those calculated by using the model. This thing can be done by selecting various combinations for each input variable. These various combinations of the possible values around the best guess, are known as the "what – if" scenarios. The model is quite often "stressed", since the variables (parameters) take values, so that they represent highly realistic scenarios.

[2] Boris Constantin, *Utilizarea calculatorului în analiza statistică*, vol.1, Editura Tehnopress, Iaşi, 2010, p. 130-165

For instance, let us consider the following simple problem: the sum of the costs for five articles. As values to be used in a "what – if" analysis, we may choose the following three points: the minimum, the best guess and the maximum. Since we have five costs (one for each article) and three values for each article, we therefore have $3^5 = 243$ possible combinations that may be generated during the analysis. Obviously this set of scenarios is far too large for a practical application. The process also suffers from two further drawbacks:

1. for each variable one uses only three values, even though in practice these values may be in large number;

2. one conducts no analysis whatsoever in what regards the probability of the emergence of the value that represents the best guess in comparison to the probability of the emergence of the minimum, respectively maximum values.

We may stress the model by raising the minimum value of the cost, so as to obtain the best scenario, or by raising the maximum value of the cost, so as to obtain the worst scenario. By doing so, we usually obtain an unrealistically great number of values that provide however no real image of the model. There is only one exception, i.e. when the scenario is still acceptable.

The quantitative risk analysis (QRA), which uses the Monte Carlo simulation, one of the most important modeling techniques, is similar to the "what if" scenarios, which generate a number of possible scenarios. Basically, one simulates scenarios for each possible value that may be taken by the variables of the model, after which these scenarios are weighted by their probability of emergence. QRA makes this thing by modeling each variable that appears in the model by means of a **probability distribution**.

In other words, the structure of a QRA model is very similar to that of a deterministic model where the variables are no longer simple values, but are represented by probability distribution functions. The objective of QRA is to calculate the combined impact of the uncertainty from the parameters of the model, with the purpose of determining an uncertainty distribution of the possible effects of the model.

The Monte Carlo method implies the random sampling of each probability distribution within a model, so as to generate hundreds or even thousands of scenarios, called **iterations** or **attempts**.

Each probability distribution is sampled in such a way so as to reproduce the shape of the distribution.

Therefore, the distribution of the values calculated for the results of the model reflect the probability of the values that may appear.

The Monte Carlo simulation provides lots of advantages, among which the most important are the following:

- the distributions of the variables of the model need not be approximated in any way;
- the correlations and other inter - dependencies among variables may be modeled;
- the level of mathematics necessary to use this simulation is basic knowledge;
- determining the distribution of the results obtained after the simulation is done entirely by the computer;
- the programs necessary to do this are commercially available;
- one may at any time include more complex mathematical notions (powers, logarithms, IF structures etc.);
- the Monte Carlo simulation is widely acknowledged as a valid method, so that the results obtained by using it are more likely to be accepted;
- the behavior of the model may be more easily investigated;
- a model may be changed really fast, the new results thus obtained being easily comparable to the results obtained by using previous methods.

The Monte Carlo simulation method may reach at least in practice any level of precision required, by the simple increase of the number of iterations. The only limitations are imposed by the number of random numbers that may be produced by using a generator of random numbers and by the time necessary for a computer to generate them.

For most of the problems in practice these limitations are irrelevant or may be easily surpassed by structuring the model into several sections.

In order to generate random samples for the input distributions of a model, one starts from a random variable X and a number p, which fulfill the condition $0 < p < 1$. We define **the quantile of order p** of the random variable X, or of its distribution function F, **the number** x_p with the following characteristics:

$$P(X \leq x_p) \geq p$$
$$P(X \geq x_p) \geq 1 - p$$

For p = 0.25 or 0.75 one obtains a **quartile** of X, and for p = 0.5 a **median line** of X. For instance, if X is distributed N(0,1) and p = 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, by interpolation, symmetry and considering the tables of normal distribution, we determine the **deciles**: $x_{0.1} = -1.282$, $x_{0.2} = -0.842$, $x_{0.3} = -0.524$, $x_{0.4} = -0.253$, $x_{0.5} = 0$, $x_{0.6} = 0.253$, $x_{0.7} = 0.524$, $x_{0.8} = 0.842$, $x_{0.9} = 1.282$. The values of the quantiles for conveniently chosen values of p allow us to have a representation on the distribution function.

Knowing them gives us a clue on the way in which the probability unit is distributed above the real line. If F(x) is a monotone continuous function, the quantile x_p is the single solution of the equation:

$$F(x_p) = p$$

If F(x) is continuous and $p' > p$, then: $P\{x_p \leq x \leq x_{p'}\} = p - p'$. The quantiles may be calculated with the help of the **quantile function,** or as it is also known, **the inverse distribution function**. Let us choose the random variable X characterized by the distribution function F(x):

$$\alpha = \mathbf{P}\{\mathbf{X} < \mathbf{x}\} = \mathbf{F}(\mathbf{x}) .$$

The inverse function

$$\mathbf{x} = \mathbf{F}^{-1}(\mathbf{x}) = \mathbf{G}(\alpha) = \mathbf{G}(\mathbf{F}(\mathbf{x}))$$

is called **the quantile function**: x = G(α) is that number for which with the probability α, the random variable has a value that does not exceed this number. In other words, if the cumulative distribution function F(x) gives us the probability P for the variable X to be higher than or equal to x ($F(x) = P(X \leq x)$), the inverse function allows us to answer the following question: which is the value of F(x) for a given value of x?. The concept of inverse function is that concept used in the generation of random samples starting from each distribution that appears in a risk analysis.

In order to **generate** a random sample for a probability distribution, one should generate a random number α between 0 and 1. This value is then introduced in the equation x = G(α) in order to determine the value that should be generated for the distribution. The random number α is usually generated starting from the uniform distribution (0,1) in order to ensure an equal opportunity for an x to be generated in any series of percentiles. The concept of the inverse function is used in almost all sampling methods. In practice, in the case of some probability distributions one may not determine an equation for G(F(x)), and this is when we appeal to numerical methods.

There are various packs of programs which may used in this respect, such as ModelRisk, @RISK, Crystal Ball etc. The ModelRisk pack uses the method of inverse function for the entire family of more than 70 single-varied distributions, also allowing the user to control the way in which the distribution is sampled via the so-called "U parameter". For example:

Normal(mu, sigma, U)

where mu and sigma are the mean value and respectively the standard deviation of the normal distribution;

Normal(mu, sigma, 0.9)

returns the 90^{th} percentile of the distribution;

Normal(mu, sigma) or Normal(mu, sigma, RiskUniform(0,1))

for the users of the @RISK pack, or

Normal(mu, sigma, CB.Uniform(0,1))

for the users of the Crystal Ball pack etc. returns the random samples from the distributions controlled by ModelRisk, @RISK or Crystal Ball.

If the random variable is continuous and one has the probability α (the generated random number), x = G(α) may be found out by solving the usually transcendent equation in a numerical way:

$$\alpha - \int_{-\infty}^{x} f(t)dt = 0$$

The survival function, written down as S(x) is defined as the probability for the random variable to have a value greater than or equal to x.

The inverse function of the survival function, also known as **the probability function**, written down as Z(α), represents that value that the random variable exceeds with the probability α:

$$x = Z(\alpha) = Z(S(x))$$
$$P\{X > Z(\alpha)\} = \alpha$$

i.e. Z(α) = G(1 - α)

where G is the inverse function of the distribution function and S is the survival function. In the case of a continuous random variable, with the probability density f(t), the value x, also known as **critical point** may be found out by solving the transcendent equation:

$$1 - \alpha - \int_{-\infty}^{x} f(t)dt = 0$$

The critical point is that point of the axis t that has the abscissa x. The function Z(α), the inverse function of the survival function, is one of mostly used statistical functions; for this function there is in the specialty literature the greatest number of tabled values.

From the relation Z(α) = G(1 - α), it results that the values of the probability function (the inverse survival function) may be obtained with the help of the quantile function, in which $\alpha \rightarrow 1-\alpha$.

The risk function, also known as **the intensity of death**, is written down as h(x) and is defined as the relation between probability density and the survival function in the point x:

$$\mathbf{h}(\mathbf{x}) = \frac{\mathbf{f}(\mathbf{x})}{\mathbf{S}(\mathbf{x})} = \frac{\mathbf{f}(\mathbf{x})}{1-\mathbf{F}(\mathbf{x})}$$

In the case of a discrete random variable, the risk function is defined in the following way:

$$\mathbf{h}(\mathbf{x}) = \frac{\mathbf{f}(\mathbf{x}+1)}{1-\mathbf{F}(\mathbf{x})} \text{ ; x whole number}$$

The cumulative risk function, written down as H(x) is defined as an integral from the risk function:

$$\mathbf{H}(\mathbf{x}) = \int_{-\infty}^{\mathbf{x}} \mathbf{h}(\mathbf{u})\mathbf{du}$$

The following relations exist:

$$\mathbf{H}(\mathbf{x}) = -\ln(1-\mathbf{F}(\mathbf{x}))$$
$$\mathbf{S}(\mathbf{x}) = 1-\mathbf{F}(\mathbf{x}) = \exp(-\mathbf{H}(\mathbf{x}))$$

In many statistical applications (building trust intervals, searching for critical fields for verification criteria of statistical hypotheses) one should find out the so-called **critical points in percentages** or the **percentage critical points**. In order to do this, in the equation 1-α-$\int_{-\infty}^{x}\mathbf{f}(\mathbf{t})\mathbf{dt} = 0$, one expresses the probability α in percentages Q, i.e. $\alpha = 0.01$Q. The critical point in percentage is defined as the root x of the equation:

$$1 - \int_{-\infty}^{\mathbf{x}} \mathbf{f}(\mathbf{t})\mathbf{dt} = 0.01\,\mathbf{Q}$$

The critical point x is the abscissa for which the shaded area represents Q percentages of the entire area under the probability density curve (= with 1).

The Monte Carlo method uses as sampling method precisely the method described above. The Monte Carlo sampling fulfils the most exigent needs of a natural random sampling method. It is extremely useful when one tries to obtain a model that should imitate a random sampling coming from a certain population or when we wish to conduct statistical experiments.

The random feature of the sampling of the Monte Carlo method refers to the fact that we may have **over-** or **under-**samplings on various pieces of the distribution, which does not give us faith that we could correctly reproduce (model) the shape of the input distribution. This aspect may be removed by considerably increasing the number of iterations done.

For most of the analyses regarding risk modeling, this random feature of the Monte Carlo sampling is not relevant. We are far more concerned to see whether **the model** reproduces the distributions determined (chosen) by us for its inputs. Therefore, why spend so much time and effort to find these correct distributions? The answer to this question has been recently provided by the sampling method named **Latin hypercube**, which provides a sampling method that **seems** to be random but **guarantees** the reproduction of the input distribution with far greater efficiency than the one provided by the Monte Carlo method.

The qualitative risk analysis of not complying with terms

The limits of the quantitative analysis lead to a qualitative approach, as well, thus facilitating the understanding of the causes of delays and subsequently a better way to prevent them.[3]

Chronologically speaking, the management of a project has a preparation stage, in which the work to be done is technically defined, based on a certain number of work hypotheses, and a simple ordinance by an achievement stage, during which the programming is applied.

The problems encountered during the execution lead quite often to a revision of the project analysis and thus to a coming-back towards the preparation stage. This type of analysis may be applied in a series of categories of risks presented in the following paragraphs of the paper.

The risks in the stage of project elaboration

In this moment of the stage, the responsible person of the project, as well as the team define the activities to be executed, conditioned by inner and outer factors and by the resources applied in this purpose. These risks may be re-grouped into four categories.

A. The internal risks when defining the project specifications

In the preliminary stages of the project, the information cannot always be very precise, defining a certain number of fundamental characteristics [4] (the list of tasks that need to be achieved, the duration periods of various tasks, the human and material resources necessary for each task, the quality criteria).

The reasons that generate these imprecisions may be the following:

- the existence of future tasks, whose exact content depends on the decisions made during previous activities that are not yet executed;
- the incomplete analysis of tasks, due to time crisis, of partial information of appealing to a temporization logic;
- the existence of various possible technical scenarios that the analysis did not intend to tackle in the research done;
- an under-assessment of the activities and what should be executed, the absence of previous experience for certain types of tasks (the inexistence of fabrication, package or control series);
- an under-assessment of the new difficulties determined by the simultaneous execution of several tasks;
- postponing to designate the responsible persons with the execution of certain tasks;
-vagueness in defining objectives of the project (quality, quantity, tolerance, durability, reliability, maintenance);
- modifying the content of the project depending on the human or material resources available;
- modifying the content of the project and the responsible persons during the execution of a task or a project.

This list should be completed before initiating the project. This process is not always possible, even unwanted due to the excessive delay caused by the search for complementary information.

The incoherence of the functional data sheets of the project

The data sheet of a project specifies the main objectives and means, but nothing guarantees the coherence between the objectives proposed and the means that can only result from the iterative

[3] Walliser, B., *Systemes et modeles. Introduction critique a l'analyse des systemes*, Economica, Paris, 1977, p. 166

[4] Opran Constantin**;** Stan Sergiu, *Managementul proiectelor,* Editura comunicare.ro, Bucureşti, 2004, p. 44

evolution between the various parts of the project. In this stage competence and honesty should prevail.

The paymasters of the project are tempted to abuse of their position so as to excessively limit the means, in relation to the objectives assigned; on the other hand, the responsible person with the execution of tasks would like to have some time and space to get ready for possible execution difficulties and to be able to comply with their arrangements.

The exchange of information may be ”distorted” from both sides, the objective of transparency being outside the power of perception, the information having nothing but a technical role and the denaturized effects of this informational transaction being only limited and not eliminated. [5]

Among the possible causes of informational incoherence in the datasheets one may mention the following:

- the date of the project finalization is too optimist (too close in time);
- the budget for the project is insufficient;
- the desired quality specifications are too ambitious;
- the technical performances of resources are over-estimated, therefore an unrealistic succession.

Technical and industrialization risks

These refer to the companies organized on project management. Under these circumstances the following cases may be emphasized [6]:

- under-estimating the complexity of the product or its innovating character may lead to a wrong perception of the difficulties at the level of the project coordination;
- choosing a new manufacturing method relies on the hypotheses regarding the development time and the performance of the method, which in turn condition the objectives of price (cost), terms and quality; these performances may not be reached if one does not mobilize more resources;
- the possible appearance of a new manufacturing method or a new technique during the execution of a project could lead to abandoning an already known technical solution, possibly partly done, if the new method diminishes the cost, increases the reliability or improves other performances;
- the anteriority relations between the tasks may double their technical connections: the specifications of a task take shape in the manufacturing of a product with precise technical characteristics; otherwise, the content itself of the guarantee task for the use of a product should be revised even taking into account additional costs and delays;
- combining several verified solutions may lead to problems difficult to predict.

The weak capacity to manage the development and tracing of projects

The organizational context of the project may or may not favor the appearance of realistic hypotheses and conditions the efficiency of the continuation of the execution. It is a factor that may lead either to the increase or decrease of risks exposed.

Tackling the organization of a project is justified by a certain number of advantages, with the help of which one may better manage time and costs; furthermore, one may also see beneficial effects in what regards the level of knowledge gained.

This means looking for alternatives from the class of specific problems and writing them under a transmissible form adequate to the limitation of the emergence of certain errors.

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[5] Alexander Carol, *Operational Risk, Regulation, Analysis and Management,* Prentice Hall, Finanacial Times, Pearson Education Limited, London, UK, 2003, p. 276

[6] Carroll Tery, WEBB Mark, *The risk factor. How to make risk management work for you in strategic planning and enterprise*, Take That Ltd., England, 2001, p. 194

In the absence of all collective reflections on this field, the capitalization is individual and reveals the expertise of the responsible persons, and transmitting the skill is difficult and tributary to the individual and the circumstances. A too fast rotation of the personnel is a major obstacle in gaining experience.[7]

The procedures of elaborating the project may lead to the emphasis of certain lacks or their explanation with the help of grids. The analysis of risks may seem useless to those who chasing for immediate results prefer to come up with an action plan without wondering about its fundamentals.

The procedures used for the elaboration of a project may limit the exchanges of information and commitments, and thus when establishing an ordinance with infinite capacity, assuming that all resources are available, the emphasis of possible conflicts that might appear at the request of using the same resources at the same moment, coming from various tasks of the project or from other projects, differ.

The procedures to continue the execution of the project may increase or decrease the effects of certain risks. The absence of formal procedures leads to a tardy detection of problems, and the correction actions taken under the pressure of emergency may not be the best (the compromises from technical validations of components transfer the risk towards the final characteristics of the product) [8].

A continuous activity is done by periodical update of work hypotheses, since the control of the project's progress may be done in comparison to a realistic technical recommendation and not to an initial recommendation lacking in significance and supported by out-of-date information and data.

The rigor implied by these updates represents the cost paid so as to be able to manage possible technical and financial deviations. The conflicts between the departments involved in the project appear inevitable. The procedures to solve or mediate these conflicts may be inexistent or may not be suited to the situation, which leads to more specific risks.

B. External risks in defining specifications

Anticipating the demand is mandatory for the launching of new products. This implies prognoses, as well as a certain level of risk: the norms that the product should comply with may change and may lead to regulated risks. Such errors may have serious consequences in specifying the resources required, with implications in delays and costly corrective actions.[9]

Unpredictable change of the environment is rather rare, but the following two risks may appear:

- the enforcement of new regulations in a certain field may be unsafe; a new law (such as pollution norms) has to be enforced, but the precise enforcement date is still unknown;
- the relative ignoring of the exact content of the future regulation.

In order to limit these types of risk, one may prefer adopting expensive technical solutions, which provide better reactivity, or maintaining restrictive specifications for the products.

Risks connected to use of resources

The risks connected to the use of resources focus on defining the resources required and their forecasted availability.

C. Risks connected to defining the resources requested

[7] Lupu Ramona Ana, Daniela Coman, *Managementul proiectelor*, Editura INFOREC, București, 2000, p. 217

[8] Prunea, Petru *Riscul în activitatea economică*, Editura Economică, Bucureşti, 2003, p. 25

[9] *****,** *Dicționar de managementul proiectelor;* AFITEP, Asociația Franceză de Managementul Proiectelor; translation from French into Romanian, Ion Năftănăilă; Editura Tehnică, Bucureşti, 2001, p. 251

The legal environment does not condition only the specifications of products, but also the use of personnel and equipment resources, thus generating regulated risks regarding the resources, the variables also according to the country in which the manufacturing process is ensured.

These restrictions may be internal (internal regulations, provisions), quite predictable, and external (laws, reports), less predictable, that are imposed upon the company: [10]

- *in what regards the personnel* the hypotheses on the environment susceptible to change may cause a modification of the personnel registries, referring to: the paragraphs imposing the duration of work (paid leave, weekly duration of work, permanent team), collective agreements, interior regulations of order;

- *in what regards the equipment* the following restrictions are to be taken into consideration at the level of the company (complying with security and safety norms) and at the level of the impact of their use on the environment (limitation of chemical, thermal, sonic pollution).[11]

The hypotheses regarding the defining of resources required may turn out to be ungrounded because of:

- ignoring the exact resources, human and material,
- ignoring their mobilization and the capacity of the execution of work required in a certain period of time.

An underestimation of the complexity of a task may require more complex resources than the ones forecasted:

- the incoherence between resources: the introduction of a new machine may have as a consequence a prior formation (or recruit) of operators, as well as an adaptation of technology and maintenance;
- the problems are bound to appear if these incidents are not brought to a minimum level.

Risks regarding the availability of resources required

Programming the project imposes special attention given to various mobilized resources, the productive potential available and the way to solve possible conflicts. A wrong definition of the productive potential may be determined by:

- ignoring the performances of certain resources (newly acquired machines, new operators) or of their reliability;
- the bad emphasis of the continuous improvement in using resources (the Kaizen approach in Japanese management);
- under-estimating the period of knowing the new resources (employing a new operator or machine may not become immediately operational);
- the bad emphasis of organizational issues (problems of coordinating the mobilization of resources).

D. Risks in the stage of project execution

During the execution of the project, unfavorable events (be they forecasted or not) may compromise the objectives of the project, and the notion of risk has a specific meaning.

The reaction of those responsible with the adaptation to a new situation may be more or less adequate, this changing the hypotheses of the labor of programming and the risks continue afterwards, as well. The risks during the stage of project execution are related to: the tardy detection of the problem, wrong diagnosis and inadequate reaction.[12]

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[10] Budica, Ilie, Mitrache, Marius, *Metode specifice de asumare a riscului în deciziile manageriale,* în: Revista Finanțe publice şi contabilitate, v. 17, nr. 5, 2006, pp. 55-57

[11] Bibu Nicolae, Claudiu Brandas – *Managementul prin proiecte,* Editura Mirton, Timişoara, 2000, p. 118

[12] **** Manual de Managementul Proiectelor,* Guvernul României, Departamentul pentru Integrare Europeană, Bucureşti, 2008, p. 117

The risk of late detection

In order to have a good diagnosis, the operator should dispose rapidly of good information and should obtain timely and adequate protection against flaws and deviations. Making use of necessary information varies according to risk: the external information regarding the surrounding technical and economic environment is relatively comfortable but often quite expensive; the internal information necessary is usually available but rarely adequate, on good support and in the right place.[13]

An active and non-passive attitude in front of information is a mandatory condition of a good reactivity. The problem of defining data to follow and the quality of the information available depends on the regularity of daily check-ups, and the emergency of other obligations is often invoked so as to differentiate certain daily check-ups; this behavior is the cause of the delays in identifying problems, which in their turn maintain the "pressure" on the operationalization of the project.

The risk of the wrong diagnosis [14]

The analysis of partial information may lead to the over or under-estimation of a problem. A diagnosis may be wrong because the phenomenon we fear does not have the degree perceived. At the same time, the error of the diagnosis may lead to the interpretation of facts:

- more possible causes may have the same effect, the cause retained being the wrong one;
- we may focus on an apparent cause, without looking for a remedy for profound causes;
- the mental representation of reality by actors (the inadequate use of the model of complete costs) always has deviations and may lead to wrong hypotheses of causal relations and consequently a false diagnosis in what regards the origin or the consequences of the problem detected.

A wrong diagnosis may lead to an inadequate answer, but a good diagnosis does not necessarily require adequate answers.

The risk of the inadequate answers

Once the diagnosis is formulated, the answer chosen may be inadequate. This phenomenon occurs if the diagnosis is justified by a local logic, because this tackles the problem only partially (the predominance from the point of view of the service performed or quite on the contrary, from the point of view of the management of projects) or does nothing else but temporize (the predominance of a budget or short-term argument), thus postponing solutions that need to be adopted, but which generate conflicts.

Another objectionable answer to the problem identified is the creation of new rules (procedures) that aim at the prevention of the reappearance of a problem with a slight chance of repeating itself, thus leading to the progressive suffocation of the system. [15]

The risk regarding the cost of the project

A risk analysis regarding the cost starts from a document, in which the various working packs contained by the project are mentioned and detailed. Each pack is then divided into a series of quantities estimating the quantity of work necessary for their achievement. Each pack is associated to an item of cost, which may also have an element of uncertainty.

These elements of uncertainty may be discreet events (of risk or opportunity), which may change the sizes of costs and are modeled by continuous distributions, such as the PERT distribution

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[13] Bowman, Wiliam Archibald, *Căi de îmbunătăţire a activităţii unei companii printr-o abordare bazată pe risc*, în: Audit financiar, v. 5, nr. 4, 2007, pp. 9-12

[14] Butler Cormac, *Mastering Value at Risc; A step-by-step guide to understanding andapplying VaR;* Financial Times, Prentice Hall; London, United Kingdom, 2001, p. 17

[15] Kieffer, J.P.*, Les systemes de production, leur conception et leur exploatation*, Edition Dunod, Paris,1997, p. 153

or the triangular distribution. We shall use here the triangular distribution, because it is highly popular in risk analysis. This distribution allows a good modeling when the minimum and maximum values of a variable, as well as its mode (the most probable value) can be estimated.

For instance let us assume that the body of a ship consists of 562 boards, and each of these boards should be clinched in its right position. Each board is clinched by a workman. The head engineer assesses that a board should be clinched the fastest in 3 hours and 45 minutes and the slowest in 5 hours and 30 minutes. The most probable value of the clinching time is thus 4 hours and 15 minutes. Clinching each board is paid with 50 lei per hour. The total cost for the entire process of clinching can be thus modeled:

Cost = 562 * Triangle (3.75, 4.25, 5.5) * 50

Having a number of 1000 simulations, one notices that we have quite a lot of values close to 3.75 and 5.5 respectively, which cannot be accepted because this means that the workmen work either too fast, or too slow. The problem appears because the triangular distribution models the uncertainties starting from the mean value of the working time for the 562 boards.

The easiest way to remedy this failure is to model each board in part. We thus obtain a column with 562 Triangle (3.75, 4.25, 5.5) distributions that we add and then multiply by 50. Even though the result is correct, the method is basically impossible to apply into practice because we would have to use a very large number of cells. In this case we shall use an aggregate model created by the company Vose Consulting and implemented in the pack ModelRisk:

VoseAggregateMC(562, VoseTriangleObject(3.75, 4.25, 5.5))

We would also like to suggest another way to solve the problem mentioned above, i.e. by applying the central limit theorem. We start from the fact hat the average mean μ and the standard deviation σ of the Triangle(3.75, 4.25, 5.5) distribution are:

$$\mu = 4.5$$

$$\sigma = 0.368$$

Therefore, considering the fact that we have 562 items, the distribution hours – total persons for the entire technological process is the following:

hours – total persons = Normal(4.5 x 562, 0.368 x $\sqrt{562}$) =
= Normal(2529, 8.724)

Therefore, the total cost for the clinching of all boards is estimated to be:

Cost = Normal(2529, 8.724) x 50

Conclusions

We consider that this paper sets the methodological and scientific bases necessary for tackling the quantitative and qualitative study of risks which may appear during a project. Generating new distributions, different from the ones used nowadays, and finalizing the algorithm for the sampling method known as the Latin square will allow in the future a much more **precise** statistical analysis of risk phenomena. The inclusion of the new distributions in the ModelRisk pack of the Vose company, specialized in risk analyses, will allow the authors to take part in **real** risk analyses together with the specialists of this company.

In the future one wishes to tackle the risks that may appear during very large projects, in which their number may be of thousands. In such a case each risk should be associated to a certain probability of appearance and a PERT – type distribution should reflect the size of that risk. We believe that in the near future the change of the organizational culture regarding the qualitative and quantitative analysis of risks of any kind should become of utmost importance.

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