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Portfolio based approach to project risk management

Représentation d'une gestion de risques de projets basée sur un portfolio

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ABSTRACT
Risk can be understood as the remaining potential of negative deviation to the business objective. Modern Risk management should provide a tool to describe the whole risk-situation of a company. Particularly, contractors active in the field of geotechnical engineering should not overstress their corporate project risk portfolio. Geotechnical projects often contain for the contractor a large amount of risks which have to be carried by the company in case of risk realisation. Therefore a well-structured corporate project portfolio will consist of a balance of high and low-risk projects. The paper describes the process of risk driven project portfolio management. Starting from risk identification on a project level the paper will deal with methods to accumulate the potential project risks to an overall description of the company situation. This is simply the sum of the risk exposure for each individual project weighted by their probability of occurrence. Probability of occurrence can be described by a Gaussian distribution and the accumulation can be modelled by means of a Monte Carlo Method. Examples for risk identification, measuring and monitoring in geotechnical projects are given. It is shown that it is important to track the project risk exposure over time. Some low-risk projects may become high risk and vice versa. The risk management process eventually provides the necessary basis for a company to decide on the extent of risk it is prepared to retain, or that which must be transferred or financed.

RÉSUMÉ
La gestion de risque devrait mettre à disposition un outil qui décrit tous les risques d'une entreprise de construction. En particulier, les entreprises actives dans le domaine de la technologie géotechnique ne devraient pas surcharger leur portfolio de projets de risque. Des projets géotechniques souvent impliquent pour l'entreprise un grand nombre de risques qu'elle doit porter en cas de réalisation. Par conséquent, un portfolio bien structuré consistera d'un équilibre de projets de gros et de faibles risques. L'article décrit le processus de la gestion de portfolio incité par risque de projet. A partir de l'identification de risque au niveau d'un projet l'article traitera des méthodes différentes afin d'accumuler des projets de risque possibles à une description de la situation globale de l'entreprise.

1 INTRODUCTION

Construction project risks are uncertainties, liabilities or vulnerabilities that may cause the project to deviate from the defined plan. Every construction project carries important elements of risk, thus it is probable that progress will deviate at some point in the project cycle. Risk in a project environment cannot be totally eliminated. The objective of a risk management process is to minimize the impact of unplanned incidents in the project by identifying and addressing potential risks before significant negative consequences may occur. In a broad sense, risk management may be defined (Wassmer 2001) as the process of making and implementing decisions designed to attenuate the adverse effect of accidental losses in addition to financial and market exposures faced by a company or organization. Making these decisions requires the risk management to be professional.

2 PROCESS OF RISK MANAGEMENT

The risk of project failure is substantially reduced if the appropriate risk management strategy is followed. In any case, the most appropriate way to safeguard the risk management project and ensure its full potential is the use of a structured methodological approach. The methodological approach that is suggested by the majority of risk managers is the implementation of the following four steps: identification, assessment, mitigation actions, follow up.

Risk identification is the first phase of the risk management process and it involves the determination of the risks that might affect the project and the documentation of their nature and characteristic. The above task should be carried out through the use of a structured methodology and not in an ad hoc manner. The identification of risks should be based on a clearly defined structure which means that risks are grouped into categories.

There is a wealth of literature that covers the subject of origin and classification of risks in the corporate environment. (e.g. Hall et al. 2001, ICE 1998, KPMG 1998). These can broadly be divided into two main groups:

- external risks
- internal risks.

External risks such as political instabilities, changes in legal framework are separate issues not to be discussed here. Internal risk can be subdivided into technology- , process- and human-risks. These three areas probably hide the most of risk sources for a construction project. Technology plays a key role in geotechnical engineering. Only with the ability of expert knowledge technical risks can be identified and analyzed. For geotechnical risk management Gudehus 2002 recommends to group geotechnical risks in a mechanical- and a geological-category. He also emphasizes that geotechnical engineers should consider the whole life-cycle of the structure and not only particular equilibrium states.

Risk assessment is the next phase where each identified risk is evaluated in two ways. Firstly, the probability of risk occurrence must be defined and then the impact that the specific risk will have on the project if it occurs has to be estimated. The multiplication of these two figures (probability of occurrence times impact on the project) will provide the risk exposure. On this basis the degree to which the contractor can influence and control the outcome and the contractor's ability to bear risk can be estimated.

The completion of risk analysis leads to the next phase of the process, which is the *Risk mitigation and control.* This is the step where the response to the identified risks, based on available technology, processes and human capital is designed. The way to cope with the risk is defined and the implementation of the decided actions should be conducted as a dialogue between all parties. Common means of risk response include avoidance (if possible), mitigation (if manageable), transfer (if applicable), and retention (if acceptable). Risk control should be leveled to the severity of the risk, be realistic within the project context, cost significant less then the impact on the project, if the risk is realized and, furthermore, be applicable within the given time frame.

3 RISK DRIVEN PORTFOLIO MANAGEMENT

The process of risk management is important not only for the specific project but also for a balanced project portfolio of a company. Portfolio management is necessary for a constructor with a large amount of parallel projects. While a portfolio in the traditional sense refers to a group of financial assets held simultaneously, the portfolio in the corporate context refers to a portfolio of cash-flow generating real assets.

Usually projects of a portfolio are diversified and connected with complex risks. The calculation of potential losses and of the required capital cushion becomes an important factor in competition against the background of increasingly scarce capital resources. Risk adjusted return must be precisely measured in the context of cash flow, capital management, and shareholder value. Furthermore, in the course of negotiation about a bit between the contractor and the investor an important information for the contractor is the level of risk which can be accepted. This question is addressed to the problem of measuring the risk in a portfolio of assets of construction projects.

3.1 *Distribution of profit and loss on a project level*

Traditionally the costs of 'trouble free' construction are calculated and a single point value risk surcharge is added in order to cover potential losses. However, the probability of occurrence of risk is not taken into consideration. Particularly, the problem of considering large losses, which exhibit rare but significant events, is not a trivial task for a company with a large and complex project portfolio. Clearly, the problem is connected with the estimation of quantifying uncertainties, thus it is much more convenient to provide a probability distribution for profit and loss of a single project.

The calculation of a risk statistic requires an estimate of the probability distribution of profit or loss (e.g. EBITDA - Earnings before Interest Taxes Depreciation and Amortization, or cash-flow depending on the companies business metric) at some future point in time. The question is how to best generate such a distribution? Experts are usually very comfortable in estimating the most likely values of an active duration, but are not as experienced at estimating lower and upper limits connected with probabilities, though an estimate is always based on an appreciation of a value by the expert. In fact, providing a distribution for an input instead of one value does not require a greater knowledge of the variable then a single point estimate - but quiet the reverse (Rodger and Petch 1999). It actually gives the experts a means to express their lack of exact knowledge.

The start of a construction project is always connected with profit or loss expectation. By means of risk assessment as described in the previous section information about probability of occurrence of the main variants are available. The simplest way to consider probability of occurrence of risk on a project level is to cumulate this information to a normal distribution. The distribution has PDF (probability density function)

$$p_{\mu,\sigma}(x) = \frac{1}{\sigma\sqrt{2\mu}} \exp\left[\frac{(x-\mu)^2}{2\sigma^2}\right] \tag{1}$$

with mean μ and standard deviation σ .

Obviously normal (Gaussian) distribution exhibits only one possible PDF. Other Distributions may also appropriate. However as a first estimate the normal distribution suffices to describe the uncertainty in the variable. It also gives a measure to the disperse around the mean e.g.:

$\pm\sigma$ of the mean = 68,0 %
$\pm 2\sigma$ of the mean = 95,0 %
$\pm 3\sigma$ of the mean = 99,7 %

3.2 *Generating Random Distribution*

To generate a series of random numbers following distribution (1) it suffices to generate the unvariate normal distribution

$$p(x) = \frac{1}{\sigma\sqrt{2\mu}} \exp\left[\frac{x^2}{2}\right] \tag{4}$$

and then apply

$$X_i = \mu + \sigma Z_i \tag{5}$$

where the Z_i, are the generated samples form the unvariate normal distribution (4) and the X_i are the resulting samples following distribution (2).

The implementation of a random number generator of uniform distributed random numbers can be found in Press et al. 1999. In many computer programs such generators are by standard implemented and thus not necessary to be described. Uniformly scattering random numbers correspond only to a series of numbers that lie within the specific range, with any one number in the range just as likely to occur as the other. The generation of non-uniform distributions is not a standard procedure and needs to be implemented in the model. Any distribution can be generated by a inverse transform method out of a uniformly scattering u (usually Unif[0,1]). Suppose

$$F(x) = \int f(x)dx \tag{6}$$

to be the area under the probability curve which corresponds to the cumulative distribution, the inverse function F^{-1} is then the desired frequency distribution (Press et al. 1999).

As there is no closed solution for P^{-1}, Beasley-Springer provided an approximating solution using the symmetry of the normal distribution (Glasserman 2004):

$$P^{-1}(u) \approx \frac{\sum_{n=0}^{3} a_n (u-1/2)^{2n+1}}{1+\sum_{n=0}^{3} b_n (u-1/2)^{2n}} \tag{7}$$

for $0.5 \le u \le 0.92$, with constants a_n, b_n given in Tab. 1. For $u < 0.92$ the function

$$P^{-1}(u) = \sqrt{\log(1-u)} \tag{8}$$

can be used.

Tab:1 Constants for the approximation of the inverse normal

a_0=	2.50662823884	b_0=	-8.47351093090
a_1=	-18.61500062529	b_1=	23.08336743743
a_2=	41.39119773534	b_2=	-21.06224101826
a_3=	-25.44106049637	b_3=	3.13082909833

Using the symmetry gives the distribution for $0 < u < 0.5$ reading

$$P^{-1}(x) \approx -g(1-u) \quad (7)$$

An fictive example of a single asset (a construction project) is displayed in Figure 1. We use EBITDA as our target variable when measuring risk exposure and analyzing the project. The return of the asset is normally distributed with a mean return of 12%. The mean displays the expected profit based on a project calculation and corresponds with a single point estimate including a risk surcharge. The standard deviation is an estimation resulting from the risk assessment of the project. In the course of project realization the expected profit and shape of the curve may change due to unforeseen events or risk realization.

The PDF gives much better information about the expected profit-loss situation of a construction project as a single point estimate or a best case / worst case scenario. Any expected return of the asset is connected with a particular probability. The tail of the normal distribution gives the possibility to consider rare events within the project context.

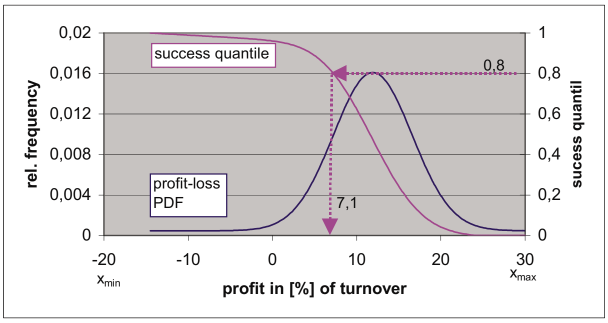

Figure 1: Expected profit and loss of a construction project

3.3 *Assembling to a portfolio*

Conventionally the project portfolio of a large company is composed out of a large amount of individual projects, each with its own risk characteristic. Since Markowitz's work on portfolio theory (Markowitz 1952, Markowitz 1959), diversification and dependencies between risk events are modeled by stochastic processes. For a contractor, functional dependencies of risk events of individual projects can be considered as low. Thus, individual processes will vary (randomly) across the set of projects. Using the distribution of each single project we can draw randomly a large number of scenarios and price the portfolio for each scenario. A rich set of scenarios will give a good approximation for the distribution of the final value of the portfolio. Technically this can be realized by means of a Monte Carlo Method. The technique is widely used in many different ways in the financial environment (e.g. Glasserman 2004).

The mathematics of measure formalizes the intuitive notion of probability, associating an event with a set of outcomes and defining the probability of the event to be its volume or measure relative to that of an universe of possible outcomes (Glasserman 2004).

Let

$$R^{p}_{[i=1,j=1]} = p_{\mu,\sigma}(x_{[i=1]_{[j=1]}})P_{[i=1]} \quad (2)$$

be a single realization of a random call for one project of the portfolio, with probability p at random node $x[j=1]$, total amount of profit $P[i=1]$ for the project $i=1$ and $R[i=1, j=1]$ the total amount of profit weighted with probability p. Then the realization of a random call j for the complete portfolio with components n is

$$R^{p}_{[j=1]} = \sum_{n} p_{\mu,\sigma}(x_{[n]_{[j=1]}})P_{[n]} \quad (3)$$

The empirical distribution function can be simulated by drawing a large number j of scenarios expressed by equation (3).

Figure 2 displays the accumulated PDF as a result of a Monte Carlo simulation of a portfolio with several hundred project presumed that each project is an uncorrelated event. The plot shows that due risk diversification the risk situation of a portfolio is much more balanced.

4 LIMITATIONS AND CONCLUSION

Financial aspects of large projects becoming increasingly complex and important. The fast development in PPP and BOT projects are examples of such increasing complexity in the construction sector. In the financial environment simulations are an intensively used tool to deal with complex situations.

Statistical instruments cannot replace expert knowledge. Expert knowledge about all details of a construction projects is the most important precondition for any assessment of risk and basic action against complexity. In the opinion of the authors it is a mistake to only relay on statistical models. However, Monte Carlo simulations can provide very valuable information for risk assessment. We have argued that quantification of exposures to risk based on a fundamental knowledge about the project should be an essential first step in a risk analysis. The bottom-up forecasted probability distribution on EBITDA then considers how, through what channels and to which risk exposure cash flow of a project is generated.

Therefore construction engineers are challenged to understand such instruments to contribute intensively and communicate with investors and financial institutions. Skepticism of the value of results should not be based on unfamiliarity with the technique.

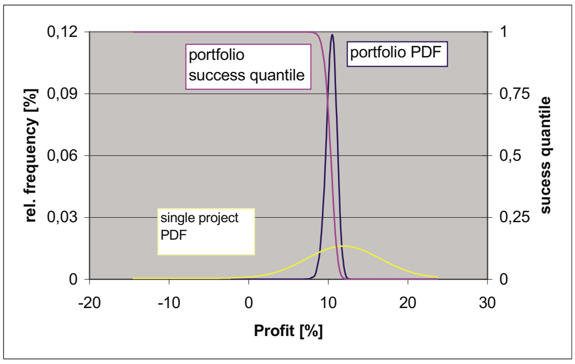

Figure 2: Result of a Monte Carlo simulation of a project portfolio

Transparent organized risk management and a well structured display of the risk situation of a project is always a key element in technical development. Technical development may lead to cheaper and faster solutions for the investor but it may also lead to more reliable and high quality solutions for a better life-cycle-performance of the outcome for the investor.

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