STOCHASTIC RISK ASSESSMENT OF PROJECTS CARRIED OUT IN A COMPANY OF CHEMICAL INDUSTRY

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Abstract

The paper presents an application of Reference Class Forecasting Method developed by Kahnemann and Tversky in planning and decision-making under uncertainty. This method is recommended by the American Planning Association as an additional one used during projects planning. Usually, according to project management methodologies recommendations, projects should be planned on the basis of statements of operations, however many of them fail and vast majority do not achieve the goals. The paper documents inaccuracy and risk in project planning in a company of chemical industry. Dozens of projects were analysed using statistical methods for further understanding of risks associated with planning. The paper presents risks unique to the industry under consideration. Based on the analysis important factors for planning were proposed.

Key words: risk management, quantitative methods & models, technology management, Reference Class Forecasting

JEL Code: G32, D81

Introduction

Concern about executing projects on time and within planned framework have become central issue of many project management methodologies; PRINCE2 introduces a management framework in order to make project success more probable; where project success is defined as meeting the project objectives and customer requirements; it is measured in six fields: budget, schedule, quality, scope, risk, and benefits. Very often the success cannot be evaluated before project's full implementation of planned results since projects helps organizations improve business as usual and deliver some benefits for them (OGC, 2009; Hinde, 2012). The standard published by Project Management Institute defines project success as meeting or exceeding customers' expectations by fine-tuning competing requirements like costs, duration, scope and

quality (PMBOK, 2008; Dinsmore, CabanisBrewin, 2010). Different methodologies define various activities concerning achieving project success; they are directed to the internal planning and project management. All methodologies present the fundamentals of project management in great detail which should help to apply the standards in real life. Project managers, especially new, have problems with meeting all the requirements of methodologies. The remedy for the problems may be the increasing number of professional associations and introduction the project management certifications. Stackpole claims that two weeks preparation for the certification is not enough. Only six month studies, reading the books of methodologies many times, doing the labs, participation in special courses allow to pass the exam (Stackpole, 2013). Despite getting acquainted with the methodologies and strict implementation of the plans projects are not carried out in accordance with the assumptions or even projects goals cannot be achieved (Flyvbjerg et. al., 2002). After introducing by Goldratt the theory of constraints new critical chain method of managing projects was accepted by professionals. There is no obligation to prepare sophisticated and detail plans now. Project teams are free to choose appropriate methods to achieve projects goals. The method attempts to take into account the impact of external factors on the projects (Goldratt, 1997; Leach, 2014). In a quantitative manner this impact is considered in Reference Class Forecasting Method (RCFM) (Kahneman 2011).

The present paper presents the attempt of application of the RCFM in chemical company to new projects planning. Several projects executed in the company by four years were taken into consideration in order to create reference classes and check the results. Although in many cases the method has been used with success, in the case of the chemical company the desired result was not achieved.

1 Literature review

In many cases even large companies use simple deterministic planning methods based on one time assumption. Unfortunately real projects generally are not implemented as planned. Flyvbjerg has rated many large projects in terms of delays and excessive costs incurred. About 250 big projects from last 70 years were examined and 90% of them costed more and lasted longer than it was planned. Costs, compared to the plan, went up by 20% to 50% depending on a project. If the bad performance of the projects was the reason for such state this could be easily corrected by better management and implementing project management methodology. Unfortunately the management did not learn from the mistakes performed in earlier projects,

however it was possible to have a sense of impending overruns (Flyvbjerg, 2003). Numerous studies were conducted aimed at discovering the reasons of the state of this situation. The Standish Group Report (2003) showed that failures are frequently covered up and ignored. The report indicated many reasons of project failures: uncertainty associated with the planning, unreliable data, inadequate planning models, lack of the management and project contractors involvement, lack of vision, clear target and real requirements for workers, lack of proper planning skills, difficulties with milestones and checkpoints definition, lack of competent personnel, unwillingness to work, random variability of project requirements.

All those problems could have been corrected with proper use of project management methodology, however it did not work. Other studies showed that the method of scheduling based on deterministic data was insufficient. In order to better evaluate the project the stochastic analysis methods, eg. stochastic models or Monte Carlo method should be used. In this case tasks durations, costs and other independent variables should be described by probability distributions. The calculations of the model were performed several times and based on the results the probability distributions of projects costs and durations were determined. Such planning might result in closer to reality values. In this case the condition for success was to obtain a reliable historical data (Dimov, McKee, 2007; Abrams, 2012).

Kahnemann identified psychological and political reasons of not completing projects on time and within budget. He noted that a person tends to have too optimistic view of the world. This atavistic attribute allowed survival. If people remember all the failures, and considered all negative consequences that may result from actions taken, they would have never discovered new lands and never engaged in new projects. For political reasons Kahnemann indicated a desire to obtain financing for the projects. Presenting optimistic plans could persuade policy makers to grant the funds. Later, after starting the project, especially in case of big projects, closing them is impossible and additional funds, willy-nilly, must be incurred (Kahnemann, 2011). Besides the reasons presented above external factors influencing projects costs and duration were presented: rising prices for materials, significant new expenses, new services, unplanned tasks, changing economic conditions etc. In case of big projects incorrect planning may cause not only economic but also social, environmental and security consequences. In order to estimate the real costs and schedules Kahneman and Tversky developed Reference Class Forecasting Method for planning and decision-making under uncertainty. RCFM takes into account projects plans but it also considers similar projects executed earlier. Cost overruns and time limits resulting from the implementation of historic projects should be proportionally

added to the current estimates. This would work only then policy makers would have a real picture of the future. For the first time this method was applied by Flyvbjerg for big infrastructure projects (Flyvbjerg et. al. 2004).

Forecasting method using reference classes includes (Flyvbjerg, 2011): collection of historical data; grouping similar data in the reference classes; it must be proven, using appropriate statistical tests or other methods, that values belonging to individual classes properly reflect comparable groups of projects; classes cannot be too broad, because the inference on the basis of this kind of classes could not be accurate enough; the classes also must not be too narrow because there could be problems with available data and the ability to assign new projects to a particular class; finding probability distributions of costs and schedules overruns for each reference class; finding a suitable scaling factor, which can be used to assess future plans.

The plan of a new project should be created using standard methods, and afterwards it should be corrected using the values based on the reference class. Forecasting method using a reference classes is recommended by the American Planning Association as an additional method used for planning. Project managers are encouraged to collect and archive data regarding all projects and use it for future planning (Flyvbjerg, 2003).

2 Research objectives

The objective of this paper is to present the use of Reference Class Forecasting Method in a chemical company. Previous work regarding RCFM has focused only on big projects (Flyvbjerg et.al., 2004, Fridgeirsson 2009; Flyvbjerg et.al., 2005). It seems reasonable because it's easier to compare projects of the same size and type. It is also easier to group projects in classes of similar category. And last but not least the RCFM involves a large amount of work. It is time-consuming and often technically difficult. Its use is unprofitable because the savings are too small in relation to expenditure. Although the method has not been used to assess small projects for the reasons mentioned above. In this paper the attempt was made to check the relevance of its application. According to Flyvbjerg's analysis (Flyvbjerg, 2004) nearly all kinds of projects do not meet their goals, so why not use RCFM for smaller ones. The objective for this research was to: use the method for small projects executed in the chemical company, build a model useful for forecasting, analyze the exactness of cost plans of chemical company projects, give a recommendation for future implementation of the method for smaller projects.

There remains a need for efficient project planning and since the RCFM is recommended by American Planning Society the method was examined for the chemical company projects.

3 Methodology

The analysis presented in this paper was prepared for the chemical company which conducts all activities as projects. Due to confidentiality reasons the company provided only general data regarding their undertakings. The projects were divided arbitrarily by the company into five groups (denoted as A, B, C, D, and E) depending on the purpose and scope of work. Group A regarded improvement of logistics operations in the company. The projects focused on optimization of loading and unloading operations, increasing their efficiency and improvement of the safety of workers and drivers. The company reported that construction projects, building renovations and roads repairs were included to this group. The projects of the group A were executed on a regular basis. It was easy to develop projects schedules, also requirements for contractors special skills were reduced in comparison to the company standards.

These groups B, C and D could be considered together. They strictly referred to the production areas. Key types of projects were modernization of tanks, vessels, apparatus and equipment, reconstruction of pipelines, installing the fittings in piping systems. Projects of these groups were comprehensive and required inter-branch coordination at the design and implementation phase. These kind of projects were carried out mostly when the plant was out of operation – during scheduled and preventing maintenance when the installations were kept in working order. Unpredicted overhauls, not previously planned in the company, resulted in additional scope and costs hence there was intensification of works in certain periods and stagnation in others. This kind of projects had to be carefully planned and scheduled. Here there were high requirements for subcontractors. The projects were divided into three groups due to the departments implementing them.

Group E aggregated relatively simple projects like purchasing turnkey systems, the assembly of readymade installations (plug and play), cross sectional projects regarding production and primarily IT operations. These projects rarely required complex plans and permits.

For purposes of this analysis it was assumed that all actions relating to the projects started from the beginning of the financial year, i.e. from of January and all projects lasted one year. It was forbidden to spend money before the official start of the projects thus the only possible action was to identify potential subcontractors and collect their offers.

Budgets of the projects contained all costs associated with a documentation, project plans and implementation (usually by the supplier, subcontractor or service). The budgets, formally, did not assume any official reserves. The differences +/-30% were acceptable on the project charter

stage, which is acceptable accuracy at that stage of planning. It was expected in the chemical company that final plans were accurate and had exact budgets. It was extremely difficult to hide any "buffers" because each cost must have been precisely documented.

Taking the information provided by the company at face value the RCFM was applied to forecast future cost overruns in the presented groups. The costs overruns C_o were calculated according to the following formula:

$$C_o = \frac{(C_R - C_P)}{C_p}$$

where

C_o - relative costs overruns,

C_R – costs of project realization, EUR, C_P

– planned costs, EUR.

The best method was to fit a probability distribution to empirical data regarding years 2012 till 2014, however it was not always possible due to an insufficient number of data regarding distinguished groups. In this case it was necessary to rely on empirical distributions. The aim was to find a required optimism bias uplift for considered classes of projects in year 2015. The company executed many projects since it was possible to assume that there was 50% chance to exceed forecasted costs. In this case the average uplift of reference class would be used for predicting the uplift of new projects performed in 2015.

4 Results

In 2012 the chemical company performed 65 projects. Over the years, the number of projects has decreased by 30% and was equal 62 in 2013, 49 in 2014 and 46 projects in 2015, additionally their budgets were smaller each year. More money were spent than planned (Figure 1a). During subsequent years the situation was different, partly due to improved planning and market conditions. The average value of planned projects has decreased by 35%, but the average value of projects performed has decreased by 52% (Figure 1b).

Expenditures for individual types of projects have evolved. The value of planned projects in group A was doubled, but the amount of money spent for this purpose has increased by only 60%. During the following years expenditures has fallen by 70% and risen again. In the group B in 2012 expenses were very high, and later were significantly reduced. Costs of group C reached a maximum in 2013, the expenses of the group D gradually declined starting from 2012.

Expenses in group E were twice higher than the originally planned. Unfortunately there could not be observed any regularities in costs incurred for each group.

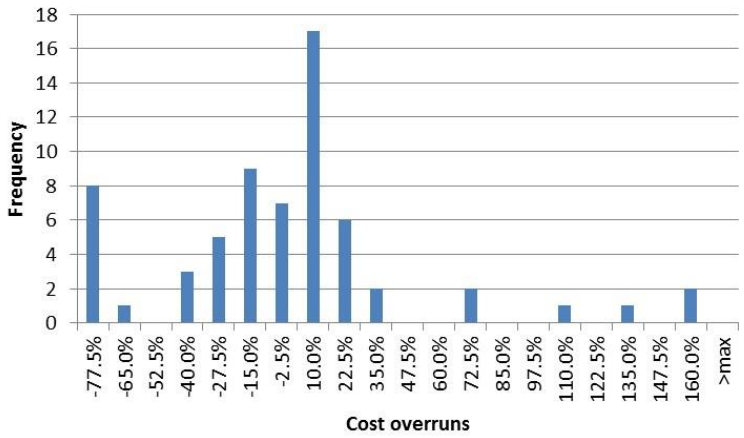
Fig. 1: Total (a) and average (b) value of projects performed by chemical company within four years

(a) (b)

Source: Authors' own research

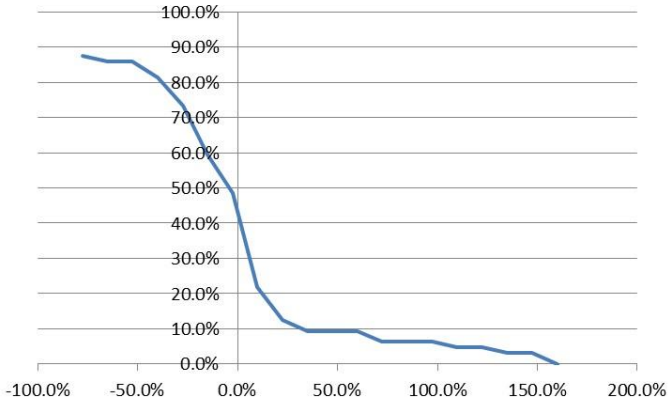
An attempt was made to fit a theoretical probability distribution of relative cost overruns to data regarding the specific groups of projects performed in 2012 to 2014 however, it was impossible due to lack of data, number of projects assigned to particular groups were too limited. No valid fits were found for distributions. It was decided to prepare empirical distributions of costs overruns and take decisions on the basis of it. The distribution of cost overruns of group A is presented in the figure 2. On the basis of the presented distribution the required raise of costs were prepared (Figure 3). Taking into account the 50% likelihood of overruns the 10% uplift should be taken into account for group A in year 2015. Indeed the average cost overrun in 2015 was 9%. The real data of project group A achieved in 2015 is presented in the table 1.

Fig. 2: Empirical cost overruns distribution for group A based on 2012-2014 data



Source: Authors' own research

Fig. 3: Propensity to risk for group A based on 2012-2014 data



Source: Authors' own research

Tab. 1: Costs and overruns of group A in 2015

Plan	Realization	Cost increase	Relative overruns
3 225	3 189	36	-1%
9 675	4 580	5 096	-53%
7 998	7 985	13	0%
18 060	10 417	7 643	-42%
12 900	11 739	1 161	-9%
23 220	21 337	1 883	-8%
32 250	23 478	8 772	-27%
32 250	32 258	-8	0%
32 250	34 404	-2 154	7%
37 410	38 744	-1 334	4%
61 920	49 239	12 681	-20%
193 500	131 584	61 916	-32%

Source: Authors' own research

Conclusion

In the presented case it was impossible to compare statistical distributions of reference 20122014 data and costs incurred in 2015. The amount of projects in each group was too small to perform a correct inference. Additionally the planning procedure did not assume costs enlargement during the planning stage. It was better when money was saved during the project than exceeding the budget. Especially large disparities arose in estimating the costs of long projects. The Reference Class Forecasting Method matched the estimates very well for large, homogeneous projects described in the literature, when it was possible to separate uniform groups of projects. Using RCFM for small companies performing limited number of project is impractical, moreover it is unnecessary waste of time. In this case it is better to predict future costs overruns on the basis of average data concerning previous years.

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