SUCCESSFUL IMPLEMENTED THEORIES FOR REFERENCE CLASS FORECASTING IN INDUSTRIAL FIELD

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Abstract: Risk management process integration in project management plans is necessary to succeed in complex projects. We structured our work in a conceptual background section and in our approach and results section for a correct state of the problem and clearly present our implementation. The aim of this paper is to present a deep literature review in terms of risk management roots and Reference Class Forecasting theories. Results and analyzes from our industrial field are presented. This paper is the result of collaboration between university and industrial field.

1 INTRODUCTION

Risk in plain usage is something going wrong and a deviation from original plan. The Risk Management Standard from Institute of Risk Management (PRM-PMI®, 2009) defined risk as the combination of the probability of an event and its consequences, with risk management being concerned with both positive and negative aspects of risk. Risk is gradually losing the stigma of only being concerned with the negative or downside. We now recognize the risk of us not meeting our goals, a risk of missing an opportunity, a risk of not recognising that something good is happening. This is the positive, upside of risk, evident in the widely used 'risk/return' tradeoff. If there is no risk, there is often little return, and there is often a higher return when the risk is higher (Collier, 2009).

In this work we present risk management roots and theories behind reference class forecasting. Experimental results from our experience and implementation are also presented.

After a brief overview of risk management theories and roots, we present our approach and implementation in a real business environement. In our case, Reference Class Forecasting theories as part of risk management field, helped in prognosis of a current project based on past experiences in order to deliver the project in predefined costs, time and quality.

Our research focuses on *probability theory* and makes a brief overview of **utility theory** (Bernoulli, 1954), (Hogarth, 1987) and **prospect theory** (Kahneman, 1979a), (Kahneman, 1979b) as main roots and influences for risk management.

As projects are unique in time and trajectory, another main aspect of risk management is the **uncertainty** which is inevitable in a project; from this reason, a proactive risk management is the key to succeed in complex projects.

In first part of this paper we provide conceptual background and theories behind our work. Next section is for our approach and implementation. Finally, relevant conclusions and future work are presented.

2 CONCEPTUAL BACKGROUND

In (Garvey, 2009), authors identify that probability theory is the formal study of events whose outcomes are uncertain. Its origins trace to 17th-century gambling problems. Games that involved playing cards, roulette wheels, and dice provided mathematicians with a host of interesting problems.

The solutions for many of these problems yielded the first principles of modern probability theory. Today, probability theory is of fundamental importance in science, engineering, and business (Garvey, 2009).

2.1 Utility Function

In our previous work (Podean et al, 2010), we

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comprehensively described a structured methodology that focuses on minimizing and mitigating project specific delay risks and highlighted that based on utility function, milestones during project and/or the end of projects or programme may be categorized in what are called soft-deadline and hard-deadline (Podean et al, 2010).

In contrast with the soft-end projects, the hard-end projects posses a decrease of utility function with a vertical asymptote character around the deadline for project completion. In extreme situations, the utility function itself may fall under zero (projects may generate losses to both constructor and customer). Existing risk analysis methodologies observe risks from monetary terms. The typical risks are correlated with an increase in final project costs. In order to estimate hard-deadline milestones and/or end of projects or programme is critical to employ the time dimension rather than the typical cost-based risk analysis. Economists distinguish between cardinal utility and ordinal utility, the last being a rank-comparison of: options, contracts, projects, execution quality etc. In risk assessment activities, customer made already a decision that company “YZ” is executing the project. Therefore, the cardinal utility function over time is more appropriate, while ordinal utility may captures only ranking and not strength of preferences (Podean et al, 2010).

2.2 Prospect Theory

The prospect theory was defined by Daniel Kahneman and Amos Tversky (Kahneman, 1979a), (Kahneman, 1979b) and is the basic theory in Reference Class Forecasting.

Reference Class Forecasting for a particular project requires the following three steps (Flyvbjerg, 2007):

- **Identification** of a relevant reference class of past, similar projects. The class must be broad enough to be statistically meaningful, but narrow enough to be truly comparable with the specific project;
- **Establishing a Probability** distribution for the selected reference class. This requires access to credible, empirical data for a sufficient number of projects within the reference class to make statistically meaningful conclusions;
- **Comparing** the specific project with the reference class distribution, in order to establish the most likely outcome for the specific project.

Those theories, that helped Kahneman win the 2002 Nobel Prize in Economics, are based on some well-observed deviations from rationality, including the following (Damodaran, 2008), (Kahneman, 1979a), (Kahneman, 1979b):

- **Framing:** Decisions often seem to be affected by the way choices are framed, rather than the choices themselves;
- **Nonlinear Preferences:** If an individual prefers A to B, B to C, and then C to A, she is violating one of the key axioms of standard preference theory (transitivity). In the real world, this type of behavior is common;
- **Risk Aversion and Risk Seeking:** Individuals often simultaneously exhibit risk aversion in some of their actions while seeking out risk in others;
- **Source:** The mechanism through which information is delivered may matter, even if the product or service is identical. For instance, people will pay more for a good, based on how it is packaged, than for an identical good, even though they plan to discard the packaging instantly after the purchase;
- **Loss Aversion:** Individuals seem to feel more pain from losses than from equivalent gains. Individuals will often be more willing to accept a gamble with uncertainty and an expected loss than a guaranteed loss of the same amount, in clear violation of basic risk-aversion tenets.

In his paper, (Flyvbjerg, 2007) agrees that when contemplating what planners can do to improve decision making, we need to distinguish between two fundamentally different situations: (1) planners and promoters consider it important to get forecasts of costs, benefits, and risks right, and (2) planners and promoters do not consider it important to get forecasts right, because optimistic forecasts are seen as a necessary means to getting projects started.

Kahneman and Tversky (Kahneman, 1979a), (Kahneman, 1979b) replaced the utility function, which defines utility as a function of wealth, with a value function, with value defined as deviations from a reference point that allows for different functions for gains and losses. In keeping with observed loss aversion, for instance (Damodaran, 2008), the value function for losses was much steeper (and convex) than the value function for gains (and concave) as presented in Figure 1.

The implication is that how individuals behave will depend on how a problem is framed, with the decision being different if the outcome is framed relative to a reference point to make it look like a gain as opposed to a different reference point to

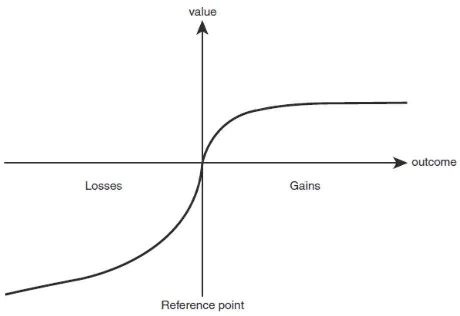

Figure 1: A Loss Aversion Function (Damodaran, 2008).

convert it into a loss. Stated in terms of risk aversion coefficients, Kahneman and Tversky assumed that risk aversion coefficients behave differently for upside than downside risk (Damodaran, 2008).

3 OUR APPROACH AND RESULTS

Starting from Reference Class Forecasting theories we developed a software application to estimate delays in complex projects. We applied our approach in industrial field, in energy sector. We analyzes past projects, identify relevant features for implemented projects and based on past experience we provide realistic paths for a current project.

The application workflow is presented in the following paragraphs.

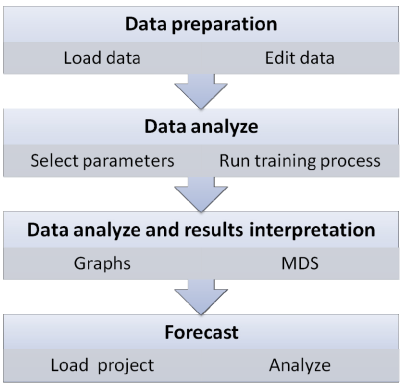

Figure 2: Our application workflow.

We developed a modular UNIX based application with high portability. Application workflow is presented in Figure 2. In first step of the application the user is allowed to load dataset with projects and features. Our template for dataset is presented in Table 1.

In this first step, minor modifications in dataset

Table 1: Dataset structure template.

Project Name	Char1	Char2	…	CharM
Project1	1x1	1x2	…	1xM
Project2	2x1	2x2	…	2xM
…	…	…	…	…
ProjectN	Nx1	Nx2	…	NxM

can be performed in order to have a clear dataset. Next step is for data analyze where the training process starts after a selection of max number of neighbors and number of iterations of a random assessment when using singular features. The training process starts and relevant results and graphics are presented. In our case, the algorithms behind were implemented in Matlab and a relevant graphic is presented in Figure 3.

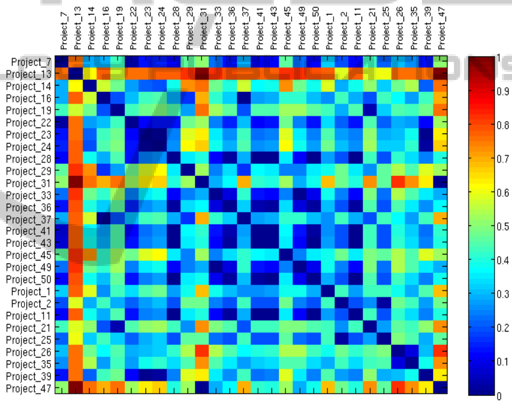

Figure 3: Dissimilarity matrix.

Dissimilarity matrix displays the distance between each two projects. The matrix is generated after all features analyses and after identification of most relevant features. In our case, a project was defined by a set of hundreds of features and we identified significant features for projects to correct manage them.

After data analyze and results interpretation step, the application generates the Multidimensional scaling (MDS) representation (Figure 4) with projects grouped in on-time and delayed, and provides tools to load a new “unknown” project to compare and based on delays features it can be positioned on closest class.

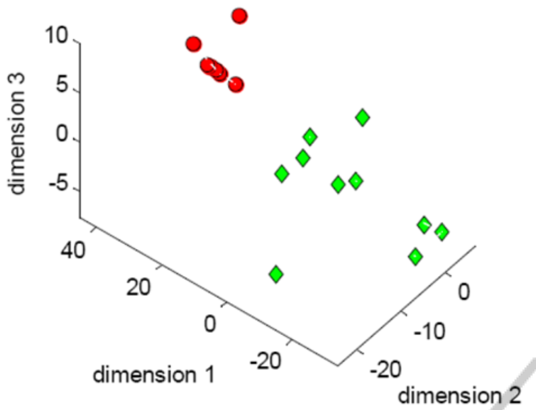

Figure 4: Multidimensional Scaling representation.

4 CONCLUSIONS

We consider our approach essential in order to deliver projects in predefined costs and to avoid delays by identifying relevant features that may influence the project in a negative manner.

This approach supports Project and Risk Management department to analyze and forecast risks in future or existing projects in terms of delays. Our approach improves the existing methodology by introducing a feature selection learning step and this tool is well designed to find the closest k observations in the training set and to predict the class of the "unknown" project profile by majority of vote (the winning label of the neighbors).

A Reference Class Forecasting approach helps project managers and stakeholders to estimate potential risks and costs in a more realistic way and to provide alternative paths.

Based on past experiences, this analyse provides assistance in decisions on whether to implement or not a project.

Results and interpretation for results are presented in a detailed manner. We consider an efficient approach that can be applied and adapted in different fields.

We have developed a complex application for risk management using reference class forecasting that fits in the company structure and behaviour.

As subject for our future work, we intend to use this approach in different fields. We also performed several tests in financial sector and in large investments projects to provide realistic paths, to clearly identify things that can go wrong and to highlight relevant features for a project to succeed.

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