MS-E2177 - Seminar on Case Studies in Operations Research

Project plan - Inclus

Robin Hagnäs (Project Manager),
Daniel Aaltonen,
Aurora Kauraala,
Sebastian Hannula

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Background

This is a project in collaboration with Inclus on understanding and developing tools and methodologies for risk management in construction projects, specifically the use of Monte Carlo simulation for quantifying risks.

Inclus is a company founded in 2016 with roots in peace mediation at CMI and methodology developed in collaboration with Aalto University's Systems Analysis Laboratory. They specialize in developing technological tools for building common understanding. Inclus' software and technology have been in use in negotiations between direct conflict parties and has been utilised in decision-making situations and in risk management, both within and between companies.

Monte Carlo simulation is used to estimate mathematical functions and the outcomes of complex systems by using random sampling and predefined probability distributions. The method simulates a given system by repeatedly sampling the distributions of the underlying random variables [1]. The outcome of the simulation depends on the distributions of these random variables and must thus be properly defined. Common distributions for the random variables include for example uniform, exponential, normal, and Poisson distributions.

In industry, Monte Carlo simulation is often used as a tool of risk management [2]. It is commonly used in finance and project management among other use cases. In construction projects, there is a convention of using Monte Carlo based tools to quantify the scheduling and monetary risk [3]. The likelihood and severity of different scenarios is then qualitatively assessed often based on questionnaires to the project managers. The answers are then translated to some distributions and Monte Carlo simulation is performed yielding a probability distribution of the risk of different decisions, that can then be used to help mitigate the risk.

This method of quantifying risk is vulnerable to biases of the project managers or other people filling out the questionnaires. These methods also often assume the different events to be uncorrelated and thus are incapable of modelling cross-dependencies between the different risks.

Inclus has developed a tool for risk management based on collecting the risk estimates from a variety of people independently leading to a lower significance in the bias. This data could be used in Monte Carlo simulation to get more reliable estimates of the risk in construction projects.

Our aim is to investigate together with Inclus how Monte Carlo simulation could best be used for risk management in construction projects. This could include data collected by inclus or suggest another way to collect data suitable for the simulation. Furthermore, we aim to investigate how to model and estimate the dependencies that may exist.

Objectives

The goal of the project is to investigate how Monte Carlo simulation can best be used for risk management in construction projects. The goal is not to produce software, but to produce recommendations on how Monte Carlo simulation can be implemented. We divide the objectives of the project into four categories.

1) Literature review of project risk modelling and exploring risk management related simulation tools with an emphasis on construction

We perform a literature review on project risk modelling and explore risk management related simulation tools with an emphasis on construction. The aim of simulation is to understand the likelihood/expectation of realizing certain project related risks such as cost, time or quality. Our goal is to take stock of how risk management simulations have been done before, which includes identifying construction events contributing to project risk, gathering expert/stakeholder insights, modelling the distribution of possible events, and performing a simulation of the project risk. We also aim to understand the main challenges in the area, and how to tackle some of the problems in the field. We present existing risk management related simulation tools. Finally, we assess how the literature can help Inclus to simulate the total risk of a construction project, and how they might identify events that have a large impact on the realized risk.

2) Methodology for selecting or suggesting suitable distributions for simulation variables, considering gathered expert assessments

This is a prerequisite to implementing an insightful Monte Carlo simulation of the total project risk (i.e., how is the total risk in euros distributed). Given some potential individual risks associated with the project (scheduling, personnel costs, material costs,...), we need to find suitable distributions for these in order to sample them in the Monte Carlo simulation.

This section entails a literature review of methodologies to form suitable probability distributions for the individual variables (risks) based on the input of experts/survey participants. We investigate how this has been done in current simulation tools (or if it even has). Furthermore, we investigate whether there is literature on generally identified construction industry related risks and their associated distributions. The challenging part is to modify the distributions to somehow be tailored to the provided expert/survey participant assessments.

We seek to create a working demonstration of choosing the distributions for particular variables (risks). Once we have a working demonstration, we consider about how to generalise the methodology for different types of variables (risks) and what the recommendation mechanism could be.

3) Risk dependencies and propagation; how to model and simulate any risk cross-dependencies that may exist

Our objective is to understand how modeling and simulating risk cross-dependencies has been done before, what challenges there are in implementing it in practise, and how to resolve some of them. Our

goal is to give recommendations on how to implement modelling and simulation of cross-dependencies in practise.

4) Analysing and presenting results; what information can and should be presented

Our objective is to understand what information in addition to the information that Inclus presents in their product is helpful for risk analysis. The aim of the project is to focus on Monte Carlo simulation tools for risk management and we aim to find efficient ways of communicating the results of the simulations. The results should be helpful and easy to understand to the customers of Inclus. We get information on what information could and should be presented through exploring literature, existing tools, and interviews with Inlcus customers. We give recommendations and ideas on what information should be presented and how in a few concrete use cases.

Beneficial project outputs for Inclus

We briefly summarize what Inclus expects our project to provide:

1. Recommendations on how to implement Monte Carlo –style simulations on top of data collected with Inclus. Focus on construction projects, but would likely be used in other situations too.
2. Recommendations on how to translate multiple differing risk assessments to a Monte Carlo –compatible probability distribution; and what distributions should be supported.
    - Likely to be implemented with a design where the service suggests the distribution and its parameters, but the user can still change the decisions before running the simulation.
3. Recommendations on how to present simulation results.
    - Best case: end user easily understands the results, but still feels they are advanced and can showcase their own professionalism by presenting the results forward.
4. Suggestions/ideas on how to combine risk cross-dependency data with the simulation.

Tasks

The outcome of the project will be a set of informed suggestions, backed up by literature on how Inclus best could incorporate Monte Carlo based simulation for risk management into their development pipeline. To achieve this, four main tasks have been identified. Literature review, summary of findings, modelling for proof of concept and reporting, which will be elaborated on below.

Literature review

A thorough literature review will be conducted on previous work done on Monte Carlo simulation in risk management for construction projects. In the review we focus on the simulation pipeline and

answer the following questions:

- How is data on risk collected?
- How are distributions of the risks modelled?
- What types of Monte Carlo simulation models are used for risk management?
- What parameters are of interest in the simulations?
- How are risk cross-dependencies accounted for?

Summary of findings based on literature review

Based on the literature review, we compare the methods that are used and compare them using a archetype of risk management in a construction project that will be developed together with Inclus and based on findings. The goal of the comparison is to help Inclus understand the utility of the different methods for their use-case, to be able to make an informed decision.

Modelling to provide proof of concept

Based on the findings, we aim to provide a simple proof of concept where we develop a model of the best option in our opinion to better showcase how the Monte Carlo simulation could be utilized for risk management at Inclus.

Reporting

The project includes three main deliverables which are the project plan(this document), an interim report and a final report. In the deliverables, we will document our findings and progress to provide a reference for Inclus to use when starting to implement Monte Carlo simulation internally.

Schedule

1. Before submitting project plan
    - Meeting with Inclus
    - Start literature review
    - Getting familiar with previous models and methods
    - Write project plan

2. Before submitting interim report
    - Start summarizing findings and suggestions to Inclus based on literature review
    - Possible meeting with a Inclus' client
    - Writing intermediate report
3. Before submitting final report
    - Writing final report
    - Presenting the final report

We will have a weekly meeting with the team to plan and work on the project. We communicate with Inclus throughout the project through Telegram and meet when necessary. There will be three excursions where we present the reports.

Resources

The group conducting the project consists of four students. We have a contact person at Inclus (Juha Törmänen), and a contact person at Aalto (Ahti Salo), who help us with the project. We have the possibility to interview one of Inclus' clients later in the project. We use Overleaf Online Latex editor for writing the reports. We have meetings at Aalto University, Inclus' office and online. For finding literature, we use the literature available for Aalto University students at google scholar.

Risks

Figure 1 shows the risks associated with the project.

Risk	Likelihood	Impact	Mitigation of likelihood	Mitigation of impact
Misdefined scope / work on objective 1 & 2 get out of hand	Medium	A lot of unnecessary work	Continuous discussions with Ahti & Inclus	Redefine scope, focus less on cross-dependencies
Data not suitable for demonstration	Low	Can make the demonstration difficult	Study the subject and communication with Inclus	Ask for help from Inclus
Suggestions are not suitable for implementation	Medium/ High	Recommendations are not useful	Comprehensive literature review /communication with Inclus & Ahti	Communicate with Inclus
Cannot meet the deadlines	Low	Failing the course	Plan work in advance & work consistently on the project	Meet the deadlines
Technical difficulties	Low	More work	-	-
Team member quits the course / free riders	Low	More work for other team members	Everyone has committed to the course	Remaining team members work a bit more
Lack of communication with Inclus	Low	Going wrong direction with the project	Making communication effortless	Keep Inclus updated and ask for help

Figure 1: List of risks associated with the project

References

[1] R. L. Harrison, "Introduction to monte carlo simulation," in *AIP Conference Proceedings*, vol. 1204, no. 1, pp. 17–21, 2010.

[2] V. N. Leopoulos , K. A. Kirytopoulos kkir@central.ntua.gr & C. Malandrakis (2006) Risk management for SMEs: Tools to use and how, Production Planning & Control, 17:3, 322-332, DOI: 10.1080/09537280500285136

[3] Martin Schieg (2006) Risk management in construction project management, Journal of Business Economics and Management, 7:2, 77-83, DOI: 10.1080/16111699.2006.9636126