Chances and Risks in Construction Management and Economics

A Systemic Approach to Dealing with Models and Uncertainties

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Topics covered

Fundamentals of chances/risks and introduction to the Monte Carlo method

Practical aspects of Monte Carlo simulations

Capturing and dealing with chance and risk potentials

Application of Monte Carlo simulations in project management, construction management and economics

Calculation of the chance/risk ratio for key project variables

New perspectives of quantitative chance/risk management with respect to preparing and executing construction projects

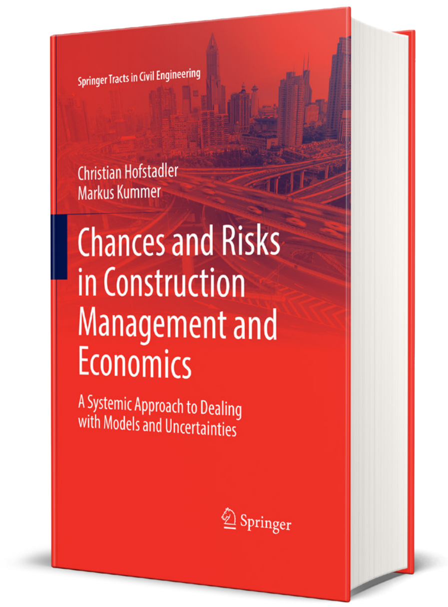
Increasing transparency and certainty in decision-making processes

Illustrating the process of managing chances and risks for construction management and economics

Outlining the systematic approach to productivity and losses of productivity

Highlighting the fundamental importance of project lead time and construction time for the achievement of project targets

User-friendly worked examples for clients and contractors in various project phases



New in June 2021

https://www.springer.com/gp/book/9783030640132

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Key benefits for readers

Provides a practice-driven and easy-to-grasp introduction to probability theory

Showcases best practice examples from project management and construction practice in which the described methods were applied successfully

Highlights the benefit of the Monte Carlo simulation method in the context of analyzing the chance/risk ratio

Provides theoretical foundations and hands-on examples helpful to project stakeholders as well as students

Introduction

Any construction business requires the optimised combination of production factors in order to work profitably. Selection and appropriate combination of the various types of production factors has a major influence on construction times and costs. The related computation methods are fraught with uncertainties that increase in line with the degree of complexity and lack of detailing of the construction project. The ability to systematically deal with uncertainties is thus imperative to achieve pre-agreed project targets. The book acknowledges this necessity by incorporating a description of the fundamentals of Monte Carlo simulations, as well as their application, including specific cases illustrated by worked examples taken from various project phases. Application of the described methods and tools helps assess and analyse uncertain computation variables and makes decision-making easier. The contents of this book particularly address clients and contractors, court-appointed experts, researchers, students, and project stakeholders with an interest in the field of construction management and economics. However, the chapters on basics and fundamentals address a broader audience that goes beyond the parties involved in construction projects.

Basics

An in-depth account of the fundamentals of chances, risks and uncertainties establishes a sound basis for a consistent understanding of the subject matter and associated relationships and correlations. The selected reference base is of crucial importance for any decision that is based on figures. The decision in favor of a certain value is associated with determining an associated chance/risk ratio.
This book focuses on this ratio to systematically assess works, projects, or project portfolios. Despite the fact that boundary conditions are specified more clearly in line with the increasing degree of detail of the project, uncertainties remain with respect to calculations performed to arrive at forecasts of future trends.
The degree of reliability of conclusions with respect to times and costs of future events essentially depends on the applied methodology as well as on the quality of used data and information. The fundamentals of stochastics outlined in this book create the scientific foundation for correctly applying Monte Carlo simulations so that maximum benefit can be derived from them.

Data, information, knowledge, and BIM

The quality of data and information creates the basis for arriving at accurate calculation results and laying a solid foundation for decision-making. Data, information, and knowledge thus form the underlying framework for systematically considering uncertainties in the management of chances and risks.
This chapter uses the knowledge stair according to North to describe the evolution of singular data and information to knowledge and, ultimately, to the key success driver enabling a unique market position. Knowledge is transferred only if data and information are interlinked on a systematic basis and are put in the context of experience and expectations. Furthermore, the role of the party generating the information is highlighted since it has a major influence on the quality and quantity of the information made available to the user. Irrespective of the degree of sophistication of a BIM model, it requires high-quality data with the associated information, including with respect to emergence and boundary conditions, to simulate construction times and costs. Only if these conditions are met will BIM models generate maximum benefit for all project phases and stakeholders, and thus for the entire lifecycle of the building or structure.

Management of chances and risks

This chapter focuses on encouraging a chance- and risk-based mindset (see Fig. 1), which is a valuable basis for efficient and effective action. The management of chances and risks provides a wide range of tools and methods to efficiently optimise the seizing of opportunities whilst coping with risks. On a superior level, this framework makes it possible to pursue agreed corporate objectives, whereas project targets can be achieved efficiently and effectively on a more detailed scale. The chance/risk-related behaviour of stakeholders determines the number of contracts that can be won and executed in a commercially viable manner.

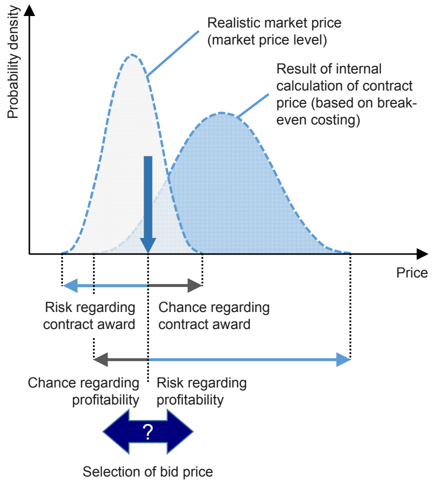


Figure 1: Selection of the bid price with a view to ensuring profitability and winning the contract

The management of chances and risks pertains to the entire organisation on the macro scale, whereas it relates to specific projects on the micro scale. A project portfolio management approach must be implemented between these two levels in order to determine the cost structure of key projects in a timely fashion. In so doing, the overarching primary objective is to secure long-term profitability, or the continued existence, of the business. This chapter outlines and describes feedback loops for successfully applying a target-driven, systematic process of managing chances and risks.

Methods of chance and risk management in project phases

To understand, describe and master complex systems, it is crucial to divide such systems into subsystems that are connected to one another by logical relationships. In construction economics, this approach can be implemented by defining several project phases, including preparation, execution, and the operation of buildings or structures. This chapter describes five project phases (PPH) commonly used in construction practice that are then related to the worked examples also contained in this book (application to PPH 1 to PPH 4). In early project phases, the ranges of quantities, productivity values, and costs are comparatively wide because a large number of factors with a potential influence on the overall project must be taken into account at this stage. In later project phases, the construction project becomes increasingly specific (with a growing degree of detail), whereas the influence of the client on project execution decreases. Decisions must be made on the basis of uncertain parameters or values, or even rough estimates. Application of the Monte Carlo simulation makes it possible to systematically deal with uncertainties.

Fundamentals of Monte Carlo simulations

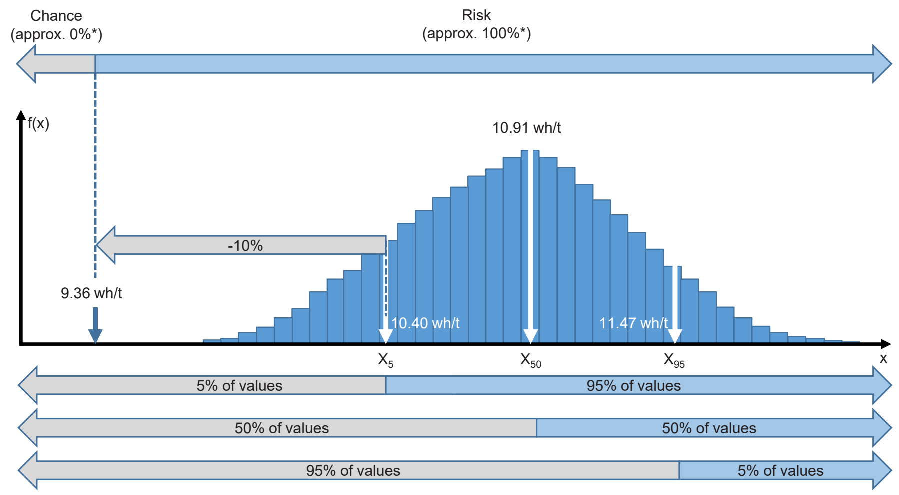
Students, researchers and, in particular, practitioners often consider calculations based on probability theory to be a seemingly insurmountable mathematical challenge, and thus shy away from its practical application. This chapter attempts to counter this situation by highlighting the difference between the Monte Carlo method and Monte Carlo simulations and allocating the latter to the various subfields of mathematics. Furthermore, it makes the important distinction between iteration and scenario. This chapter outlines correlations to demonstrate how Monte Carlo simulations work in general and how they can be applied in a meaningful and systematic manner – on the basis of prior mathematical understanding and of the computation model developed for the task at hand. The basic knowledge required to understand the following chapters should stimulate independent thinking and application; this body of knowledge is explained in a plausible, hands-on manner using worked examples. Ranges, distribution functions, and correlations are of crucial importance for Monte Carlo simulations. The effects of various distribution functions and correlations on results are illustrated and interpreted. As is the case for any software program, the quality of calculation results essentially depends on the know-how and, even more importantly, "know-why" of the user.

Application of Monte Carlo simulations

This chapter focuses on the prerequisites and fundamentals required for practical application, as well as on the target-driven, value-adding use of Monte Carlo simulations. It stresses that their use will add value only if "realistic" distribution functions with project-specific, relevant input values are applied to uncertain input parameters. If a contextual database derived from practical findings (empirical evidence) is available, data fitting can be used to directly transfer this data to a distribution function. In this case, the results of future simulations will be highly significant. The selection and application of distribution functions for labor consumption rates and quantity deviations directly derived from construction practice is outlined in a transparent manner. The next step involves appropriate modelling and explanation of the simulation results with reference to practical examples, which is a key aspect of applying Monte Carlo simulations. In conclusion, this chapter emphasises that the reference base (value) selected from a histogram subsequently represents the associated chance/risk ratio.

Influence of project lead time and construction time on project targets

For any project, quality, time, cost, quantity, susceptibility to disruptions, and process quality are the key design and decision-making variables that must be thoroughly analysed to be able to reliably evaluate a building or structure. This chapter stresses the significance of project lead time and estimated construction time for successful project completion. Excessively short construction times will lead to losses of productivity, disruptions, errors, quality deficiencies, and additional costs. This chapter comprehensively outlines the fundamentals of the production system and of the concept of productivity whilst placing particular emphasis on the correlation between construction time and productivity. On the quantitative level, it highlights the effects of excessively long or short construction times on productivity, as compared to a "normal" construction time. Furthermore, the implications of deviations from the "normal" construction time on construction costs are considered. Construction time is considered to be "normal" if the type, number, and combination of production factors enable progress on the construction site according to plan without exceeding thresholds to losses of productivity.



* No value ≤ 9.36 wh/t could be determined after 50,000 iterative steps (Latin-Hypercube sampling method). This is why the simulation results in a 0% chance and a 100% risk of an underrun of 9.36 wh/t.

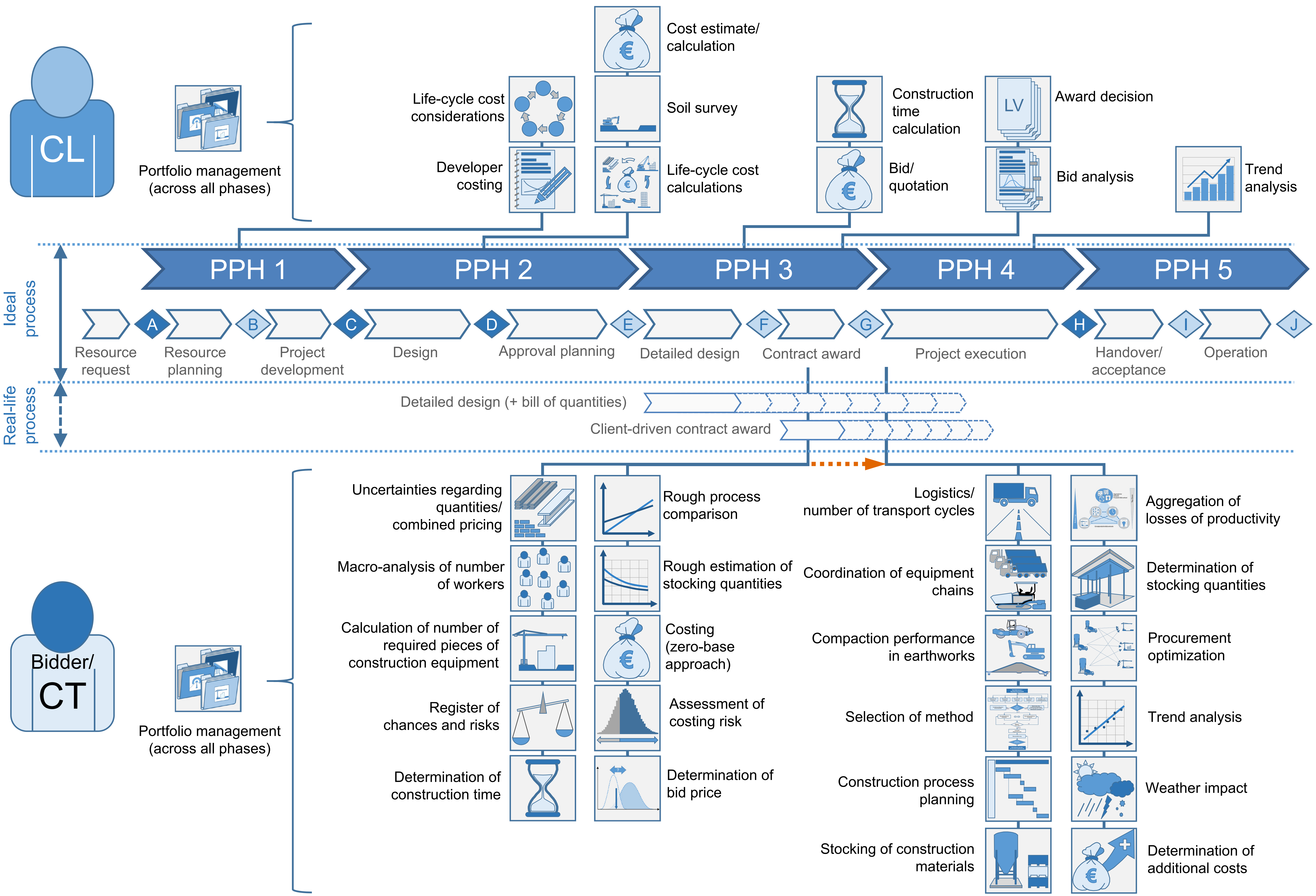
Figure 2: Distribution as a result of a Monte Carlo simulation to illustrate how to determine a labor consumption rate minimum for reinforcing works

Worked examples – clients and contractors

Monte Carlo simulations are applied to tasks derived from actual practice in a user-friendly and plausible manner, both for clients (including in-depth bid assessment, see Fig. 2) and contractors. Outlined methods and application charts can also be used by other parties involved in construction projects either in modified form or in their basic structure presented in this book.

Which type of information and examples can be found in the book?

What benefits can you derive in which project phases?



PPH 1 Project preparation | PPH 2 Design | PPH 3 Preparation of execution | PPH 4 Execution | PPH 5 Project completion

A Request release | B Resource planning release | C Design decision | D Execution decision | E Start of detailed design |
F Release of BoQ | G Award | H Acceptance/handover | I Documentation of use, real-life operation | J Project evaluation/project end

◆ Key decisions for all projects
◇ Decisions for major projects

PPH… Project phase
CL … Client
CT … Contractor

Source: Hofstadler/Kummer (2021). Chances and Risks in Construction Management and Economics – A Systemic Approach to Dealing with Models and Uncertainties. Springer Tracts in Civil Engineering