# The interdependency factor: Managing risks in client-contractor relationships

CME5200: Master thesis

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# Preface

After months of dedication, challenges, and growth, it feels surreal to be writing this final section of my thesis. The journey of researching and writing this thesis has been both demanding and rewarding, pushing me beyond my limits while teaching me invaluable lessons about risk management, client-contractor relationships, and the complexities of decision-making in construction projects. Looking back, these past months have not only strengthened my research skills, but also reinforced my passion for tackling complex industry challenges.

This thesis would not have been possible without the support and guidance of many people. First of all, I would like to express my deepest gratitude to my supervisory committee at TU Delft. A special thanks to my first supervisor, Martijn Leijten, whose guidance and insights were invaluable throughout this process. The theoretical foundation he provided proved to be the missing puzzle piece that allowed me to structure my research and ultimately turn it into a success. I also want to sincerely thank my second supervisor, Hans Ramler, who always managed to bring me back down to earth when I was caught up in unnecessary stress. His perspective and calming influence helped me navigate the challenges of this research with a clearer mindset. In addition, I am incredibly grateful to my chair, Marian Bosch-Rekveldt, for her thoughtful feedback and support, which greatly contributed to the refinement of my work.

Beyond academia, I want to extend my heartfelt appreciation to Bas van de Weijer. I am truly grateful to Bas for giving me the opportunity to graduate at BAM, an experience that has been incredibly valuable for my learning and professional development. His dedication, involvement and exceptional guidance have played a crucial role in shaping my research and I sincerely appreciate his willingness to challenge me and help me grow.

I also want to thank all the professionals who took the time to participate in interviews and share their expertise, contributing to the strength of this research. Their insights provided essential practical perspectives that enriched my findings.

Finally, I could not have completed this journey without the unwavering support of my family and friends. Their encouragement, patience, and belief in me kept me motivated, even in the most challenging moments. A special thanks to my housemate, who helped me with my visualisations and creative thinking. A special thanks to my parents for co-reading my research and for always reminding me of my capabilities, as well as to those who provided much-needed distractions when I needed a break from research.

Writing this thesis has been a journey of both professional and personal growth that prepares me for the next steps in my career. I hope that the insights from this research contribute to a deeper understanding of risk management in construction and help improve collaboration between clients and contractors in complex projects.

Jesse de Groot
Delft, Friday 4th April, 2025

# Executive summary

In complex construction projects, risks rarely stem from isolated events. Instead, they often arise from the misalignment and poor management of interdependencies between clients and contractors. These interdependencies critically influence decision making, governance structures, and the effectiveness of risk mitigation strategies. However, traditional project management approaches tend to overlook these systemic dynamics, which can lead to delays, inefficiencies, and cost overruns.

This research addresses this gap by examining how interdependencies shape risk mitigation in practice and how governance models can be adapted to better manage these relationships. By focussing on the relational and structural complexities between key project stakeholders, the study aims to improve alignment, improve collaboration, and ultimately contribute to more resilient and efficient project outcomes.

The research is guided by the central question:

> **How can the management of interdependencies in the client-contractor relationship enhance risk mitigation strategies in complex construction projects?**

To answer this question, the research follows a structured methodology that integrates both theoretical and empirical analysis.

The study begins by establishing a theoretical framework to systematically classify and analyse the interdependencies in construction projects. This is done by integrating the Normal accident theory of Perrow (2011) and the TOE framework of Bosch-Rekveldt et al. (2011). Within this framework, the TOE model serves as the categorisation method for complexity, breaking it down into technical, organisational, and environmental factors. However, the literature review reveals that complexity is not a singular concept. The cause and manifestation of complexity can fall into different categories. This relationship is simplified in Figure 1.

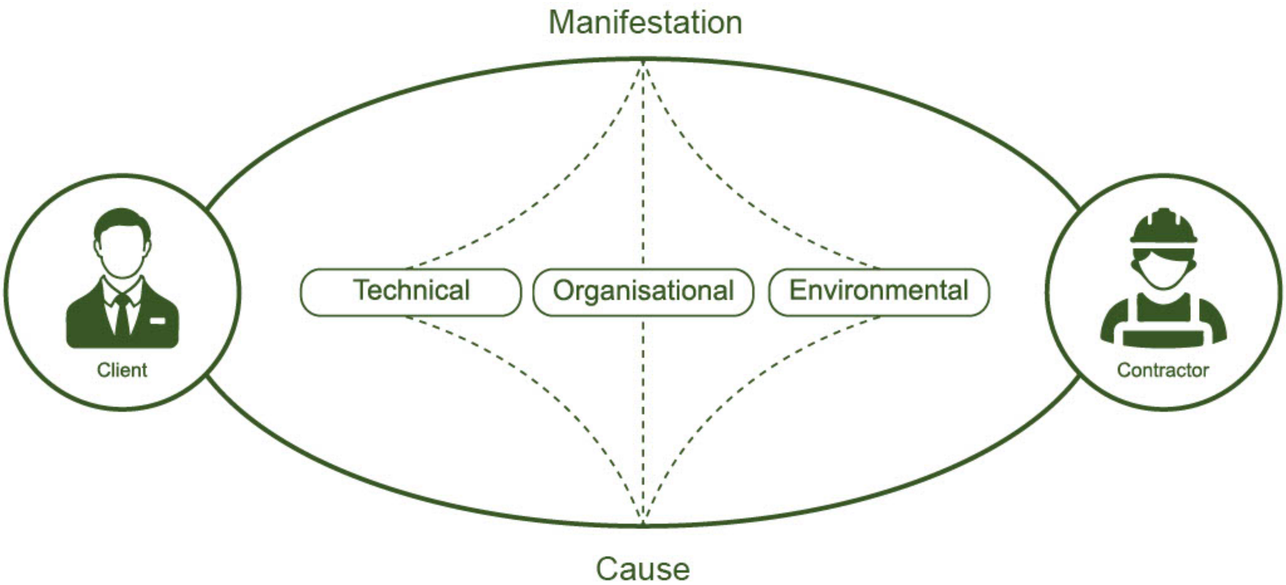


**Figure 1:** Simplified relation of complexity and interdependency in client-contractor relationships

A project may face technical complexity due to differences in scope, yet the real impact may emerge as organisational complexity, such as slow decision-making or lack of trust. Similarly, environmental regulations can cause technical complexities that require design modifications. This misalignment between the cause and manifestation of complexity creates interdependencies, as different elements influence each other in unexpected ways. This interdependency between the difference in cause and manifestation can then be classified using Perrow's normal accident theory. Perrow's framework moves beyond categorisation to focus on how interdependencies shape risk exposure. It does so by distinguishing between tight and loose coupling and linear and complex interactions. A tight coupling system has little flexibility, meaning that small failures quickly escalate, whereas a loosely coupled system allows more time for intervention. Likewise, linear interactions follow predictable sequences, while complex interactions involve unexpected dependencies, making risk management more challenging. By classifying the interdependencies using the Perrow framework, a corresponding management structure can be prescribed. When projects exhibit tight coupling and complex interactions, centralised governance is necessary to maintain control and prevent cascading failures. In contrast, projects with loose coupling and linear interactions benefit from decentralised governance, allowing for greater flexibility in risk management. This structured approach, in which complexity is first categorised using the TOE framework, then classifies the interdependency through Perrow's matrix, and finally linked to a suitable governance model, provides a foundation for assessing real-world construction projects.

To test the theoretical framework in practice, the study analyses two completed construction projects, examining how interdependencies in client-contractor relationships influence risk mitigation strategies. The practical analysis consists of three main research methods: quantitative financial analysis, project document analysis, and semi-structured interviews. These methods provide objective financial information and subjective stakeholder perspectives, ensuring a comprehensive evaluation of interdependencies and governance structures.

The first step in empirical analysis is a quantitative cash flow analysis to identify critical events in the project. This is done by comparing tender cash flow data with realisation cash flow data, detecting deviations. Financial fluctuations could reveal moments where project interdependencies influenced outcomes, such as delays caused by approval processes or budget overruns due to supply chain disruptions. The second step involves a document analysis of progress reports. This step provides a contextual understanding of the financial deviations, helping to determine whether these events were caused by interdependencies. By evaluating the events through a short survey with the project managers, three key events were identified. To complement the empirical phase, the third step consists of semi-structured interviews with the project managers from both client and contractor. These interviews explore how interdependencies affected decision-making, risk perception, and governance structures in key events. By gathering insights from both perspectives, the study can identify differences in risk mitigation approaches, interdependency classification, and governance preferences between clients and contractors. The interviews also provide qualitative data on how communication, contractual relationships, and management structures influenced project outcomes.

The evaluation of the research systematically compares the findings from the perspective of the client and the contractor to identify patterns, discrepancies, and best practices to manage interdependencies and mitigate risks in construction projects. This part of the research is determining how different stakeholders perceive and manage risk and whether governance structures align with the nature of interdependencies in practice.

The findings reveal that clients and contractors often manage interdependencies in different ways, leading to inefficiencies in risk mitigation. Clients typically rely on centralised governance structures that emphasise regulatory compliance, financial oversight, and formalised decision-making. Although this approach provides structure and accountability, it often introduces delays, particularly in processes involving permit approvals, design modifications, and financial transactions. Contractors, on the other hand, operate in dynamic environments where rapid adjustments are necessary to manage unexpected conditions on-site. They favour decentralised decision making, allowing for greater adaptability, but sometimes at the expense of long-term risk planning. This misalignment results in bottlenecks, communication gaps, and reactive rather than proactive risk management.

An important insight from the research is that while Perrow's normal accident theory provides a structured method to classify interdependencies, its application in real-world projects is inherently subjective. Clients and contractors often assign different classifications to the same interdependency, influenced by their distinct roles, responsibilities, and organisational perspectives. For example, a client may view a regulatory process as a linear interaction, expecting predictable sequences and procedural clarity. In contrast, the contractor may perceive the same process as complex due to unclear approval pathways, dependencies on third parties, or inconsistent stakeholder feedback. These differing interpretations can result in misaligned governance structures and inconsistent risk responses. To address this, the research advocates for a hybrid governance model, an approach that deliberately combines elements of centralised governance for linear interaction that require control and oversight with decentralised governance for complex interaction, operational elements requiring flexibility, and quick decision making. By accommodating varying stakeholder perspectives and adapting governance to the nature of each interdependency, hybrid governance enhances alignment, reduces friction, and strengthens collaborative risk mitigation throughout the project lifecycle.

The research concludes that effective management of client-contractor interdependencies enhances risk mitigation by aligning governance structures with the specific interdependency profile of the project. Rather than applying a one-size-fits-all risk management strategy, project stakeholders must tailor their governance models based on whether interdependencies require control-driven oversight or adaptive collaboration. This ensures that risks are addressed holistically, preventing conflicts and inefficiencies that arise from governance misalignment.

To translate these insights into practice, the research proposes several recommendations aimed at improving interdependency management and enhancing risk mitigation for BAM:

- **Joint classification of interdependencies at the start of the project**
  Client and contractor must collaboratively identify and classify the key interdependencies before project execution. Rather than proposing a singular classification method, the emphasis lies on establishing a mutual understanding of dependencies, whether they come from design coordination, regulatory approval, or third-party supplier constraints. Early classification supports better alignment of governance structures and risk strategies throughout the project lifecycle.
- **Adopt a hybrid governance approach**
  Adopt a hybrid governance model in complex construction projects, combining centralised oversight with decentralised flexibility. This approach enables governance structures to be adapted to the nature of interdependencies. By applying hybrid governance, BAM can improve coordination, improve risk mitigation, and better align with the needs of both internal teams and external partners.
- **Establish and align risk mitigation goals with the client**
  The case studies revealed that clients often prioritise quality and regulatory compliance, while contractors aim to deliver and operate efficiently. To avoid conflicting strategies and delayed approvals, both parties should align their risk mitigation goals during the early planning phase. This alignment helps to create shared priorities and expectations, improving risk response, and collaboration.
- **Enhance transparency by documenting informal coordination and tensions**
  A finding of the thesis was the lack of formal documentation on informal decision making, particularly when tension between parties increased. Documenting informal resolutions and critical moments, even if politically sensitive, contributes to long-term organisational learning and improves adaptability in future projects.
- **Broaden stakeholder involvement in decision-making**
  Project performance is hindered by decisions made without operational insight. Involving engineers, subcontractors, and site managers in risk discussions ensures that mitigation strategies are grounded in practical knowledge. The formation of cross-functional advisory teams can support timely and informed decisions.
- **Shift from contract-driven control to trust-based collaboration**
  Overreliance on contractual enforcement introduces rigidity. This research advocates for trust-based mechanisms such as joint risk registers, shared accountability models, and flexible milestone agreements to enable proactive risk responses and collaborative problem solving.

These recommendations collectively support the implementation of hybrid governance. Hybrid governance is not simply a compromise between centralised and decentralised structures, but a context-sensitive approach that aligns management structures with the nature of the interdependencies present. Because the nature of the interdependency can be categorised differently, a management structure that adapts to the specific situation and the classification is needed. Within a hybrid governance model, strategic decisions and high-risk areas remain centralised, ensuring oversight, compliance, and coherence with organisational objectives. The hybrid part is formed by operational decisions and local project adaptations are decentralised, empowering those with contextual knowledge to act quickly and effectively.

By implementing these practices, BAM can improve the alignment between the client and the contractor, increase the responsiveness to emerging risks, and foster a project culture grounded in transparency, shared ownership, and adaptive governance, ultimately enhancing both efficiency and resilience in complex construction projects.

Although this research provides valuable information, it has certain limitations. The study is based on two infrastructure projects, which may limit the generalisability of the findings to other types of construction projects. Furthermore, interdependencies were identified primarily through financial data, potentially overlooking relevant dependencies that were not financially visible. The TOE framework, while useful for structuring interdependency analysis, does not always account for overlapping complexities in real-world projects. Lastly, the perspectives collected were mainly from project managers, meaning that the insights of other key stakeholders, such as procurement officers and site engineers, were not fully incorporated. Future research should address these limitations by expanding the dataset, refining interdependency classifications, and integrating a broader range of stakeholder perspectives.

# Contents

# List of Abbreviations

| Abbreviation | Definition |
|---|---|
| ISA | International Standard Atmosphere |
| PM | Project management |
| PRM | Project risk management |
| TOE | Technical, Organisational and External |
| NAT | Normal accident theory |
| DBB | Design-bid-build |
| DB | Design-build |
| ICE | Institution of civil engineers |
| PMBOK | Project management body of knowledge |
| RAMP | Risk analysis and management for projects |
| ECI | Early contractor involvement |
| IPD | Integrated project delivery |
| TVP | Trein vrije periode |
| VTW | Verzoek tot wijziging |
| TAO | Turn around order |
| UO | Uiteindelijk ontwerp |

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# 1 Introduction

## 1.1. Context

In today's construction industry, projects are increasingly complex in scale and scope, often resulting in significant uncertainties and risks that affect project results. These projects are characterised by multiple stakeholders, long timelines, and external dependencies, which increase the likelihood of risk events occurring (Hatefi & Tamošaitienė, 2019). These risks lead to financial challenges, such as budget overruns, operational inefficiencies, safety hazards, and project delays (Ghaleb et al., 2022; Lafhaj et al., 2024). Despite the adoption of various risk management methodologies, including widely recognised models such as RISMAN, construction projects around the world continue to face cost overruns and delays. Research suggests that up to 65% of megaprojects do not meet initial cost and time estimates (Winch, 2012), indicating a significant gap in the effectiveness of current risk mitigation strategies (Assaf & Al-Hejji, 2006; Kazaz et al., 2012).

Methodologies such as RISMAN (De Rijke et al., 1997) are commonly used to assess risks, but often lack a focus on the ongoing evaluation of mitigation measures throughout the life cycle of the project (Chapman, 2019). Without a clear framework of standards to define and evaluate effective mitigation measures, inconsistencies arise in their application (Serpell et al., 2015). The literature reveals that while risk management approaches focus on risk identification, they do not ensure proactive risk control, which contributes to projects that do not meet their goals (Sharma & Gupta, 2019; Siraj & Fayek, 2019).

Moreover, the construction sector often adopts a reactive approach to managing risks, applying mitigation measures only after risks occur, rather than preventing them in advance (Tripathi & Mittal, 2024). Common factors contributing to cost and time overruns include poor planning, delays in decision-making, and contractor incompetency, which further complicate risk management (Assaf & Al-Hejji, 2006; Kazaz et al., 2012). This suggests the benefit of adopting a more structured and systematic approach to defining mitigation measures, with particular attention to the interdependencies between clients and contractors. In addition, it indicates the value of evaluating mitigation measures to support risk management strategies that align with the collaborative dynamics of construction projects.

This research aims to bridge this gap by focussing on the role of managing interdependencies between the client and the contractor in construction projects. By focussing on interdependencies that arise from technical, organisational, and external complexities, the research seeks to explore how these relationships influence risk management strategies. Additionally, it suggests the potential advantages of transitioning from reactive to proactive risk management, which can contribute to improved project outcomes in terms of cost, time, and quality.

## 1.2. Problem statement

In the construction sector, risk management is fundamental to project success, particularly in navigating the challenges posed by the increasing complexity, scale and scope of modern projects. Although improvements in risk identification frameworks, such as RISMAN and ISO 31000, have improved the industry's ability to recognise potential risks (Qammaz & AlMaian, 2020), significant gaps remain in addressing the interdependencies that underscore effective risk control. Current practices often fail to account for dynamic relationships between the client and the contractor, leading to insufficient evaluation and monitoring of mitigation measures. This shortcoming is particularly relevant in managing interdependencies, where factors such as regulatory restrictions, client requirements, and stakeholder alignment introduce significant risks (Bosch-Rekveldt et al., 2011).

The construction industry often adopts a corrective approach to risk management, addressing problems only after they occur (Flyvbjerg et al., 2003; Tripathi & Mittal, 2024; Winch, 2012). This corrective attitude, worsened by the lack of evaluation, makes projects vulnerable to inefficiencies, including cost overruns, delays, and reduced quality (Flyvbjerg et al., 2003; Winch, 2012). The absence of structured evaluation mechanisms to assess how mitigation measures perform throughout the project lifecycle creates uncertainties about their effectiveness. This is especially problematic in projects characterised by interdependencies between clients and contractors, where misaligned goals or unclear responsibilities worsen risks (Assaf & Al-Hejji, 2006; Kazaz et al., 2012).

Interdependencies in construction projects can often be rooted in technical, organisational, and external complexities, as outlined in the TOE framework (Bosch-Rekveldt et al., 2011; Lafhaj et al., 2024). These complexities shape the nature of interdependency and influence the management of strategies. However, current practices do not systematically evaluate how these relationships impact the outcomes of the mitigation measures applied and which management structure would be most effective if applied. For example, poorly managed interdependencies can result in miscommunication, delays in decision-making, and insufficient resource allocation (Alashwal & Al-Sabahi, 2019; Ökmen et al., 2024). This lack of alignment and oversight contributes to the recurring pattern of poor project outcomes in the industry.

To address these gaps, this research emphasises the need for an approach that integrates the evaluation of interdependencies into risk management practices. Specifically, it focusses on the relationship between the client and the contractor, examining how interdependencies influence the choice and effectiveness of mitigation strategies. By categorising interdependencies through the TOE framework and analysing their implications using the theory of Perrow (2011), this study aims to provide actionable insights on risk management practices. These insights are particularly relevant for improving decision making and fostering collaboration in projects with high levels of complexity and interdependencies.

The problem this research seeks to address is therefore:

> **In construction projects, the interdependencies in client-contractor relationships are often inadequately managed, resulting in misaligned mitigation strategies, misaligned goals and a lack of evaluation. This undermines risk control, particularly in projects characterized by high complexity and interdependencies between client and contractor, leading to increased costs, delays, and compromised project outcomes.**

Although there is extensive research on risk identification and assessment, fewer studies have focused on how client-contractor interdependencies influence risk mitigation and management. This research addresses this gap by examining these interdependencies in practice, evaluating their impact on risk management strategies, and identifying ways to improve alignment and collaboration in complex construction projects.

## 1.3. Research objective

This research analyses how interdependencies in construction projects influence risk management strategies, with a particular focus on the client-contractor relationship. The study aims to provide practical recommendations that help contractors improve their approach to managing interdependency-related risks. By integrating theoretical insights with empirical findings, this research seeks to bridge existing knowledge gaps in interdependency management within the construction industry.

To achieve this, the research focusses on the following objectives:

1. Identify and classify how the interdependencies in the client-contractor relationship, such as decision-making, requirements, and regulatory constraints, are addressed in the existing literature. This will provide a theoretical foundation for understanding the relationship and interdependency between the client and the contractor.
2. To evaluate how risks and interdependencies are managed in practice in real-world construction projects, with particular attention to client and contractor strategies and differences in goals. This will involve analysing the current implementation of mitigation measures and identifying any gaps or inefficiencies from the contractor's perspective.
3. Analyse the impact of mitigation strategies on project outcomes, specifically in terms of cost, time, and quality. The aim is to determine whether differences in these goals impact mitigation strategies.
4. Develop practical recommendations for improving risk management practices in construction projects, with a particular focus on optimising the use of mitigation strategies that address interdependencies. These recommendations will contribute to improving project success rates in terms of meeting the budget, timeline, and quality goals.

This master's thesis will review both theoretical and practical approaches to risk management, focussing on the evaluation of risk mitigation measures in construction projects. In doing so, the thesis not only evaluates how risk mitigation strategies are currently implemented and monitored, but also reveals where evaluation processes fall short in practice. By highlighting these shortcomings, the research contributes to a more nuanced understanding of how interdependencies affect risk over time and under varying project conditions. The resulting recommendations are intended to support contractors in refining their governance approaches, improving adaptive decision making, and fostering more resilient collaboration with clients in complex project environments.

## 1.4. Research relevance

This research is relevant to the construction industry, academic research, and social challenges, as it addresses a gap in the management of interdependencies between clients and contractors, directly influencing risk mitigation, governance structures, and overall project efficiency.

The scientific relevance of this study is that it builds on existing research on risk management and governance in construction projects by integrating Perrow's normal accident theory and the TOE framework into an empirical analysis of client-contractor relationships. Although these frameworks are well-established in complexity theory, their practical application in minimising construction risk in combination with interdependencies has not been much researched. By evaluating these models through real-world case studies, this research aims to provide deeper insight into how interdependencies influence project risk and decision-making structures. Furthermore, it highlights the limitations of purely centralised or decentralised governance models, suggesting that for a hybrid approach that better aligns with the dynamic nature of interdependencies.

The practical relevance of this research lies in its ability to provide construction professionals, project managers, and policy makers with actionable strategies to improve risk mitigation, governance structures, and collaboration. The findings show that many construction projects still rely on reactive risk management strategies, which address issues only after they escalate. By offering a structured approach to identifying, categorising, and managing interdependencies, this study helps industry stakeholders with practical tools to proactively mitigate risks, reducing delays, cost overruns, and inefficiencies. Furthermore, by analysing real-world project cases, this research provides recommendations that can be implemented in contract structuring, stakeholder coordination, and decision-making processes.

Beyond its practical impact, this research has significant social relevance, particularly in maintaining a strong and positive client-contractor relationship to prevent friction within and between projects. Effective risk mitigation strategies are not only about the performance of construction projects, but also based on trust, transparency, and collaboration between clients and contractors. By reducing the number of conflicts that can lead to disputes, delays, or inefficiencies, the relationship between the client and the contractor could be maintained positive. Strengthening these relationships ensures smoother project execution, prevents tensions from escalating across multiple projects, and promotes a more stable and efficient construction industry.

Ultimately, this study bridges the gap between theory and practice, offering a comprehensive analysis of the management of interdependencies in complex construction projects. By shifting from reactive to proactive risk management, it enables construction firms, policymakers, and researchers to develop more resilient, adaptive, and efficient governance structures, ensuring better project outcomes and a more sustainable approach to risk mitigation in the built environment.

## 1.5. Report structure

The report is structured on the basis of subject-related chapters. Chapter 1 introduces the context and relevance of the research, highlighting the challenges of managing interdependencies in construction projects and their impact on risk mitigation and governance structures. The research objectives and questions are presented along with a discussion of the practical and academic relevance of the study.

Chapter 2 describes the research methodology, detailing the theoretical foundation, case study selection, data collection methods, and analytical frameworks. The chapter also explains how interdependencies are classified and how risk mitigation strategies are assessed within client-contractor relationships.

Chapters 3 and 4 present the literature review, providing an in-depth exploration of project complexity, interdependencies, and governance models in construction projects. Theoretical insights into centralised vs. decentralised governance, preventive vs. corrective risk strategies, and stakeholder influences are discussed to establish a foundation for the empirical study.

Chapters 5 and 6 focus on empirical findings from case studies, analysing how interdependencies shape risk management from both the contractor's and the client's perspectives. Through an examination of key project events, this section highlights differences in risk perception, governance approaches, and decision-making processes, revealing discrepancies in how both parties approach risk mitigation.

Chapter 7 synthesises the findings, identifying key patterns and misalignments in the management of client-contractor interdependency. By comparing theoretical frameworks with real-world observations, this chapter provides insights into the effectiveness of different governance structures and risk mitigation strategies.

Chapter 8 discusses the implications of the findings, proposing a hybrid governance model that balances structured oversight with adaptive flexibility to improve risk management. The chapter also presents practical recommendations for construction companies on how to align risk strategies with interdependency complexity.

Finally, Chapter 9 concludes the thesis by answering the central research question and summarising the key contributions. Recommendations are provided for industry application, policy development, and future research directions, alongside a reflection on the research process and its limitations.

# 2
# Research methodology

In this chapter, the research methodology will be described. First, the scope of the research will be described. The research questions will then be presented. Following that, the methodology of the research and the structure of the report will be explained in more detail.

## 2.1. Research scope

To ensure the added value of the research is maintained, the scope of the study has been clearly defined. Figure 2.1 illustrates what is included and excluded from the scope of this research.

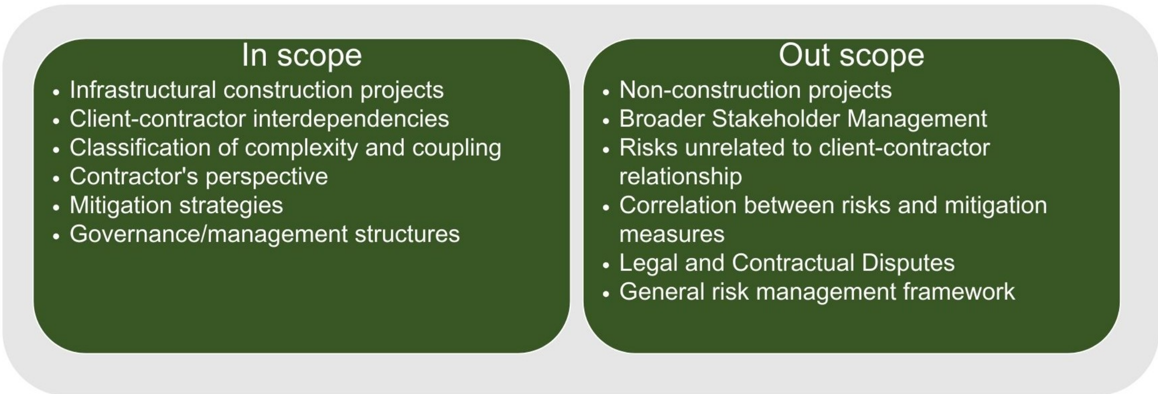


**Figure 2.1:** Scope of the research

- *Infrastructural construction projects:* Within BAM, various segments operate in different fields of construction. This research will focus on infrastructure construction projects. These projects typically involve the development and construction of complex systems that are crucial to societal functioning. Infrastructure projects are particularly relevant to this study because they are characterised by high levels of project complexity and client-contractor interdependency, which can influence how risks emerge and are managed.
- *Client-contractor interdependencies:* Mutual dependencies between the client (e.g. project owner) and the contractor (e.g. executing party), which shape how decisions are made, risks are shared and responsibilities are managed. Rather than a one-directional relationship, these interdependencies are dynamic and evolve throughout the project, often becoming a central factor in how risk is experienced and managed.
- *Classification of complexity and coupling:* Using the TOE framework and Perrow's matrix, the study categorises complexity elements and evaluates how the degree of coupling affects project risks and mitigation strategies.
- *Governance/management structures:* The formal and informal mechanisms through which decisions are made and the authority is distributed in a project. In this thesis, governance is evaluated in terms of how well it matches the interdependency profile. Centralised structures for tightly coupled, predictable systems and decentralised or hybrid structures for complex, unpredictable settings
- *Mitigation measures:* In this research, mitigation measures refer to strategies and actions taken to reduce the likelihood and impact of identified risks. These measures help minimise disruptions related to scheduling delays, cost overruns, and quality issues.

- *Contractor's perspective:* This research is carried out on behalf of a contractor and is therefore based on the contractor's position within infrastructure projects. The contractor's documentation, experience, and perspective have guided both data collection and analysis. Taking the contractor's point of view as the leading, the research aims to provide practical information to improve risk management from the contractor's side of the client–contractor relationship.

## 2.2. Research question

This research aims to apply a structured theoretical approach to evaluate risk mitigation strategies in construction projects, with a particular focus on how the interdependencies are managed in the relationship between the client and the contractor. The study investigates how mitigation strategies address risks related to cost, schedule, and quality by examining the role of governance structures and interdependency classifications. Through the integration of these elements, the research demonstrates how a structured theoretical approach can enhance the evaluation and improvement of risk management practices in complex construction projects. To achieve these objectives, the central research question is formulated as follows:

***How can the management of interdependencies in the client-contractor relationship enhance risk mitigation strategies in complex construction projects?***

To address and support this central research question, the study is structured around several sub-questions, which will help explore different facets of the research.

1. *How can interdependencies in client-contractor relationships be identified and analysed using complexity elements based on theoretical insights?*
2. *How are client-contractor interdependencies managed and risk mitigation strategies applied in practice from contractors perspective?*
3. *How are client-contractor interdependencies managed and risk mitigation strategies applied in practice from client perspective?*
4. *What strategies can be developed to improve risk mitigation through better management and more alignment of client-contractor interdependencies?*

The sub-questions have been drawn up to explore the theoretical and practical dimensions of client-contractor interdependencies and their influence on risk mitigation strategies in complex construction projects. They investigate how interdependencies can be identified and analysed using complexity elements, assess how these interdependencies and mitigation strategies are managed in practice, and evaluate whether there is a gap between theoretical models and the execution of real-world projects.

## 2.3. Methodology

This section describes the methodology used to provide a clear and structured breakdown of the research approach for your thesis, divided into three parts of the research: Review of the literature, analysis of empirical data, and evaluation. Each part serves a specific purpose in addressing the research questions, leading to a comprehensive understanding of the topic. The methodology is shown in Figure 2.2.

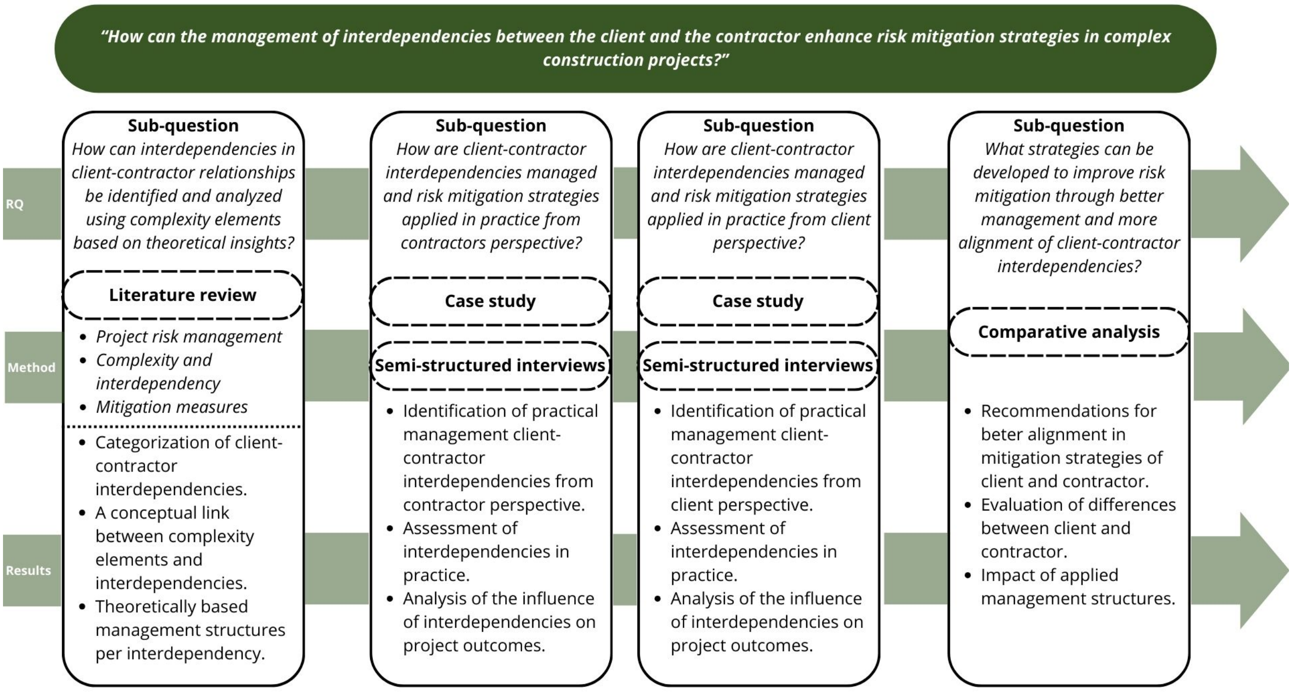


**Figure 2.2:** Visualisation of research methodology

### 2.3.1. Literature review

The start of this research focusses on developing a theoretical framework to systematically classify and analyse interdependencies between clients and contractors. This is done through an extensive literature study that examines the theoretical foundations of project complexity, interdependencies, and risk management. In conducting this literature study, a systematic search strategy was employed to ensure a comprehensive coverage of relevant sources. The search aimed to identify the literature on client-contractor interdependencies, risk mitigation strategies, governance, and complexity of construction projects, using databases such as Google Scholar, the TU Delft Repository and Scopus. Boolean search queries were formulated by combining key terms such as 'client-contractor interdependencies', 'construction project complexity', 'risk mitigation strategies', 'TOE framework', 'Governance structures', and 'normal accident theory'. Inclusion criteria limited the scope to English-language publications from 1998 to 2025, primarily peer-reviewed journal articles and pertinent academic papers in the field of construction and risk management. Identified sources were first screened by title and abstract to assess relevance, and then those deemed suitable were examined in full text. In addition, a snowball technique was applied. The reference lists of key publications were reviewed to discover more relevant literature. Through this search process, the literature review presented in Chapters 3 and 4 is grounded in a theoretical foundation.

Based on the literature collected, the TOE framework of Bosch-Rekveldt et al. (2011) is used as a guide to categorise the interdependencies within projects at the technical, organisational and external levels. In addition, Perrow (2011)'s Normal Accident Theory is applied to assess the extent to which systems in construction projects are characterised by high complexity and tight coupling between project elements, suggesting a management structure for each interdependency. This part of the research also includes an analysis of existing risk management strategies, evaluating preventive and corrective measures in relation to their effectiveness in complex project environments. The outcome is an analytical framework that serves as a reference for the empirical analysis and the selection of relevant case studies. The goal is to establish a structured basis that allows interdependencies to be understood not only in theory but also to be identified and analysed in practice.

### 2.3.2. Empirical data

After the theoretical bases, the focus is on analysing how interdependencies between clients and contractors influence risk management in practice. To achieve this, a structured approach is taken. Financial data is used as a starting point to identify key project events. These events are then further investigated through project documentation and interviews.

One of the elements in this part of the research is the generation and analysis of cash flow data from the contractor. By calculating and comparing the tender cash flow with the realisation cash flow, deviations in financial performance are detected. These deviations often indicate critical project events, such as delays, unforeseen costs, or disruptions in project execution. By analysing cash flow trends, significant fluctuations can be linked to specific time periods in the project timeline. This forms the basis for identifying and analysing moments where risks and interdependencies between the client and the contractor became visible and influenced the project results.

Once key events are identified from the cash flow data, these moments are further examined using progress reports and project documentation from a contractor's perspective. The goal is to determine what occurred during each identified event and whether a clear interdependency between the client and the contractor played a role. This involves assessing whether the event was caused by, or had consequences for, decisions made by one of the parties, and whether risk mitigation strategies were applied. By systematically reviewing project reports, it is possible to reconstruct the chain of events and categorise the interdependencies between technical, organisational, or external complexity using the TOE framework.

To complement this document analysis, semi-structured interviews with client and contractor project managers are conducted. These interviews provide additional information on the context of each event, helping to clarify how decision-making processes and management approaches were influenced by interdependencies. The interview questions focused on the mitigation of issues, which allowed identifying patterns in whether risk management strategies were primarily preventive or corrective, whether they prioritised time, cost or quality, and the extent to which the governance structure influenced the mitigation of project risk. These interviews were used not only to gather empirical information, but also to ensure that interdependencies, event classifications, and management structures were accurately documented. As mentioned, the projects studied have already been completed, so a short survey was conducted before the interviews to help project managers recall key events and ensure that they had a clear understanding of the required information. The same project managers as interviewed are asked to fill in the survey. Due to their role as final decision makers and facilitators of collaboration between the involved parties, project managers were asked to complete the survey. This not only ensured that the necessary context was fresh in their minds during the interview but also served as an evaluation step to confirm that the selected events were indeed the most critical moments in the project. Their perspective helps to assess how interdependencies influenced project execution and risk management.

The results of this empirical study provide a systematic categorisation of interdependencies within specific project events by applying the TOE framework and positioning them within the Perrow matrix. This approach allows for an assessment of both the interaction and coupling of each situation, offering deeper insights into how interdependencies influence risk exposure.

### 2.3.3. Evaluation

The final chapters of this research focus on evaluating the findings of the empirical study by systematically comparing the perspectives of the client and the contractor. This evaluation aims to identify patterns in how interdependencies are perceived and managed by both parties and to assess how different governance structures influence risk mitigation strategies in construction projects. By structuring and interpreting these findings, the foundation is provided for drawing conclusions and developing recommendations for both practice and future research.

A central part of these chapters is the comparison between the client and the contractor's approaches to risk management and interdependencies. This involves examining differences in risk perception, decision-making structures, and strategies used to manage uncertainties throughout the lifecycle of the project. Structured findings will highlight how interdependencies shape project governance and whether risk management approaches align or diverge between both parties.

Following this comparison, the research will discuss the key findings in relation to the theoretical framework established in the literature study. The discussion will explore how the categorisation of interdependencies within the TOE framework and their placement in Perrow's matrix relate to the dynamics of the observed project. This part of the research will also reflect on the broader themes emerging from the research, such as the role of communication, collaboration, and governance structures in managing risks in complex construction projects.

In addition to discussing the findings, this step of the research will outline the scope and limitations of the research. Considerations such as the availability of project documentation, the influence of project-specific factors, and the applicability of theoretical models to real-world cases will be addressed to ensure transparency regarding the study constraints.

Finally, based on the structured evaluation, this part of the research will formulate conclusions and provide recommendations. The conclusions will summarise the key insights gained from the research, while the recommendations will provide guidance on improving interdependency management and risk mitigation strategies in construction projects. These recommendations will be directed at both practitioners and researchers, addressing potential improvements in governance structures, stakeholder coordination, and areas for further study.

# 3 Risk management in client-contractor relationships

## 3.1. Understanding project risk management

Project Risk Management (PRM) is a structured and systematic process designed to identify, assess, respond to, and monitor risks that can arise throughout the life cycle of a project (ICE, 2014). The goal of PRM is twofold: to minimise the negative impacts, or threats, that could derail project success, and to maximise the positive impacts, or opportunities, that can improve outcomes and performance (De Bakker et al., 2011; PMI, 2021; Williams, 2017). Risks are essentially uncertainties, events, or conditions that, if they occur, could affect key project objectives such as scope, time, cost, quality, and stakeholder satisfaction (Atkinson, 1999; De Bakker et al., 2011; Galli, 2017; Williams, 2015). As explained by Atkinson (1999), a framework that illustrates the relationship between these aspects is shown in Figure 3.1.

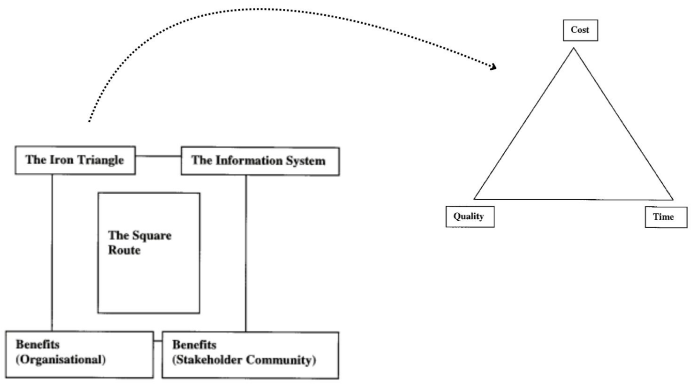


**Figure 3.1:** Project objective by Atkinson (1999)

The Atkinson framework (Atkinson, 1999) was developed as a project management framework. Historically, PRM originated in traditional PM practices, but has evolved significantly over the years. Initially, PRM was mostly reactive, focussing on addressing problems only after they had already materialised (Dionne, 2013). This approach often led to disruptions, delays, and cost overruns, especially in complex projects. As industries, especially construction, became more complex (Bosch-Rekveldt et al., 2011), the need for a proactive and systematic approach to managing risks became evident (Williams, 2017). Today, PRM is not only about mitigating negative events, but also about identifying and capitalising on opportunities that can lead to greater project success (ICE, 2014). In today's project landscape, effective risk management is a strategic capability that allows teams to navigate uncertainty and make informed decisions, thereby enhancing overall project outcomes.

PRM has become an integral part of broader project management methodologies, such as the Project Management Body of Knowledge (PMBOK) and the Risk Analysis and Management for Projects (RAMP) framework, both widely used across industries, particularly in construction (Del Caño & De La Cruz, 2002). These frameworks provide structured approaches for managing risks systematically, offering tools and techniques that ensure that risks are addressed throughout the project life cycle. They have also influenced the development of specialised risk management methods, such as quantitative risk modelling, scenario analysis, and advanced risk monitoring technologies (ICE, 2014; PMI, 2021).

The evolution of PRM can be traced back to the mid-20th century, after World War II (Dionne, 2013; Jalhoom & Mahjoob, 2023). In the 1990s, structured methodologies such as PRINCE2 and PMBOK had formalised risk management processes, marking a shift towards a comprehensive and proactive approach (Al-Freidi, 2015). This shift was driven by the increasing complexity of construction projects, particularly those involving multiple stakeholders, long duration, multiple technologies, and cross-functional teams (Ahn et al., 2016). The need to coordinate between designers, contractors, suppliers and regulators made that integration of risk management at every phase of the project life cycle became more acknowledged. As a result, advanced tools such as Monte Carlo simulations, scenario planning, and risk-adjusted decision-making became integral to project management (Kwak & Ingall, 2009; Torres et al., 2002).

A key element of PRM is the structured approach that it provides, which can be broken down into several key phases. According to the PMBOK Guide and Karam et al. (2021), PRM involves four main phases: Risk identification, risk analysis, risk response planning, and risk monitoring and control. These four phases are shown in Figure 3.2 and summarised in Figure 3.3 (ICE, 2014; Lmoussaoui & Jamouli, 2014; PMI, 2021).

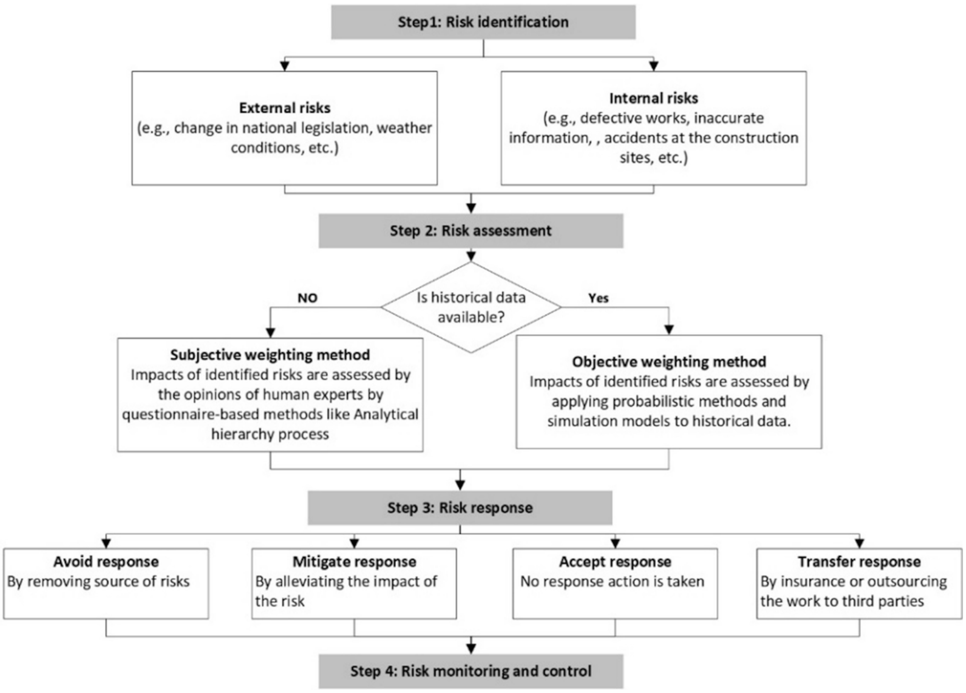


**Figure 3.2:** The four-step procedures of project risk management of Karam et al. (2021)


**Figure 3.3:** PRM cycle by ICE (2014)

As Figure 3.3 shows, PRM is an ongoing iterative process that requires active collaboration among all project stakeholders. In industries like construction, where risks are inherent due to both external factors and internal factors , PRM plays a relevant role in ensuring that projects are delivered on time, within budget, and to the required standards of quality and safety. Construction projects often rely on structured methodologies like PMBOK, RAMP, or RISMAN, advanced tools companies designed themselves, and regular risk review meetings to manage risks effectively.

In conclusion, PRM has undergone significant development over the decades, evolving from a reactive, ad hoc activity into a proactive, structured discipline. Today, PRM is a vital component of successful project management, particularly in high-risk sectors such as construction. By following the key phases of risk identification, analysis, response planning, and monitoring, project teams can address potential risks before they escalate, ensuring that projects remain resilient to both internal and external challenges. The effectiveness of risk management depends on aligning risk mitigation strategies with governance structures and stakeholder collaboration. Moreover, PRM not only helps prevent project failures, but also enables teams to capitalise on opportunities, driving projects toward greater success.

## 3.2. Governance structures in risk management

The chosen governance model influences how risk-related decisions are made, who is responsible for managing risks, and how flexibility is balanced with control (Van Asselt & Renn, 2011). The literature distinguishes three dominant risk management structures: centralised, decentralised, and hybrid approaches (Deng et al., 2021; Jong & Faerman, 2021; Perrow, 2011; D. Rahman et al., 2024). Each has distinct characteristics, offering advantages and challenges depending on the complexity and demands of the project. A further distinction can be made between governance structures. However, in this study, only centralised, decentralised, and hybrid governance structures will be included.

In a centralised risk management structure, the decision-making authority is concentrated at the client or a central project organisation (Jong & Faerman, 2021). Risks are controlled through a top-down approach, where formalised procedures, compliance mechanisms, and structured approval processes dictate how risks are managed (Jong & Faerman, 2021). This structure is commonly applied in large-scale projects that require high levels of standardisation and regulatory oversight (Jong & Faerman, 2021; D. Rahman et al., 2024). Centralised risk management ensures clear accountability, systematic risk identification, and strong adherence to established frameworks, reducing uncertainty through structured oversight (Jong & Faerman, 2021). However, its rigidity can limit adaptability to unforeseen risks, as response times can be slowed by hierarchical decision-making processes (Jong & Faerman, 2021; D. Rahman et al., 2024).

In contrast, decentralised risk management structures distribute responsibility among various stakeholders in the project, particularly at the contractor and operational level (Jong & Faerman, 2021; Mbate, 2017; D. Rahman et al., 2024). Instead of relying on central control, risk-related decisions are made within project teams, allowing faster responses to emerging risks and greater flexibility in adjusting mitigation strategies (Jong & Faerman, 2021; Mbate, 2017). This approach is often seen in projects with integrated teams, where dynamic collaboration is needed to manage evolving challenges (D. Rahman et al., 2024). Decentralised structures promote continuous assessment and proactive risk management, making them particularly effective in complex environments. However, they require strong communication and coordination mechanisms to prevent fragmented or inconsistent risk management between different project teams (D. Rahman et al., 2024).

Many projects could employ a hybrid risk management structure that combines elements of centralised and decentralised approaches (Deng et al., 2021; Jong & Faerman, 2021; D. Rahman et al., 2024). This model allows for structured governance where necessary, while allowing flexibility where beneficial (Deng et al., 2021; Mbate, 2017). Hybrid structures provide a framework for balancing control and adaptability, ensuring that project teams can respond to operational risks efficiently while maintaining alignment with overarching project objectives (Deng et al., 2021; Jong & Faerman, 2021). Effective hybrid governance requires balancing formal control (contracts and oversight) with informal mechanisms (trust-building and collaboration) (Deng et al., 2021). This approach is especially useful in long-term or multi-stakeholder projects, where risks vary across different phases and require different levels of oversight (D. Rahman et al., 2024).

## 3.3. Dependency in construction projects

Dependencies in construction projects are inherent in the relationships between stakeholders, processes, and resources (Bilgin et al., 2017; Paolo et al., 2018). These interconnections significantly influence project results and amplify the complexity of managing construction projects. Dependencies go beyond individual risks, encompassing broader relational, procedural, and resource-based interactions. Effectively understanding and managing these dependencies is relevant for achieving project success (Bilgin et al., 2017; Li et al., 2015; Mok et al., 2014).

In construction projects, dependencies manifest in various forms, shaping project dynamics and introducing varying degrees of complexity. To better understand these interactions, it is useful to differentiate between independency, dependency, and interdependency as shown in Figure 3.4 (Maheswari & Varghese, 2005; Paolo et al., 2018).

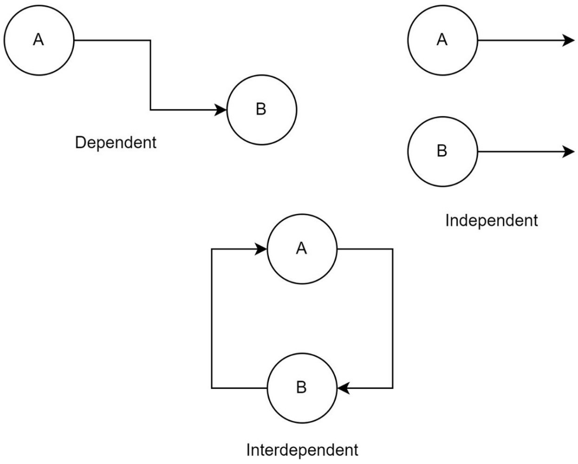


**Figure 3.4:** Types of dependencies adapted from Maheswari and Varghese (2005)

Some tasks in construction projects operate independently, meaning that their execution does not directly influence other tasks. These independent tasks allow for straightforward scheduling and resource allocation. However, true independence is rare in complex projects, as most processes are interconnected in some way. Overlooking hidden dependencies can introduce unforeseen risks, leading to inefficiencies and delays (Paolo et al., 2018).

Dependencies occur when one task or process directly influences another in a unidirectional manner. A typical example is a delay in material delivery that affects the construction schedule, leading to disruptions across multiple phases. This type of dependency follows a sequential or hierarchical structure, where one task acts as a precursor to another. Managing dependencies requires careful planning, structured sequencing, and proactive risk mitigation to prevent bottlenecks (Kwan & Leung, 2011). Dependencies in construction projects can be categorised into financial, resource, learning, and outcome dependencies (Bilgin et al., 2017). Financial dependencies arise when projects rely on shared financial resources, making cash flow vulnerabilities a major risk factor. Resource dependencies occur when multiple projects share assets, such as skilled labour, specialised equipment, or materials, meaning that disruptions in one project can affect others. Learning dependencies involve the transfer of knowledge between projects, where lessons learnt from one initiative contribute to the efficiency and success of future projects. Outcome dependencies link the success of one project to another, often in sequential workflows where the completion of one phase is necessary before subsequent activities can proceed.

The attributes and relative importance of these dependencies, as identified by Bilgin et al. (2017), highlight the central role of external stakeholders in shaping project outcomes. For example, financial dependency is related to the client, highlighting how payment structures and financial management influence overall project performance. Table 3.1 presents an overview of dependency attributes and their respective weights.

**Table 3.1:** Weights and attributes of dependencies (Bilgin et al., 2017)

| Dependency Type | Overall Weight | Attributes to Measure | Attribute Weight |
|---|---|---|---|
| **Financial Dependency** | 0.271 | Client | 0.533 |
| | | Currency | 0.467 |
| **Resource Dependency** | 0.270 | Personnel | 0.279 |
| | | Manpower | 0.245 |
| | | Machinery and Equipment | 0.256 |
| | | Material | 0.220 |
| **Learning Dependency** | 0.223 | Country | 0.154 |
| | | Project Type | 0.157 |
| | | Client | 0.133 |
| | | Technology | 0.150 |
| | | Contract Type | 0.135 |
| | | Project Delivery System | 0.141 |
| | | Partnering Company | 0.130 |
| **Outcome Dependency** | 0.237 | - | - |

Beyond internal dependencies, external stakeholders, such as regulatory agencies, suppliers, and environmental bodies, further complicate dependency management. These entities have independent priorities that may not align with project timelines. Regulatory compliance requirements may introduce approval delays, while supply chain disruptions can lead to material shortages, affecting multiple interdependent tasks. Managing these external dependencies requires proactive engagement, risk identification, and mitigation strategies before they affect project execution (Bilgin et al., 2017; Chan & Oppong, 2017; Diyagama et al., 2023).

A fundamental aspect of dependencies in construction projects is the client-contractor relationship, which plays a crucial role in determining project success (Bilgin et al., 2017). Initially, this relationship may appear as a one-sided dependency, where the contractor relies on the client for scope approvals, financial payments, and contractual modifications. However, as projects progress, this dependency often evolves into interdependency, where both parties become mutually dependent on each other. Although the contractor relies on timely client decisions for efficient project execution, the client also depends on the contractor's expertise, risk management, and adherence to project schedules to achieve the overall project objectives. This reciprocal influence transforms a simple dependency into an interdependent relationship, where decision-making on both sides must be coordinated and aligned to ensure smooth project progression (Mok et al., 2014; Osipova, 2014).

Interdependency introduces a more complex relationship in which two or more elements mutually rely on each other (Paolo et al., 2018). Unlike simple dependencies, where one factor depends on another without reciprocity, there are interdependencies when both parties influence and are influenced by each other (Kwan & Leung, 2011). A classic example in construction projects is the collaborative design process, where engineers rely on input from architects, while architects simultaneously depend on engineering feedback to refine their designs. These interdependent relationships require continuous communication, coordination, and adaptability to prevent inefficiencies and ensure smooth execution (Paolo et al., 2018).

Interdependencies can also emerge when the cause and manifestation of a risk or complexity differ (Baccarini, 1996). A risk may originate in one project phase but primarily affect another, requiring both parties to coordinate responses. For example, a design error made in the early stages of a project may not cause immediate disruption but could later lead to structural complications during construction. Although the engineering team is responsible for the initial design decisions, the contractor is ultimately impacted by their consequences. Similarly, financial instability on the client's side may not immediately stop construction, but could create payment delays, affecting downstream contractor operations. These cases highlight that interdependencies are not only about active collaboration, but also about the ripple effects of risks that link different project participants. Recognising these indirect interdependencies could be used to mitigate long-term project risks and ensuring coordinated risk responses between stakeholders.

Effectively managing interdependencies requires more than structured sequencing and planning. It requires collaborative governance, joint risk assessment, and adaptive decision-making to align client and contractor priorities (Oppong et al., 2017). Misalignments in expectations, lack of communication, or conflicting stakeholder interests can exacerbate risks, leading to project delays and cost overruns. To address these challenges, trust-based frameworks such as Integrated Project Delivery (IPD) and Early Contractor Involvement (ECI) have been proven effective (Mosey, 2009; Rahmani, 2020). These approaches emphasise early-stage collaboration, shared risk allocation, and transparent decision making to mitigate the complexities of interdependent relationships (Mosey, 2009; Rahmani, 2020).

Dependencies are an integral aspect of construction projects, influencing project execution in all aspects of scheduling, financial management, and stakeholder coordination. Although dependencies often start as one-sided influences, they frequently evolve into interdependencies, particularly in client-contractor relationships where mutual reliance increases over time. Understanding this change from dependency to interdependency allows construction teams to implement adaptive management strategies, improve collaboration, and align project goals. By integrating proactive dependency management techniques, project teams can improve efficiency, mitigate risks, and drive successful project completion in complex construction environments (Bilgin et al., 2017; Diyagama et al., 2023; Mok et al., 2014).

## 3.4. Control and mitigation measures

In the context of risk management in construction projects, control and mitigation measures are key strategies aimed at reducing the likelihood or impact of identified risks, or, in some cases, completely eliminating them (Afifa & Santoso, 2022; Banaitiene, 2012). These measures play a role in managing the various risks that arise throughout the project life cycle, ranging from financial uncertainties to operational challenges and stakeholder-related risks (Ivić & Cerić, 2024). The primary objective of mitigation measures is to ensure that projects can progress with minimal disruption while managing both internal project dependencies and external factors such as regulatory changes, supplier issues, or client demands. As noted in Banaitiene (2012), the effective implementation of mitigation measures ensures that known and unknown risks (Higgins & Perera, 2018) are adequately managed throughout the project.

To deepen our understanding of mitigation strategies, it is important to examine the various risk response strategies available to project teams. These strategies include acceptance, avoidance, transference, reduction, and escalation, each serving different purposes depending on the nature of the risk and the context of the project (ICE, 2014). A comprehensive explanation of these strategies is provided in Appendix A, but in summary:

- Acceptance involves acknowledging the risk without taking immediate action.
- Avoidance modifies the project plan to completely eliminate risk.
- Transference shifts the responsibility for the risk to a third party, typically through contracts or insurance.
- Reduction (or mitigation) involves actions that aim to minimise the probability or impact of the risk.
- Escalation elevates the risk to higher management if it is beyond the control of the project team.

Although all of these strategies are valuable for managing risks, the concept of mitigation is most closely associated with the risk reduction strategy. Mitigation measures are specifically designed to reduce the likelihood that risk events occur or minimise their impact if they occur (ICE, 2014). In the context of construction projects, mitigation involves practical and proactive steps to address risks by managing both internal factors, such as task dependencies, and external factors, including stakeholder dynamics and regulatory challenges.

Mitigation measures must be carefully tailored to the unique dependencies present in each project (Banaitiene & Banaitis, 2012; Ivić & Cerić, 2024). Risks within a project are rarely isolated; they often involve interdependencies between tasks as well as relationships with external stakeholders (Bilgin et al., 2017; Ivić & Cerić, 2024). For example, internal dependencies can include interconnected tasks, resource sharing, or sequencing issues throughout project phases, while external dependencies often involve relationships with clients, suppliers, or regulatory bodies (Bilgin et al., 2017). The ability to manage these external relationships is preferred in construction, where external influences, such as changes in regulatory requirements or supplier delays, can introduce significant risks to project timelines, costs and quality.

Mitigation measures in risk management can be categorised into two broad types: preventive and corrective measures (Banaitiene, 2012; PMI, 2021). Preventive measures are designed to anticipate risks before they occur due to root factors that, if not managed, could lead to broader problems later in the project (PMI, 2021). These proactive strategies focus on reducing the probability of risk events and are needed to manage risks at their source. For example, in construction projects, preventive measures could include detailed design reviews to identify potential errors early or stakeholder engagement at the outset to align expectations and avoid communication breakdowns. Early collaboration with clients, contractors, and suppliers ensures that all parties are aligned with project objectives, reducing the likelihood of disputes or delays. Preventive strategies are well suited for projects where anticipating challenges and building resilience early on can lead to significant cost savings and schedule reliability (Lafhaj et al., 2024).

In parallel, the concept of proactive risk management refers to the broader approach of identifying and addressing risks before they occur (Cordova et al., 2023; Rasmussen & Svedung, 2000). Proactive measures often include anticipating regulatory changes, negotiating terms with suppliers, or maintaining continuous engagement with stakeholders to detect potential issues early. By proactive strategies, disruptions can be prevented before they impact project parameters such as cost, schedule, or quality (Amarkhil et al., 2021). Proactive approaches are closely tied to preventive measures, as both seek to mitigate risks before they can affect the project.

In contrast, corrective measures are employed once a risk has already occurred. These reactive measures aim to minimise the impact of a risk event on the project (PMI, 2021). For example, in construction projects, corrective actions could involve activating contingency plans, such as schedule or budget buffers, to absorb the effects of delays or cost overruns. Additional corrective strategies might include reallocating resources or adjusting timelines to respond to unforeseen challenges such as new regulatory requirements or unexpected site conditions. If, for example, a regulatory change delays the project, the team might reassign labour or extend deadlines to mitigate the disruption.

Although reactive mitigation tends to be less effective than preventive strategies because it deals with risks after they have occurred, it remains a relevant component of risk management, particularly in handling unknown unknowns or last minute changes in client requirements (Higgins & Perera, 2018).

For mitigation measures to remain effective, their implementation and impact must be continuously monitored and adapted as project conditions evolve (Sánchez & Gallardo, 2005). As projects progress, new risks often emerge, particularly when external stakeholders are involved (Olander, 2006). The client's requirements can change during the project, or the suppliers can face unforeseen challenges. To address these evolving risks, the project team must regularly review and adjust its mitigation strategies. Preventive mitigation reduces the initial burden of managing these interdependencies by streamlining processes, aligning expectations, and resolving potential conflicts before hand (Sharma & Gupta, 2019). Corrective mitigation complements this by providing the agility to handle residual or unforeseen issues, ensuring that interdependencies do not escalate into larger challenges (Siraj & Fayek, 2019). In addition, feedback loops from previous projects can provide valuable insight, allowing teams to refine their risk management practices over time and improve the results of future projects.

In conclusion, control and mitigation measures are important for risk management in construction projects. These measures allow project teams to take proactive steps to manage risks by addressing their root causes, manifestations, and external dependencies. Although some risks, especially those involving external factors, may be unavoidable, focussing on the cause of risks and maintaining strong stakeholder relationships could improve the likelihood of project success.

## 3.5. Project risk management frameworks: Incorporating the client's role

Project risk management frameworks, such as PMBOK (PMI, 2021) and ISO 31000, provide structured approaches for identifying, assessing, and responding to risks throughout the project life cycle. These frameworks recognise the importance of stakeholder participation, including clients, in the risk management process.

The PMBOK emphasises that stakeholder participation, including active client participation, is an important component of effective risk management. It advises project managers to consider stakeholders' needs and expectations in risk assessments and to incorporate their input into the development of mitigation strategies. Similarly, ISO 31000 (2018) highlights the importance of understanding stakeholders' risk attitudes and incorporating this knowledge into the risk management plan. Clients, as primary stakeholders, play a vital role in shaping the risk context and influencing decisions on how risks are treated. As Yin et al. (2020) concludes on the basis of his research, clear risk allocation is crucial to maintaining a balanced client-contractor relationship, while weak or unclear risk allocation can lead to conflicts, misaligned expectations, and inefficiencies in project execution.

The literature indicates that the degree of client involvement in risk management activities significantly impacts the success of mitigation efforts (Hoseini, 2020). Hoseini (2020) found when clients actively participate in risk assessments, risk workshops, or decision-making processes, they contribute to more accurate risk identification and better alignment of risk response strategies with project objectives. In contrast, a lack of client participation can lead to overlooked risks or poorly coordinated mitigation measures, resulting in reactive rather than preventive risk management.

By incorporating the client's role into structured risk management frameworks, project teams can improve the comprehensiveness of their risk management plans and better anticipate challenges. The involvement of the client and the contractor in continuous risk monitoring also helps ensure that emerging risks are addressed promptly and mitigation measures are adjusted as needed to reflect changing project conditions.

## 3.6. Conclusion

This chapter has demonstrated that PRM has evolved into a structured and proactive discipline, particularly in construction projects, where risks emerge from interdependencies between stakeholders, resources, and processes. Managing these risks effectively requires not only identifying and mitigating them but also ensuring that governance structures align with the nature of these interdependencies.

A key insight is that governance structures play a crucial role in shaping risk mitigation strategies. Centralised approaches prioritise compliance and financial oversight, ensuring structured decision-making and accountability. Decentralised approaches promote flexibility and shared decision making, allowing quick adaptation to changing project conditions. However, relying solely on one governance model can lead to inefficiencies, reinforcing the need for hybrid governance structures that balance control with adaptability, making risk management more effective in complex project environments.

Additionally, the chapter highlights that risks in construction projects are rarely isolated but emerge from interdependencies. These relational, procedural, and resource-based dependencies amplify risk exposure and require proactive stakeholder engagement, trust-based collaboration, and clear alignment of objectives to prevent inefficiencies and delays.

The chapter also distinguishes between preventive and corrective risk mitigation measures. Preventive strategies anticipate and minimise risks before they escalate, whereas corrective strategies address risks after they occur. The findings suggest that preventive measures are generally more effective, particularly in managing complex interdependencies, as they help avoid disruptions rather than simply reacting to them.

Ultimately, risk management should not function as a standalone process, but should be integrated into project governance. A structured approach to risk identification and mitigation should be embedded in decision-making processes and collaboration efforts, ensuring that projects remain resilient against uncertainty.

Building on these insights, the next chapter develops a theoretical framework for analysing and managing interdependencies between clients and contractors. The next chapter uses multiple theoretical frameworks for analysing and managing interdependencies in client-contractor relationships. The use of theoretical frameworks systematically categorises complexity using the TOE framework and applies Perrow's matrix to assess how governance structures influence risk mitigation strategies. This theoretical foundation provides the basis for the empirical analysis conducted in subsequent chapters.

# 4

# Structuring interdependency and complexity to understand governance and mitigation strategies

The interdependency between clients and contractors plays a fundamental role in the design of risk mitigation strategies in construction projects. While clients influence risk exposure through governance structures, contract models, and decision-making authority, contractors must navigate these interdependencies to manage risks effectively. Understanding how these interdependencies influence risk control requires a structured theoretical approach that incorporates project risk management frameworks. These frameworks provide the foundation for analysing how risk responsibilities, decision making dynamics, and governance mechanisms shape both client-driven and contractor-driven risk management strategies. By examining risk mitigation through the lens of interdependencies, this research aims to uncover how complexity and project structures affect the choice of mitigation measures.

## 4.1. Relationship between complexity and interdependency

A deeper exploration of complexity and interdependency highlights the structural factors shaping client-contractor interactions in construction projects. Baccarini (1996) defines project complexity as a system element that is a combination of differentiation and interdependency. Differentiation refers to the number of different elements within a project or system, such as stakeholders, technical components, and work processes. Interdependency describes the degree to which these elements interact and rely on one another, determining how risks propagate across the project lifecycle. The greater the interdependency, the higher the level of complexity, which in turn impacts risk exposure, decision-making processes, and project performance (Yin et al., 2020).

Baccarini (1996)'s theory is foundational in this research in understanding how projects evolve into complex systems. He argues that projects with high differentiation and high interdependency are inherently more difficult to manage due to the increased need for coordination, integration, and risk mitigation. This highlights why complex projects require more advanced governance models, as traditional management approaches may fail in highly interconnected environments. The continued use of Baccarini (1996)'s theory in contemporary studies confirms its ongoing relevance (Bosch-Rekveldt et al., 2011; Lafhaj et al., 2024; Mikkelsen, 2020).

Building on the theory of Baccarini (1996), Lafhaj et al. (2024) argues that interdependencies are not just a component of complexity but its primary driver. In construction projects, client–contractor relationships form a network of interactions that shape project outcomes. As these interdependencies increase, so does the overall complexity of the project, leading to higher levels of uncertainty in time, cost, and quality (Baccarini, 1996; Lafhaj et al., 2024). Figure 4.1 illustrates how Lafhaj et al. (2024) argues the intertwine of complexity and interdependency.

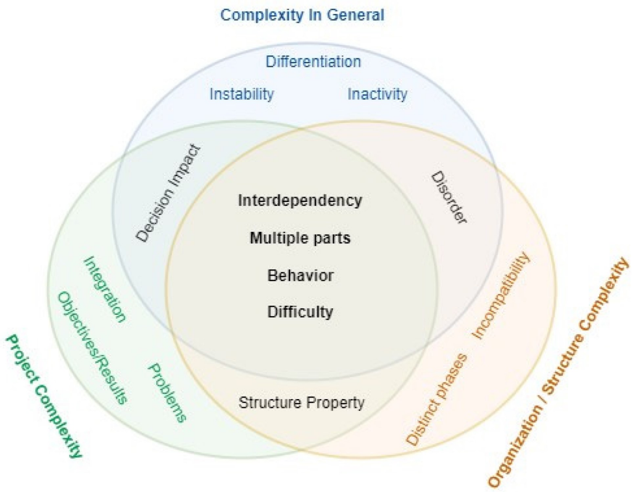


**Figure 4.1:** Keywords in project complexity (Lafhaj et al., 2024)

To make this more tangible, Lafhaj et al. (2024) identifies three critical interdependencies that impact project complexity and risks:

1. Decision-making: Collaborative decisions between clients and contractors about design modifications, scope adjustments, and approval processes are often loaded with uncertainty. Misalignments or delays in consensus increase inefficiencies and disrupt project timelines (Lafhaj et al., 2024; Olander, 2007).
2. Resource allocation: Shared access to resources such as funding, expertise, or knowledge, and materials creates bottlenecks when shortages or delays occur. These bottlenecks increase costs and increase risks associated with achieving project objectives (Lafhaj et al., 2024; Oppong et al., 2017).
3. Communication: Effective communication is essential for managing interdependencies. A subcategory in this is trust in the other party. Miscommunication or delays in information exchange exacerbate risks related to task coordination, compounding challenges and jeopardising project execution (Lafhaj et al., 2024; Müller & Turner, 2010; Oppong et al., 2017).

Although Lafhaj et al. (2024) highlights that interdependencies and complexity intertwine, it does not provide a structured categorisation of the components of the interdependencies. To systematically categorise complexity and analyse their influence on project dynamics, Bosch-Rekveldt et al. (2011) developed the TOE framework. This framework makes it possible to categorise complexity into three dimensions: technical, organisational and external. The entire TOE framework with all the complexity elements per dimension is shown in Appendix B.

**Table 4.1:** Subcategories of TOE

| Technical | Organizational | External |
|---|---|---|
| Goals | Size | Stakeholders |
| Scope | Resources | Location |
| Tasks | Project team | Market conditions |
| Experience | Trust | Risk |
| Risk | Risk | |

The subcategories of the TOE framework, as shown in Table 4.1, offer a structured approach to categorising the components of project complexity across technical, organisational and external domains. However, understanding complexity in projects requires more than systematic categorisation alone. As Mikkelsen (2020) emphasises, project complexity is not a purely objective characteristic, but is shaped by the perspective of the observer: *"project complexity exists in the eye of the beholder."* This suggests that the perceived cause of complexity may differ from how and where that complexity becomes visible in practice, its manifestation.

Building on this insight, the TOE framework can be used not only to classify the types of complexity present in a project, but also to distinguish between their underlying causes and observable effects. In other words, project complexity, as a system element, has both a cause and a point of manifestation. Identifying mismatches between how the cause and manifestation of complexity are categorised provides a valuable lens for uncovering the interdependencies that exist within the project system (Baccarini, 1996; Mikkelsen, 2020).

This dynamic becomes especially evident when considering the relationship between organisational and technical complexity. According to Lafhaj et al. (2024), complexity arises through interdependencies between system components. For example, organisational complexity, such as unclear coordination mechanisms or ineffective communication, can lead to misaligned goals among project stakeholders. The cause is categorised as organisational complexity, whereas the manifestation is technical complex. In such cases, organisational complexity (as the underlying cause) and technical complexity (as the manifestation) are not independent but mutually reinforcing: One cannot be fully understood or mitigated without addressing the other.

By analysing these events in a project, the relationships between different elements of complexity can be uncovered and situated within the Perrow classification matrix. Misaligned goals (technical complexity) increase the likelihood of complex interactions, while inadequate coordination mechanisms (organisational complexity) can indicate whether the system is loosely or tightly coupled. This enables a better understanding of the degree of interaction and the degree of coupling, facilitating a systematic classification of project complexity within Perrow (2011)'s matrix.

### 4.1.1. Managing interdependency

Although Baccarini (1996), Bosch-Rekveldt et al. (2011), Lafhaj et al. (2024), and Mikkelsen (2020) explain how project complexity can be structured and linked to interdependencies, they do not address how these interdependencies can escalate project risks. The Natural Accident Theory of (Perrow, 2011) provides complementary insights into the analysis of risks in complex systems, making it possible to connect project complexity, interdependency, and risk management structures. Perrow (2011) categorises systems based on interaction and coupling. These dimensions define how system components interact, how disruptions propagate, and the level of risk involved in managing such systems. Interaction refers to how predictable dependencies within a system are, while coupling describes the rigidity of interconnections between components and how flexible the system is in responding to disruptions (Perrow, 2011). Classifying events within Perrow's matrix requires a careful assessment of the specific characteristic (Coze, 2023). Table 4.2 shows the notion of coupling and interaction. The tight coupling is marked by the absence of buffers or redundancies, a fixed sequence of processes, and the direct impact of delays. Loose coupling, on the contrary, offers room for alternatives and delays, with sufficient buffers to minimise the consequences of disruptions. Linear interactions involve predictable dependencies and rely on direct information, following a straightforward sequence of actions. Complex interactions, however, are difficult to trace, involve hidden dependencies, and depend on indirect information, often requiring coordination between multiple interdependent systems. Explanations of the specific elements for each coupling and interaction are described in Appendix C.

**Table 4.2:** Perrow's notion of coupling and interaction (Coze, 2023)

| Coupling: loose or tight | Level of interaction: linear of complex |
|---|---|
| Delay in process (yes, no) | Spacing between components (much, none) |
| Invariance in sequence order (yes, no) | Production steps' location (distant, close) |
| Alternative method (yes, no) | Common mode of connections (unlikely, possible) |
| Level of slack in resources (low, high) | Possibility of isolation of failed components (yes, no) |
| Redundancies/Buffers (yes, no) | Personnel specialisation (low, high) |
| Substitution possibilities (yes, no) | Likelihood of unexpected feedback loops (low, high) |
| | Potential interactions in control parameters (low, high) |
| | Type of information sources (direct, indirect) |
| | Understanding of processes (full, partial) |

Linear systems exhibit clear cause-and-effect relationships, where interactions are direct, easily traceable, and operate according to a structured sequence. These systems rely on predictable dependencies, making disruptions easier to anticipate and control. Complex systems, on the other hand, involve non-linear interactions, hidden dependencies, and unpredictable feedback loops. In such systems, small disruptions can escalate disproportionately due to indirect access to critical information and high interdependency between components (Coze, 2023; Perrow, 2011). Inevitable uncertainty in complex systems requires adaptive management approaches, as structured mitigation measures may be insufficient to prevent cascading failures (Yin et al., 2020).

The degree of coupling further determines how strongly the system components rely on each other. Tightly coupled systems exhibit high interdependency between components, following a rigid sequence of processes with minimal flexibility. As shown in Table 4.2, these systems lack buffers and redundancies, which means that even minor delays or failures can rapidly escalate throughout the system. Because failures multiply rapidly, tightly coupled systems require real-time monitoring and rapid intervention, as their rigid structure leaves little room for alternative workflows or error correction (Coze, 2023).

In contrast, loosely coupled systems allow for delays, alternative pathways, and redundancies, making them more resilient to disruptions. Failures in loosely coupled systems tend to remain localised rather than spreading uncontrollably, since buffers and lack of resources ensure that disturbances can be effectively contained and managed (Coze, 2023; Perrow, 2011; PMI, 2021).

By assessing the complexity and coupling of the interaction, the systems can be classified to identify their risk exposure and required management strategies. Understanding these characteristics is necessary to determine whether preventive or corrective risk management strategies are necessary and what management structure should be applied. Figure 4.2 visualises the different quadrants of Perrow's theory.

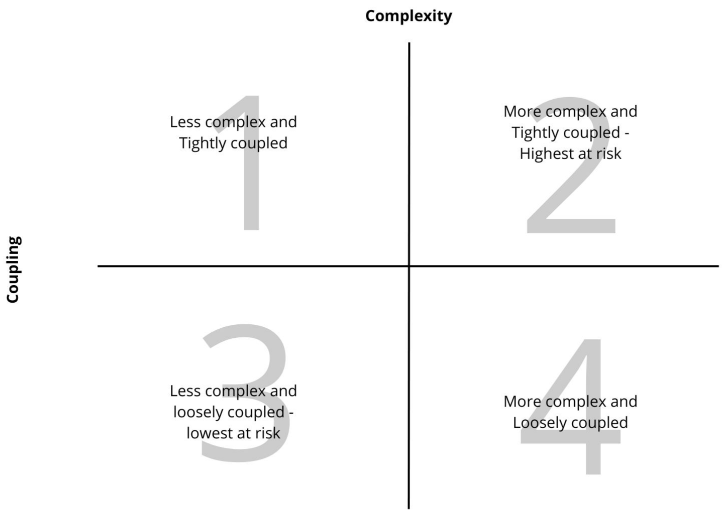


**Figure 4.2:** Four quadrants of Perrow's theory

The different quadrants of the matrix are further explained in Table 4.3, which includes a recommended management structure for each quadrant. In Appendix D the management structures are pictured in the matrix.

**Table 4.3:** Explanation of Perrow (2011) quadrants

| | Explanation | Recommended management structure |
|---|---|---|
| **1** | Tight coupled & linear interaction | Centralised |
| **2** | Tight coupled & complex interaction | Neither centralised or decentralised |
| **3** | Loose coupled & linear interaction | Centralised or decentralised |
| **4** | Loose coupled & complex interaction | Decentralised |

Table 4.3 highlights how different types of systems require different management structures to mitigate and manage the risk of interdependency. Centralised management is characterised by hierarchical decision making, standardised protocols, and strict regulatory compliance, ensuring uniform responses to disruptions (Coze, 2023; Perrow, 2011). This means that management is not based on collaboration and is done with one party. Decentralised management, on the other hand, promotes autonomy at the lower organisational levels, allowing adaptive responses to emerging risks (Perrow, 2011). This means that management is more collaborative and consists of involving multiple stakeholders. Quadrant 1 and Quadrant 3 benefit from centralised control, ensuring oversight and standardised responses to disruptions. Quadrant 4 requires decentralised management, allowing flexibility in handling unpredictable interactions. However, Quadrant 2 presents a fundamental governance paradox: tight coupling requires centralised control for immediate intervention, but complexity requires

decentralisation to adapt to emergent risks. Perrow (2011) argues that this contradiction makes tightly coupled complex systems inherently susceptible to failures that escalate beyond control. Hopkins (1999) strengthened this by stating that accidents in such systems are largely unavoidable because no management approach can fully mitigate their risks. Coze (2023) extends this by highlighting that global risks, such as financial crises, pandemics, and supply chain failures, exhibit similar contradictions, where interdependencies cause cascading failures faster than governance structures can react. Although redundancy, crisis teams, and adaptive strategies help mitigate risks, no governance model fully prevents systemic failures in such environments.

Understanding these management structures helps determine the best strategies for risk mitigation in various systems. By aligning governance approaches with the characteristics of each quadrant, organisations can better prepare for potential failures and disruptions.

### 4.1.2. Connection of theories

The integration of Baccarini (1996), Bosch-Rekveldt et al. (2011), and Perrow (2011) offers a comprehensive understanding of complexity and interdependency in construction projects. More importantly, it provides a structured approach to determining the most effective management structures for handling interdependencies.

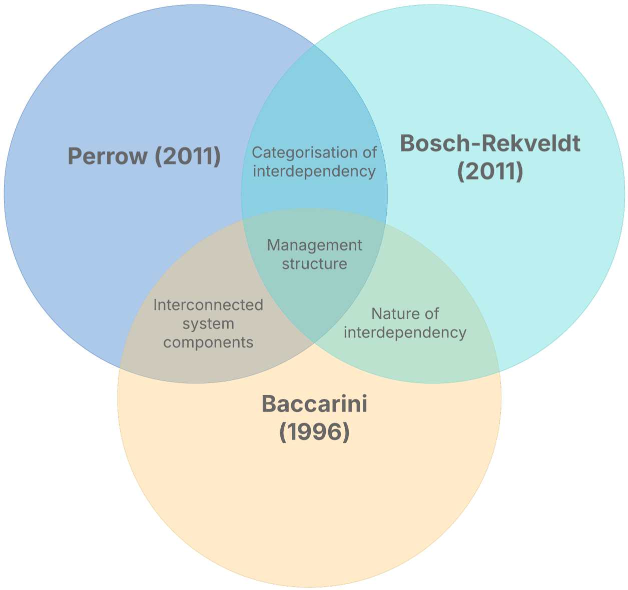


**Figure 4.3:** Overlap of theories

Figure 4.3 illustrates the connection between the three theories, highlighting their complementary perspectives on complexity and interdependency. Baccarini (1996) conceptualises complexity as the interplay between differentiation and interdependency. This view emphasises that complexity is not solely determined by the number of components but rather by the relationships between them. Bosch-Rekveldt et al. (2011) can be used to expand on this by categorising complexity into technical, organisational, and external dimensions. By the assumption that project complexity depends on the perception of the involved parties (Mikkelsen, 2020), the TOE framework can provide a structured way to distinguish the cause and manifestation of complexity. This classification reinforces the idea that complexity consists of multiple components, each influencing and interacting with others, creating interdependencies within a project system.

Although Baccarini (1996) and Bosch-Rekveldt et al. (2011) focus on how complexity is structured and categorised, they do not explicitly address how interdependencies contribute to risk mitigation and management structures. This is where Perrow (2011) provides a critical connection, interpreting interdependency as a factor determining the vulnerability of the system. Whereas Baccarini views interdependency as a structural characteristic of complexity that requires coordination, Perrow sees interdependency as a determinant of system risk, where tightly coupled systems are more susceptible to cascading failures. The connection between these perspectives is established through the recognition that complexity consists of both a cause and a manifestation, which may belong to different dimensions of the TOE framework. This integration allows for a more comprehensive understanding of complexity in construction projects, linking structural interdependencies to risk propagation and governance strategies.

This study adopts Baccarini (1996)'s definition of interdependency as a feature of complexity, but refines Perrow's framework by applying it beyond technical system failures to interdependencies in client-contractor relationships, governance and decision-making structures. The refinement allows us to use the matrix of Perrow (2011) as a classification tool to understand how the interdependencies between the client and the contractor influence risk and which management structure is recommended.

Through this integrated perspective, the study establishes a connection between complexity classification and risk-based governance decisions, reinforcing that understanding complexity alone is insufficient. It reinforces that understanding project complexity alone is insufficient. Management strategies should align with the nature of interdependencies present in the project to improve risk mitigation outcomes. By connecting project complexity to interdependency in the defined way, this section provides a foundation for the rest of the research and forms a bridge between the theoretical frameworks discussed earlier and their empirical application in later chapters.

## 4.2. Risk allocation

Proper risk allocation is a critical element in the management of construction projects, as it influences both the success of the project and the effectiveness of mitigation measures (Tembo-Silungwe & Khatleli, 2017). It involves systematically distributing risks between the client and the contractor to ensure that each risk is managed by the best-equipped party to handle it (Shrestha et al., 2019). When risks are appropriately allocated, disruptions can be minimised, disputes reduced, and mitigation strategies implemented more effectively (Hassan & Le, 2020). In contrast, poor risk allocation can result in increased costs, delays, and adversarial relationships, ultimately affecting project success (Tembo-Silungwe & Khatleli, 2017).

Recent research has shown that improper risk allocation stimulated opportunistic behaviour among contractors, further deteriorating project efficiency (Yin et al., 2020). When contractors perceive that they are unfairly loaded with risks, they can engage in strong or weak opportunistic behaviours, such as withholding information, manipulating contract terms, or reducing performance to protect their financial position (Yin et al., 2020). This behaviour introduces new challenges for risk governance, reinforcing the importance of balanced risk-sharing mechanisms that do not overly disadvantage one party. The study also found that while formal control mechanisms reduce strong opportunism, they do not prevent subtle risk-exploiting behaviours, highlighting the need for trust-based governance structures (Yin et al., 2020).

### 4.2.1. Contract types and their influence on interdependency

Risk allocation is greatly influenced by the procurement method used in a construction project, which determines how responsibilities and risks are shared between the client and the contractor (Khalef et al., 2020). The two primary procurement models, Design-Bid-Build (DBB) and Design-Build (DB), structure risk allocation differently, leading to distinct interdependencies that impact contractor risk exposure. Both structures are visualised in Appendix E.

In DBB contracts, the design and construction phases are contractually separated, which means that the client retains responsibility for design-related risks, including errors, omissions, and regulatory compliance (Al-Enezi & Sabah, 2023; de Ridder, 2009; Tsai & Yang, 2010). The contractor, in turn, is responsible for the risks of construction, but has little influence on design decisions, which can lead to technical complexity. This often results in inefficiencies, as design-related risks are identified only after construction begins, requiring adjustments that increase costs and delays (de Ridder, 2009). In addition, organisational complexity arises due to fragmented communication between the design team and the contractor, making coordination more difficult (de Ridder, 2009). Poor risk allocation in DBB contracts can exacerbate contractors' opportunistic behaviour if they feel that their financial position is threatened by unexpected design flaws (Yin et al., 2020).

In DB contracts, a single entity is responsible for both design and construction, which integrates risk management and reduces interdependencies (Al-Enezi & Sabah, 2023; de Ridder, 2009; Tsai & Yang, 2010). Since the contractor controls both processes, design and constructability risks are managed together, allowing greater flexibility and real-time decision making. However, DB contracts also create new interdependencies, particularly with regulatory approvals, which often remain the client's responsibility (de Ridder, 2009). Delays in securing these approvals can disrupt the contractor's schedule, demonstrating that while DB contracts reduce internal project interdependencies, they increase reliance on external regulatory processes (Al-Enezi & Sabah, 2023). The study by Yin et al. (2020) supports this by showing that risk exposure in DB contracts is less likely to trigger opportunistic behaviour when risk allocation is perceived as fair. However, in cases where clients impose excessive risk burdens, trust worsens and the contractor's willingness to proactively manage risks reduces.

In summary, DBB contracts create rigid interdependencies due to the separation of design and construction, while DB contracts integrate risk management but increase the contractor's responsibility for design-related uncertainties (de Ridder, 2009). Furthermore, the findings of Yin et al. (2020) suggest that trust-building mechanisms are crucial for mitigating opportunistic responses to risk allocation, regardless of the type of contract.

Therefore, project governance should not rely solely on formal control, but should also incorporate trust-based collaboration to prevent risk-exacerbating behaviours.

### 4.2.2. The impact of early contractor involvement

Regardless of the type of contract, Early Contractor Involvement (ECI) plays a critical role in mitigating risk-inducing interdependencies by integrating the contractor earlier in the project lifecycle. By involving contractors at an earlier stage, projects benefit from improved risk identification, streamlined coordination, and improved alignment between design, execution, and regulatory approvals (Wondimu et al., 2020). This proactive approach contrasts with traditional risk allocation methods, where contractors assume responsibility for risks only after the design phase is completed, often leading to inefficiencies and reactive problem solving (Mosey, 2009).

One of the key advantages of ECI is its ability to reduce technical interdependencies between design and construction. When contractors participate early in the process, they can assess the feasibility of design elements before construction begins, identifying potential challenges to constructability that may otherwise go unnoticed until later stages (Mosey, 2009). By addressing these issues in the design phase, the likelihood of costly rework and late-stage modifications is minimised, improving overall project efficiency. This approach ensures that risk allocation is better aligned with practical execution realities, rather than dictated solely by contractual structures (M. Rahman & Alhassan, 2012).

ECI also significantly improves organisational interdependencies by fostering closer collaboration between clients, designers, and contractors. Traditional procurement models often create fragmented communication channels, leading to coordination challenges and delays in decision making. When contractors are involved early, they work alongside the client and design team to develop risk sharing strategies that align with the project goals, ensuring that responsibilities are assigned to the party best equipped to manage them (Mosey, 2009). This integrated approach improves decision-making efficiency, allowing risks to be proactively managed rather than resolved through contractual disputes or late-stage negotiations.

Beyond internal coordination, ECI contributes to reducing external interdependencies, particularly in relation to permitting and regulatory approvals. In conventional procurement methods, regulatory challenges often arise once construction is already underway, causing unexpected delays. However, when contractors engage in early stage discussions, they can identify potential regulatory risks before they become critical issues, allowing the client to obtain the necessary approvals in a manner that aligns with the construction timeline (M. Rahman & Alhassan, 2012). This forward thinking approach ensures that legal and compliance-related risks are addressed as part of the project planning phase, rather than being treated as obstacles that must be managed reactively.

Although ECI is naturally embedded in Design-Build (DB) contracts, where the contractor is responsible for both design and execution, its implementation in Design-Bid-Build (DBB) contracts requires explicit structuring. In DBB projects, ECI can be facilitated through early-stage consulting agreements, where contractors provide constructability input during the design phase before formal contract execution. This arrangement helps bridge the gap between design and construction, ensuring that design decisions are made with practical execution in mind (M. Rahman & Alhassan, 2012).

Ultimately, ECI strengthens risk allocation by shifting risk management from reactive problem solving to proactive mitigation. By engaging contractors at an early stage, project teams can identify risks before they escalate, establish clear coordination mechanisms, and create a structured approach to managing technical, organisational, and external interdependencies. This collaborative process ensures that risk allocation is based on experience and real-world execution needs, rather than rigid contractual definitions, ultimately improving project efficiency and reducing the likelihood of disruptions (M. Rahman & Alhassan, 2012).

## 4.3. Studies on adapting preventive mitigation measures in construction projects

From previous research, it is clear that preventive mitigation measures have a profound impact on the cost and time effectiveness of construction projects. Studies suggest that preventive approaches, when applied early, can reduce project delays, enhance cost control, and improve overall project outcomes. This section reviews key studies exploring preventive strategies and their implications for project success, with a particular focus on how these strategies can be integrated into construction risk management.

The study by Olawale and Sun (2010) explored the inhibiting factors that affect cost and time management in UK construction projects, identifying common obstacles such as design changes, project uncertainties and subcontractor performance issues. Their research classified 90 mitigation strategies into four types: preventive, predictive, corrective, and organisational.

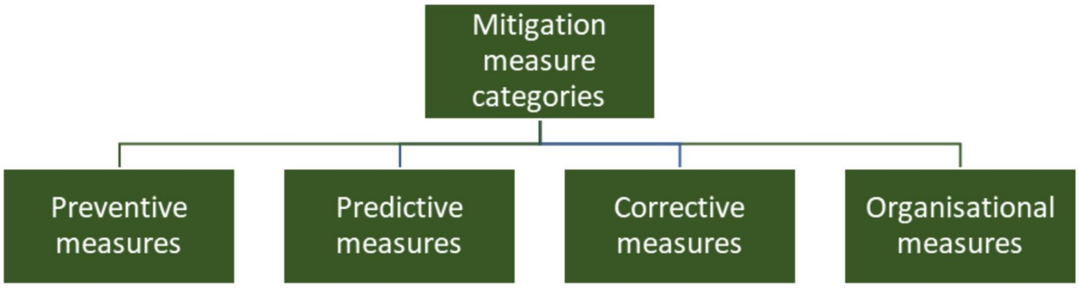


**Figure 4.4:** Types of mitigation measures by Olawale and Sun (2010)

In particular, preventive measures, which included accurate initial assessments, stakeholder alignment, and proactive planning, emerged as the most effective in minimising cost overruns and delays. This early intervention approach highlights the importance of addressing risks early to avoid costly adjustments later in the project lifecycle.

Building on the concept of proactive risk management, Asiedu et al. (2017) introduced a framework, categorising strategies into preventive, predictive, and corrective actions. Asiedu et al. (2017) identified that preventive measures, such as detailed early stage planning, comprehensive stakeholder engagement, and establishing emergency budgets, significantly reduced project disruptions and improved adherence to timelines. The study highlights that sharing risk responsibilities and ownership among all stakeholders, including clients, contractors, and regulatory bodies, was needed to identifying risks early. This collaborative approach supports the integration of preventive measures in all stages of the project, fostering an environment where potential challenges are addressed proactively. A summary of mitigation measures by role and approach of Asiedu et al. (2017) is shown in Table 4.4.

**Table 4.4:** Summary of mitigation measures by role and approach

| **Responsible Party** | **Total Measures** | **Preventive Measures (%)** | **Predictive Measures (%)** | **Corrective Measures (%)** |
|---|---|---|---|---|
| Client | 50 | 25 (50%) | 15 (30%) | 10 (20%) |
| Contractor | 30 | 15 (50%) | 10 (33.3%) | 5 (16.7%) |
| Consultant | 34 | 15 (44.1%) | 9 (26.5%) | 10 (29.4%) |
| All Parties | 10 | 4 (40%) | 3 (30%) | 3 (30%) |
| Shared Parties | 12 | 5 (41.7%) | 4 (33.3%) | 3 (25%) |

The reviewed studies consistently underscore the value of preventive mitigation measures in managing costs and time effectively within construction projects. Early risk assessments, proactive stakeholder engagement, and continuous monitoring of high-risk areas contribute to a more resilient project framework. By embedding preventive approaches early in the project and fostering collaboration among all stakeholders, construction projects can achieve reduced delays, controlled costs, and enhanced adaptability to unforeseen risks. Studies suggest that preventive measures offer a solid foundation for successful project risk management and thus could be labelled as effective.

## 4.4. Conclusion

This chapter explored how the relationship between the client and the contractor influences risk mitigation strategies in managing complexity and interdependency in construction projects. It answers the sub-question:

**How can interdependencies in client-contractor relationships be identified and analysed using complexity elements based on theoretical insights?**

The findings indicate that interdependencies in client-contractor relationships can be systematically identified by categorising project complexity using the TOE framework of Bosch-Rekveldt et al. (2011). Rather than directly defining interdependencies, the TOE framework provides a structured way to classify technical, organisational, and external complexities, allowing for a systematic assessment of how interdependencies manifest within a project. Technical complexity arises from project scope, task coordination, and constructibility, influencing execution feasibility and requiring strong coordination between stakeholders to prevent inefficiencies. Organisational complexity relates to decision-making structures, resource distribution, and trust between parties, where responsibilities and communication flows directly affect the effectiveness of risk management. The complexity of the environment arises from external regulations, market conditions, and stakeholder influences, introducing uncertainties that require proactive mitigation strategies.

To further analyse the interdependencies, the matrix of Perrow (2011) provides a method to assess their level of complexity and degree of coupling. Linear and predictable interactions can be managed through clear procedures and well-defined contracts, while complex and unpredictable interdependencies require adaptive risk management approaches. Tightly coupled systems, where failures propagate rapidly, require strong coordination and centralised control, whereas loosely coupled systems allow for greater flexibility, making decentralised decision-making a more effective approach. By combining Perrow's matrix with the TOE framework, complexity elements can be systematically categorised, offering a structured method to understand how interdependencies shape project risks and governance strategies. While the TOE framework categorises complexity, Perrow's matrix helps determine whether risk mitigation requires centralised or decentralised management structures. The way in which the theoretical flow can be applied to empirical data is visualised in Figure 4.5.


**Figure 4.5:** Theoretical flow

The literature suggests that risk mitigation depends on the alignment between interdependency characteristics and governance structures. Tightly coupled, complex projects benefit from centralised management and preventive strategies, while loosely coupled projects are better suited to decentralised management with corrective strategies. In linear systems, centralised control remains effective, with preventive measures applied in tightly coupled environments and corrective strategies in loosely coupled ones.

The empirical phase of this research builds directly on the theoretical insights presented in this chapter, using the TOE framework, Perrow's matrix, and governance structures as structuring tools to analyse complexity and interdependencies in real-world client-contractor relationships. The empirical phase of this research does not merely evaluate theoretical frameworks, but uses them as analytical tools to interpret real-world risk management approaches. The governance structures discussed in the literature, centralised versus decentralised, serve as a reference for assessing how risk mitigation strategies are implemented in response to interdependencies.

Building on these theoretical insights, in empirical analysis, this framework can be applied to real-world construction cases. It investigates how interdependencies manifest in practice, how they are managed by clients and contractors, and to what extent the theoretical models align with or deviate from practical realities.

# 5
# Interdependency analysis and management: The contractor perspective

This chapter presents the findings of the analysis of cash flow patterns, event identification, interdependency categorisation, and applied management structure from a contractor perspective. It demonstrates how these insights provide a structured approach to understanding the interplay between complexity and risk.

Firstly, the methodology used to identify and analyse significant project events is detailed in Section 5.1, including the case selection criteria, event identification, and semi-structured interviews. In Section 5.2 notable events from the cases are highlighted and described. In Section 5.3, the events are evaluated through a project manager interview and the progress reports, providing contextual depth and practical insights. Lastly, Section 5.4 concludes the findings from the contractor's point of view on the identified events. These findings form the basis for recommendations on improving risk management processes within construction projects.

## 5.1. Research approach for understanding client-contractor interdependencies

An exploratory approach has been adopted to investigate current practices to manage and understand the relationship between client-contractor dynamics and risk mitigation strategies in construction projects. To collect relevant data, semi-structured interviews and cross-case analyses of two projects are conducted. These methods facilitate a detailed exploration of decision-making processes and the effectiveness of mitigation measures in real-world scenarios. The selection of two projects is based on practical considerations such as time constraints and data availability, combined with the analytical focus on three selected events per project that serve as the primary empirical input, rather than an assessment of the projects in their entirety. Figure 5.1 visualises the research approach and flow between the different topics.

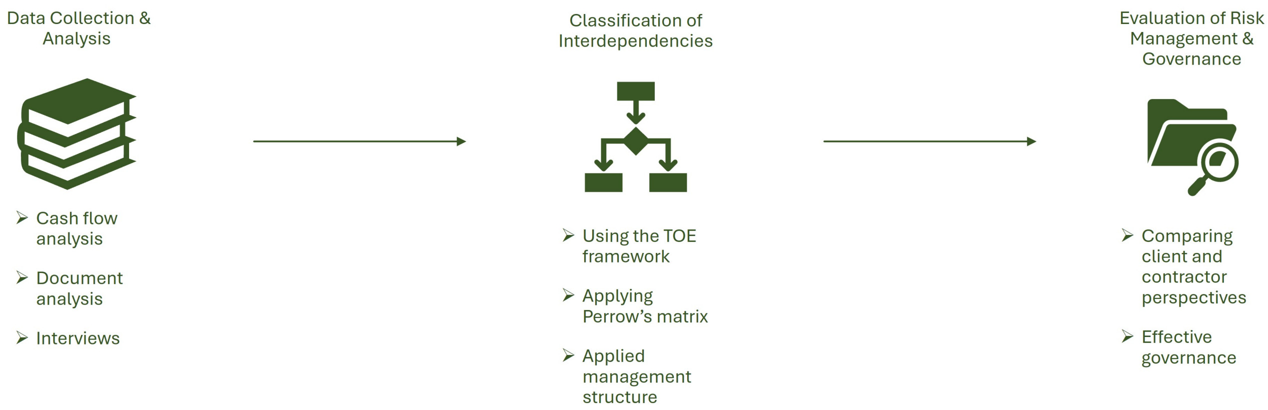


**Figure 5.1:** Research approach

### 5.1.1. Selection of case studies and identification of key events

The selection of cases for this research was guided by the need to ensure the relevance, comparability, contract form of DB and the availability of high-quality data. Two completed construction projects were chosen based on their ability to provide a foundation for analysing the relationship between complexity elements, interdependencies, and management structure. These cases stand out for their documented data, the possibility of viewing this documentation, and clearly defined client-contractor dynamics, allowing a detailed examination of the underlying risk management processes. Additionally, selecting completed projects where the ”dust has settled” allows for a more objective post-project analysis, as the outcomes and impacts of decisions have become fully evident, and the project managers are willing to talk about what went well and what did not.

A critical element of this research is the identification of key project events through cash flow analyses. Within construction companies, cash flow serves as the only formal and universally recognised indicator to track project progress. By examining cash flow patterns, significant moments such as peaks or troughs are pinpointed and analysed. These events represent critical junctures where project dynamics shifted, offering potential insight into the interaction between client and contractor. Only events that exhibit a clear relationship to the client-contractor dynamic are included in the study, ensuring that the analysis remains focused on interdependencies and risk management directly tied to these relationships.

### 5.1.2. Cash flow analysis as a tool for event identification

The analysis of cash flow patterns forms a critical component of this research, providing insights into the financial dynamics of the project that allows highlighting significant events that reveal client-contractor interactions. To achieve this, tender cash flow and realisation cash flow were calculated and compared, allowing deviations to be identified and interpreted within the context of project complexity and interdependencies.

The tender cash flow represents the anticipated financial schedule established during the tender phase, based on project budgets, milestones, requirements, and contractual agreements. This cash flow was obtained directly from the project documentation, where milestone payments and expected expenditures were described. The tender cash flow for each period was calculated using the formula:

$$TCF_t = \sum_{i=1}^{n} M_i \tag{5.1}$$

**Where:**

- $TCF_t$: Tender cash flow for period $t$,
- $M_i$: Milestone payment $i$ expected during period $t$,
- $n$: Total number of milestone payments within period $t$.

In contrast, the realisation cash flow reflects the actual financial movements during the project. Unlike tender cash flow, realisation cash flow was calculated directly based on data extracted from an online project management environment. This environment provided detailed financial records, including revenue, expenditures, receivables, and payables. The general formula for realization cash flow is as follows:

$$RCF_t = \sum_{i=1}^{m} R_i - \sum_{j=1}^{n} E_j \tag{5.2}$$

**Where:**

- $RCF_t$: Realization cash flow for period $t$
- $R_i$: Revenue inflow $i$ during period $t$
- $E_j$: Expenditure outflow $j$ during period $t$
- $m$: Total number of revenue inflows during period $t$
- $n$: Total number of expenditure outflows during period $t$

In the cases analysed, this was translated into different topics. The RCF formula can therefore be rewritten. To operationalize this calculation in the project environment, the following detailed formula was applied within an Excel-based model to generate cash flow comparison graphs:

$$RCF_t = \sum OW_t - \sum GoFo_t - \sum C_t + \sum D_t \tag{5.3}$$

**Where:**

- $OW_t$: Total amount of work performed but not yet billed during period $t$
- $GoFo_t$:Goods already present but not yet billed during period $t$
- $C_t$: Total amount of outstanding payables during period $t$
- $D_t$: Total amount of outstanding receivables during period $t$

The deviations between the tender and realization cash flows could calculated using the following formula:

$$D_t = TCF_t - RCF_t \tag{5.4}$$

**Where:**

- $D_t$: Deviation between tender and realization cash flows for period $t$,
- $TCF_t$: Tender cash flow for period $t$,
- $RCF_t$: Realisation cash flow for period $t$.

To evaluate the analysis, the calculated cash flows and deviations were cross-verified with financial reports and project documentation. Cash flow trends were visualised as time series graphs, with tender and realisation cash flows plotted alongside their deviations to highlight significant events. These visualisations served as a basis for identifying potential events, linking financial fluctuations to project documentation, providing deeper insights into client-contractor dynamics and critical moments within the project.

This combined approach of retrieving tender cash flows from documentation and calculating realisation cash flows from detailed project records ensures a comprehensive understanding of financial performance. It forms the formal line for analysing what happened in the project. Based on what happened in the projects, interdependency and complexity can be indicated.

### 5.1.3. Semi-Structured interviews for practical understanding of events

Semi-structured interviews are a qualitative research method that combines the flexibility of unstructured interviews with the consistency of structured ones. This format allows for in-depth exploration of participants' experiences while maintaining a focus on specific research topics. The flexibility inherent in semi-structured interviews enables interviewers to delve deeper into emerging themes, providing rich, detailed data that may not surface through more rigid interview structures (George, 2023). The interviews were conducted with four project managers, representing both the client and the contractor sides of the two selected construction projects. This selection ensured that each project was approached from both stakeholder perspectives, allowing for a balanced and comparative analysis of how interdependencies were perceived and managed. Interviewing project managers from both organisations allowed the research to identify discrepancies in interdependency classification, governance preferences, and risk mitigation approaches. An overview of the interviewees is provided in Table 5.1.

**Table 5.1:** Interview participants

| Interviewee | Function | Case |
|---|---|---|
| **1** | Project manager of contactor | Case 1 |
| **2** | First execution manager, later project manager of contractor | Case 2 |
| **3** | Project manager of client | Case 1 |
| **4** | Project manager of client | Case 2 |

In the context of this study, the interviews are explicitly designed around key project events identified from the cash flow analyses. By focussing on these events, characterised by significant peaks or troughs in cash flow and documentation, the interviews aim to uncover the underlying factors driving these financial changes. This approach allows participants to articulate their experiences and reasons in their own words, providing insight into the interdependency between client-contractor and the reasoning of various risk management strategies. Moreover, the adaptability of semi-structured interviews is particularly advantageous in construction research, where project dynamics can vary significantly (George, 2023).

The semi-structured interviews are directly linked to the identified events of the case studies, which are evaluated through a survey. This allows project managers of the cases to reflect on the specific circumstances and decisions associated with them. The interview questions are listed in Appendix F. This targeted approach ensures that the interviews are contextually grounded, enabling participants to provide detailed insights into the relationships between complexity, interdependencies, and risk management.

By focussing interviews on key project events and using the frameworks to structure the analysis, this research offers a robust methodological framework. The combination of financial analysis, event-based categorisation, and qualitative interviews ensures a comprehensive understanding of the interaction between complexity elements, interdependencies, and management structures. This approach not only bridges the gap between theory and practice, but also provides actionable insights to improve risk management strategies in construction projects.

## 5.2. Identification of events through cash flow analysis

This section analyses two cases in their cash flow. The cash flow is not analysed as a financial performance indicator, but rather as a tool to detect significant fluctuations. When notable changes in cash flow occur, they serve as an indication of possible events that have influenced the project's progress. Identification of these events ensures that these moments are analysed in the progress reports to understand the event and interplay between client and contractor.

### 5.2.1. Case study 1 - Tramway conversion

The graph in Figure 5.2 provides an overview of the project cash flow throughout its lifecycle. Peaks and troughs in the cash flow highlight key moments of financial activity that correspond to significant events and decisions within the project. Of all these events, events with clear client-contractor relationship are subtracted based on project documentation.

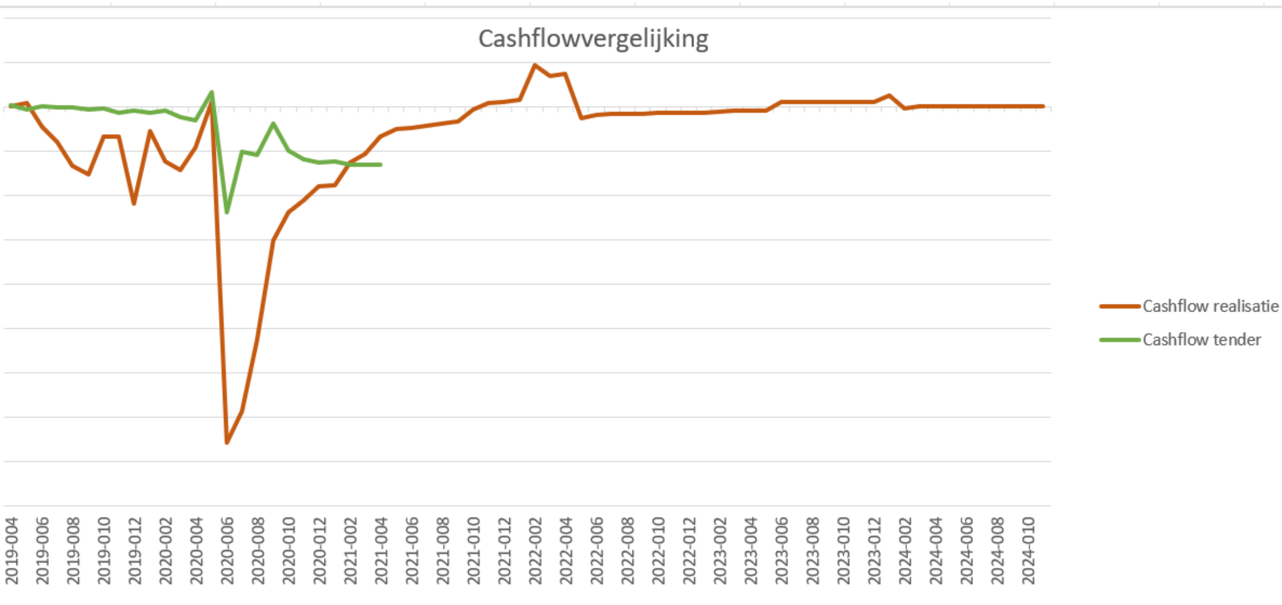


**Figure 5.2:** Cash flow visualisation of case 1

From the graph, the following events can be extracted and analysed on the basis of the progress reports of the contractor:

1. 009-2019 and 010-2019 (voortgangsrapportage-p10, 2019)
   In October 2019, significant challenges arose due to unclear assumptions and errors in the alignment[1] of the client's reference design, which affected the project timeline and coordination. The alignment, which was yet to be finalised in the reference design by the client, could not be incorporated into the final design. This delay stemmed from permitting complexities, particularly related to political and regulatory approvals. Furthermore, investigations into existing conditions began late due to permitting backlog, potentially requiring mid-project design adjustments. However, these mid-project adjustments were considered to have a limited impact as they did not lie on the critical path. In addition, there were interdependencies in achieving an agreement between the client and the contractor on the construction of the station tracks, which required formal approval.
2. 011-2019 and 012-2019 (voortgangsrapportage-p11 & p12, 2019)
   During this period, several critical issue dossiers were identified within the project, with the client acknowledging responsibility for their causes. These dossiers are related to technical and organisational challenges and have direct implications for both the schedule and coordination between the parties.

   One significant dossier concerns the incomplete and wrong alignment. This issue resulted in rework, part of which is being incorporated into the final design. Although the time impact of this issue has been absorbed into the project schedule, it has incurred considerable costs. To address these costs, a contractual specialist from the contractor has been appointed. In addition, the design claim of Arcadis is being reviewed, adding further complexity to the dossier.

   The second issue involves coordination with subcontractors. Coordination agreements have yet to be finalised, leaving the client effectively responsible for coordination, while the contractor only facilitates this without bearing formal responsibility. This lack of formal agreements creates uncertainty about the timely delivery of the information required for the integrated design.

   The stability of the trackbed turned out to be the most critical concern of this event. A second opinion from RHDHV, the client's consultant, confirmed the existence of a significant problem, although the exact scope and implications remain under discussion.

   Finally, RHDHV conducted a new exploratory study on the load-bearing capacity of four structures. This study is crucial to determine the next steps in the project. These issue dossiers highlight the interdependencies between the client and the contractor and emphasise the need for clear coordination, shared responsibility, and timely decision making to mitigate further risks and delays.
3. 003-2020 (voortgangsrapportage-p03, 2020)
   The outbreak of COVID-19 significantly disrupted the workflows of the project. Permitting processes, already identified as a weak point, were further delayed due to structural inefficiencies. Furthermore, late delivery of security designs impeded the implementation of key project activities. Communication breakdowns within the project team exacerbated these delays, highlighting the importance of organisational coordination.

   This event underscored the interdependence of the project with external factors, such as permitting, as well as internal organisational interdependencies, such as resource allocation and team coordination. Despite mitigation efforts, including restructuring team responsibilities, delays had a cascading effect on subsequent project activities.
4. 006-2020 (voortgangsrapportage-p5, 2020)
   By mid-2020, unresolved permitting issues led to extended project delays. A critical interdependency was identified: the permitting process was managed by a single individual, creating a bottleneck that significantly slowed progress. This interdependency with a limited resource not only delayed critical approvals but also introduced additional risks to the project schedule.

   This event highlighted the interplay between organizational and external interdependencies. The lack of alternatives in the permitting process and the high reliance on a single resource reflected the tight coupling in this aspect of the project. Efforts to address this interdependency included reassigning responsibilities, although the impact of the delays remained significant.

The cash flow graph provides a visual representation of the project's financial trends and supports the identification of critical moments where interdependencies influenced project dynamics. The rest of the critical moments

[1] Alignment refers to the geometric layout and positioning of linear infrastructure, such as railways or roads, in both horizontal and vertical dimensions to ensure functionality, safety, and efficiency (Pu et al., 2023).

are neglected because these moments are not clearly about client-contractor interdependency. By integrating these insights with qualitative data from further project documentation and interviews, this analysis deepens the understanding of the interaction between the client and the contractor and the mitigation that was performed.

### 5.2.2. Case study 2 - Train station conversion

The graph in Figure 5.3 provides an overview of the project cash flow throughout its lifecycle. Peaks and troughs in the cash flow highlight key moments of financial activity that correspond to significant events and decisions within the project. Out of all these events, events with clear client-contractor relationship are subtracted based on project documentations. These moments serve as a basis for identifying interdependencies and analysing their implications.

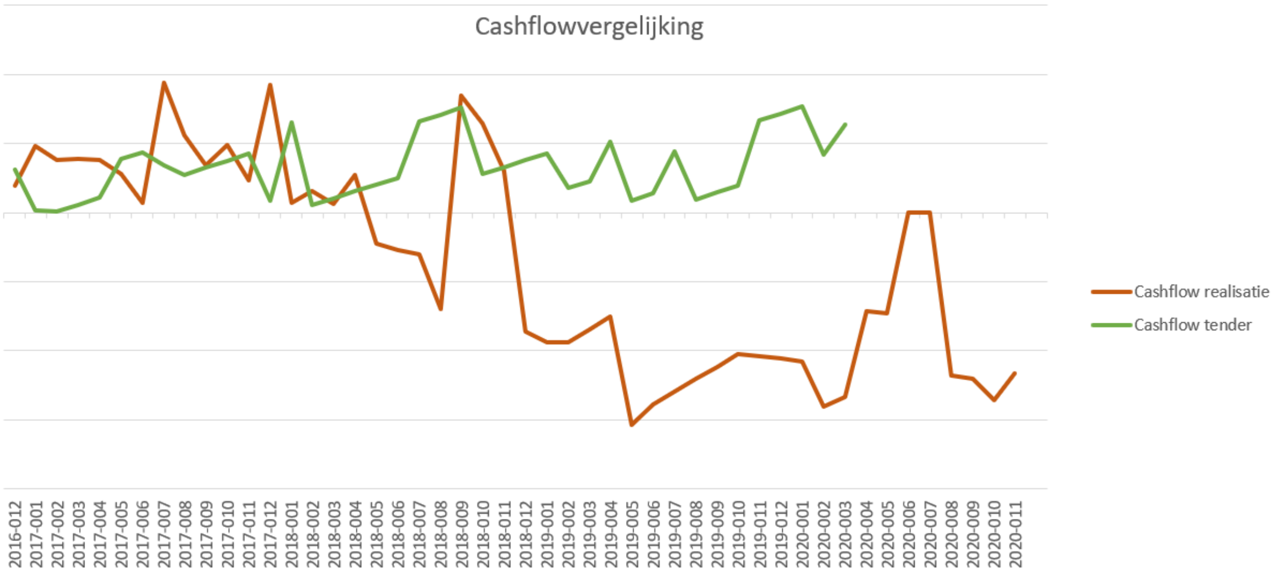


**Figure 5.3:** Cash flow visualisation of case 2

Figure 5.3 gives insight into the financial flows of the project. The first point to note is the negative cash flow in the end. This is because the project made a loss. Out of all the peaks and troughs in the graph, events with a clear client-contractor relationship are subtracted based on the project documentation. These moments serve as a basis for identifying interdependencies and analysing their implications.

From the visualisation of the cash flow in Figure 5.3, the following events are subtracted:

1. 007-2017
   Little information is known about this event. Documentation is limited and there was minimal interdependency between client and contractor subtracted from the documents. However, the available documentation indicates that the client considers time to be a key criterion from a contractor's perspective. The contractor has responded to this by making decisions based on the tight schedule.
2. 012-2017 (voortgangsrapportage 6, 2017)
   In December 2017, important decisions were made regarding the design and construction of the platform roof (perronkap), marking a critical moment in the project. The platform roof had been a significant point of discussion, requiring clear choices from the client to finalise the design and ensure further progress. These decisions were needed to address the interdependencies between technical and organisational complexity that had previously caused delays.

   During this period, several collaborative initiatives were undertaken to facilitate decision-making and improve the design process. By starting technical meetings again, a structured platform was created to resolve design-related issues. This step significantly improved communication between the parties involved and accelerated the clarification of design principles. In addition, a detailed review of the design issue list was conducted in collaboration with the client. This review helped clarify the outstanding points and ensured alignment with the project's technical requirements.

   In addition, final decisions were made regarding the design of the platform roof, while additional discussions with the client addressed optimisations and architectural preferences. To further enhance collaboration, a Performance under Fire (PfU) session was held, involving key project stakeholders. This session was highly valued by all participants and contributed to better coordination and teamwork.

These joint efforts aimed to streamline the decision-making process and advance progress in relevant design elements, establishing a solid foundation for the further execution of the project.

3. 005-2018 (kwartaalrapportage Q2, 2018) (voortgangsverslag 20, 2018)
The collaboration between client and contractor was characterised as positive during this period. Regular discussions were held, which encouraged open communication and alignment between the parties. For example, the client expressed a preference for an integrated tolerance analysis that involves multiple disciplines and subcontractors, including civil works, railway systems, and platforms. This request underscores the client's focus on ensuring precision and coordination throughout the project.

However, some challenges emerged during this period. One notable issue concerned the restoration of the platform roof. Although the client agreed with the direct costs associated with the subcontractor, there was ambiguity in the interpretation of certain agreements. This lack of clarity highlighted the importance of effective communication and shared understanding between the parties. In addition, the client sought decisions on a project detour and asked the contractor to conduct an investigation into the maximum allowable ballast thickness for certain structural layers.

Tensions also arise in the execution of civil works, which appeared to be behind schedule. These delays introduced pressure, prompting both parties to re-evaluate priorities. In one instance, the contractor indicated in a preliminary meeting and progress report that it no longer intended to use the TVP reservation for week 39 of 2019. Although the client initially questioned this early cancellation, the parties concluded that the TVP added no value relative to other planned track possessions and agreed to its cancellation. This decision reflected a level of trust between the parties, but also underscored the importance of aligning short-term and long-term project needs.

A financial dispute also arose regarding the costs of standby teams after major outages. These costs were proposed to be allocated to the client via a Change Request (VTW), which the client did not approve. The contractor was tasked with assessing the necessity of these standby teams, particularly in relation to turnaround orders (TAO) and potential penalties.

This event illustrates the dynamic interaction between technical, financial, and organisational complexity. The documentation seems to show a strong focus on time by the client, and certain decisions and disputes revealed underlying challenges in coordination and risk-sharing. The emphasis on a tight schedule required both parties to act decisively and collaboratively, ensuring that project milestones could be achieved while navigating the complexities in cost allocation, civil work progress, and tolerance analysis. This period highlights the role of trust and proactive communication in managing interdependencies and maintaining project momentum.

4. 009-2018 (voortgangsverslag 22, 2018)
During this period, the project faced challenges related to the coordination and resolution of open design issues. From the documentation, it became clear that there was a mutual desire from both the client and the contractor to dedicate a week to finalising outstanding issues, including open design notes and pending approvals. However, this ambition was viewed as overly optimistic given the ongoing constraints and the project timeline.

The phasing steps for the project were also discussed, with the decision to submit these to the client for formal acceptance. This step aimed to ensure alignment and approval on key project milestones, mitigating potential delays.

Regarding the monumental platform roof, the required permits were submitted, marking progress in addressing previous interdependencies. Despite this advancement, technical discussions, typically held to resolve design-related issues, had not been conducted due to overlapping factors, including the holiday season and the scheduling of TVP 220. Recognising this gap, the contractor expressed a preference to address the remaining open issues during the "Werkoverleg/uitvoering" meetings. These meetings were held weekly on Tuesday mornings, except on Tuesdays reserved for progress meetings.

This event highlights the challenges of maintaining consistent coordination during the critical phases of the project. Although progress was made in submitting permits and aligning the phasing steps with the client, the absence of regular technical discussions created a backlog of unresolved issues. By proposing the use of existing weekly meetings to address these issues, the contractor aimed to streamline decision-making and ensure that the project remained on track. This period underscores the importance of proactive communication and flexibility in adapting coordination structures to overcome scheduling constraints.

5. 011-2018 (voortgangsverslag 25, 2018) (kwartaalrapportage Q4, 2018)
During this period, the project made progress and faced challenges related to team organisation, risk

management, and scheduling adjustments. The evaluation of TVP 220 was highly successful and the client expressed satisfaction with the results. However, concerns were raised about the reduction of project staff. Although the team was reported to be balanced and performing well, the client highlighted the importance of properly distributing the remaining workload to ensure continuity, particularly as the client's team maintained its required capacity.

At the same time, the client expressed concerns about the possible risks associated with ongoing changes and the perceived weakening of the contractor's project organisation. This was particularly evident in the discussions around the UO (Uitvoeringsontwerp) for fencing at the Hertenkamp. The contractor planned to begin work on the fencing in early 2019 and had already ordered materials, even though the UO had not yet been approved by the client. An evaluation meeting was scheduled for 8 January to address these outstanding issues. The client viewed this preemptive action as a risk assumed by the contractor, especially since details, such as the placement of the gate near the Hertenkamp, still required coordination with key stakeholders.

Another key development involved the rescheduling of the TVP from December to February, after discussions between the client and the contractor. This change introduced concerns about possible freezing conditions in February, which could disrupt work. The client assigned this risk to the contractor and requested an internal review to determine how this should be managed before reporting to the client.

### 5.2.3. Selection of key events and survey design

From the events in Section 5.2, three events per project were included in the survey and the interviews. These events were chosen based on their representation of relevant dependencies between the client and the contractor, their alignment with specific project values (time, cost, quality), and their significance in progress reports. In addition, the events highlight the challenges in managing these interdependencies, making them ideal for deeper analysis. The selected events of project 1 are:

1. 009-2019 Lack of clarity regarding the alignment
2. 011-2019 Track stability issue
3. 006-2020 Permitting bottlenecks

From the second project, the following three events were extracted:

1. 012-2017 Platform roof design changes
2. 005-2018 Delayed delivery of railway switches
3. 011-2018 TVP scheduling adjustments

The chosen events represent distinct moments where the interdependencies had a significant impact on the project outcomes. Each event is characterised by a clear interdependency, such as alignment with design goals, timely approvals, or resource allocation, and demonstrates how these interdependencies influenced decision-making and management strategies. Furthermore, these events were selected due to the availability of comprehensive data, including documentation and stakeholder input, which ensured a foundation for analysis. The involvement of key stakeholders, both from client and contractor, further supports the selection, as their perspectives can provide insight into the management of these interdependencies.

To complement the analysis of selected events, a survey was designed to provide structure and context for subsequent interviews. The survey serves two primary purposes: to provide a concise summary of the selected events, to ensure that the interviewees are familiar with the context, and to establish a baseline understanding of how management practices aligned with project values such as time, cost, and quality.

The survey includes questions designed to evaluate the effectiveness of management strategies for each event. In the context of this research, effectiveness is defined as the degree to which a strategy achieved its intended goal. For example, in events where time was the primary concern, effectiveness is assessed based on whether delays were mitigated or avoided. This practical definition aligns with the way professionals view project management, ensuring that the survey captures relevant information.

The survey also explores which values (time, cost, quality) were prioritised in managing each event. By asking respondents to reflect on these priorities, the survey provides preliminary data on the rationale behind management decisions. This structure not only guides the interviews, but also ensures that the interviewees have a shared understanding of the events and their significance.

The survey is not designed to replace interviews, but rather to enhance them. By offering a structured overview of events and prompting participants to reflect on key aspects of management, the survey creates a common reference framework. This preparation ensures that interviews can focus on deeper insights, such as the reasoning behind specific decisions and the challenges in managing interdependencies.

The survey results are also used to evaluate the findings of the document analysis and the theoretical frameworks applied in this investigation. For example, comparing survey responses to the categorisation of interdependencies using the TOE framework and Perrow's matrix, this research tries to assess whether these frameworks align with the experiences of practitioners. In addition, the survey allows for a preliminary evaluation of management effectiveness, which can be further explored during interviews.

## 5.3. Interdependency classification and applied management structure

This section provides the analysis of six key project events from the contractor's perspective, three from each project and identified in Section 5.2.3. For each event, the nature of the interdependency is assessed using the TOE framework, identifying the cause and manifestation of the complexity.

Subsequently, each interdependency is classified within Perrow's matrix to evaluate the degree of coupling and interaction. This allows a deeper understanding of the contractor's risk exposure and decision-making constraints. Finally, the applied management structure for each event is described and compared with the governance structure that Perrow's theory would suggest. This analysis reveals how the contractor approached risk mitigation in practice and whether the chosen governance model aligned with the complexity of the situation.

### 5.3.1. Event analysis of Case 1

#### Event 1: Lack of clarity regarding the alignment

In October 2019, significant delays arose due to the client's inability to finalise the alignment in the reference design, directly affecting the contractor's ability to proceed with the final design (voortgangsrapportage-p10, 2019). Without an approved reference design, the contractor could not finalise its design, causing severe project disruptions (Interviewee 1, personal communication, January 21, 2025). This created a critical interdependency, where progress became entirely dependent on the client's decision-making process.

The contractor was expected to strictly adhere to the client's reference design, but since this design remained incomplete, the contractor could not go further in finalising the final design and thus the project (voortgangsrapportage-p10, 2019). This resulted in technical complications and later adjustments, forcing adjustments to the original workflow and increasing the complexity of the project (Interviewee 1, personal communication, January 21, 2025). The situation also led to organisational challenges, as the contractor had no control over resolving the alignment in the design, but still faced mounting schedule pressures.

From the interview, it was found that the most pressing mitigation goal for the contractor was time-related, as the project had to meet a TVP deadline (Interviewee 1, personal communication, January 21, 2025). The contractor attempted to mitigate these risks by adjusting planning strategies and optimising internal workflows. However, since the approval process remained outside the contractor's control, these measures could only partially compensate for the delays, leaving the contractor highly vulnerable to timeline delays and dependent on the client (Interviewee 1, personal communication, January 21, 2025).

**Table 5.2:** TOE categorisation of event 1.1

| Dimension | Description of complexity |
|---|---|
| **Technical** | The incomplete reference design directly impacted the contractor's ability to produce a final design, requiring schedule and execution adjustments and uncertainty in methods. |
| **Organizational** | The contractor was fully dependent on the client's design approval and choice on the alignment. The Which means the complexity was caused by organisational elements. |
| **External** | Regulatory approvals and political requirements added external dependencies, but not interdependencies between complexity elements. |

The categorisation of complexity shows how the complexity of this event manifests itself as a technical complexity but has his cause in organisational complexity. This shows the nature of interdependency of the complexity in this event. Table 5.2 shows that the client's failure to make a decision about alignment, an organisational complexity, ultimately translated into technical complexity. Because the reference design remained unresolved, the contractor was unable to determine the applicable quality requirements or the appropriate design methods. This left the contractor without control over the progress of the design phase and, consequently, the achievement of key project milestones. (Interviewee 1, personal communication, January 21, 2025) and (voortgangsrapportage-p10, 2019).

From the contractor's perspective, the interdependency was tightly coupled with complex interactions, which means that there were no alternative workflows, and unpredictable delays emerged from dependencies beyond its control (Interviewee 1, personal communication, January 21, 2025). The event had complex interactions with hidden connections and feedback loops between design coordination, regulatory approvals, and project execution. The approval process affected many later project activities, and unexpected problems in one area led to unpredictable changes in others. This made managing risks difficult, because fixing one issue often created new challenges in different parts of the project.

**Table 5.3:** Perrow classification of event 1.1

| Dimension | Analysis |
|---|---|
| **Coupling** | Tight coupling: The alignment decision was a important interdependency, and without approval, no progress could be made. |
| **Interaction** | Complex interaction: Unforeseen delays in approvals created feedback loops that affected multiple project phases. |

From a risk management perspective, the contractor applied an internal schedule-based mitigation strategy. Since there was no ability to influence alignment approvals, the contractor attempted to optimise internal workflows and parts of the final design to compensate for lost time (Interviewee 1, personal communication, January 21, 2025). This strategy focused on lean planning adjustments for any future design errors, ensuring that once approvals were granted, execution could proceed without further delays (voortgangsrapportage-p10, 2019) and (Interviewee 1, personal communication, January 21, 2025).

**Table 5.4:** Management approach of event 1.1

| Aspect | Description |
|---|---|
| **Applied approach** | The contractor focused on schedule-based risk mitigation, using lean planning and internal workflow adjustments to manage the TVP deadline. |
| **Effectiveness** | While this reduced some immediate scheduling risks, it did not address the underlying dependency on the client's reference design. |
| **Categorisation** | Centralised, schedule-driven management: The contractor had no control over the alignment decision and was forced to manage risk through planning adjustments. |

This event illustrates the challenges of managing risks in tightly coupled systems when key dependencies remain under centralised external control. Although the contractor used centralised risk mitigation strategies within its operational domain, the dependency on the reference design of the client meant that these strategies could not eliminate external scheduling disruptions. This highlights that in tightly, complex systems, centralised adjustments alone cannot fully mitigate risks when the primary decision-making authority remains centralised.

### Event 2: Track stability

In December 2019, track stability became a critical issue, creating technical and organisational challenges (Interviewee 1, personal communication, January 21, 2025). The foundation was found to be too weak to properly support the track, raising concerns about safety and long-term functionality (voortgangsrapportages p-11 & p-12, 2019). However, instead of involving the main contractor in resolving the issue, the client outsourced the work to an external company, meaning that the contractor was excluded from both decision making and execution of this critical part of the project (Interviewee 1, personal communication, January 21, 2025).

From the contractor's perspective, this decision changed the structure of the project, shifting responsibility to a third party and creating new interdependencies outside of the contractor's control (Interviewee 1, personal communication, January 21, 2025). The contractor was not involved in the solution of the problem, which meant that it had no influence on the solution, the timeline, or the way the work was carried out. Although this meant that the contractor's contract scope remained the same, it also introduced uncertainty, as the project's progress now also depended on an external party.

**Table 5.5:** TOE categorisation of event 1.2

| Dimension | Description of complexity |
|---|---|
| **Technical** | The foundation was too weak and needed reinforcement, but the contractor was not involved in the solution. Technical complexity was not for the contractor in this event. Technical issues were based on the expertise of the external party. |
| **Organizational** | The contractor was fully dependent on a correct track stability the client provided. Based on the interview and documentation, it can be argued that the client did not have the right resources available in this event. |
| **External** | The track stability was solved by an external stakeholder, creating a dependency on this external stakeholder. The correct track stability had to follow regulatory geotechnical standards, adding further uncertainty for the contractor and involved a new stakeholder, that was critical to the project. |

This event demonstrates an interdependency between organisational and external complexity elements. The cause of complexity stemmed from the organisational complexity that the client did not have the right resources and decided to contract an external stakeholder. The manifestation of complexity was external, as the contractor had to adjust its planning based on the progress of the external specialist (Interviewee 1, personal communication, January 21, 2025) (voortgangsrapportage p-11 & p-12).

Based on the interview with the contractor, it can be stated that the decision to involve an external stakeholder decision introduced operational uncertainty and rigid sequencing, as it could not proceed with certain activities until the external party completed its work (Interviewee 1, personal communication, January 21, 2025). Although this approach was the client's responsibility, it created inefficiencies and risks for the contractor, who had no mechanism to directly influence the resolution timeline or ensure seamless integration of corrective measures into the broader project schedule (Interviewee 1, personal communication, January 21, 2025).

Given this structure, the event can be classified within Perrow's framework as a tightly coupled system with linear interactions. The absence of alternative workflows meant that the contractor did not have flexibility. The interviewee (Interviewee 1, personal communication, January 21, 2025) highlights that the work could only continue once the external party resolved the issue. The interactions remained linear, as the problem followed a structured, step-by-step sequence. The foundation had to be stabilised before any further construction could proceed (Coze, 2023). This classification highlights the contractor's constrained position in risk management, as tight coupling and external dependencies restricted its ability to implement proactive mitigation measures.

**Table 5.6:** Perrow classification of event 1.2

| Dimension | Analysis |
|---|---|
| **Coupling** | Tight coupling: There were no alternative ways to continue the work. The contractor had to wait for the track stability issue to be solved before being able to proceed. |
| **Interaction** | Linear interaction: The problem was handed over to an external company, and the contractor had to adjust its schedule without having any direct involvement in the process |

From a management perspective, the contractor had to work within a decentralised risk structure, as it was fully dependent on external problem solving. The client made the decision to outsource, but the contractor had no control over execution, planning, or risk management. As a result, the contractor had to adjust its own schedule according to an externally controlled process.

**Table 5.7:** Management approach of event 1.2

| Aspect | Description |
|---|---|
| **Applied approach** | The contractor had to adjust its planning to fit an externally managed solution, without having control over the timeline or execution. |
| **Effectiveness** | The problem was solved without major delays, but the contractor faced uncertainty and scheduling limitations due to its lack of involvement. |
| **Categorisation** | Centralised: The contractor had no influence over the solution and had to rely entirely on external progress. There was no involvement to the risk sessions. |

From the contractor's perspective, outsourcing the track stability problem led to a centralised risk structure, where key decisions were made externally or by the client. Although this meant that the contractor's contract scope stayed the same, it also introduced uncertainty as project progress became dependent on the performance of an external party. The tight coupling of track stability to overall project progress left the contractor with no ability to reduce delays, showing the risks of decentralised risk control in tightly coupled situations.

### Event 3: Permitting bottlenecks

By mid-2020, unresolved permit issues had caused a bottleneck, leading to significant project delays and increasing potential delays. The client was responsible for securing the permits required for the project, while the contractor was entirely dependent on these approvals to proceed with execution (voortgangsrapportage-p05, 2020). This situation created strong external complexity, as the permitting process relied entirely on external regulatory bodies beyond the control of both the client and the contractor (Interviewee 1, personal communication, January 21, 2025).

Although the primary complexity manifested itself as external, organisational complexity forms the cause of the complexity. The client retained authority over permit submissions and corrections (Interviewee 1, personal communication, January 21, 2025). However, once a mistake occurred in the application process, the contractor was unable to proceed, and the project became entirely dependent on the timing and efficiency of the external permitting authority (Interviewee 1, personal communication, January 21, 2025). The absence of backup processes or alternative approval pathways made the permitting system rigid, amplifying the consequences of any delays (voortgangsrapportage-p05, 2020).

Efforts to resolve the issue included redistributing responsibilities within the permitting authority, but this was a reactivate measure that did not eliminate the underlying dependency on external approvals. The project timeline remained at risk, as the regulatory process followed its own schedule, independent of project needs.

**Table 5.8:** TOE categorisation of event 1.3

| Dimension | Description of complexity |
|---|---|
| **Technical** | No direct technical complexity. The delay stemmed from administrative processes rather than technical issues. |
| **Organizational** | The client retained decision-making control but had no direct influence over regulatory approval timelines. Come out of the complexity lied in organisational complexity. |
| **External** | The project was fully dependent on external regulatory bodies, with approval timelines beyond the control of both client and contractor. This made the cause of complexity in external stakeholders. |

The complexity in this event stemmed from an interdependency between organisational and external elements as described in Table 5.8. Although the manifestation of complexity was external, the cause was rooted in the organisational structure of the client's decision-making process. The client had retained authority over the permit application process but lacked direct control over approval timelines, creating an organisational bottleneck that directly impacted project execution (voortgangsrapportage-p05, 2020) (Interviewee 1, personal communication, January 21, 2025).

This interdependency made the contractor highly vulnerable to delays beyond its control, as no alternative workflows or contingency measures were in place to mitigate the impact of permit-related disruptions (Interviewee 1, personal communication, January 21, 2025). The rigid structure of the permitting process further reinforced this dependency, making the project highly susceptible to external delays. The combination of these factors resulted in a tightly coupled system, where the inability to obtain timely approvals directly hindered the contractor's ability to proceed with construction. The level of interaction, on the other hand, can be categorised as linear. The processes were clear, there was little change in unexpected feedback loops, and the type of information was direct.

**Table 5.9:** Perrow classification of event 1.3

| Dimension | Analysis |
|---|---|
| **Coupling** | Tight coupling: The permitting process had no backup resources or alternative workflows, making delays highly impactful. |
| **Interaction** | Linear interaction: The approval process followed a structured sequence, where progress depended entirely on correcting the permit before the contractor could proceed. |

This classification shown in Table 5.9 highlights the risks of tightly coupled external processes, where delays spread immediately and disrupt the project schedule. Since the permitting system followed a fixed sequence, delays could not be mitigated through alternative workflows, making it a single-point failure within the project structure.

To manage the permitting bottleneck, the contractor focused on accelerating the submission of required documents to support the approval process and minimise further delays (voortgangsrapportage p-05, 2020). By ensuring that all necessary paperwork was provided in a timely manner, the contractor aimed to reduce processing time and prevent administrative setbacks (Interviewee 1, personal communication, January 21, 2025). However, this approach was reactive rather than preventive, as it did not address the underlying dependency on the regulatory approval process.

The effectiveness of this strategy is difficult to assess as the contractor had no direct influence on the approval timeline (Interviewee 1, personal communication, January 21, 2025). Although swift submission of documents may have helped to avoid additional delays due to incomplete or incorrect submissions, the core issue remained unresolved, which means that the project still depended on external regulatory timelines and resource availability within the permitting authority. As a result, despite the contractor's efforts to streamline the process, approval delays remained largely outside of its control.

**Table 5.10:** Management approach of event 1.3

| Aspect | Description |
|---|---|
| **Applied approach** | The contractor focused on promptly submitting all required documents to support the approval process. |
| **Effectiveness** | Based on the interview and the documentation it is difficult to measure, as the contractor had no control over the external permitting authority's approval speed. |
| **Categorisation** | Centralised: The contractor managed documentation submission but remained dependent on client and regulatory timelines. |

The centralised nature of this management approach meant that while the contractor could control its own administrative processes, the ultimate approval rested with the client and external regulatory authorities. This highlights the challenges of managing external dependencies, as the contractor's ability to mitigate delays was inherently limited by factors beyond its direct influence.

This event highlights the challenges of managing tightly coupled processes that rely on external regulatory approvals. Although contractor corrective measures helped streamline documentation submission and prevent additional administrative setbacks, they did not manage to mitigate the fundamental dependency on the permitting authority. As a result, the project remained vulnerable to future approval delays, as the core issue was left unaddressed.

### 5.3.2. Event analysis of Case 2

#### Event 1: Platform roof design decisions

In December 2017, the contractor faced a fundamental change to the design of the station after a late stage requirement of the client to reuse and integrate the existing monumental platform roof (voortgangsrapportage 6, 2017). At that point, the contractor had already developed a design based on previously agreed functional and technical requirements. The sudden enforcement of material reuse, introduced well after initial design work had begun, required significant structural modifications. These included adjustments to ensure that the reused elements met contemporary safety, engineering, and architectural standards. Although the resulting complexity appeared as a technical challenge in the design and engineering process, the underlying cause of these changes lay in the client's organisational decision-making (Interviewee 2, personal communication, January 16, 2025).

One of the most impactful and unexpected challenges, as emerged from the interview and project documentation, was the discovery of chromium-6 in the reused platform cover. This introduced strict quality requirements for hazardous materials, limiting execution flexibility, and mandating additional safety protocols. This technical complexity resulted in further delays and cost increases (voortgangsrapportage 6, 2017).

The contractor had to make structural reinforcements to ensure that the reused materials met modern engineering and safety standards. This required extensive collaboration between multiple disciplines, including structural engineers, environmental specialists, and heritage preservation authorities (Interviewee 2, personal communication, January 16, 2025). As a result, organisational complexity increased due to the necessity of intensive stakeholder coordination, additional technical meetings, and iterative design adjustments.

The nature of these interdependencies can be categorised using the TOE framework, as shown in Table 5.11.

**Table 5.11:** TOE categorisation of event 2.1

| Dimension | Description of complexity |
|---|---|
| **Technical** | The reuse of the platform roof required significant structural modifications to ensure compliance with modern safety and engineering standards. The discovery of chromium-6 introduced strict quality requirements for material handling, which limited design flexibility and increased technical risk. The technical complexity thus manifested through uncertainty in methods and elevated quality demands. |
| **Organizational** | The late-stage design changes required intensive coordination between contractors, engineers, and architects. The organisational complexity emerged due to the availability of skills and resources and the requirement to enforce material reuse. |
| **External** | Regulatory compliance regarding hazardous materials (chromium-6) and heritage preservation laws restricted flexibility in execution, increasing project constraints. This external factor became a key driver of project delays. |

This event illustrates a triangular interdependency, where organisational complexity, driven by client decisions, required technical modifications, which were further influenced by external constraints such as heritage preservation laws and hazardous material regulations. The interdependency between these three dimensions created rigid constraints, leaving little flexibility for alternative workflows and increasing the risk of cascading delays (Interviewee 2, personal communication, January 16, 2025).

Since the complexity originated from organisational and external factors but manifested in technical execution, the event demonstrates how decision-making structures and regulatory frameworks can directly shape engineering challenges. This aligns with Perrow's concept of tightly coupled systems with complex interactions, where changes in one domain trigger adaptive responses across multiple disciplines.

The tight coupling of this event was evident in the absence of alternative workflows. The integration of the existing platform roof into the new station design created a fixed sequence of activities, where approvals and design modifications directly influenced construction schedules. The inability to introduce alternative design solutions amplified the rigidity of the process, strengthening the risk of delays.

The interactions in this scenario were highly complex. Although structured processes such as design reviews and technical meetings were followed, the overlap of responsibilities between engineers, architects, and regulatory authorities led to frequent iterations. Compliance with hazardous materials safety regulations and heritage preservation laws further increased coordination challenges, requiring constant adjustments to the design and approval process. Table 5.12 provides a brief summary of the classification based on the Perrow matrix.

**Table 5.12:** Perrow classification of event 2.1

| Dimension | Analysis |
|---|---|
| **Coupling** | Tight coupling: The integration of the platform roof had direct consequences on subsequent project phases, with no flexibility for alternative design solutions. |
| **Interaction** | Complex interaction: Interdependencies between structural design, regulatory compliance, and stakeholder coordination required structured communication but faced frequent adjustments. The need for specialized personal is high and there is no possibility of isolation of the failed component. |

This classification shows that tight coupling and complex interaction events made the project highly sensitive to disruptions. Although processes followed a structured path, delays in approvals or design conflicts cascaded into other phases as a result of the lack of flexibility in workflows (Interviewee 2, personal communication, January 16, 2025).

To manage the challenges introduced by the design modifications, several practical interventions were implemented (voortgangsrapportage 6, 2017). The approach relied primarily on technical meetings, collaboration, and structured design reviews, which brought together experts from various disciplines to address design, regulatory, and structural issues (Interviewee 2, personal communication, January 16, 2025). This collaborative process facilitated stakeholder alignment and ensured that modifications met the necessary feasibility and compliance requirements. These efforts were needed to resolve the issues as they arise and to maintain progress despite the complexity of the situation.

However, these measures were reactive in nature and were designed to address the challenges that had already emerged due to the obligation to reuse the platform roof (voortgangsarapportage 6, 2017). The reliance on cross-disciplinary coordination revealed gaps in early-stage planning, as many of the constraints could have been identified and mitigated earlier in the project. Additionally, the decentralised approach, which leveraged expertise from multiple stakeholders, allowed flexibility in problem solving but also led to slower decision-making due to the iterative nature of solving complex dependencies.

**Table 5.13:** Management approach of event 2.1

| Aspect | Description |
|---|---|
| **Applied approach** | Technical meetings and structured design reviews facilitated collaborative problem-solving, focusing on expertise of every stakeholder. |
| **Effectiveness** | Communication was key in this mitigation. By relying on each person's expertise, control was completed as successfully as possible. Based on trust, it was ensured that the project could go ahead so there were no time issues. Decisions about costs were made directly and in collaboration with each other. |
| **Categorisation** | Decentralised: Expertise and decision-making were distributed across disciplines, with coordination mechanisms in place to integrate inputs. Communication was key in this event, leading to involvement and ownership of all stakeholders in the project (Interviewee 2, personal communication, January 16, 2025). |

Although the collaborative approach helped mitigate immediate risks and ensure compliance, it did not resolve the systemic weaknesses in early stage planning and feasibility assessments. The decentralised management structure, which relied on distributed expertise and iterative adjustments, was effective in addressing immediate challenges (Interviewee 2, personal communication, January 16, 2025).

This event demonstrates that practical management efforts focused on cross-disciplinary collaboration were effective in managing existing problems, but were limited in their ability to prevent delays or disruptions proactively. Moving forward, integrating more structured early stage planning processes and risk assessments would enhance the ability to identify constraints early and streamline decision making in similarly sized projects.

### Event 2: Delayed delivery of railway switches

The delayed delivery of railway switches was a critical issue for the contractor, as it directly affected the planned installation of track decks and the TVP deadline (Interviewee 2, personal communication, January 16, 2025). As mentioned by the interviewee, missing this deadline would have resulted in a minimum project delay of one year, making the resolution of this issue a top priority. Although being contractually responsible for procurement, the contractor mentioned in the interview that he had no direct control over supplier timelines, creating an external dependency that severely limited their ability to mitigate the risk.

**Table 5.14:** TOE categorisation of event 2.2

| Dimension | Description of complexity |
|---|---|
| **Technical** | The switch delivery was crucial for track deck installation, directly impacting project feasibility. From contractor documents and interviews, there were no specific technical complexity element that misaligned in this event. |
| **Organizational** | The contractor experienced resource unavailability, as critical components could not be delivered on time. This organisational complexity was caused by the misalignment between contractual responsibility for procurement and the inability to influence supplier performance. Internal planning was disrupted due to missing inputs at key project stages. The contractor mentioned it was contractually responsible for procurement but lacked direct control over supplier timelines, relying on external coordination and client intervention. This made it a resource issue. |
| **External** | The cause of the complexity lay in the contractor's dependency on an external supplier, whose production and logistics were beyond the contractor's control. This external dependency created delays and removed the possibility of direct mitigation, requiring eventual client involvement. |

The complexity in this event was caused by an external dependency that manifested itself in the unavailability of resources. Specifically, the contractor relied on a third-party supplier for the delivery of switches, but had no direct control over the supplier's logistics and production planning. This external dependency became the underlying cause of organisational complexity as it led to a resource availability issue. The contractor was contractually responsible for ensuring timely delivery, but could not access or allocate the required components when needed. The absence of these resources at critical project stages disrupted internal planning and execution processes. Thus, the nature of interdependency was between external and organisational complexity and stemmed from the project's structural dependency on an uncontrollable external actor (Interviewee 2, personal communication, January 16, 2025).

The switch delivery delays created a tightly coupled dependency within the project. The lack of alternative workflows meant that any delay in delivery had immediate and unavoidable consequences for subsequent activities, particularly for the installation of the track deck by the contractor (kwartaalrapportage Q2, 2018). The contractor had no flexibility in adjusting the construction sequencing without switches, making this event highly sensitive to disruptions.

The interactions in this event were linear, since the resolution of the issue depended only on the engagement of the supplier and contractual agreements. Unlike complex interactions, where risks may propagate unpredictably, this issue followed a straightforward dependency chain. There were no unpredictable cascading failures, but the project remained vulnerable to a single point of failure due to the absence of redundancy or contingency options.

**Table 5.15:** Perrow classification of event 2.2

| Dimension | Analysis |
|---|---|
| **Coupling** | Tight coupling: The switch delivery was a critical condition for track installation, with no flexibility for alternative solutions or sequencing. |
| **Interaction** | Linear interaction: The issue followed a clear interdependency, with no unexpected feedback loops or secondary disruptions. |

This classification confirms that the contractor's risk exposure was structurally high due to the tight coupling of procurement and construction execution. The lack of alternative solutions and the dependency of the suppliers reinforced the vulnerability of the project to external delays, demonstrating the challenges of managing procurement risks in large-scale infrastructure projects.

The management structure applied by the contractor in response to the switch delivery delays was primarily decentralised, as procurement was externally managed by the supplier, and the contractor had no direct control over enforcing or accelerating delivery (Interviewee 2, personal communication, January 16, 2025). The contractor's initial mitigation efforts included contractual penalty clauses and internal scheduling adjustments, but these measures proved ineffective, as they did not resolve the root cause, the supplier's logistical limitations (Interviewee 2, personal communication, January 16, 2025).

Recognising the high risk and lack of direct control, the client assumed a more active role, shifting the management approach to shared responsibility (kwartaalrapportage Q2, 2018). The client's involvement in supplier negotiations, commitment to 24-hour monitoring, and willingness to cover additional costs led to the successful resolution of the delay (Interviewee 2, personal communication, January 16, 2025). This shared risk management approach ultimately ensured that the switches were delivered on time, preventing severe project delays that would otherwise have resulted in a minimum one-year setback.

**Table 5.16:** Management approach of event 2.2

| Aspect | Description |
|---|---|
| **Applied approach** | The contractor attempted to enforce supplier compliance through penalty clauses and internal scheduling adjustments but had no direct control over delivery. |
| **Effectiveness** | The contractor's mitigation efforts did not resolve the issue; client's intervention was necessary to secure timely delivery. |
| **Categorisation** | Centralised transitioning to decentralised: The contractor lacked centralised authority, and the issue was only resolved after client intervention. |

The contractor's applied management structure was ineffective in mitigating procurement risk, as the contractor's limited authority over supplier timelines meant that internal measures had no real impact on ensuring timely delivery. The shift to shared management with the client's intervention and collaboration ultimately led to a successful resolution of the issue, demonstrating that external supply chain risks require collaborative mitigation efforts rather than isolated contractor-driven strategies. This case reinforces the importance of structured contingency agreements and proactive client involvement in high-risk procurement dependencies.

#### Event 3: TVP scheduling challenges

The rescheduling of the TVP required close coordination between the client and the contractor to ensure alignment with operational requirements and external conditions (Voortgangsverslag 25, 2018). Adjusting the schedule introduced multiple interdependencies in technical, organisational, and external dimensions. Although external factors such as freezing temperatures posed a risk to execution, effective collaboration ensured that adjustments were implemented with minimal disruptions (voortgangsverslag 25, 2018). The interviewee stated that this event stands out as an example of successful project management, where flexibility, risk sharing, and preventive contingency planning allowed the project to progress efficiently despite external uncertainties (Interviewee 2, personal communication, January 16, 2025).

The technical complexity of this event involved adjusting the schedule while ensuring that the execution of the task was in line with operational constraints, preventing disruptions in rail traffic. Organisational complexity required collaboration between the client and the contractor to reallocate resources and maintain efficiency

(Kwartaalrapportage Q4, 2018). External complexity was the most uncertain factor, as weather conditions such as freezing had to be taken into account when determining the feasibility of the revised schedule (Kwartaalrapportage Q4, 2018). The complexity elements of this event are categorised in Table 5.17.

**Table 5.17:** TOE categorisation of event 2.3

| Dimension | Description of complexity |
|---|---|
| **Technical** | The rescheduling required precise alignment of task execution with operational constraints, ensuring minimal disruption to rail traffic. |
| **Organizational** | Collaboration between the client and contractor was needed to adjust resource planning and maintain efficiency. |
| **External** | Weather conditions, particularly freezing weather, introduced unpredictable risks that needed to be factored into scheduling decisions. |

The complexity in this event was primarily triggered by external uncertainty, specifically the risk of freezing temperatures affecting the feasibility of the rescheduled TVP (Voortgangsverslag 25, 2018). Although external elements caused the complexity, its manifestation occurred at the organisational level. Close coordination was required between the client and the contractor to reallocate resources and align the schedules. Technically, the revised planning had to remain compatible with operational constraints to avoid disrupting rail services. This event illustrates how externally driven complexity can be effectively managed through collaborative planning and proactive risk mitigation (Interviewee 2, personal communication, January 16, 2025).

Unlike previous scheduling challenges that had caused delays, this event was effectively managed through preventive planning and coordination. With clear communication between client and contractor, and the ownership of both parties, the control of the interdependency was successfully (Interviewee 2, personal communication, January 16, 2025). The loose coupling allowed for adaptability, meaning that changes could be implemented without affecting other project components. The placement of this event in Perrow's matrix, detailed in Table 5.18, reflects how the low complexity and loose coupling of this event contributed to its successful management.

**Table 5.18:** Perrow classification of event 2.3

| Dimension | Analysis |
|---|---|
| **Coupling** | Loose coupling: The rescheduling did not create cascading delays or critical disruptions, as tasks remained adaptable. |
| **Interaction** | Linear interactions: While weather conditions introduced uncertainties, the impact was manageable and predictable. |

The loose coupling in this case was evident in the lack of rigid dependencies between tasks, allowing adjustments without significant disruptions. Furthermore, the linear interaction classification is justified by the predictability of scheduling adjustments and the effectiveness of contingency planning, which helped mitigate external uncertainties. The success of this event can be largely attributed to the use of a decentralised and flexible management approach, where both the client and the contractor share responsibility for risk management and decision-making (Interviewee 2, personal communication, January 16, 2025).

To facilitate effective risk management, a collaborative decision-making process was implemented (Interviewee 2, personal communication, January 16, 2025). Rather than relying on a single authority to dictate the rescheduling, both parties actively contributed to the process, allowing a flexible response to changing conditions. This decentralised approach ensured that potential risks were identified early and adaptive measures were incorporated into the scheduling strategy. The applied management approach and key recommendations are summarised in Table 5.19.

**Table 5.19:** Management approach of event 2.3

| Aspect | Description |
|---|---|
| **Applied approach** | While a collaborative approach was followed, the client retained official control over the approval of the TVP rescheduling, requiring the contractor to align its planning accordingly. |
| **Effectiveness** | The structured approval process ensured minimal disruptions, as scheduling adjustments were implemented only after formal client authorization, allowing adaptations to external conditions.. |
| **Categorisation** | Decentralised, because the rescheduling was formed in good collaboration. |

The decentralised approach used in this event ensured that decision-making was distributed, rather than being controlled by a single entity (Interviewee 2, personal communication, January 16, 2025). By allowing both parties to actively participate in risk management and scheduling, the team could quickly adjust the plans in response to changing conditions. The use of contingency planning further strengthened the project's ability to adapt to external risks, reducing potential disruptions.

This event illustrates the benefits of decentralised decision-making in loosely coupled situations. Unlike challenges that require centralised intervention, shared responsibility and flexible management were key factors in the successful handling of this scheduling adjustment. Future projects can apply similar collaborative strategies to effectively mitigate external uncertainties while maintaining project momentum and adaptability.

## 5.4. Conclusion of contractors perspective

Looking at the events analysed in this study, a pattern emerges in terms of the types of interdependencies, the degree of coupling, and the way the risks were managed from the contractor's perspective. These patterns reveal how different governance approaches impact project execution, particularly in managing interdependencies and mitigating risks in complex construction projects. With these insights, subquestions 2 can be answered:

***How are client-contractor interdependencies managed and risk mitigation strategies applied in practice from contractors perspective?***

**Table 5.20:** Summary of findings from the contractor perspective

| Event | Interdependency | Perrow categorisation | Applied management structure | Effectiveness |
|---|---|---|---|---|
| Lack of clarity regarding the alignment | Organisational & Technical | Tight coupling, Complex interaction | Centralised (Client-controlled) | Delays due to rigid approval processes. |
| Track stability issue | Organisational & External | Tight coupling, Linear interaction | Centralised (Outsourced by client) | Loss of control and scheduling uncertainty |
| Permitting bottlenecks | Organisational & External | Tight coupling, Linear interaction | Centralised (Client-controlled) | High risk propagation due to regulatory delays |
| Platform roof design changes | Organizational & Technical | Tight coupling, Complex interaction | Decentralised (Client-led) | Effective, but required strong cross-disciplinary collaboration |
| Delayed delivery of railway switches | External & Organizational | Tight coupling, Linear interaction | Centralised transitioning to decentralised | Effective after external intervention |
| TVP scheduling adjustments | External & Organizational | Loose coupling, Linear interaction | Decentralised and collaborative | Highly effective with proactive adjustments |

The findings of selected project events are shown in Table 5.20 and pictured in Appendix G. The findings show that from a contractor perspective, the client-contractor interdependencies are primarily caused by organisational and external complexity but often manifest as technical and operational complexities for the contractor. Tightly coupled dependencies, where approvals, permits, or supplier delays restricted progress, frequently forced the contractor into a reactive position, adapting to external decisions rather than proactively managing risks. In these cases, a centralised governance structure, in which the client retained full control, led to inefficiencies, limiting the contractor's ability to effectively mitigate risks. In contrast, when governance was more decentralised and collaborative, as seen in schedule adjustments, the contractor had greater flexibility to manage interdependencies and respond to related risks.

A key finding of this analysis is the discrepancy between the formal documentation of the project and the realities described in interviews. When tensions between the client and the contractor increase, reporting on these conflicts systematically diminishes. This becomes clear in Event 2.2, where the documentation addresses contractor interdependence and responsibility at a minimum. The contractor's role in this negligence appears on purpose, as formal documentation remains focused on technical progress, while organisational friction, informal negotiations, and strategic decision-making remain undocumented. However, interviews provide a more comprehensive view of how interdependencies influenced project execution, highlighting decision points and the ways tensions were managed behind the scenes. This suggests that the contractor's selective reporting practices serve as a risk containment strategy, maintaining flexibility in contract discussions while avoiding formal accountability for contentious project moments.

Although this approach may be beneficial in the short term, it creates vulnerabilities in long-term risk management by limiting learning opportunities and transparency. The absence of formal records on interdependencies makes it difficult to refine governance structures and risk mitigation strategies in future projects. The findings suggest that effective risk management requires a dynamic governance approach, balancing structured control for approvals and regulatory compliance with flexible, decentralised collaboration for operational adjustments. In addition, ensuring that key interdependencies and decision-making processes, regardless of tension or conflict, are transparently documented will be important to strengthen governance and foster more effective risk management strategies in complex construction projects.

# 6

# Interdependency analysis and management: The client perspective

This chapter focusses on the categorisation of interdependencies identified in two case studies, based on insights collected through interviews with the client. Using the TOE framework and the Perrow matrix, it analyses technical, organisational, and external interdependencies and highlights the management structure applied by the client. The findings offer a detailed understanding of mitigation strategies from a client perspective.

## 6.1. Research approach of the client perspective

The client perspective in this study was obtained exclusively through semi-structured interviews with project managers representing the client organisation. These interviews were designed to capture the client's decision-making processes, risk perception, and interdependency management in response to key project events.

The events analysed in this chapter were identified based on contractor documentation, including cash flow analyses and project progress reports (see Section 5.1). These events represent critical moments where client-contractor interactions played a significant role in project outcomes. This was also evaluated through the survey. Although the contractor's perspective on these events was derived from both document analysis and interviews, the client's perspective was collected only through interviews with client project managers. This approach ensures that the client's interpretation of these events is based on their own experiences and strategic considerations, independent of the contractor's documentation.

To ensure a structured and comparative analysis, responses from client interviews were analysed using the TOE framework to categorise complexity factors and interdependencies, followed by classification in the perrow matrix to assess the management structure. This methodology enables a direct comparison between the client and contractor perspectives, highlighting differences in risk perception, governance strategies, and interdependency management.

## 6.2. Interdependency classification and applied management structure

This section examines the same aspects and events as in Chapter 5 but from the client's perspective. The information from the client perspective is fully based on interviews with the project managers of the projects.

### 6.2.1. Event analysis of Case 1

#### Event 1: Lack of choice regarding alignment

The project encountered delays in finalising the alignment design, which became a key bottleneck in the progress of the design phase. The delay was caused by the client's decision to postpone selecting a definitive alignment, while at the same time expecting the contractor to strictly adhere to the existing reference design (Interviewee 3, personal communication, February 4, 2025). This created a situation in which the contractor could not proceed, as the design input regarding the alignment remained incomplete.

From the client's perspective, the complexity was caused organisationally, primarily by a strong internal project drive for quality. The client maintained high expectations for technical outcomes and transferability at handover, which translated into strict quality requirements. This quality-driven approach led to a cautious and controlled decision-making process, particularly around alignment choices.

The manifestation of this complexity was technical. Because the alignment decision remained unresolved, the design team lacked the information needed to define quality requirements, scope boundaries, and interface conditions. This ambiguity stalled the technical design process. Although the issue appeared technical in nature, it was a direct result of internal decision-making processes and strict governance controls exercised by the client (Interviewee 3, personal communication, February 4, 2025).

**Table 6.1:** TOE categorisation of event 1.1

| Dimension | Description of complexity |
|---|---|
| **Technical** | The strong quality drive of the steering group resulted in strict quality requirements of the alignment. |
| **Organizational** | The client postponed the alignment decision due to a strong focus on long-term quality and transferability. This cautious approach created internal decision-making bottlenecks and limited design progress. |
| **External** | External complexity was not an issue during this event. |

This clarifies the role of organisational complexity in creating the delay, as the client's approach to decision-making and design restrictions became the main bottleneck. The absence of external constraints further confirms that the delay was internally driven, with the lack of proactive alignment decisions as the key issue.

The complexity and coupling classification in Table 6.2 highlights how the alignment approval process was tightly coupled, which means that there was no flexibility for alternative solutions once delays occurred (Interviewee 3, personal communication, February 4, 2025). The strict dependency on alignment approval meant that any delay had direct and immediate consequences for subsequent project phases, leaving no room for adjustments. However, despite the tight coupling, the interaction was linear rather than complex. It is clear from the interview that the client gave little or no room for changes in the design (Interviewee 3, personal communication, February 4, 2025). The only interaction between the client and the contractor with an alignment decision was from the client, which meant that once the alignment was finalised, progress could continue (Interviewee 3, personal communication, February 4, 2025).

**Table 6.2:** Perrow's classification of event 1.1

| Dimension | Analysis |
|---|---|
| **Coupling** | Tight coupling: The alignment approval was a critical interdependency, with no flexibility for alternative solutions. |
| **Interaction** | Linear interaction: The alignment process followed a structured sequence, with clear dependencies but without unexpected disruptions or feedback loops. |

Based on the answers in the interview, the client's management strategy, as detailed in Table 6.3, was structured around contractual rigidity combined with controlled problem solving discussions (Interviewee 3, personal communication, February 4, 2025). The reference design constraints were strictly enforced and while disagreements over modification flexibility led to ongoing discussions, the decision-making power remained fully within the client's control (Interviewee 3, personal communication, February 4, 2025). Who focused, as the interviewee highlights, mainly on quality control during this mitigation. According to the interviewee, the reason for this is that the project should be handed over and will only be taken over if it is qualitatively correct (Interviewee 3, personal communication, February 4, 2025).

When disputes arose, the client introduced a third-party mediator to facilitate discussions, allowing both parties to present their arguments objectively (Interviewee 3, personal communication, February 4, 2025). However, the interviewee pointed out that the final resolution was always reached through direct negotiations between project managers rather than dictated by the decision of the third party. This highlights a structured but centrally controlled problem-resolution approach, where the client retained ultimate authority over alignment approvals while allowing space for direct contractor discussions.

The classification of the management approach suggests a predominantly centralised decision-making structure, as shown in Table 6.3. The contractor was required to follow the client's reference designs (Interviewee 3, personal communication, February 4, 2025). Without a fully completed reference design, the contractor was unable to proceed. The interviewee said that they handled the resolution of the disputes internally within the project management team. Although the interviewee highlights that there were elements of negotiation, it became clear from his justification that final decision-making power was in the hands of the client, reinforcing the hierarchical nature of control. The absence of binding third-party mediation further supports this classification, as the client ultimately determined how a decision was reached and the final decision itself.

**Table 6.3:** Management approach of event 1.1

| Aspect | Description |
|---|---|
| **Applied approach** | Disputes were peeled back to their core issues, and a third-party mediator was involved. However, final resolutions were always reached through direct negotiation between project managers as mentioned in the client interview, without enforcing the third party's ruling. |
| **Effectiveness** | While this approach maintained collaboration, the resolution process remained time-consuming, as repeated discussions were needed to reach agreement. Early-stage clarity on alignment flexibility could have reduced the need for dispute resolution. |
| **Categorisation** | Centralised: The client maintained ultimate control over alignment approvals and reference design adherence, while allowing controlled negotiation at the project management level. |

This revised analysis ensures that the management structure is clearly categorised as centralised, aligning with the client's structured control over approvals while acknowledging the interactive problem solving at the project level.

#### Event 2: Track stability

The track stability issue was identified in December 2019 as a critical challenge within the project. The interview revealed that the client decided to keep the contractor strictly within its original scope and tendered the problem of external retaining walls (Interviewee 3, personal communication, February 4, 2025). The interviewee indicated that the external tendering was two-fold. One, they want to keep the contractor stuck to the scope and two, because of the high costs of the contractor to do this additional work (Interviewee 3, personal communication, February 4, 2025). The external tender was primarily based on cost considerations, as the expenses proposed by the main contractor to resolve the stability of the track could not be justified to the upper steering group (Interviewee 3, personal communication, February 4, 2025). To maintain budget control and financial accountability, the client chose to handle the issue independently rather than integrate it into the existing scope of the contractor.

By taking full responsibility for the track stability issue, the client ensured that the problem was resolved on time without introducing major financial and process-related risks to the project (Interviewee 3, personal communication, February 4, 2025). However, this decision created an interdependency between organisational and external complexities. Although the client maintained control over financial decision making and procurement, the contractor's progress became dependent on an external party's ability to complete stabilisation work. This created scheduling uncertainties, as the contractor had no influence on the progress and timeline of this external intervention.

**Table 6.4:** TOE categorisation of event 1.2

| Dimension | Description of complexity |
|---|---|
| **Technical** | The track stability issue directly impacted the structural integrity of the railway. While a technical problem, the decision-making regarding its resolution was not technical in nature. |
| **Organizational** | The client chose to exclude the contractor from this issue and took full responsibility, as the costs proposed by the contractor could not be justified to the steering group. This reduced the level of interdependency between parties while maintaining financial control. |
| **External** | The external procurement of stabilization work created external complexity, as the project timeline became dependent on a third party's performance. |

This classification highlights that the root cause of complexity was organisational, as financial governance and budget justification dictated the trust of the client in the contractor. The manifestation of complexity was external, as external dependency on a third party introduced uncertainties in scheduling and execution. The interdependency between these complexities underscores the challenge of balancing financial constraints with operational efficiency, demonstrating how resource allocation decisions impact the broader execution of the project.

This event added a new dementia. Since this research focusses on the client-contractor relationship, the Perrow classification is also plotted on that relationship. In this investigation, the interdependence between the external party and the client or contractor is not considered.

**Table 6.5:** Perrow classification of event 1.2

| Dimension | Analysis |
|---|---|
| **Coupling** | Loose coupling: By tendering this issue separately, the contractor felt out of this scope, the client retained flexibility and resolved the issue independently. |
| **Interaction** | Linear interaction: The issue is resolved independently of the contractor, ensuring a linear interaction between the parties. |

From the client's perspective, the Perrow classification highlights that the track stability problem was loosely coupled in the context of the client-contractor relationship. By addressing the problem through an external party, the client minimised the involvement of the contractor, thereby retaining flexibility and financial control over the resolution process (Interviewee 3, personal communication, February 4, 2025). The interaction remained linear, as the resolution process was structured independently of the contractor's responsibilities, ensuring that no complex feedback loops emerged between the two parties. This classification reinforces how the client strategically managed the organisational and external complexities to maintain project efficiency while limiting direct interdependencies with the contractor (Interviewee 3, personal communication, February 4, 2025).

**Table 6.6:** Management approach of event 1.2

| Aspect | Description |
|---|---|
| **Applied approach** | The client ensured that the contractor remained within its predefined scope and outsourced the retaining wall works externally to maintain budget control and avoid high costs. |
| **Effectiveness** | This approach successfully resolved the problem without impacting the main project timeline or incurring additional high costs. |
| **Categorisation** | Centralised: The client took full ownership of the issue, minimizing involvement of the contractor. |

The management approach was centralised as the client took direct control of the problem rather than involving the contractor. This decision was dual. The client primarily focused on keeping the contractor in its pre-defined scope. In addition to the scope focus, the mitigation was cost-driven, as the client had to ensure financial accountability to the upper steering group. By outsourcing the issue, the client successfully mitigated financial risks while keeping the project on schedule (Interviewee 3, personal communication, February 4, 2025).

The client's main concern was cost control, driven by the need to justify all expenses to the upper steering group. The decision to outsource track stability work rather than assign it to the contractor was not purely technical, but fundamentally a financial strategy to maintain budget oversight and accountability. Although this approach successfully prevented cost overruns and timeline disruptions, it reflects a highly transactional risk management strategy, prioritising financial efficiency over collaborative problem-solving. However, despite the centralised approach, the outcome of the mitigation measure was positive. Little disruption as possible occurred from this event.

#### Event 3: Permitting bottlenecks

The permit issue arose due to the client applying for incorrect permits as mentioned by the interviewee, which meant that the contractor could not carry out the project (Interviewee 3, personal communication, February 4, 2025). Despite this, the interviewee attributed some challenges to the contractor's difficulties in compiling the final delivery documents. This situation resulted in organisational and external complexity and interdependency, as the contractor was dependent on the client for regulatory approvals and correct applications, while the client was dependent on the contractor for complete documentation (Interviewee 3, personal communication, February 4, 2025).

**Table 6.7:** TOE categorisation of event 1.3

| Dimension | Description of complexity |
|---|---|
| **Technical** | The contractor's technical completion was ready, but final delivery was delayed due to missing permits. This means no technical elements were present in this event. |
| **Organizational** | The client's incorrect permit application created an issue in resources for the contractor. That created a dependency for the contractor to wait for approvals, delaying project handover. On the other hand, from the client interview it became clear that contractor faced internal challenges in finalizing delivery documents. |
| **External** | The permitting process involved other stakeholders and regulatory constraints. |

The complexity was caused by organisational misalignment in the preparation and submission of permit applications, involving both the client and the contractor. The manifestation of this complexity occurred in the external dimension, where project execution was blocked by missing regulatory approvals. The event reflects an interdependency, where the client relied on contractor documentation, while the contractor relied on correct client submissions to external authorities (Interviewee 3, personal communication, February 4, 2025).

The interaction and coupling classification in Table 6.8 highlights that the permitting process was tightly coupled, as there was no flexibility for alternative workflows once the incorrect permit was submitted and this specific permit was required. The entire project delivery was dependent on this approval, which means that any delay in correcting the permit had direct and immediate consequences on the project handover. Without the correct permit in place, the contractor was unable to complete the project and no workaround was available to bypass this regulatory requirement.

Despite the tight coupling, the interaction within the process remained linear rather than complex. The permit approval followed a structured sequence, in which the client had to submit the correct documentation and the contractor had to deliver the documents. The process was well understood, with direct information flow and no hidden dependencies. Since the issue comes from a single misstep, there were no unpredictable feedback loops and once the permit was corrected, progress resumed without further disruptions (Interviewee 3, personal communication, February 4, 2025).

**Table 6.8:** Perrow classification of event 1.3

| Dimension | Analysis |
|---|---|
| **Coupling** | Tight coupling: The permitting process was a strict prerequisite, with no alternative workflows available. Any error immediately halted progress. |
| **Interaction** | Linear interaction: The process followed a structured sequence, with clear dependencies and direct information exchange, without unexpected disruptions or feedback loops. |

This classification within Perrow's framework highlights the risks associated with tightly coupled linear processes in regulatory environments. The absence of redundancy in the permitting process meant that a single administrative mistake caused system-wide delays.

The classification of the management approach suggests a predominantly centralised decision-making structure, as shown in Table 6.9. The permitting process was entirely controlled by the client, with no direct involvement from the contractor in securing regulatory approvals (Interviewee 3, personal communication, February 4, 2025). The dependency on a single-point approval process meant that once the incorrect permit was submitted, the contractor had no means to accelerate or influence the resolution process. Although internal adjustments were made within the client's organisation to correct the error, the lack of preventive evaluation mechanisms resulted in an unavoidable interaction. As the interviewee points out, every effort was made within the client to obtain the correct licence on time. Also because they made the mistake of requesting the wrong permit (Interviewee 3, personal communication, February 4, 2025).

**Table 6.9:** Management approach of event 1.3

| Aspect | Description |
|---|---|
| **Applied approach** | The client maintained full control over the permitting process, with no contractor involvement. Interviewee highlights that it was not the concern of the contractor. After the incorrect permit application was identified, responsibilities were restructured within the client's organization to address the issue. |
| **Effectiveness** | The correction process was corrective rather than proactive, meaning that delays were inevitable once the permit issue surfaced. The dependency on the external stakeholder's timeline further exacerbated project delays. |
| **Categorisation** | Centralised: The permitting process was fully managed by the client, with the contractor having no authority to intervene. The absence of redundancy or alternative approval pathways reinforced the tight control structure. |

This revised analysis confirms that the management structure was highly centralised, with the client having exclusive control over the permitting process. The decision to manage permits internally allowed the client to maintain direct oversight and ensure compliance with regulatory requirements. However, this structure also placed the client in full responsibility, requiring proactive coordination and internal resource management to prevent bottlenecks.

### 6.2.2. Event analysis of Case 2

#### Event 1: Platform roof design decisions

In December 2017, critical decisions were made regarding the design and construction of the platform roof, marking a pivotal moment in the project. From the client's perspective, the complexity of this event arose from the interdependence between external constraints and technical execution. Initially, the client intended to retain the original platform roof, but technical evaluations revealed structural inadequacies and the presence of hazardous materials such as chromium VI, making full reuse infeasible. This triggered a need to redesign the roof structure while preserving its historical character, thus introducing both engineering and regulatory challenges (Interviewee 4, personal communication, January 13, 2025).

The interviewee mentioned that external complexity was the root cause, as the requirement to comply with heritage preservation regulations introduced external approval processes that directly influenced project timelines and feasibility. These regulatory restrictions limited the flexibility of design solutions and required formal validation from the governmental and regulatory authorities before any modifications could proceed (Interviewee 4, personal communication, January 13, 2025).

The manifestation of the complexity can be categorised as organisational. Due to the fact that the client only these constraints. The inability to retain the original roof caused engineering challenges that required alternative materials and design solutions while maintaining historical aesthetics (Interviewee 4, personal communication, January 13, 2025). The client mentioned neither they or the contractor had prior experience with this type of integration, further complicating the execution.

**Table 6.10:** TOE categorisation of event 2.1

| Dimension | Description of complexity |
|---|---|
| **Technical** | The technical challenges related to structural redesign and safety compliance were managed by the contractor and specialists. As the client was not directly responsible for design execution, this was not perceived as technical complexity. |
| **Organizational** | The complexity manifested in the coordination of different disciplines and the lack of skills available. The client faced difficulties related to resource and skills availability, and the need to manage interfaces across disciplines. |
| **External** | The complexity was caused by heritage preservation regulations, which imposed legal restrictions on design decisions and required formal validation from regulatory authorities before proceeding. |

The cause of the complexity, as perceived by the client, lay in the external dimension. The project was subject to strict heritage preservation laws that required formal approval of all proposed design changes. These legal restrictions were outside the client's control but had direct consequences on the project.

However, the manifestation of the complexity lay in managing the organisational conditions necessary to enable a compliant and feasible design process. One factor was the lack of internal resources and skills (resource and skills availability) (Interviewee 4, personal communication, January 13, 2025). As the interviewee noted, neither the client nor the contractor had prior experience in integrating heritage structures under such regulatory constraints.

In addition, the client faced complexity in the form of interdisciplinary interfaces (interface management between disciplines). The redesign required constant alignment between heritage, engineering, and environmental requirements, each governed by different actors and approval logics. The client's role was not to resolve technical details, but to ensure that the overall coordination and decision-making process remained coherent, aligned, and timely (Interviewee 4, personal communication, January 13, 2025).

In summary, the complexity for the client was externally caused but organisationally manifested. It was not the technical solution itself that posed the greatest challenge.

When mapped to the Perrow matrix, this event can be placed within the quadrant characterised by tight coupling and complex interactions, as detailed in Table 6.11. The tight coupling resulted from the rigid dependencies between the platform roof's design approval process and its execution. The obligation to reuse the platform roof further restricted flexibility, as deviations from the original intent required regulatory validation, limiting alternative solutions, and enforcing a strict sequence of approvals and implementation.

The complex interaction resulted from the participation of multiple stakeholders, including the client, the contractor, the regulatory authorities, and the heritage preservation bodies (Interviewee 4, personal communication, January 13, 2025). Although the approval process followed predefined steps, the high degree of personnel specialisation and intricate dependencies between approval and execution created an unpredictable dynamic. The partial understanding of processes and the interrelated nature of technical modifications and regulatory compliance added to the complexity, as unexpected feedback loops could arise, influencing both design feasibility and project timelines (Interviewee 4, personal communication, January 13, 2025).

**Table 6.11:** Perrow classification of event 2.1

| Dimension | Analysis |
| --- | --- |
| **Coupling** | Tight coupling: The approval and adaptation of the platform roof design were directly linked to regulatory and executional timelines, leaving little room for flexibility. Additionally, the obligation to reuse the platform roof further tightened the coupling, as deviations required formal approvals. |
| **Interaction** | Complex interaction: While the process required coordination between multiple stakeholders, the dependencies were relatively predictable, with predefined approval steps. However, high personnel specialization, partial process understanding, and interdependent technical and regulatory interactions made the process complex, as feedback loops could lead to unexpected delays and design modifications. |

This classification emphasises that from the client's perspective, the execution of the project was highly constrained by external regulatory obligations, making deviations difficult to manage. Although the approval processes followed a structured path, the interactions between technical feasibility and external constraints created a complex web of dependencies, reinforcing the need for close coordination and proactive risk management throughout the project (Interviewee 4, personal communication, January 13, 2025).

The management approach applied for this event was a shared governance model, where decision making was collaborative while the ultimate responsibility remained with the client (Interviewee 4, personal communication, January 13, 2025). Recognising that interdependencies are not determined by contracts alone, but rather by informal collaboration and shared risk sessions (Interviewee 4, personal communication, January 13, 2025). Due to this knowledge and recognition, the client actively engaged the contractor in discussions, ensuring that decisions reflected mutual priorities and constraints. This approach aimed to restore trust, improve communication and effectively manage dependencies while maintaining control over key project goals (Interviewee 4, personal communication, January 13, 2025). The collaborative approach is summarised in Table 6.12.

**Table 6.12:** Management approach of event 2.1

| Aspect | Description |
|---|---|
| **Applied approach** | Shared decision-making through structured coordination meetings, risk assessments, and continuous engagement with the contractor. While the client retained final responsibility, joint evaluations and collaborative problem-solving were important. |
| **Effectiveness** | The collaborative approach ensured that project dependencies were managed efficiently. Although delays occurred, the proactive strategy of shared discussions and risk mitigation reduced their impact. A strict contractual approach was considered but rejected to preserve trust and cooperation. |
| **Categorisation** | Decentralised & Centralised: The project relied on a model where the client maintained control but actively worked with the contractor to resolve challenges. |

The management structure was collaborative, yet structured, acknowledging the mutual dependencies between the client, contractor, and subcontractors. Joint decision making was evident in critical aspects that ensured that risks were evaluated and mitigated together. The client recognised that a rigid, contract-driven approach could have undermined trust and efficiency, opting instead for shared control through frequent coordination meetings and risk reviews.

This event underscores the importance of balancing structured governance with cooperative participation in projects with complex interaction and tight coupling. The experience suggests that early stakeholder alignment, transparent communication, and coordinated risk management contribute significantly to reducing disruptions. Although the client retained overall accountability, the effectiveness of the approach lay in leveraging collective expertise to navigate challenges, ultimately enhancing the resilience of the project.

#### Event 2: Delayed delivery of switch tracks

Late delivery of railway switches has been the biggest issue in this event (Interviewee 4, personal communication, January 13, 2025), putting planned track completion in danger and forcing potential changes to the railway layout. The supplier warned that they could not deliver on time, which caused an urgent problem that neither the client nor the contractor could directly control. Although the contractor was officially responsible for the procurement, the client decided to step in and share ownership of the issue (Interviewee 4, personal communication, January 13, 2025). By actively working with the supplier, they helped ensure that the switches were delivered on time. This intervention was crucial in preventing extreme project delays.

From the client's perspective, the cause of the complexity was external, as the problem arises externally due to the supplier's inability to meet the delivery timeline. This created an unavoidable dependency on a third party, over which the project team had no direct control (Interviewee 4, personal communication, January 13, 2025). The absence of alternative suppliers further intensified the issue, making it a critical external constraint that directly affected the execution of the project.

The manifestation of complexity was organisational, as the delay forced the client to take a more active role in risk management than originally planned (Interviewee 4, personal communication, January 13, 2025). The client had to intervene in a process that was contractually assigned to the contractor, reallocating resources, and engaging directly with the supplier to ensure delivery (Interviewee 4, personal communication, January 13, 2025). This shift altered the governance structure of the project and introduced additional coordination efforts, highlighting how an external constraint transformed into an internal management challenge.

**Table 6.13:** TOE categorisation of event 2.2

| Dimension | Description of complexity |
| --- | --- |
| **Technical** | The delayed switch delivery posed a major technical risk, requiring immediate intervention to avoid extensive modifications to the railway layout. Nevertheless, no technical complexity elements are affected (Interviewee 4, personal communication, January 13, 2025). |
| **Organizational** | The client assumed an active role in supplier management due to a lack of confidence in the contractor's ability to resolve the issue independently. |
| **External** | The root cause was fully external, as the supplier controlled delivery timelines. The client's ability to influence this external stakeholder played a decisive role in the resolution. |

Unlike other project risks, this issue was primarily external because the control was beyond the control of both the client and the contractor. The absence of alternative solutions meant that the engagement with the supplier was the only viable risk management strategy (Interviewee 4, personal communication, January 13, 2025). Although the formal responsibility for procurement was with the contractor, the urgency of the situation caused the client to assume shared responsibility and actively engage with the supplier to secure a timely solution (Interviewee 4, personal communication, January 13, 2025). The client highlighted that the whole project was dependent on the delivery of the rail switches. By going beyond its contractual obligations, the client helped prevent significant disruptions that would have forced major adjustments to the design of the railway track. This intervention highlights the importance of proactive engagement in the cases of tightly coupled externally driven risks (Interviewee 4, personal communication, January 13, 2025).

**Table 6.14:** Perrow classification of event 2.2

| Dimension | Analysis |
| --- | --- |
| **Coupling** | Tight coupling: The supplier's failure directly impacted the project, forcing immediate intervention by the client. No alternative supplier options meant the project was highly sensitive to this disruption. |
| **Interaction** | Linear interaction: The process itself followed a predictable and structured sequence: order, production, delivery, installation. There were no unexpected feedback loops or interwoven system behaviours. |

The Perrow classification confirms that the tight coupling of this issue left the project highly vulnerable to supply chain disruptions. The inability to replace the supplier or reconfigure the supply chain without external intervention increased the project's exposure to single-point failures (Interviewee 4, personal communication, January 13, 2025). Furthermore, the linear interaction between supplier performance and project execution meant that the failure followed a predictable sequential path: the supplier's delay directly affected delivery, installation, and overall scheduling. There were no feedback loops or cascading effects. Once the issue was identified, it could be addressed through direct escalation and coordination between the client and the supplier (Interviewee 4, personal communication, January 13, 2025). This classification reinforces the importance of integrating supplier risk assessments into early stage project planning, ensuring that potential disruptions can be anticipated and mitigated before they escalate to critical delays.

The management structure to resolve switch delivery delays was characterised by shared control, where the client assumed an active role despite not being contractually responsible (Interviewee 4, personal communication, January 13, 2025). Recognising the high-risk nature of the delay, the client directly engaged the supplier to ensure prioritisation, effectively bridging the gap between supplier constraints and project needs (Interviewee 4, personal communication, January 13, 2025). This proactive approach prevented disruptions, kept the project on schedule, and demonstrated the value of flexibility in managing external dependencies (Interviewee 4, personal communication, January 13, 2025).

**Table 6.15:** Management approach of event 2.2

| Aspect | Description |
|---|---|
| **Applied approach** | The client took an active role in supplier coordination despite not being contractually responsible, ensuring prioritization and risk mitigation. |
| **Effectiveness** | This proactive intervention prevented significant delays, allowing the project to stay on schedule. The client's engagement filled a critical gap between supplier constraints and project demands. |
| **Categorisation** | Decentralised: The contractor remained responsible for procurement, but the client intervened due to external supplier risks. The client did not dictate procurement decisions but influenced critical risk mitigation measures, and provided financial resources, making this a shared governance model rather than a strictly hierarchical or autonomous approach. |

This table summarises the management approach taken to address switch delivery delays, demonstrating that decentralised governance was necessary to effectively handle this high-risk situation. The client's intervention compensated for supplier shortcomings, even though procurement was formally the contractor's responsibility. This highlights the need for adaptive governance, where external dependencies require flexible decision making beyond strict contractual boundaries. Interviewee 4 indicated that this was only possible due to the sense of ownership of the project. Higher organisational layers did not have this and stuck to contractual agreements. Ownership of the project is a crucial factor in effective management of risks and interdependencies (Interviewee 4, personal communication, January 13, 2025).

### Event 3: TVP scheduling challenges

The rescheduling of the TVP in November 2018 was a critical element of project execution that required proactive planning, stakeholder coordination, and risk management. Using the TOE framework, this event can be analysed by distinguishing the cause of complexity and its manifestation across technical, organisational, and external dimensions.

The cause of complexity in this event was organisational, as the primary challenge arose from the need for coordination between multiple stakeholders, including the operational client, contractor, and railway teams (Interviewee 4, personal communication, January 13, 2025). The requirement to align TVP with long-term rail operational schedules meant that delays or misalignments in planning could have led to significant disruptions. Additionally, the need to engage all relevant parties early and manage differing interests introduced organisational dependencies that had to be navigated carefully.

The manifestation of complexity was technical, as rescheduling directly affected the execution of track renewals, safety system updates, and logistical operations. The effectiveness of these activities depended on precise sequencing and resource availability. Any misalignment in scheduling or delays in approvals would have had a direct impact on the ability to execute planned work within the available time frame (Interviewee 4, personal communication, January 13, 2025).

**Table 6.16:** TOE categorisation of event 2.3

| Dimension | Description of complexity |
|---|---|
| **Technical** | The TVP was critical for completing major construction tasks, such as track renewals and safety system updates, requiring precise coordination and sequencing to avoid disruptions. This was where complexity manifested. |
| **Organizational** | The complexity originated from the need for coordinated decision-making between the client, contractor, and operational railway authorities. Misalignment in planning could have led to severe scheduling conflicts and inefficiencies. |
| **External** | The TVP schedule was influenced by external conditions such as weather constraints and regulatory approvals, requiring built-in flexibility to mitigate potential disruptions. |

This classification highlights that the organisational cause of complexity came from the need to align multiple stakeholders and ensure efficient communication to prevent misalignment in scheduling. This complexity manifested technically, as any deviation from the plan directly impacted the feasibility of the construction and safety operations scheduled within the TVP.

Applying Perrow's framework to this event helps determine the degree of coupling and interaction complexity within the rescheduling process.

**Table 6.17:** Perrow classification of event 2.3

| Dimension | Analysis |
|---|---|
| **Coupling** | Loose coupling: While the TVP was essential for scheduled work, the flexibility in project scheduling allowed adjustments without major cascading failures. |
| **Interaction** | Linear interaction: The interactions were predictable, with established protocols guiding railway closures and coordination. |

The classification of this event within Perrow's matrix emphasises that the TVP scheduling process was loosely coupled, which means that although the event was significant, its impact on the broader project could be managed by minor adjustments without causing extensive disruptions. Unlike tightly coupled systems, where a single delay can have widespread consequences, TVP adjustments remained adaptable (Interviewee 4, personal communication, January 13, 2025).

Furthermore, the linearity of the interactions in this event was attributed to clear scheduling frameworks and predefined coordination protocols that guided decision-making. The stakeholders had a structured process to discuss and resolve scheduling conflicts, ensuring predictability and minimising unforeseen risks (Interviewee 4, personal communication, January 13, 2025).

This classification underscores that proactive planning, structured coordination mechanisms, and flexible decision making contributed to the successful execution of the TVP scheduling process, reinforcing the importance of adaptability in loosely coupled systems.

The management approach of this event was characterised by decentralised coordination, allowing multiple stakeholders to collaboratively oversee adjustments while maintaining project alignment. Rather than imposing a centralised directive, the client and the contractor actively engaged in shared decision-making, ensuring that the rescheduling process remained adaptable to changing circumstances (Interviewee 4, personal communication, January 13, 2025).

**Table 6.18:** Management approach of event 2.3

| Aspect | Description |
|---|---|
| **Applied approach** | A decentralised and flexible management structure was used, allowing different teams to coordinate tasks efficiently while adapting to emerging constraints. |
| **Effectiveness** | The collaborative approach led to a well-executed TVP, with all planned works completed on time, minimizing operational disruptions. |
| **Categorisation** | Decentralised: Decision-making authority was distributed across multiple parties, ensuring adaptability and efficiency in responding to scheduling constraints. |

The decentralised approach proved effective in loosely coupled systems, as it enabled real-time adjustments while avoiding unnecessary escalation of scheduling conflicts. Relying on proactive stakeholder participation, structured contingency planning, and collaborative risk assessment ensured that the TVP was successfully rescheduled with minimal disruption.

This case highlights the effectiveness of adaptive management strategies in rail infrastructure projects, demonstrating that when interdependencies are well defined and flexible, a decentralised approach fosters resilience and operational efficiency.

## 6.3. Conclusion of client perspective

The analysis of project events from the client's perspective reveals clear patterns in interdependencies, the degree of coupling, and the governance structures applied to manage project risks. These patterns provide insight into how the client approached decision-making, risk mitigation, and project control. With this insight, the third sub-question can be answered:

> ***How are client-contractor interdependencies managed and risk mitigation strategies applied in practice from client perspective?***

Table 6.19 summarises the key events, their classification within the Perrow matrix, and the management structures applied from the client's perspective.

**Table 6.19:** Summary of findings from the client perspective

| Event | Interdependency type | Perrow categorisation | Applied management structure | Effectiveness |
|---|---|---|---|---|
| Lack of choice regarding alignment | Organisational & Technical | Tight coupling, Linear interaction | Centralised | Delays due to rigid approval processes and limited flexibility. |
| Track stability issue | Organisational & External | Loose coupling, Linear interaction | Centralised | Successful cost and schedule control through external procurement. |
| Permitting bottlenecks | Organizational & External | Tight coupling, linear interaction | Centralised | High risk propagation due to regulatory delays and lack of contractor influence. |
| Platform roof design changes | External & Organizational | Tight coupling, Complex interactions | Centralised & Decentralised | Ensured compliance but led to extended approval timelines. |
| Delayed delivery of railway switches | External & Organisational | Tight coupling, Linear interaction | Centralised transitioning to shared control | Client intervention successfully mitigated risk, preventing major disruptions. |
| TVP scheduling adjustments | Organizational & Technical | Loose coupling, Linear interaction | Decentralised | Highly effective due to proactive planning, flexibility and stakeholder engagement |

A pattern emerges across these events, showing that the client's governance model was adapted to interdependencies, with centralisation applied in regulatory-dependent situations and decentralisation used when flexibility was required, such as in TVP scheduling and external procurement. The client prioritised risk mitigation through structured control mechanisms, ensuring that major decisions remained within its authority. This approach was effective in ensuring compliance with regulations, quality control, and financial oversight, but frequently caused delays due to rigid approval structures and limited flexibility for rapid adjustments.

One key observation is that interdependencies between organisational complexity and external complexity were the primary drivers of project risks, often outweighing purely technical challenges. Organisational complexity often arises from structured decision-making hierarchies, while external complexity arises due to regulatory constraints, stakeholder dependencies, and supply chain risks. Although technical complexities existed, from the client's perspective, the interdependencies evolved mainly from organisational bottlenecks due to the structured decision-making hierarchy and external dependencies, such as regulatory approvals. The strict control over specifications and contractor responsibilities ensured consistency but also restricted adaptability, making it difficult to react efficiently to unforeseen challenges.

Tight coupling was present in most events, which means that once an issue arose, it had an immediate impact on project progress, with limited alternative pathways for mitigation. When centralised governance was applied, meaning that the client retained full decision-making authority, delays were common due to procedural constraints and bureaucratic dependencies. In contrast, loosely coupled events, such as external procurement for track stability issues or TVP scheduling adjustments, were managed more effectively due to greater flexibility and risk-sharing.

The strict control of the client over the permitting and design processes contributed to project bottlenecks, particularly in cases where approvals were required before the contractor could proceed. The permitting process, for example, demonstrated the limitations of a centralised structure in regulatory-dependent scenarios, as the contractor had no control over risk mitigation. This suggests that for highly regulated processes, early-stage risk assessment and redundancy planning should be integrated into the client's governance model to avoid similar delays.

However, there were also cases where the client successfully adapted its governance approach, particularly when external pressures forced a shift from rigid control to shared responsibility. The switch delivery issue highlighted the benefits of transitioning from a centralised to a shared control model, where the client intervened despite procurement being the contractor's responsibility. This proactive risk management strategy prevented major disruptions, suggesting that in critical, tightly coupled scenarios, a more flexible, interventionist approach leads to better project outcomes.

The most successful governance approach was observed in the TVP scheduling adjustments, where a decentralised and collaborative model was applied. The client facilitated proactive stakeholder engagement, structured contingency planning, and adaptive scheduling, which resulted in an efficient and well-coordinated execution. This case demonstrates that, for loosely coupled interdependencies with predictable interaction patterns, decentralised governance enhances adaptability and efficiency.

Overall, the findings suggest that in tightly coupled and complex interdependencies, a rigidly centralised model leads to delays and inefficiencies, while a structured but adaptive governance approach results in better project outcomes. The client's ability to balance control with flexibility, particularly in critical supply chain dependencies and regulatory processes, is key to minimising project risks. In future projects, the implementation of hybrid governance models, where structured oversight is combined with adaptable mechanisms, will help ensure compliance and financial control while allowing faster response times and improved collaboration with contractors and external stakeholders.

This analysis reinforces the importance of context-specific governance models, where the degree of control is aligned with the nature of interdependencies. Tightly coupled, regulatory-dependent processes require early risk identification and structured flexibility, while loosely coupled operational processes benefit from decentralised decision making and proactive collaboration. Future projects that integrate these governance principles will be better equipped to handle interdependencies in complex construction environments.

# 7 Differences between client and contractor

This section provides an in-depth evaluation of the differences in how clients and contractors categorise interdependencies, classify events within the Perrow framework, and apply management structures in construction projects. These distinctions, derived from empirical findings in Chapters 5 and 6, reveal variations in how both parties perceive, manage, and mitigate risks. By focussing on these differences, this analysis aims to contribute to strategies to improve risk mitigation through better alignment and management of client-contractor interdependencies and to answer the last sub-question.

***What strategies can be developed to improve risk mitigation through better management and more alignment of client-contractor interdependencies?***

## 7.1. Differences in interdependency categorisation

The analysis of Chapters 5 and 6 highlights a difference in how interdependencies are classified and experienced by clients and contractors. Although both parties operate within the same project and in the same event, their perspectives on complexity and interdependency diverge , shaped by their respective roles and responsibilities.

Clients primarily classify interdependencies in terms of organisational and environmental complexity, focussing on factors such as regulatory dependencies, financial structures, and stakeholder alignment. From their perspective, interdependencies emerge as a result of external constraints that require structured management and oversight. These dependencies are often perceived as loosely coupled, meaning that, while they influence the project, they are seen as controllable through predefined frameworks and contractual agreements. Clients tend to view dependencies as manageable risks that can be mitigated by establishing clear procedures, approval pathways, and governance structures, ensuring that all stakeholders involved adhere to a coordinated process.

Contractors experience interdependencies as operational constraints, where dependencies manifest in workflow disruptions, resource bottlenecks, and sequencing conflicts. Rather than viewing complexity as a structured system that can be navigated through formalised processes, contractors experience dependencies as tightly coupled interactions, where one delay or constraint rapidly escalates into a series of disruptions across the project. Their classification of interdependencies is largely execution-driven, focussing on how decisions, approvals, and external factors affect the continuity and feasibility of on-site activities. Dependencies related to material procurement, subcontractor coordination, and approval timelines are perceived as critical, time-sensitive constraints that require immediate responses rather than procedural oversight.

A pattern emerges in the classification of the interdependencies between the two perspectives. Clients perceive dependencies as structured relationships that can be addressed through coordination and planning, while contractors experience them as immediate constraints that directly impact execution. This leads to a fundamental misalignment in how interdependencies are categorised. Clients focus on their origin and governance, while contractors emphasise their manifestation in project execution. The same interdependency may be classified by the client as an administrative or contractual dependency, while the contractor experiences it as a direct limitation to progress on-site.

The observed difference in interdependency classification between clients and contractors appears to reflect more than a difference in perspective. It suggests a potential structural misalignment in the way complexity is approached in practice. In the interviews conducted for this research, project managers on the client side tended to classify interdependencies in terms of governance mechanisms, such as decision-making authority and contractual boundaries, while project managers on the contractor side focused more on operational implications, including task sequencing and on-site coordination. Although based on a limited number of interviews, this contrast indicates that interdependency is interpreted through the lens of each actor's role and responsibilities within the project structure. These preliminary findings point to the value of adopting a more integrated classification framework, such as combining governance-based and execution-based perspectives, to ensure that both formal and practical interdependencies are adequately addressed. Further research with a larger sample could help validate and expand these insights.

## 7.2. Differences in Perrow classification

The classification of events within the Perrow framework highlights a difference in how clients and contractors perceive the complexity of coupling and interaction. The interpretation of events is directly influenced by the way each party experiences interdependencies. Although both clients and contractors face the same project events, their classification within the Perrow matrix diverges systematically due to the differing conceptions of the complexity of the project. As Mikkelsen (2020) states, *"project complexity exists in the eye of the beholder."*.

Clients predominantly classify events as tightly coupled with linear interactions. Since their perspective is driven by governance and financial oversight, they experience dependencies as strictly interconnected with little flexibility for alternative solutions. However, they also assume that the interactions remain structured and predictable, following predefined approval processes and oversight mechanisms. This classification reflects the structured approach in which clients manage risk: controlling key dependencies through centralised oversight, procedural control, and contractual constraints. For example, in the case of track stability, the client classified the event as tightly coupled, as the resolution required a sequential process with no alternative paths available once the external solution was engaged. However, they considered the interaction to be linear, assuming that the issue would be resolved in a structured, step-by-step manner without unforeseen complications.

Contractors also classified many events as tightly coupled but often identified interactions as complex rather than linear. Since contractors experience the direct operational impact of constraints, they are more likely to perceive dependencies as having unpredictable consequences and cascading effects. In the case of track stability, the contractor similarly recognised the tight coupling, as the work sequence could not continue until stabilisation was complete. However, from the contractors perspective the interaction was not purely linear. External dependencies introduced uncertainty in the sequencing and feedback loops, meaning that even when the stabilisation process followed a predefined sequence, unforeseen delays in one phase could disrupt multiple aspects in other phases.

The analysis reveals a pattern in the way clients and contractors classify events within Perrow's framework. Both classify dependencies as tightly coupled, indicating that once a constraint is in place, neither party sees significant flexibility in alternative solutions. However, the classification of interaction complexity diverges. Clients assume linear interactions, as they view risks through structured and predefined processes. Contractors, however, frequently classify interactions as complex because of their direct exposure to cascading disruptions. This divergence reinforces the fundamental difference in complexity perception.

Although Perrow's framework was originally designed to objectively classify technical systems based on their structural characteristics, this thesis demonstrates that such classifications become inherently subjective in multi-actor project environments. The interpretation of coupling and interaction is not fixed, but shaped by the differing perspectives, roles, and responsibilities of stakeholders. Clients and contractors may face the same event but classify it differently due to their distinct positions within the project system. As a result, the Perrow framework, when applied outside purely technical contexts, reflects not only system properties but also actor-specific perceptions of risk and complexity, making the classification process interpretive rather than deterministic.

## 7.3. Applied management structures and their impact

The management structures applied by clients and contractors in construction projects differ significantly. These differences directly influence how interdependencies are managed and how efficiently risks are mitigated. The analysis of governance structures in Chapters 5 and 6 reveals a clear contrast in management philosophies, where clients typically adopt centralised, compliance-driven oversight, whereas contractors operate under decentralised, execution-orientated management models.

Clients predominantly structure their management approach around centralised governance, ensuring control over budget allocation, regulatory compliance, and stakeholder coordination. This structure emphasises formalised decision-making hierarchies, where approvals must pass through multiple levels before implementation. Reliance on strict approval processes, while ensuring adherence to contractual and regulatory obligations, often results in limited flexibility, making it difficult to quickly adapt to evolving project conditions. For example, in the case of permitting bottlenecks, the client's insistence on structured procedural oversight led to delays, as the contractor had no authority to manage regulatory risks proactively. Although this approach ensured compliance, it restricted agility, creating bottlenecks that affected execution timelines.

Contractors try to operate under decentralised and reactive governance models, focussing on flexibility and execution efficiency. Their management approach prioritises real-time adaptation to operational risks, allowing immediate adjustments in scheduling, resource allocation, and subcontractor coordination. Although this decentralised approach enables a rapid response to project uncertainties, it can lead to fragmented risk ownership when coordination with the client is insufficient. In the event of delays in the procurement of railway switches, the contractor faced execution challenges due to supply chain dependencies that were outside their direct control. The lack of joint governance mechanisms meant that while the contractor had the responsibility to manage procurement, they lacked the authority to intervene in upstream supply chain risks, resulting in cost overruns and scheduling interruptions.

A pattern emerges in the applied management structures. Clients prefer centralised governance for structured oversight, which ensures compliance and financial control but often leads to decision-making bottlenecks and slow adaptability. Contractors, on the contrary, rely on decentralised models, allowing for executional agility but facing challenges in coordinating risks beyond their immediate control. The most effective governance models observed in the case studies involved shared responsibility, where decision-making authority was distributed based on interdependency complexity and project phase. When both the client and the contractor collaborated in risk mitigation, such as in TVP scheduling and procurement negotiations, project results improved, with fewer delays and greater adaptability.

Ultimately, the difference in management structures between clients and contractors is due to their distinct priorities. Clients focus on controlling financial and regulatory risks, leading to hierarchical decision making and procedural oversight. Contractors focus on execution efficiency and adaptability, resulting in flexible but sometimes fragmented risk ownership. This divergence underscores the need for hybrid governance models, where structured oversight is combined with adaptable mechanisms to balance compliance and execution efficiency.

## 7.4. Potential strategy to improve risk mitigation

The comparative analysis between clients and contractors reveals misalignment in how interdependencies are perceived, classified, and managed. Although clients tend to interpret interdependencies as tightly linear, contractors experience the same dependencies as tightly coupled and operationally disruptive, requiring responsive and adaptive approaches. These contrasting views lead to inefficiencies in mitigation and governance. An example is the different management structures in the delayed railway switches event. This event underscores that successful project execution requires both structured responsibility and the flexibility to adjust when critical risks arise. The lack of alternative suppliers and the urgency of the issue forced the client to step beyond a passive role, yet without taking full ownership of the procurement, reinforcing why this case does not fit a fully centralised or decentralised classification.

To address this gap, a hybrid governance strategy offers a promising direction. Hybrid governance is not simply a compromise between centralised and decentralised structures, but a context-sensitive approach that aligns management structures with the nature of the interdependencies present. Because the nature of the interdependency can be categorised differently, a management structure that adapts to the specific situation and the classification is needed. Within a hybrid governance model, strategic decisions and high-risk areas remain centralised, ensuring oversight, compliance, and coherence with organisational objectives. The hybrid part is formed by operational decisions and local project adaptations are decentralised, empowering those with contextual knowledge to act quickly and effectively.

The hybrid governance structure is flexible in its form and adapts to the dynamic character of interdependency classification. In the case studies, three recurring variants were observed:

- Governance by exception: Local actors are empowered to decide autonomously unless a predefined threshold is reached, at which point central oversight is triggered.
- Standardised frameworks with local adaptability: Risk protocols and processes are centrally defined but tailored to specific project circumstances, allowing consistency and responsiveness.
- Shared governance platforms: Digital tools, regular alignment meetings, and joint dashboards support transparency and collective decision-making.

Importantly, hybrid governance is not unilaterally imposed. It emerges through negotiation and shared recognition of the complexity involved. The study shows that neither the client nor the contractor can or should define governance structures in isolation. Instead, governance arrangements evolve iteratively in response to the classification of interdependencies, the degree of trust between parties, and the distribution of relevant expertise. In this sense, governance is not only a structural or managerial function, but also a relational process, grounded in communication quality, mutual respect, and the willingness to share control when project conditions demand it.

By aligning the governance structure with the actual interdependencies encountered in the project, hybrid governance enables more effective risk mitigation. It allows project teams to balance control and adaptability, avoid rigid or fragmented responses, and ultimately create a more resilient and collaborative project environment.

## 7.5. Evaluation of findings

To ensure that the findings in this study reflect the perspectives of both clients and contractors, a structured approach was taken in the evaluation of the interview data. The evaluation process consisted of three key steps: confirm key project events in interviews, collect detailed information during interviews, and briefly verify the accuracy of the interpreted responses afterward.

Before conducting the interviews, a short survey was sent to each participant to help them recall critical project events and verify that the selected moments were indeed the most significant. This ensured that discussions remained focused on the most relevant occurrences and that both interviewees from the same project, both clients and contractors, were aligned in terms of which events were considered central to project outcomes. The survey responses also helped to structure the interviews, allowing targeted questioning of how interdependencies influenced risk management strategies.

The interviews themselves served as the primary method for collecting qualitative insights, providing a deeper understanding of how interdependencies were experienced and managed in practice. Through structured discussions, project managers explained the causes and consequences of key events, described their decision-making processes, and reflected on how risk mitigation strategies were applied. Particular attention was paid to how interdependencies shaped the complexity of events, whether challenges were perceived as technical, organisational, or environmental, and whether they were classified as tightly or loosely coupled within the Perrow framework.

After completing the interviews, a short follow-up step was taken to confirm whether the extracted information accurately reflected the perspectives of the interviewees. Instead of presenting a complete analysis for validation, key responses were summarised and sent back to the respective participants, allowing them to confirm that their statements had been correctly understood and interpreted. This was a brief but important step to ensure that no misrepresentations occurred before the data was formally analysed. In some cases, minor refinements were made based on this feedback, further strengthening the accuracy of the findings.

By integrating these steps, the study ensured that the classification of interdependencies, risk perceptions, and applied management structures were grounded in real-world experiences while maintaining consistency with theoretical frameworks. The survey before the interviews provided a foundation for selecting key events, the interviews themselves served as the main source of empirical data, and the short post-interview confirmations acted as a safeguard to ensure that the interpretations remained true to the perspectives of both clients and contractors. This structured approach strengthened the reliability of the study findings while maintaining a balance between theoretical classification and practical industry insights.

# 8 Discussion

This discussion is structured as follows: first, the findings will be interpreted in relation to the expectations set by the theoretical framework, including an assessment of risk management strategies employed by contractors and how these compare to the risk expectations from the matrix of Perrow (2011). Second, the discussion will contrast the perspectives of contractors and clients, examining how decision-making structures influence project execution. Finally, the broader implications of these findings for the construction industry will be explored, followed by an evaluation of the limitations of the study and recommendations for future research.

## 8.1. Interpretation of findings

The results of this study show that the dynamics between the client and the contractor in construction projects is influenced by how interdependencies are classified, interpreted, and managed. An empirical insight is that these interdependencies are not neutral or purely technical in nature, but are socially constructed through the distinct roles, priorities, and perspectives of the stakeholders involved. This means that the classification of complexity, and by extension the governance response, is shaped as much by perception and organisational logic as by objective project features.

The case studies reveal diversity in the way clients and contractors mitigate risks. Clients tend to prioritise quality assurance, legal compliance, and financial control, often assuming that contractors are primarily motivated by profit. This perception drives the implementation of control-orientated governance structures focused on financial oversight and procedural enforcement. In contrast, contractors prioritise time efficiency and operational workability, favouring flexibility and responsiveness in decision making. This misalignment can lead to increased friction, particularly when governance decisions are based solely on formal contractual logic rather than mutual understanding and joint responsibility.

This divergence becomes visible in the way in which interdependencies are classified. Identical project events are interpreted differently by each party. Clients may categorise a situation as tightly coupled and requiring central control, while contractors may see the same situation as loosely coupled and solvable through local autonomy. This subjective classification could result in the application of misaligned governance structures, which in turn generates delays, escalations, or procedural inefficiencies.

To address these issues, a hybrid governance strategy offers a promising alternative. Within a hybrid governance model, strategic decisions and high-risk areas remain centralised, ensuring oversight, compliance, and coherence with organisational objectives. The hybrid part is formed by operational decisions and local project adaptations that are decentralised, empowering those with contextual knowledge to act quickly and effectively. In practice, hybrid governance involves a flexible and collaborative approach to project management. One that acknowledges the limitations of rigid structures and instead promotes shared responsibility, adaptability, and relational coordination in response to emerging complexity.

Another empirical finding is that shared control, where responsibilities and decisions are jointly managed, results in better risk mitigation than purely internal or external control structures. Internal control (where one party governs all decisions within its domain) and external control (where one party depends on another to manage risks) both turned out to be inadequate in the researched settings. In contrast, shared control allows for proactive and flexible responses to emerging risks, provided that trust, transparency, and communication are sufficiently established. This supports the recommendation for a hybrid governance model.

The introduction of a communication coach in both cases further underlined this point. Both clients and contractors acknowledged that this role improved trust, reduced escalations, and facilitated joint decision-making. The presence of a neutral intermediary created space for collaborative problem-solving, shifting the governance dynamic from adversarial to co-productive.

Finally, analysis of cash flow data adds a financial dimension to these insights. Cash flow deviations not only reflected project progress but also signalled the underlying quality of cooperation. In situations of low trust, financial agreements became more rigid, limiting flexibility and responsiveness. In contrast, where trust was high and communication effective, cash flow arrangements supported rather than restricted operational management.

In sum, this thesis demonstrates that hybrid governance enhances project performance in complex, interdependent settings by aligning decision-making structures with the actual and perceived characteristics of the interdependencies involved. It also establishes that governance is not a static top-down design choice but a negotiated process shaped by the interaction of roles, perceptions, and evolving relationships throughout the project lifecycle.

## 8.2. Research use in practice

This research provides a theoretical basis for improving the alignment between project governance, risk management, and collaboration in complex construction projects. The findings demonstrate that many project challenges arise not from isolated risks, but from interdependencies between processes, actors, and systems that are interpreted differently by clients and contractors. These different interpretations influence how complexity is managed, how responsibilities are distributed, and how governance structures are selected.

A practical implication of the study is that awareness of interdependencies must become an integral part of risk management and governance design. This begins with the classification of interdependencies at the beginning of the project, using a combination of the TOE framework and the Perrow matrix. By identifying whether the interdependencies are technical, organisational, or environmental, and assessing the degree of coupling and interaction complexity, both the client and the contractor can establish a shared understanding of the complexity profile of the project. This joint classification reduces the risk of fragmented governance and provides a basis for further project coordination.

The findings indicate that the nature of interdependencies should inform the choice of governance structure. Research shows that when interdependencies are classified differently by stakeholders, it often leads to mismatched governance. For example, enforcing centralised control in highly complex and dynamic environments can result from unaligned interpretations of project complexity.

In practice, this means that governance should not be chosen on the basis of contract type or organisational tradition, but derived from the jointly assessed interdependency profile of the project. Hybrid governance in particular offers a suitable response when strategic control must coexist with operational flexibility. It combines formal oversight with the ability to respond adaptively to dynamic project conditions. In both case studies, hybrid governance was observed in the form of shared decision-making bodies , structured escalation protocols, and transparent communication platforms.

To support this, structured communication mechanisms are necessary. Research shows that communication quality is a key determinant of trust, alignment, and risk sharing. The introduction of a communication coach in both cases provided a neutral platform to eliminate surface tensions, align interpretations, and reduce escalation. Such roles can support the ongoing coordination required by hybrid governance structures.

In addition, the study highlights the importance of early value alignment. Differences in strategic priorities, such as emphasis on time, cost, or quality, often reflect deeper differences in how interdependencies are perceived and acted upon. By linking value discussions with interdependency classification, teams can ensure that governance decisions and risk mitigation strategies are aligned with shared project goals.

Finally, the findings point to the need for periodic reassessment. Because interdependencies and complexity perceptions evolve over the course of a project, governance structures must be reviewed regularly to remain effective. This adaptive approach ensures that the structures chosen continue to match the realities of the project and the expectations of the stakeholders.

In summary, this research offers a practical contribution by demonstrating how interdependencies can serve as a basis for adaptive governance in construction projects. By jointly classifying complexity, selecting appropriate governance structures, embedding hybrid coordination mechanisms, and maintaining alignment through communication and trust, organisations can improve collaboration and improve project performance in complex environments.

## 8.3. Connection to previous literature

This research builds on and extends previous studies on risk mitigation, complexity, and interdependencies in construction projects, contributing to theoretical and practical discussions. By integrating the Normal accident theory of Perrow (2011), the TOE framework of Bosch-Rekveldt et al. (2011), and combination research such as Baccarini (1996), Coze (2023), and Hopkins (1999), this study refines existing frameworks and offers new insights into how risk mitigation can be tailored to interdependency structures.

One of the key findings is that risk mitigation in construction is most effective when clients and contractors align their objectives and priorities. This aligns with previous research by Collinge (2012), who emphasised the importance of stakeholder alignment in complex projects. Similarly, Cordova et al. (2023) highlight that moving beyond reactive strategies to proactive risk planning improves project outcomes. This study confirms these insights by showing that projects with a shared understanding of risks between clients and contractors experience fewer interruptions and more efficient decision making (Cordova et al., 2023).

Another key contribution of this research is its application of Perrow (2011)'s matrix to construction projects. Coze (2023) discusses how coupling and complexity impact risk in global systems, suggesting that highly interconnected environments require structured but flexible governance. This study applies these principles to construction risk management, demonstrating that tightly coupled complex projects require structured governance, whereas loosely coupled systems can benefit from more decentralised approaches (Coze, 2023; Hopkins, 1999; Perrow, 2011).

In addition, this research contributes to discussions on risk allocation and governance structures in construction projects. Studies by Shrestha et al. (2019) and Siraj and Fayek (2019) highlight how misaligned risk allocation can increase project costs and delays. The findings of this study reinforce this view, showing that governance structures must be adaptive to reflect real-world project interdependencies.

Finally, research refines the TOE framework of Bosch-Rekveldt et al. (2011) by showing that complexity can have a cause and manifestation, resulting in interdependencies that overlap the categories. This challenges previous applications of the framework, which assume clear separations between categories. The study suggests that future research should explore integrated approaches to modelling interdependencies.

All these connections mean that this study confirms and builds on previous research, demonstrating that risk mitigation strategies in construction must balance control with adaptability. By refining the matrix of (Perrow, 2011) and the TOE framework of (Bosch-Rekveldt et al., 2011) with a focus on the interdependence (Baccarini, 1996) between the client and the contractor, this research provides a more practical approach to risk categorisation and governance structure. Future research should continue to explore how governance models can be optimised to align with interdependencies, ensuring more resilient and effective risk management strategies.

## 8.4. Limitations

Although this research provides valuable information on the management of client-contractor dependencies and risk mitigation strategies in construction projects, several limitations must be acknowledged.

One major limitation is the availability of data and the selection of events for analysis. The study relied on project documentation, financial records, and interviews with project managers, but some relevant informal decision-making processes and undocumented coordination efforts may not have been captured. Furthermore, key events were identified based on cash flow fluctuations from the contractor's perspective, assuming that significant financial deviations were correlated with critical project challenges. This method, while effective in highlighting major issues involving strong client-contractor relationships, may have excluded interdependencies that were not financially visible but still significant in project execution.

Another limitation is that only two infrastructure projects were analysed, limiting the generalisability of the findings. Although the case studies provided in-depth insight into interdependencies and risk management practices, a broader dataset covering multiple projects would be necessary to establish quantitative relationships. In addition, the study focused exclusively on infrastructure projects, meaning that the findings may not be directly transferable to other types of construction projects, such as residential or commercial buildings. Differences in project scale, procurement methods, and regulatory frameworks suggest that further research is required to assess the applicability of these insights to other sectors.

Furthermore, the research categorised the interdependencies using the TOE framework, which was originally designed for complexity analysis. The framework assumes that technical, organisational, and environmental complexity are distinct categories, but in practice, these boundaries are not always clear. Many interdependencies overlap, influencing multiple project dimensions simultaneously. This limitation suggests that, while the TOE framework is useful for structuring interdependency analysis, future research should explore ways to refine its application to better reflect the interconnected nature of real-world project dependencies.

Finally, the perspectives captured in this study are primarily those of project managers. Although project managers supervise risk management and decision making, their views can be biased toward operational concerns and contractor-client interactions. This makes the classification of the interdependency primary from technical aspects. The inclusion of perspectives from other stakeholders, such as procurement officers, contract managers, or site engineers, could have provided a more holistic understanding of how risk management structures influence project outcomes. In addition, several findings may emerge from the analysis that includes events with a focus on the organisational or environmental aspect.

# 9 Conclusion

This chapter will be divided into two parts. First, the main research question will be answered in. After that, the second part will provide a recommendation for future research, but also a recommendation for practice.

## 9.1. Main conclusion

This study examined how the classification and perception of interdependencies between clients and contractors shape project governance and risk mitigation in complex construction projects. By applying the Normal accident theory (Perrow, 2011) and the TOE framework (Bosch-Rekveldt et al., 2011), the research offers a structured foundation to analyse how technical, organisational, and environmental complexity influence interdependency profiles and decision-making. Through two in-depth case studies, the findings show that interdependencies are not passive constraints, but dynamic drivers of collaboration and risk response, influencing how governance structures are selected and how effectively they function.

*How can interdependencies in client-contractor relationships be identified and analysed using complexity elements on theoretical insights?*

The first sub-question is answered by showing that interdependencies in client–contractor relationships can be systematically identified and analysed by understanding project complexity as a system composed of both causes and manifestations. The TOE framework offers a structured method to categorise the sources of complexity into three dimensions: technical, organisational, and environmental. These categories provide insight into where complexity originates and how it becomes visible within the project, revealing interdependencies between actors, processes, and systems.

The relationship between the cause and manifestation of complexity defines the nature of interdependency. To analyse this further, Perrow's interaction–coupling matrix is applied to assess how tightly the elements are connected (coupling) and how predictably they interact (interaction). This dual classification makes it possible to determine whether interdependencies are linear or complex, loosely or tightly coupled, each with different implications for coordination and risk.

By combining the TOE framework with the Perrow matrix, interdependencies can be identified and classified as theoretically grounded and structured. This enables project stakeholders to assess where risks may arise and how they should be managed. Importantly, the research also finds that such a classification is not always objective. Clients and contractors often interpret complexity differently, leading to divergent views on interdependencies and governance responses. As such, shared classification and early alignment are needed for developing effective and coordinated risk mitigation strategies.

*How are client-contractor interdependencies managed and risk mitigation strategies applied in practice from contractors perspective?*

The second sub-question was answered through empirical case studies. The findings show that, from the contractor's point of view, the interdependencies between the client and the contractor are mainly caused by organisational and environmental complexity, but often manifest as technical and operational limitations during the execution. These interdependencies are related to delayed approvals, regulatory procedures, and external supplier dependencies. From the contractor's point of view, such dependencies are perceived as tightly coupled and complex. They involve limited flexibility, are sensitive to disruptions, and often require immediate resolution without clear control over decision-making.

This classification, tight coupling, and complex interaction reflect how contractors experience the execution environment. Unpredictable, constrained by the client and dependent on continuous coordination. Contractors do not formally document this classification, but their behaviour and interview statements reveal this implicit understanding.

In practice, contractors managed these interdependencies informally and reactively. Risks were addressed through short communication lines, rapid adjustments, and avoidance of formal escalation. Structured risk logs or formal governance instruments were rarely used to report or mitigate interdependency risks. Instead, contractors relied on experience, relational negotiation, and operational problem solving.

A finding was the discrepancy between the formal documentation of the project and the lived reality. Official documents focused narrowly on technical progress, while interviews revealed that many interdependencies, especially those involving friction with the client, remained undocumented. Contractors deliberately avoided reporting conflicts or misalignments, using selective documentation as a containment strategy to preserve flexibility in ongoing contractual discussions and to avoid formal accountability.

Contractors did not actively shape governance structures, but rather adapted to client-defined governance. In centralised structures, this often restricted their ability to apply preventive risk measures. In more decentralised or collaborative arrangements, contractors had greater flexibility in managing interdependencies. Furthermore, the relational climate between client and contractor had a strong influence: in low-trust settings, contractors became more reserved and defensive; in high-trust settings, they were more open to joint problem solving.

In summary, contractors classified interdependencies as tightly coupled and complex, managed them through informal and reactive means, and applied risk strategies shaped by governance constraints, relational dynamics, and execution pressure rather than through formal and structured approaches.

*How are client-contractor interdependencies managed and risk mitigation strategies applied in practice from client perspective?*

The third sub-question examined how governance structures were applied in practice from the client's perspective. The findings indicate that clients primarily managed interdependencies through centralised governance structures, ensuring compliance and financial control, but often causing delays in tightly coupled processes such as permitting and design approvals. Organisational and environmental complexity were the main drivers of project risks, as structured decision-making hierarchies and regulatory constraints limited flexibility. However, when external pressures required a change, the client successfully adapted to shared control, effectively mitigating risks in supply chain dependencies. Loosely coupled interdependencies, such as scheduling adjustments, were managed more efficiently through collaborative and decentralised governance. The findings suggest that a hybrid governance model, which balances structured oversight with adaptive flexibility, improves risk mitigation, and improves project outcomes.

*What strategies can be developed to improve risk mitigation through better management and more alignment of client-contractor interdependencies?*

This research shows that misalignment in the way clients and contractors perceive and manage interdependencies is a challenge in risk mitigation. Clients often approach complexity through formal governance, focussing on control, compliance, and predictability. Contractors, on the other hand, experience complexity as operationally uncertain, time sensitive, and shaped by external dependencies beyond their control. These different perspectives lead to inconsistent governance responses and fragmented risk strategies.

To address this, the findings suggest that hybrid governance emerges as the most appropriate strategy. Rather than imposing a uniform governance model, hybrid governance enables a flexible distribution of decision-making authority in response to the nature of the interdependencies. It allows strategic oversight to remain centralised where control and compliance are necessary, while operational decisions are decentralised to allow responsiveness and contextual adaptation. This approach aligns governance with the complexity and interdependency that is actually experienced in the project and creates the conditions for shared risk ownership, more effective coordination, and ultimately better risk mitigation.

In conclusion, risk mitigation improves when both parties share a common understanding of interdependencies, when governance structures reflect the realities of complexity, and when informal coordination is recognised as part of the actual risk response system of the project.

The final sub-question highlights the fundamental differences in how clients and contractors manage interdependencies and how this affects risk mitigation. Clients assume linear and controllable dependencies, relying on structured decision-making and procedural oversight. Contractors experience complex and unpredictable interactions, where cascading risks require flexibility and real-time adaptation. Effective risk mitigation requires hybrid governance models, where structured oversight is maintained in regulatory-dependent processes, while decentralised collaboration is applied in operational interdependencies. Aligning decision-making authority with the type of interdependency ensures better risk mitigation, improved coordination, and reduced inefficiencies.

Bringing together the findings of the sub-questions, the main research question can now be answered:

> ***How can the management of interdependencies in the client-contractor relationship enhance risk mitigation strategies in complex construction projects?***

The study demonstrates that management of interdependencies requires governance structures that align with the nature of interactions and coupling within a project. Rigid centralised governance structures were found to be successful in events where regulatory compliance, financial oversight, and standardisation were relevant. However, centralised governance turned out to create delays and uncertainty. In contrast, decentralised governance enhances flexibility in loosely coupled interdependencies, where real-time adaptation is needed. To enhance risk mitigation, projects should adopt hybrid governance models that balance structured oversight with adaptable collaboration. This means that in highly regulated, tightly coupled interdependencies, preventive risk strategies should be applied through centralised governance, whereas for operational interdependencies, where complexity is high and interactions are unpredictable, decentralised collaboration allows for more effective risk management.

To bridge the gap between client and contractor perspectives, transparent documentation of interdependencies is important, ensuring that both governance and execution realities are taken into account. By moving beyond rigid contract-driven risk management approaches and adopting interdependency-sensitive governance strategies, construction projects can improve adaptability, improve risk response times, and create more resilient project management frameworks. The ability to integrate structured control where necessary and decentralised flexibility where beneficial is key to mitigating risks and improving coordination in complex construction environments.

## 9.2. Recommendations

Based on the findings of this research, this section provides practical recommendations for contractors to enhance their risk management strategies in client-contractor relationships. These recommendations focus on aligning risk mitigation goals, integrating interdependencies into risk frameworks, improving communication, fostering trust-based risk management, and optimising decision-making processes. Additionally, this section outlines key areas for further research to deepen our understanding of governance structures, trust dynamics, and communication mechanisms in risk mitigation. By implementing these insights, contractors can navigate interdependencies more effectively and improve overall project outcomes.

### 9.2.1. Practical recommendation

- **Jointly classify interdependencies at the start of the project**
  Before project execution, clients and contractors should collaboratively identify and classify the key interdependencies that will influence project success. This includes dependencies related to design coordination, regulatory approvals, third-party suppliers, and internal interfaces. Rather than relying on a predefined method, the focus should be on developing a shared understanding of how complexity is experienced. Early classification enables better alignment of governance structures and risk strategies throughout the project lifecycle.
- **Adopt a hybrid governance approach aligned with interdependencies**
  Based on the shared classification, project teams should adopt a governance structure that reflects the nature of the interdependencies. Tightly coupled and linear systems may require central oversight, whereas complex or operationally uncertain dependencies benefit from decentralised or hybrid arrangements. Hybrid governance, which combines strategic control with local responsiveness, ensures better coordination, more effective risk mitigation, and alignment between internal and external project actors.
- **Align risk mitigation goals between client and contractor**
  The case studies reveal that clients often prioritise quality and compliance, while contractors aim for operational efficiency and timely delivery. These goals must be aligned during the planning phase through structured dialogue to avoid friction, delays, and conflicting risk strategies. Establishing shared priorities strengthens collaboration and enables a more unified response to uncertainty.
- **Document informal coordination and tensions to improve transparency**
  The research shows that informal coordination often plays a central role in risk management, especially when tensions rise. However, these practices are rarely documented. Capturing informal decisions and

workarounds supports long-term learning, enables better reflection on governance effectiveness, and improves adaptability in future projects.

- **Broaden stakeholder involvement in decision-making processes**
  Delays and inefficiencies often arise when decisions are made without input from those with operational insight. Risk mitigation should therefore include subcontractors, engineers, and site managers in key discussions. Establishing cross-functional advisory teams and conducting early stakeholder alignment sessions can enhance the quality and speed of decision-making.
- **Shift from contract-driven control to trust-based collaboration**
  Overreliance on formal contracts can limit flexibility and responsiveness. The research highlights the need to complement formal control with trust-based mechanisms, such as joint risk registers, shared accountability frameworks, and flexible milestone agreements, to support collaborative problem solving and adaptive risk responses.

### 9.2.2. Recommendations for further research

- **Exploring the impact of trust on risk mitigation**
  This study found that trust plays a crucial role in financial control, decision making, and overall project collaboration. However, more research is needed to quantify the direct impact of trust on risk mitigation strategies. Future studies could explore how trust levels influence governance structures and whether increasing trust leads to more effective risk sharing mechanisms.
- **Refining the TOE framework**
  The study highlighted that the interdependencies of technical, organisational, and environmental functions do not function alone, but often overlap. Future research should focus on developing an integrated framework that explicitly acknowledges these overlaps. This could improve the predictive capabilities of risk models and help construction professionals anticipate risks before they materialise.
- **Comparative studies on governance models**
  This research suggests that a hybrid governance model that balances central oversight with decentralised decision making is the most effective for managing interdependencies. However, more empirical research is needed to compare different governance models between various types of projects and industries. Are certain governance structures more suited to specific types of project?
- **The role of communication coaches in construction projects**
  Interviews indicated that projects where communication coaches were involved saw improved collaboration between clients and contractors. Future research should investigate whether formalising the role of communication coaches as a standard project function reduces conflicts and enhances risk mitigation strategies.
- **Long-term effects of shared governance**
  The study suggests that shared governance leads to better risk mitigation and collaboration. However, the long-term effects of this approach remain uncertain. Future research could focus on the long-term that track the long-term performance of projects where shared governance is implemented. This could help determine whether this model leads to sustained improvements in risk management.

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# A

# Risk mitigation strategies

- **Accept** Accept occurs when the project team acknowledges a risk but decides not to take any proactive measures to address it. This strategy is typically chosen when the cost of mitigating the risk outweighs its potential impact, or when the risk is considered minor and unlikely to significantly affect the project's outcomes. By choosing to accept the risk, the project team remains aware of its existence but takes no action unless the risk actually materializes. In some cases, this might involve simply monitoring the risk and having a contingency plan in place should it arise. For example, a construction team might accept the risk of minor equipment malfunctions, as the cost of preventing such malfunctions may be higher than the occasional cost of repairs.
- **Avoid** Avoid is the process of eliminating a risk entirely by altering the project plan or scope to ensure that the risk cannot occur. This approach is often applied to risks that pose a serious threat to the success of the project and are deemed unacceptable. By changing the project's objectives, timeline, or location, the team can prevent the risk from materializing. For instance, in construction projects, avoidance might involve relocating the project site to avoid environmental risks such as flooding or landslides. While this can be an effective strategy, it often requires significant adjustments to the project's original plan, which can introduce new challenges or costs.
- **Transfer** Transfer involves shifting the responsibility for managing a risk to a third party, often through contracts, insurance, or outsourcing. The risk itself remains, but its financial or operational impact is transferred to another entity that assumes responsibility for managing it. This strategy is particularly useful for risks that are difficult for the project team to control or when a third party is better positioned to handle the consequences. For instance, a construction company might transfer the risk of fluctuating material prices to a supplier by negotiating a fixed-price contract, thereby ensuring that cost increases do not affect the project's budget. Although transference does not eliminate the risk, it reduces the project team's direct exposure to its potential consequences.
- **Reduce** Reduce focuses on reducing the likelihood or impact of a risk rather than eliminating it entirely. Unlike avoidance, which seeks to prevent the risk, mitigation works to make the risk more manageable if it does occur. This proactive approach involves taking specific steps to lessen the risk's potential harm to the project. For instance, if a construction team is concerned about weather-related delays, they might build extra time into the schedule or have contingency plans in place to minimize the impact of adverse weather conditions. Mitigation is particularly effective for risks that cannot be avoided but can be controlled to some degree, allowing the project to proceed with reduced vulnerability.
- **Escalate** The newest recognized strategy in risk management, is applied when a risk is beyond the authority or capabilities of the project team to manage. In such cases, the risk is escalated to higher management or stakeholders who have the necessary authority or resources to address it. Escalation is typically used for high-impact risks that require decisions or interventions at a higher organizational level. This approach ensures that the risk is managed by those who are better positioned to resolve it, especially when it involves organizational policy, large-scale financial commitments, or strategic decisions. For example, in a construction project, if a critical regulatory change is anticipated that could affect the project's compliance, the project team might escalate the issue to the organization's legal department or executive management to handle.

# B

# TOE framework

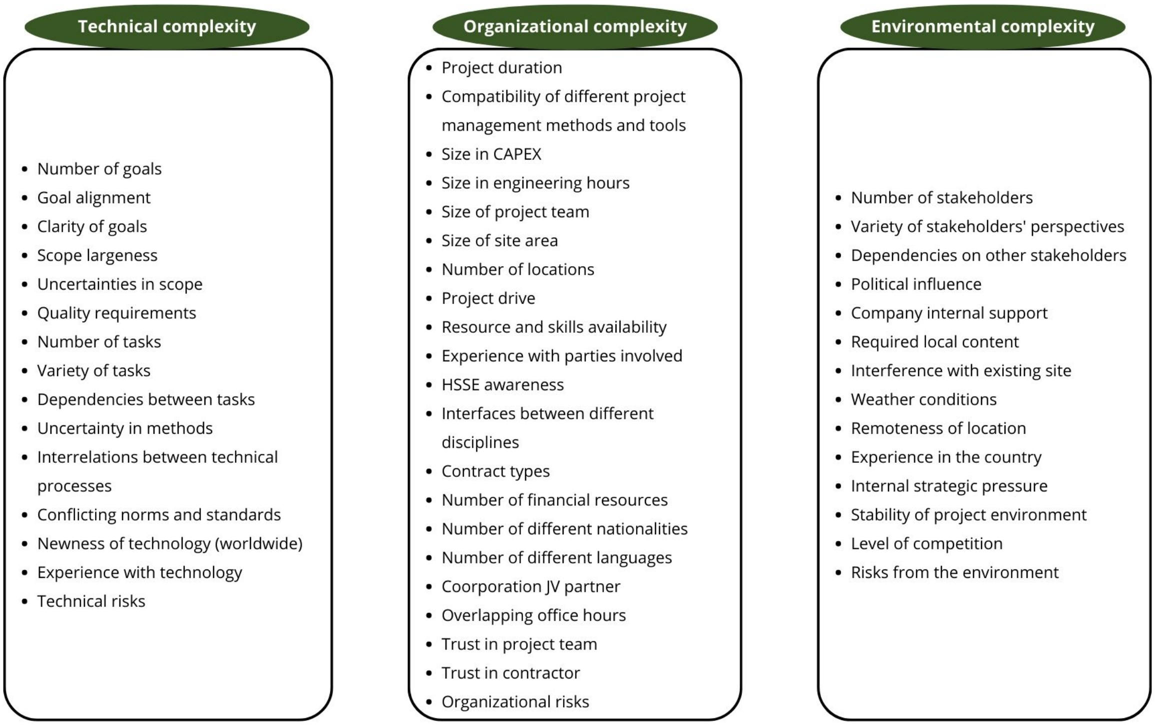


**Figure B.1:** Elements per category of TOE (Bosch-Rekveldt et al., 2011)

| TOE | Sub-ordinating | ID | Source L/B/E | Elements Defined | Explanation |
|---|---|---|---|---|---|
| T | Goals | TG1 | L | Number of goals | What is the number of strategic project goals? |
| T | Goals | TG2 | B | Goal alignment | Are the project goals aligned? |
| T | Goals | TG3 | B | Clarity of goals | Are the project goals clear amongst the project team? |
| T | Scope | TS1 | B | Scope largeness | What is the largeness of the scope, e.g., the number of official deliverables involved in the project? |
| T | Scope | TS2 | B | Uncertainties in scope | Are there uncertainties in the scope? |
| T | Scope | TS3 | E | Quality requirements | Are there strict quality requirements regarding the project deliverables? |

| TOE | Sub-ordinating | ID | Source L/B/E | Elements Defined | Explanation |
|---|---|---|---|---|---|
| T | Tasks | TT1 | B | Number of tasks | What is the number of tasks involved? |
| T | Tasks | TT2 | B | Variety of tasks | Does the project have a variety of tasks (e.g., different types of tasks)? |
| T | Tasks | TT3 | B | Dependencies between tasks | What is the number and nature of dependencies between the tasks? |
| T | Tasks | TT4 | B | Uncertainty in methods | Are there uncertainties in the technical methods to be applied? |
| T | Tasks | TT5 | B | Interrelations between technical processes | To what extent do technical processes in this project have interrelations with existing processes? |
| T | Tasks | TT6 | B | Conflicting norms and standards | Are there conflicting design standards and country-specific norms involved in the project? |
| T | Experience | TE1 | B | Newness of technology (worldwide) | Did the project make use of new technology, e.g., non-proven technology (new worldwide, not just to the company)? |
| T | Experience | TE2 | B | Experience with technology | Do the involved parties have experience with the technology involved? |
| T | Risk | TR1 | B | Technical risks | Do you consider the project being high risk (number, probability, and/or impact) in terms of technical risks? |
| O | Size | OS1 | L | Project duration | What is the project duration? |
| O | Size | OS2 | B | Compatibility of different project management methods and tools | Do you expect compatibility issues regarding project management methodology or project management tools? |
| O | Size | OS3 | L | Size in CAPEX | What is the capital expenditure (CAPEX) of the project? |
| O | Size | OS4 | L | Size in engineering hours | What is the total number of engineering hours required for the project? |
| O | Size | OS5 | L | Size of project team | How many people are part of the project team? |
| O | Size | OS6 | L | Size of site area | What is the total area of the project site? |
| O | Size | OS7 | B | Number of locations | How many site locations are involved in the project, including contractor sites? |
| O | Resources | ORE1 | B | Project drive | Is there strong project drive (cost, quality, schedule)? |

| TOE | Sub-ordinating | ID | Source L/B/E | Elements Defined | Explanation |
|---|---|---|---|---|---|
| O | Resources | ORE2 | B | Resource and skills availability | Are the resources (materials, personnel) and skills required in the project, available? |
| O | Resources | ORE3 | B | Experience with parties involved | Do you have experience with the parties involved in the project (JV partner, contractor, supplier, etc.)? |
| O | Resources | ORE4 | E | HSSE awareness | Are involved parties aware of health, safety, security and environment (HSSE) importance? |
| O | Resources | ORE5 | B | Interfaces between disciplines | Are there interfaces between different disciplines involved in the project (mechanical, electrical, chemical, civil, finance, legal, communication, accounting, etc.) that could lead to interface problems? |
| O | Resources | ORE6 | B | Number of financial resources | How many financial resources does the project have (e.g. own investment, bank investment, JV-parties, subsidies, etc.)? |
| O | Resources | ORE7 | B | Contract types | Are there different main contract types involved? |
| O | Project teams | OP1 | B | Number of different nationalities | What is the number of different nationalities involved in the project team? |
| O | Project team | OP2 | B | Number of different languages | How many different languages were used in the project for work or work related communication? |
| O | Project team | OP3 | B | Cooperation JV partner | Do you cooperate with a JV partner in the project? |
| O | Project team | OP4 | B | Overlapping office hours | How many overlapping office hours does the project have because of different time zones involved? |
| O | Trust | OT1 | B | Trust in project team | Do you trust the project team members (incl JV partner if applicable)? |
| O | Trust | OT2 | B | Trust in contractor | Do you trust the contractor(s)? |
| O | Risk | OR1 | B | Organizational risks | Do you consider the project being high risk (number, probability and/or impact of) in terms of organizational risks? |

| TOE | Sub-ordinating | ID | Source L/B/E | Elements Defined | Explanation |
|---|---|---|---|---|---|
| E | Stakeholders | ES1 | B | Number of stakeholders | What is the number of stakeholders (all parties (internal and external) around the table, pm=1, project team=1, NGOs, suppliers, contractors, governments)? |
| E | Stakeholders | ES2 | B | Variety of stakeholders' perspectives | Do different stakeholders have different perspectives? |
| E | Stakeholders | ES3 | B | Dependencies on stakeholders | What is the number and nature of dependencies on other stakeholders? |
| E | Stakeholders | ES4 | B | Political influence | Does the political situation influence the project? |
| E | Stakeholders | ES5 | B | Company internal support | Is there internal support (management support) for the project? |
| E | Stakeholders | ES6 | B | Required local content | What is the required local content? |
| E | Location | EL1 | E | Interference with existing site | Do you expect interference with the current site or the current use of the (foreseen) project location? |
| E | Location | EL2 | E | Weather conditions | Do you expect unstable and/or extreme weather conditions; could they potentially influence the project progress? |
| E | Location | EL3 | E | Remoteness of location | How remote is the location? |
| E | Location | EL4 | E | Experience in the country | Do the involved parties have experience in that country? |
| E | Market Conditions | EM1 | E | Internal strategic pressure | Is there internal strategic pressure from the business? |
| E | Market conditions | EM2 | B | Stability of project environment | Is the project environment stable (e.g. exchange rates, raw material pricing)? |
| E | Market conditions | EM3 | B | Level of competition | What is the level of competition (e.g. related to market conditions)? |
| E | Risk | ER1 | B | Risks from environment | Do you consider the project being high risk (number, probability and/or impact of) in terms of risk from the environment? |

# C

# Notion of Perrow's elements

| Element | Tight coupling | Loose coupling |
| --- | --- | --- |
| Delay in process | No room for delays; a disruption in one process directly impacts others. | Delays in one process have limited or no impact on other processes. |
| Invariance in sequence order | Processes must follow a strict sequence; deviations are not possible. | Processes can occur in varying orders without significant consequences. |
| Alternative method | No alternative methods available; the system depends on a single pathway. | Alternative methods are available, providing flexibility to the system. |
| Level of slack in resources | Resources are tightly constrained, with little to no extra capacity available. | Resources have adequate slack, allowing for adjustments and flexibility. |
| Redundancies/Buffers | No redundancy or buffers exist to absorb disruptions. | Redundancy and buffers are available to isolate and mitigate disruptions. |
| Substitution possibilities | No substitution options exist; components or processes cannot be replaced. | Substitution options are available, enabling continuity of operations. |

**Table C.1:** Tight and Loose coupling characteristics

| Element | Linear Interaction | Complex Interaction |
|---|---|---|
| Spacing between components | Components have limited to none space between them. | Components are closely connected, with much space between the connected ones. |
| Production steps' location | There are minimal steps needed to transport from production location to the rest of the network. The production steps' location is close. | There are much steps between production location and the rest of the network. The production steps' location is distant. |
| Common mode of connection | Shared connections have limited impact, and failures are unlikely to cascade. | Shared connections create vulnerabilities, where a single failure can disrupt multiple components or systems. |
| Possibility of isolation of failed components | Failed components can be easily isolated, preventing further disruptions. | Failures are difficult to isolate, often causing widespread or cascading disruptions. |
| Personnel specialization | Minimal specialization required; processes are simple and well-understood. | High specialization required to understand and manage the complexity of processes and their interactions. |
| Potential interactions in control parameters | Changes in control parameters have predictable and straightforward effects. | Small changes in control parameters can lead to unpredictable, amplified, or cascading effects. |
| Type of information sources | Information is direct, clear, and readily accessible. | Information is indirect, fragmented, or difficult to interpret, complicating decision-making. |
| Understanding of processes | Processes are fully understood, making it easy to predict outcomes and resolve issues. | Processes are only partially understood, leading to uncertainty and difficulty in managing interactions. |

**Table C.2:** Linear and Complex Interaction Characteristics

# D

# Management structures in Perrow's matrix

Centralisation/decentralisation of authority relevant to crises[a]

| Coupling | Interactions | |
|---|---|---|
| | Linear | Complex |
| Tight | CENTRALISATION for tight coupling | CENTRALISATION to cope with tight coupling |
| | CENTRALISATION compatible with linear interaction | DECENTRALISATION to cope with unplanned interactions of failures |
| Loose | CENTRALISATION or DECENTRALISATION possible | DECENTRALISATION for complex interaction desirable |
| | | DECENTRALISATION for loose coupling desirable |

[a] Source: Perrow, C., 1984. Normal Accidents: Living with High-risk Technologies. Basic, New York, p. 332.

**Figure D.1:** Management structure of Perrow matrix

# E

# Different contract types

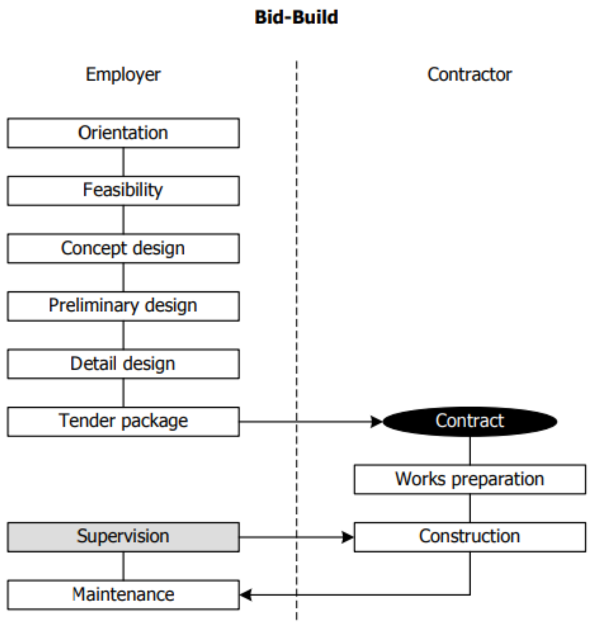


**Figure E.1:** The process of DBB procurement (de Ridder, 2009)

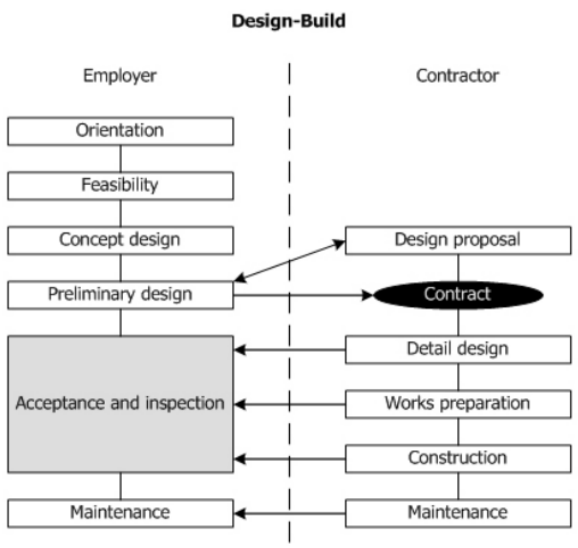


**Figure E.2:** The process of DB procurement (de Ridder, 2009)

# F

# Interview questions

## Introductie vragen

0. Wat was uw rol in het project en hoe heeft u deze ingevuld op het gebied van projectbeheersing?

## Vragen gericht op keuze van beheersing

1. Welke beheersingsstrategie heeft u toegepast tijdens gebeurtenis 1?
2. Wat was volgens u de belangrijkste reden om voor de gekozen beheersingsstrategie te kiezen tijdens (specifieke gebeurtenis)?
   a. Was dit een bewuste keuze of een noodzaak door externe omstandigheden?
   b. Hoe zijn alternatieve strategieën overwogen?
3. In hoeverre heeft de afhankelijkheid tussen opdrachtgever en opdrachtnemer uw keuze voor beheersing beïnvloed?
   a. Kunt u uitleggen waar de afhankelijkheid voornamelijk in zat?
   b. Kunt u een voorbeeld geven van hoe afhankelijkheden een rol speelden bij het bepalen van de aanpak?

## Vragen over gedeelde beheersing

4. Is tijdens (specifieke gebeurtenis) overwogen om een gedeelde beheersingsstrategie toe te passen?
   a. Zo ja, hoe werd deze samenwerking vormgegeven?
   b. Zo nee, wat waren de belangrijkste belemmeringen om dit gezamenlijk op te pakken?
5. Hoe heeft u geprobeerd de verantwoordelijkheid te delen tussen opdrachtgever en opdrachtnemer?
   a. Waren er momenten waarop u dacht dat gedeelde beheersing effectiever zou zijn geweest?

## Vragen over de effectiviteit en impact van beheersing

6. Hoe beoordeelt u de effectiviteit van de gekozen beheersingsstrategie bij het beheersen van tijd, geld, en kwaliteit?
   a. Welke van deze drie dimensies kreeg prioriteit, en waarom?
7. Wat waren volgens u de belangrijkste voordelen en nadelen van de gekozen beheersing?
   a. Heeft dit bijgedragen aan het versterken of verzwakken van de samenwerking tussen opdrachtgever en opdrachtnemer?

## Reflectieve vragen over beheersing en afhankelijkheden

8. Hoe heeft u ervoor gezorgd dat de gekozen beheersing de afhankelijkheden binnen het project effectief adresseerde?
   a. Zijn er voorbeelden waar afhankelijkheden de gekozen beheersing beïnvloedden?
9. Als u terugkijkt, denkt u dat een andere vorm van beheersing (intern, extern, gedeeld) beter had kunnen werken? Waarom wel of niet?

## Afsluitende vraag

10. Welke lessen heeft u geleerd over het kiezen en toepassen van beheersingsstrategieën in projecten met sterke afhankelijkheden?
    a. Hoe zou u deze lessen in toekomstige projecten toepassen?

# G
# Event classification of contractor in Perrow matrix

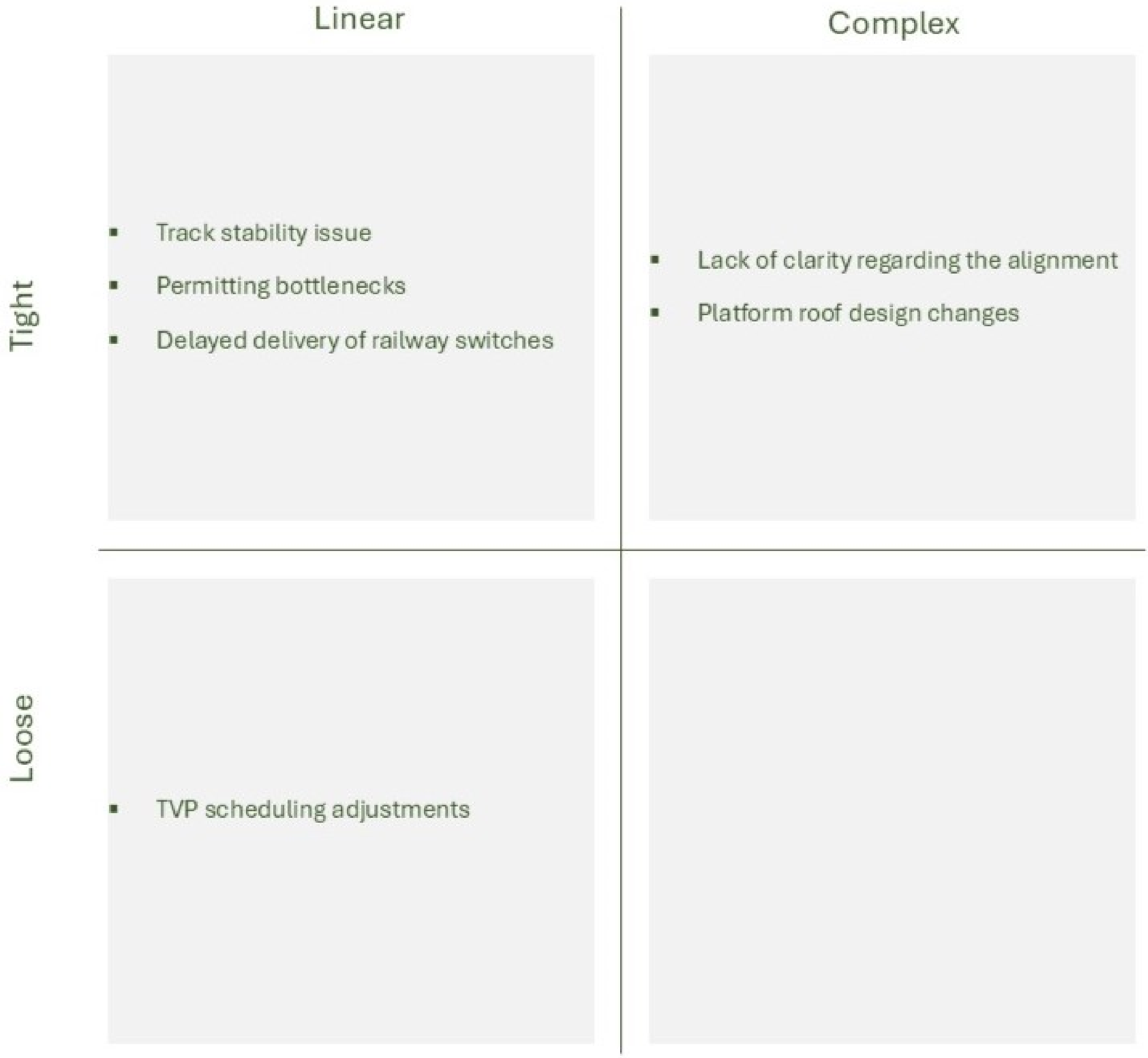


**Figure G.1:** Event classification of contractor in Perrow matrix

# H

# Event classification of client in Perrow matrix

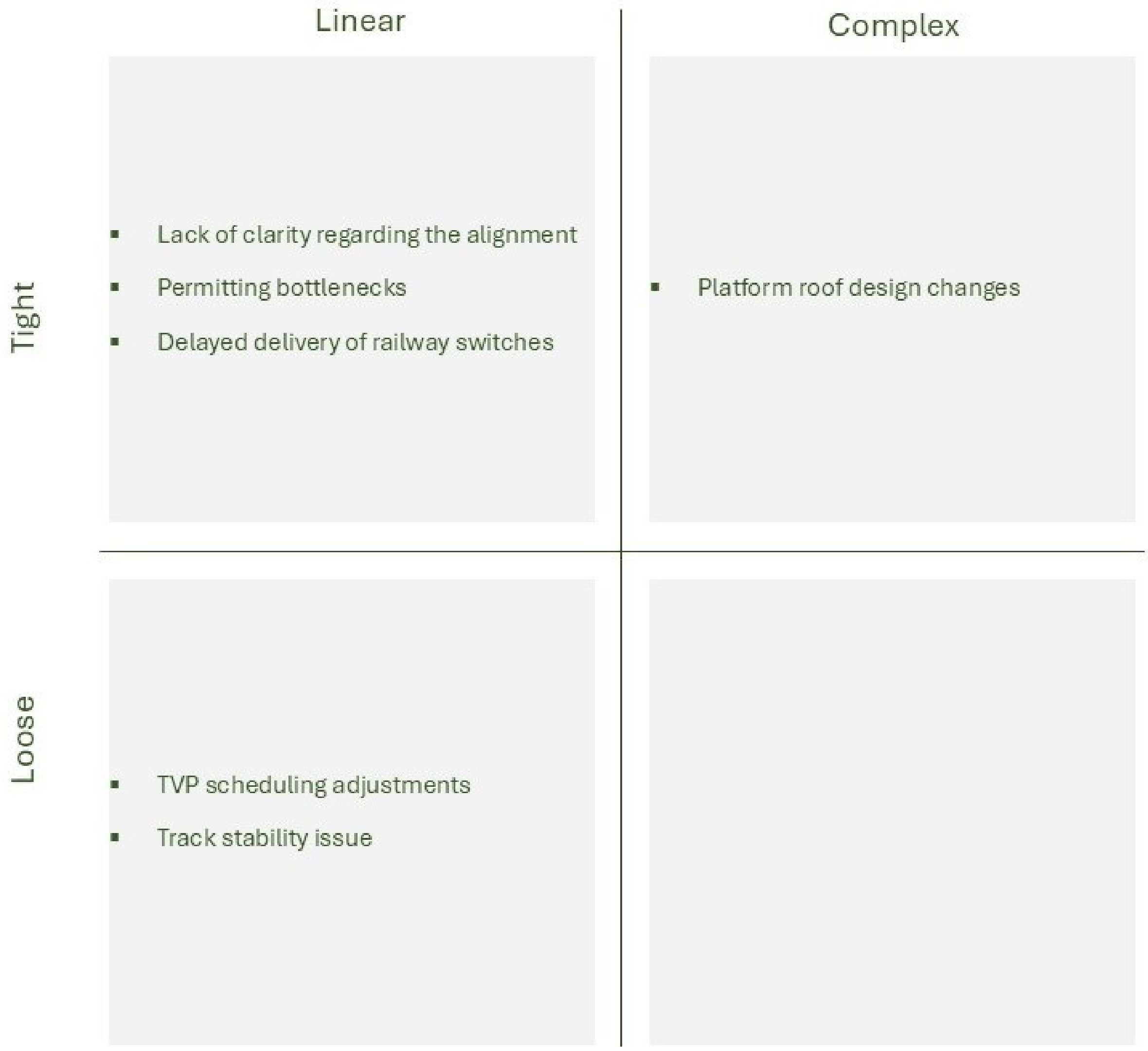


**Figure H.1:** Event classification of client in Perrow matrix