THE ADDED VALUE OF BOUWTEAMS

An analysis of its costs and benefits in Dutch infrastructure projects

CIVIL ENGINEERING AND MANAGEMENT
INTEGRATED PROJECT DELIVERY

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Management samenvatting

De bouwsector staat bekend om zijn projectgeoriënteerde en competitieve focus. Hoewel dit op korte termijn besparingen kan opleveren, wordt de meerwaarde van alternatieve aanpakken zoals Bouwteams vaak over het hoofd gezien. Het gebruik van Bouwteams biedt ruimte voor een samenwerking waarbij de aannemer vroegtijdig betrokken is bij het ontwerpproces. De vroegtijdige betrokkenheid zorgt ervoor dat de expertise van de aannemer beter kan worden benut. Zo zijn ontwerpwijzigingen namelijk minder duur en kan risicomanagement beter worden ingericht.

Er is een groeiende vraag naar het verzamelen en delen van ervaringen met Bouwteams, omdat dit waardevolle inzichten kan bieden voor besluitvorming en advisering bij projecten. Dit onderzoek richt zich op de vraag of het gebruik van Bouwteams leidt tot meerwaarde door betere voltooiing van projectdoelen en/of verlaging van de investeringskosten.

Als uitgangspunt voor het onderzoek is er een conceptueel raamwerk opgesteld. Een literatuuronderzoek onthulde zowel de kostenimplicaties en voordelen van het gebruik van Bouwteams. Kostenimplicaties hebben betrekking op het effect van Bouwteams op directe kosten, risicomanagement en kostenbeheersing gedurende het ontwerp en de uitvoering van het project. De voordelen zijn onderverdeeld in proces- en productverbeteringen, evenals toegenomen innovatie en kennisdeling.

Tijdens een congres over bouwteams werd een enquête gehouden om te beoordelen of de kostenimplicaties en voordelen ook van toepassing zijn op Bouwteams in de Nederlandse infrastructuur. De resultaten suggereren verdeelde meningen over de kostenimplicaties, maar de voordelen waren duidelijk. Bijna de helft van de deelnemers was het ermee eens dat Bouwteams leiden tot hogere kosten in de ontwerpfase. Bijna alle deelnemers waren het er echter over eens dat het gebruik van Bouwteams bijdraagt aan het voorkomen van conflicten, betere bouwbaarheid, efficiëntere risicotoewijzing, vermindering van meerwerkkosten, meer uitwisseling van informatie en expertise, en toegenomen kennisdeling.

Een casestudie werd uitgevoerd om te onderzoeken hoe de kostenimplicaties en voordelen kunnen worden toegeschreven aan het gebruik van Bouwteams. Bij het vergelijken van de twee onderzochte projecten werd duidelijk dat vroegtijdige betrokkenheid van de aannemer, samenwerking en transparantie de basis vormen voor de effecten van Bouwteams. Bovendien werden er twee nieuwe voordelen van het gebruik van Bouwteams ontdekt: minder omgevingshinder en meer werkplezier.

Nu de voordelen van het gebruik van Bouwteams duidelijk zijn geworden, was het waardevol om meer inzicht te krijgen in de kostenimplicaties. Voor het onderzoek naar het effect van Bouwteams op de kosten gedurende het project, zijn projectgegevens verzameld en geanalyseerd van Bouwteam- en twee-fase projecten in de Nederlandse infrastructuur. Door deze resultaten te vergelijken met benchmarkgegevens uit de sector en geïntegreerde projecten, konden de verschillen worden geïdentificeerd.

In totaal hebben 31 unieke projecten deelgenomen aan het onderzoek. Hieruit bleek dat het gebruik van Bouwteams kan leiden tot hogere kosten in de ontwerpfase als gevolg van de vroegtijdige betrokkenheid van de opdrachtnemer. Bovendien was er een gemiddelde toename van 29% in het budget voor de uitvoering van werkzaamheden tussen het begin en het einde van de Bouwteamfase. Deze toename werd veroorzaakt door een gebrek aan competitie bij de uiteindelijke prijsvorming, wijzigingen in scope, en verhoogde kosten voor materieel, materiaal en manuren.

Daarentegen lieten de resultaten in de realisatiefase positieve effecten zien van het gebruik van Bouwteams. Er waren relatief lage kostenoverschrijdingen van gemiddeld slechts 4%, in vergelijking met een gemiddelde van 25% tussen de contractsom en werkelijke kosten bij geïntegreerde projecten, en een gemiddelde van 17% tussen het besluit tot bouwen en de werkelijke kosten in de hele sector. Deze cijfers suggereren dat Bouwteams bijdragen aan de voorspelbaarheid van de uitvoering, wat kan worden toegeschreven aan een vermindering van risico's, nauwkeurigere kostenramingen en een verlaging van meerwerkkosten. Over het algemeen zijn de deelnemers ervan overtuigd dat het gebruik van Bouwteams heeft bijgedragen aan kostenefficiënte waarde creatie in hun projecten.

Het onderzoek biedt praktische adviezen voor adviseurs, opdrachtgevers, aannemers, project- en contractmanagers, en beleidsmakers. Het gebruik van Bouwteams resulteert in aanzienlijke voordelen in complexe projecten, zoals projecten met grote risico's of een focus op verduurzaming. Opdrachtgevers zouden moeten realiseren dat Bouwteams de mogelijkheid bieden om waarde toe te voegen aan projecten, ondanks de toegenomen inspanningen bij ontwerp en het verhoogde budget. Deze investeringen kunnen helpen bij het voorkomen van kostenoverschrijdingen, het verbeteren van de bouwbaarheid, het vergroten van klanttevredenheid, en het stimuleren van innovatie en kennisdeling.

Bij het selecteren van een bouwteam zouden opdrachtgevers vooraf moeten nadenken over het type samenwerking en de ruimte voor oplossingen, zodat ze efficiënt hun projectdoelen kunnen bereiken. Daarnaast moeten ze bij uitdagingen zoals het gebrek aan concurrentie in de uiteindelijke prijsvorming verder kijken dan het simpelweg verhogen van competitie. Het omarmen van een relationele aanpak en transparante onderhandelingen kan ook zorgen voor een eerlijke prijs.

Tot slot beveelt dit rapport aan om verder evaluatief onderzoek uit te voeren naar het gebruik van Bouwteams. Meer onderzoek naar voltooide projecten kan helpen om beter inzicht te krijgen in de ontwerpkosten, kostenoverschrijdingen en de mate van naleving van de projectplanning. Daarnaast wordt aanbevolen om te onderzoeken hoe verschillen in samenwerking en oplossingsruimte kunnen leiden tot veranderingen in kostenefficiëntie en toegevoegde waarde bij Bouwteam projecten.

Keywords

Bouwteam, Two-Phase, Cost implications, Benefits, Added Value, Early Contractor Involvement, Procurement, Contracts, Collaboration.

Executive summary

In the infrastructure sector, there is traditionally a project-oriented and competitive focus. Despite its ability to optimise costs in the short term, this approach tends to overlook the added value that alternative approaches like Bouwteams can create. Bouwteams promote a collaborative and transparent way of working in which the contractor is involved early in the design process. The contractor's early involvement enables relatively cheap design changes and the creation of impact by managing risk and uncertainty.

More experiences with Bouwteams must be collected and shared for advice and decision-making. This research investigated whether using Bouwteams can add value to Dutch infrastructure projects by either better achieving the project goals or decreasing the project costs.

A conceptual framework has been established as a starting point. A literature review revealed that Bouwteams, two-phase projects, collaboration, and early contractor involvement are associated with several cost implications and benefits. Cost implications refer to the effects of using Bouwteams on direct costs, risk management, and cost control in the project. Benefits include process improvement, product improvements, increased innovation capability, and learning.

To ensure these effects are also applicable to Dutch infrastructure projects using Bouwteams, an expert survey was employed at a congress on Bouwteams. Interestingly, the results showed rather disparate views on the factors driving expenses in Bouwteams, whereas the benefits were confirmed. For instance, about half of the participants indicated that the use of Bouwteams leads to higher costs in the design phase. Almost all participants agreed that Bouwteams leads to the prevention of conflicts, better constructability, collaborative risk allocation, reduction of additional construction costs, learning, and increased sharing of information and expertise.

A comparative case study was employed to investigate the causes of the cost implications and benefits in Bouwteams. It could be concluded that early use of contractor expertise, collaboration, and transparency lay the basis for these effects Bouwteams. Also, two new benefits were revealed, which are decreased construction nuisance and increased job satisfaction.

To reveal the effects of Bouwteams on the costs throughout the project, cost data of 31 Bouwteam or two-phase projects in the Dutch construction sector were collected. Differences have been revealed by comparing these findings against benchmark data of the sector and integrated projects. Using Bouwteams leads to higher costs in the design phase due to the contractor's involvement. Aside from this, an average increase of 29% between the task-based budget and the construction cost estimation was observed due to changes in scope, indexing costs and lack of competition in the price forming.

In the realisation phase, more positive effects were witnessed, as smaller cost overruns were observed. On average, the realisation costs in a Bouwteam were 4% higher than the construction cost estimate, compared to an average cost overrun of 25% between the contract sum and realisation in integrated projects and 17% between the decision to build and realisation in the sector. This demonstrates that using a Bouwteam leads to greater predictability in the construction phase due to reduced risks, more accurate estimates, and fewer additional construction costs. Participants generally agreed that Bouwteams provided a cost-effiect approach for adding value to their projects.

Furthermore, this research offers practical implications for advisors, clients, contractors, project and contract managers, and policymakers. Using Bouwteams in complex projects, especially for managing large risks or sustainability concerns, yields substantial benefits. Clients and policymakers should recognise that Bouwteams can enhance value creation despite increased design effort and initial budget allocations. These investments can help mitigate cost overruns, improve constructability, enhance end-user satisfaction, and stimulate innovation and knowledge sharing.

In selecting a Bouwteam, clients and policymakers should carefully consider the collaboration type and solution space to achieve project goals efficiently. Addressing challenges such as limited competition in the final price formation, decision-makers need to look beyond simply increasing competitiveness. Embracing relationship-focused approaches and transparent negotiation strategies can establish fair pricing.

Finally, this study recommends further research to evaluate the use of Bouwteams. More ex-post project evaluations and quantitative assessments are needed to understand the impacts of Bouwteams on design costs, cost overruns, adaptation costs, and schedule performance. Additionally, investigating how different types of collaboration and solution spaces within Bouwteams affect cost-efficiency and overall benefits is crucial for advancing understanding in this area.

''It takes two flints to make a fire.''

Louisa May Alcott

Preface

Before you lies the result of my graduation research, marking the end of the MSc in Civil Engineering and Management. I selected Bouwteams as my research topic due to its potential to reshape collaboration in the traditionally competitive construction sector, aligning with my interests in procurement strategies and project organisation.

Throughout the five months of study, the title 'Added value of Bouwteams' sparked many debates. These discussions reflected diverse perspectives on the benefits and drawbacks of Bouwteams. It has been fulfilling to explore this topic and exchange insights with experts in the field.

This research would not have been such a success without the support of numerous individuals and organisations. I would like to express gratitude to my supervisors from the University of Twente for their collaborative guidance. Special thanks to Hans Boes for his enthusiastic contribution to shaping the research and Hans Voordijk for his expertise in scientific writing and engaging conversations.

Also, I am grateful to my supervisors at Witteveen+Bos, whose welcoming environment provided me with an inspiring workspace to conduct this project. Gerard Buunk's practical insights and his trust enriched the project, while Mehmet Uzun's supervision and constructive feedback also contributed to its success.

My appreciation extends to my parents and brother for their support throughout my studies. I am also grateful to all individuals who contributed to this research through interviews, surveys, project visits, discussions, and network connections. Your collective enthusiasm makes me look out to entering the industry, and I hope this report reflects my enthusiasm. I wish you a rewarding reading experience.

Jip Scheper

Enschede, 03-07-24

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1. Introduction

This chapter begins by examining the background of using Bouwteams and then provides a detailed description of the problem. Subsequently, it outlines the research objectives and questions. Finally, a reading guide for the remainder of the report is provided.

1.1. Background

The construction industry's project-based and site-specific nature often leads companies to prioritise financial control and decentralised decision-making for individual projects. Clients typically ask engineers to create a design tailored to a specific project. Once the design is completed, the contract is awarded to the lowest-bidding contractor.

Although activities in the construction industry have been typically geared towards cost optimisation for the client, they also resulted in unintended consequences. For instance, the fragmented supply chain and the use of price-focused competitive tendering could have led to strategic myopia (Dubois & Gadde, 2002).

At the start of this millennium, collusion practices were discovered in the Dutch construction sector. Contractors would meet before project awarding to compare prices and agree on the winning bid. This bid-rigging ensured profitability and reimbursed tender preparation expenses to the contractors who did not win the project. In 2002, the Netherlands' parliamentary inquiry Committee on Construction Fraud recommended eliminating these practices by increasing the focus on competition (Dorée, 2004).

Consequently, contractors may have only fulfilled the client's minimum requirements to maximise their profitability. Furthermore, this cost-focused approach could have led to sub-optimisation, hindering innovation and technological development. Similarly, increasing competition might have been counterproductive from an organisational perspective, (Dorée, 2004).

Furthermore, many conflicts arose between the parties involved in competitive construction projects. These conflicts could occur due to several factors, such as the speed of construction, costs and quality control, stringent building regulations, design errors, discrepancies or ambiguity in the contract, mistakes in cost estimates, cultural differences in the construction team, changed conditions, and communication challenges with the client (Jaffar et al., 2011). Such disputes could have caused project delays, undermined team spirit, increased project costs, and damaged business relationships (Cheung & Suen, 2002).

To address these challenges, the construction industry has recently shifted towards more collaborative approaches. The director of Rijkswaterstaat called for collaboration to manage more complex projects requiring an integral approach, as detailed in their vision of the construction market (Rijkswaterstaat, sd). Increasing collaboration aims to tackle societal challenges and move away from self-interest, acting reactively, opportunistic behaviour (Marktvisie, sd) and adversarial relationships (Loraine, 1994).

Eventually, the use of collaborative-focused contract forms, like two-phase contracts was advocated to increase productivity and foster innovation (Rijkswaterstaat, 2019). Specifically, two-phase contracts can contribute to collaboration towards addressing societal challenges, increasing productivity, improving risk management, and providing space for innovation (Rijkswaterstaat, 2023).

Several parties in the Dutch construction industry have adopted a two-phase approach using Bouwteams to cope with risks inherent in infrastructure projects. This method is particularly useful in large and complex projects (Van den Berg, 2010). The Bouwteam's market share in publicly awarded projects increased from 2% in 2017 to 8% in 2023 (Bouwend Nederland, 2024). Bouwteams involve early contractor involvement in the design phase, contributing to improved project control, budget and time savings, and innovative solutions (Lenferink et al., 2012).

1.2. Problem description

Despite the rising popularity of Bouwteams, more theoretical and practical research remains needed to fully understand their benefits and costs, thereby supporting informed decision-making. Rijkswaterstaat emphasised the importance of gathering experiences to advise about follow up projects (Rijkswaterstaat, 2023). Additionally, research commissioned by the Hoogwater-beschermingsprogramma revealed the substantiation of the choice for using a two-phase approach frequently leads to discussion (Significant Synergy, 2023).

At Witteveen+Bos, there has also been a recognised necessity for additional investigation. On one hand, contract advisors at Witteveen+Bos perceived that Bouwteams incurred higher costs during the design and preparation of Bouwteams than competitively procured projects. They attributed this to higher communication costs during the process, as well as early analysis and budgeting of risks. On the other hand, they believed that Bouwteams offers advantages towards societal and project goals. For example, they were convinced there could be better risk management, more robust planning, improved constructability, less construction nuisance and improved collaboration and communication between the client and the contractor. Furthermore, Witteveen+Bos has experienced how Bouwteams can help provide space for sustainability ambitions and innovation.

In addition to the practical significance of the research, there has been a clear call for further study in the literature. Lagemaat (2015) pointed out that clients struggle to quantify the benefits of using Bouwteams compared to the lack of competition. Also, CROW recommended gaining more knowledge which could help with the decision-making regarding the use of Bouwteams (Peters, Sival, & van der Veer, 2018). Verweij, Koppenjan, & Hombergen (2023) recommended selecting a suitable evaluation strategy for Bouwteams and suggested collecting total project cost efficiency data. This data could serve as an important basis for improving decision-making over future projects and can further explain the added value of Bouwteams.

1.3. Research objectives

Several stakeholders have expressed interest in further evaluating Bouwteams to foster informed decision-making. It would be helpful to reveal the cost implications and benefits of working in Bouwteams compared to competitively procured projects. Together, these two aspects were used to find the added value of Bouwteams, which formed the core of the master thesis. Given that the research focused on the evaluation of Bouwteams, it was framed as a practice-oriented research project. The goals of the research could have been achieved through the following research objectives:

1. To analyse the theory on the characteristics of Bouwteams and its cost implications and benefits affecting added value during the Bouwteam and construction phase compared to competitively procured projects.

2. To achieve insights into the presence and causes of cost implications and benefits affecting added value in Dutch Bouwteam projects compared to competitively procured projects.

3. To quantitively evaluate the cost implications influencing added value using Bouwteams/two-phases during Dutch infrastructure projects' design and construction phase relative to competitively procured projects.

1.4. Scope

The research goals outlined above sketch the scope of the study. More specifically, the research investigated the cost implications and benefits leading to added value within the design and construction phase of Bouwteam projects, or other two-phase projects using early contractor involvement. The cost implications considered the effects of using Bouwteams on direct spending, cost estimations and risk management, and allocation in the design and construction phases. The benefits manifested as improvements, optimisations, or innovations of processes or products that contributed to societal and project goals and occurred during the design and construction phase of Bouwteam projects. The Bouwteams were compared to competitively procured projects, which typically involved traditional or integrated approaches and were primarily awarded based on the lowest price for constructing works according to requirements or specifications.

The scope of the research was demarcated by excluding the preparation, maintenance, and end-of-life phases of Bouwteam projects. Also, other forms of collaboration that did not use a two-phase approach, such as alliances or public-private partnerships, were not considered. Cost implications not directly associated with Bouwteams or occurring outside of the analysed project phases, like real estate costs or end-of-life costs, have not been investigated. Also, the focus of the research was limited to added value aligned with societal and project goals. Considerations related to external events or conditions, as well as the interests of private parties, were not within the scope of this research.

1.5. Research questions

Further specifications for the direction of the research project have been established by setting out clear and guiding research questions. This helped to reach the objectives of the research efficiently. The overarching question was formulated as follows:

> *What is the added value of Bouwteams based on their cost implications and benefits compared to competitively procured projects?*

Subsequently, three further questions were posed, each corresponding to one of the three research objectives. Answering these questions facilitated the fulfilment of the respective objectives. Furthermore, the main questions are divided into several sub-questions, which helped to further specify the direction of the research. Likewise, the following three main research questions, along with accompanying sub-questions, were posed:

1. What are the cost implications and benefits of Bouwteams during the design and construction phase of infrastructure projects according to the literature?
    a. Which characteristics, outlined in the literature, distinguish working with Bouwteams from competitively procured projects?
    b. How does the literature describe the cost implications and benefits in Bouwteam projects compared to competitively procured projects?
    c. Which causes of cost implications and benefits of Bouwteams are identified in literature?
2. Why do the cost implications and benefits of Bouwteams, compared to competitively procured projects, manifest during the design and construction?
    a. How do experts perceive the cost implications and benefits of Bouwteams during the design and construction of projects compared to competitively procured projects?
    b. Why do the cost implications and benefits in Bouwteams, compared to competition-based approaches, manifest in the comparative case study of two Bouwteam projects?
    c. Are there correlations between project characteristics and costs or benefits in Bouwteam projects in the Dutch construction sector?
3. Are the cost implications significant in two-phase projects in the Dutch infrastructure sector compared to statistics on the competition-based approach from the literature?
    a. What is the magnitude of design costs, budgeted risks, cost estimations, and realised construction costs for Bouwteam or two-phase projects in the Dutch construction sector?
    b. What is the degree of occurrence of the cost implications in Bouwteam or two-phase projects in the Dutch construction sector?
    c. What are the trends for design costs, budgeted risks, cost estimations and realised construction costs in competitively procured projects?

1.6. Reading guide

This document examines the added value of Bouwteams, beginning with a literature review (Chapter 2) that defines Bouwteams, covers their theoretical cost implications and benefits, and discusses cost trends for competitively procured projects. The methodology (Chapter 3) describes the research design and data collection. Results are presented in Chapter 4, followed by a discussion of interpretations, implications, limitations, and recommendations (Chapter 5). The study concludes with a summary of findings (Chapter 6) and is supported by a bibliography (Chapter 7) and appendices (Chapter 8).

2. Literature review

This chapter presents the literature review, beginning with a research design. It then outlines the literature study's findings and concludes with a discussion and presentation of the theoretical framework.

2.1. Research design

The conceptual framework was formed by consulting existing works. Desktop research was well-suited for gathering existing material without direct contact with the research object (Verschuren & Doorewaard, 2007). The primary advantage of a desktop literature review was that the researcher has quick access to an extensive selection of data (Verschuren & Doorewaard, 2007). However, there were also drawbacks. For instance, this data was often collected for different purposes, and the available resources limited the researcher (Verschuren & Doorewaard, 2007). Additionally, the original authors of the resources could not have clarified their work to the researcher.

The first step to constructing the conceptual framework involved desktop research on the distinctive characteristics of Bouwteams. The research focused on the extent of collaboration, the roles and behaviour of the client and contractor in Bouwteam projects, and the tender procedure, which addressed sub-question 1.a.

Thereafter, these characteristics were used as input for the search terms for desktop research on the cost implications and benefits of Bouwteams, addressing sub-question 1.b. Subsequently, the causes of these effects were explored, addressing sub-question 1.c. The final part of the literature review considers project cost trends in the sector, addressing sub-question 3.c. The detailed method of data collection for these sections is presented in Appendix A.

2.2. Characteristics of the Bouwteam

Answering research question 1.a involves performing desktop research on the characteristics that differentiate Bouwteams from competitively procured projects. First, the Bouwteam and two-phase approach are detailed. Thereafter, collaboration within Bouwteams is considered. Finally, the goals of using a Bouwteam are discussed.

2.2.1. Bouwteam

Laeven et al. (2023) defined the Bouwteam as a collaborative arrangement between the contractor and the client on a project base, incorporating early contractor involvement. The contractor actively participates in the preparation and design phase, contributing expertise in constructability, design, realisation, and costs. Similarly, CROW (2020) emphasised the importance of collaboration and trust within Bouwteams. Furthermore, CROW (2020) described the significance of communication, transparent expectations, and clear arrangements.

Two-phase approach

In contrast to competitively procured projects using UAV (traditional contract) or UAV-GC (integrated contract), a Bouwteam project adopts a two-phase approach. Specifically, the client and contractor divide the design and the construction of works into two distinct phases (CROW, 2020) as illustrated in Figure 1.

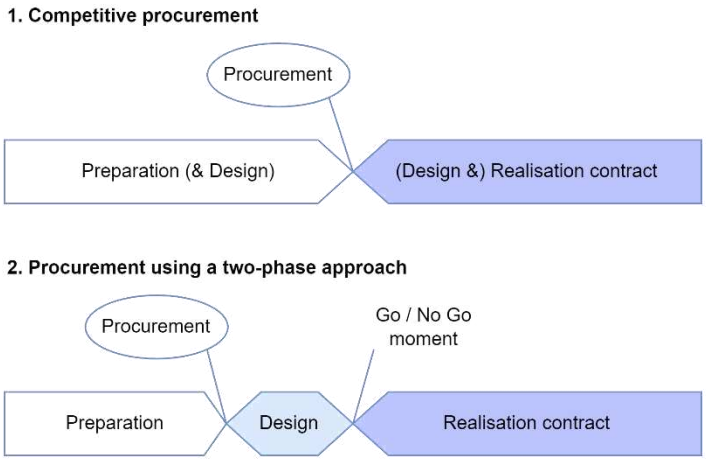

Figure 1 Comparison of competitive procurement and the two-phase approach (translated and modified from CROW, 2020)

The first phase is the Bouwteam, during which the client and a selected contractor collaborate on the project's design (CROW, 2020). Rijkswaterstaat (2023) emphasised that this phase aims to establish a robust project plan through an iterative process. Additionally, risk management and cost estimations can be performed, as noted by Laeven et al. (2023). Both parties can exchange ideas and propose solutions (CROW, 2020). Laeven et al. (2023) further highlighted that the start of the first phase can be based on a sketch design, program of demands, scope, project goals, or specifications (e.g., Dutch RAW). Starting the Bouwteam early in the design process creates flexibility, whereas starting later can optimise project execution methods.

During the Bouwteam, the client benefits from the experience and the expertise of the partaking contractor. For instance, the contractor's expertise can be used to obtain more detailed cost data and certainty and can lead to an open and honest process (Mosey, 2009). It is advantageous for the contractor to become familiar with the project's content, associated risks, design, and pricing. Furthermore, this allows the contractor to prepare and submit an offer to construct the works.

Following the first phase, CROW (2020) described a go/no go moment regarding the realisation of the specified works. This moment indicates whether the client and contractor can agree on the project's construction phase. If both parties agree, the construction can be initiated. Otherwise, if there is no agreement, the two-phase contract gets terminated upon completion of the first phase. According to Laeven et al. (2023) the start of the second phase may entail a shift in roles. For example, while the client may lead in the first phase, the contractor may lead in the second phase.

Tendering of Bouwteams

The two-phase approach using Bouwteam distinguishes itself from integrated contracts as the contractor is selected before the detailed design and price formation. Additionally, CROW (2020) noted that Bouwteams distinguishes itself from alternative collaborative approaches by sharing a design phase before the final price formation.

In the tendering of two-phase contracts, the focus is not solely on finding a party capable of providing a product but rather on identifying a collaboration partner (Laeven, et al., 2023). Preference is given to awarding the works based on qualitative criteria related to quality and collaboration. According to

Rijkswaterstaat (2023), qualitative criteria are predominant in the award criteria for two-phase contracts. Laeven et al. (2023) advocated for awarding contracts based on 100%, although they acknowledge the role of price in the award criteria. However, they suggested that the price need not be directly included. Instead, criteria such as a set price, budget or price management can be utilised (Laeven, et al., 2023). In practice, award criteria like a dossier of chances and risks, collaboration and team composition are commonly employed (CROW, 2020). Similarly, Laeven et al. (2023) proposed considering qualitative criteria related to the processes required to complete the Bouwteam phase successfully.

Additionally, a portion of quantitative criteria related to price can be included. For instance, Rijkswaterstaat (2023) and Laeven et al. (2023) described several options; these include prices for specific components, using unit prices and hourly wages, and incorporating margins for general costs, profit, risks and price management methods. However, the more emphasis is placed on the price, the more challenging it becomes to foster an open and fair collaboration and mitigate strategic behaviour. Rijkswaterstaat (2023) suggested that only the qualitative inclusion of price management appears to mitigate strategic behaviour but does not give certainty on the price.

To prevent changes outside the scope of the procured works, CROW (2020) suggested that the scope of the Bouwteam should allow ample space for the design process, which can be specified at the start of the tender request. Rijkswaterstaat (2023) added that flexibility can be obtained by a more comprehensive tender specification, setting changes, and providing space in the risk allocation. To address associated uncertainties for the client, CROW (2020) outlined three steps. Firstly, the scope and available budget should be clear initially, including whether the design phase is included and how it is financed. Secondly, CROW (2020) recommended transparently illustrating the impact of design choices on the price. Finally, there should be a clear go/no go decision for the contract regarding the construction of works.

Given the high importance of collaboration between the client and the contractor, CROW (2020) suggested using forms of personal interaction, such as interviews, to award the contract. Laeven et al. (2023) further elaborated assessments enable the prediction of collaborative dynamics. Serious gaming could also be used as an alternative interactive method.

Due to the focus on collaboration in the design phase following the contract reward, Laeven et al. (2023) and CROW (2020) recommended using a private tender, including three to five participants selected on objective criteria, depending on the expected project turnover. Alternatively, for large and complex projects, Laeven et al. (2023) proposed the use of the competitive dialogue. Rijkswaterstaat (2023) recommended competitive dialogue as the most suitable approach, as it fosters using the market's expertise to reduce risks and capitalise on opportunities. Furthermore, a market consultation is often employed to gather insights on the procedure, demands, and criteria.

Legal forms

According to van Schouwenburg & Küçük (2021) and Laeven et al. (2023), there are three Bouwteam agreements commonly used for infrastructure projects. The original model is the VG Bouw model agreement 1992, abbreviated as VGB1992. This model has undergone two revisions. Namely, the Model Bouwteam Duurzaam Gebouwd 2020, abbreviated as DG2020, was released, followed by the publication of the Bouwend Nederland Model Agreement 2021, abbreviated as BN2021.

Laeven et al. (2023) described DG2020 was set up with the conviction that a practical set of rules for working in Bouwteams is needed. This agreement outlines tasks and roles while addressing requirements for behaviour and attitudes towards collaboration. In addition, there are specific provisions on sustainability and constructive safety.

The main difference between VGB1992 and DG2020 is that VGB1992 focuses on setting specifications with the contractor and using UAV 1989 (or later, 2012). In contrast, DG 2020 sets out an order for the specifications, construction planning and risk documentation and enables the use of UAV-GC 2005 as well, according to Schouwenburg & Küçük (2021). Laeven et al. (2023) specified that BN2021 is a modernisation of the VGB1992 and seeks to enable the contractor to add value while striving for a fair and consistent division of tasks and liabilities.

In comparison to DG 2020, BN2021 is more compact. Also, BN2021 specifies that the works agreement is started when it is within the target budget, whereas DG2020 leaves the choice to the client. BN2021 shows similar content, only compared to DG2020 it presented fewer liabilities for the contractor and maintains flexibility regarding the leadership role (van Schouwenburg & Küçük, 2021).

At the award of the Bouwteam project, a Bouwteam agreement is used, after which the first phase is started under the DNR or general purchasing conditions. Subsequently, the second phase may proceed under the UAV or UAV-GC. Further differences are elaborated in the following section. Alternatively, the UAV-GC can be applied for both phases of a two-phase contract, leading to a leadership role for the contractor.

2.2.2. Collaboration in Bouwteams

Adversarial dynamics have long characterised the construction industry. A focus on costs, low trust, and low teamwork was found in a pilot study by Wood & Ellis (2004). Typical relationships in construction were also described as limited interaction among firms but intense interaction at the site to adjust to the project context by Gadde & Dubois (2010). Furthermore, Gadde & Dubois (2010) pointed out the interaction patterns in the construction relationships did not foster collaborative elements, which made adversarial conditions dominating. Snippert et al. (2015) illustrated how self-interest can cohere with opportunistic behaviour, using the agency theory to assign work from the principal to the agent. Haaskjold et al. (2019) listed several different forms of opportunistic behaviour. Namely, they described the reduction of margins in bids and sought profit recovery by claims, submission of unbalanced bids by exploiting information asymmetry, searching, and taking advantage of mistakes in documentation or scope, using misleading information and withholding information. Thereby, the opportunistic behaviour of the contractor led to transaction costs for the client.

In a Bouwteam project, the aim is to increase collaboration between the client and contractor in the design of infrastructure construction projects. Thompson and Sanders (1998) distinguished between four stages of partnering, which are depicted in Figure 2. Here, it is illustrated how the four stages incorporate a progressive degree of objective alignment and potential benefits related to partnering.

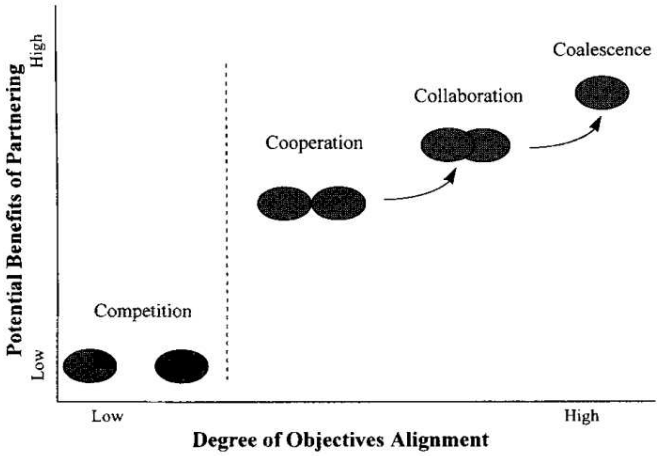

Figure 2 Partnering Continuum (Thompson & Sanders, 1998)

By textbook definition, competition is the situation where someone is trying to win something or trying to be more successful than someone else, cooperation is the act of working together with someone or doing what they ask you, and collaboration refers to the situation of two or more people working together to create or achieve the same thing (Cambridge Dictionary, 2024).

In the context of infrastructure construction projects, cooperation refers to the sharing of information, capital, or training (Polenske, 2010). Laeven et al. (2023) emphasised that shared results can be achieved by adding to each other's strengths. However, cooperation distinguishes itself from collaboration as the parties involved are not commonly related in terms of vision, and there is a separate project organisation (Schöttle, Haghsheno, & Gehbauer, 2014). Collaboration has been used as an umbrella term for alliances, joint ventures, networking and partnering (Hughes, Zhaomin , & Williams, 2012).

A survey among participants involved in collaborative construction projects in the UK, Hughe, Zhaomin and Williams (2012) revealed a difference in the precise understanding of collaboration between clients and contractors. Both agreed that collaboration referred to the non-adversarial team-based environment in which correct contracts and early warning systems are deployed, and everyone understands other people's roles and responsibilities. However, the study found that while clients focus on reducing claims and using a fair share of risks, contractors focus on solving problems together and developing long-term relationships.

Schöttle, Haghsheno, & Gehbauer (2014) identified that collaboration is highly focused on soft characteristics, such as trust, communication, transparency, commitment, knowledge sharing and information exchange. They explicitly named collaboration to refer to an interorganisational relationship and emphasised the role of clear contracts and shared responsibilities. Strickland (2010) agreed and suggested that using an integrated approach placed greater responsibility on contractors to define the project scope.

The guides on two-phase contracts by Rijkswaterstaat (2023) and CROW (2020) differentiated between coordinated cooperation and integral collaboration. Rijkswaterstaat (2023) described the intensity of the involvement depending on the extent to which both parties needed each other in the design phase of a Bouwteam project. They specified coordinated cooperation as a scenario where both parties have a clear role and contribution to the project. CROW (2020) further elaborated that the contractor uses their knowledge to enrich the design in a coordinated collaboration.

Alternatively, integral collaboration offered a distinct approach where there was an effort to establish equal partnerships, with both parties operating in a team, according to Rijkswaterstaat (2023) and CROW (2020). Also, they emphasised that in integral collaborations, both parties contributed to informed decision-making, where CROW (2020) highlighted the importance of mutual trust and transparency. An integral approach can better provide space for soft qualities, which cannot be as easily expressed in money (Krosse, Rotmans, & Avelino, 2012). Rijkswaterstaat (2023) remarked that both forms of collaboration are extremes, meaning that other forms of collaboration which share characteristics of both extremes are also possible.

In conclusion, collaboration refers to a non-adversarial inter-organisational relationship in which contracts and warning systems are used to shape a relationship that promotes trust, communication, transparency, and knowledge and information exchange. Cooperation refers to clear roles for both parties working together, whereas collaboration involves sharing goals and equal partnership among teammates.

2.2.3. Goals of using a Bouwteam

Public bodies in the construction industry primarily act as clients in construction projects, with various project goals outlined in Appendix B. Due to project specificity and contextual factors, achieving these goals and maximising added value often requires different paths towards efficient public spending. The use of Bouwteams offers clients two choices, resulting in four possible project goals, as specified in Figure 3.

Figure 3 The four goals of two-phase contracts (Based on CROW, 2020)

For a project, one should first determine whether to utilise a limited or wide solution space. Namely, this influences the contractor's freedom. Opting for a limited solution space would motivate the contractor to optimise, which involves improving efficiency, functionality, or cost-effectiveness. During the Bouwteam phase, which concludes at a later design stage, the contractor advises on costs and construction. Thereafter, the contractor could execute the works under the UAV, which is best suited to a coordinated collaboration. Laeven et al. (2023) described that the choice for UAV implies an elaborate level of detail.

A wide solution space would call for innovation, which refers to developing and implementing novel ideas, technologies, processes, or designs. This scenario often arises when the contractor is leading in the design. Consequently, the works are mainly realised under a UAV-GC contract (Jansen C. , 2021). This approach focuses on the development of the design using an integrated collaboration, where the client and contractor are equal and collectively make design choices (Rijkswaterstaat, 2023). Laeven et al. (2023) emphasised that using UAV-GC gives the contractor more freedom and steering. Nonetheless, it also comes with increased responsibility, uncertainty, and liability, as the Bouwteam ends earlier in the design process.

2.3. Cost implications and benefits of Bouwteams

In the last section, it was revealed that the characteristics of a Bouwteam are a collaborative approach in which early contractor involvement is used with a two-phase contract. These characteristics of the Bouwteam distinguished it from the competitively procured projects and are descriptive and constant over time. Adopting Bouwteams could result in several cost implications and benefits through the design and construction of infrastructure projects compared to competitive procurement approaches. Although these cost implications and benefits were associated with using Bouwteams, they might not necessarily have been caused by these characteristics. Therefore, the causes of the cost implications and benefits were also investigated.

First, it is explained what is meant with the cost implications and benefits throughout a construction project. Then, the cost implications and benefits found in the literature are detailed. Here, a categorisation will introduce the types of cost implications and benefits. Thereafter, the effects are detailed and explained.

2.3.1. Creating added value in Bouwteam projects

Throughout a construction project, the value could be understood as the degree to which the societal and project goals are achieved relative to project costs, as illustrated in Equation 1. Added value is reached when the value in Bouwteam projects exceeds that in competitively procured projects. The benefits of using Bouwteams include their impact on realising project and societal goals compared to competitively procured projects. These effects may have been harder to monetise. Cost implications refer to the financial consequences of adopting Bouwteams compared to competitively procured projects. Also, the value could have been enlarged by decreasing the costs of realising the same societal and project goals.

$$Value = \frac{functionality}{investment} = \frac{benefits\ towards\ societal\ and\ project\ goals}{project\ costs} \qquad (Equation\ 1)$$

Figure 4 illustrates that there is a more significant ability to impact project cost and functional capabilities early in the project (The American Institute of Architects, 2007), enabling the creation of added value. Additionally, as the project progresses, the level of risk and uncertainty decline (Laeven, et al., 2023), while the cost of implementing design changes increases (The American Institute of Architects, 2007). Furthermore, using integrated project delivery, the design effort occurs earlier in the project (The American Institute of Architects, 2007).

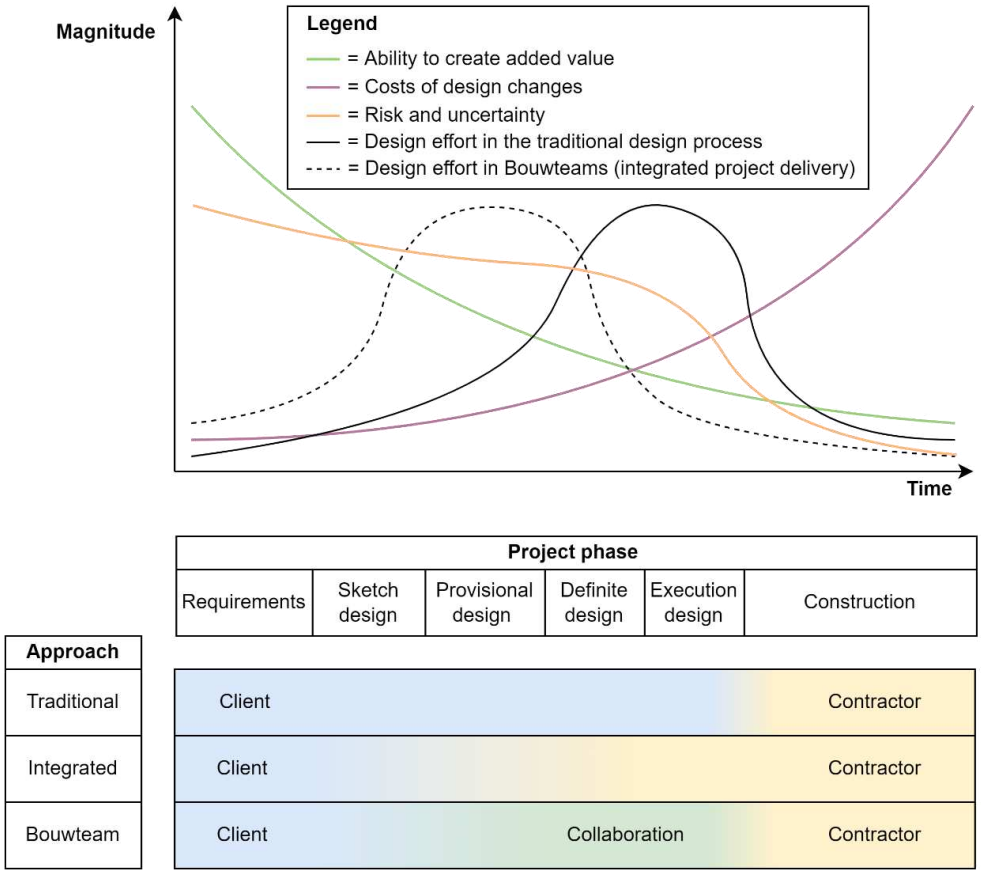

Figure 4 Ability to create added value (based on The American Institute of Architects, 2008 & CROW, 2016)

In this report, the competitively procured projects were divided into traditional and integrated approaches. In the traditional approach, the client is responsible for project preparation and design, while the contractor focuses solely on construction (CROW, 2016). Typically, contracts were tendered based on the price of the works using building specifications. In an integrated approach, the contractor is also responsible for (a part of) the design activities. In a Bouwteam, the client and contractor start a collaboration early in the project (CROW, 2016). This allows the contractor to bring in their expertise earlier, such that they can contribute more towards adding value. Additionally, design changes imposed by the contractor are less costly compared to the traditional approach.

2.3.2. Categorisation

The application of Bouwteams could have led to various effects on a project's design and construction phases. These cost implications and benefits were divided into different categories, partly based on project aims, as illustrated by Laeven et al. (2023). Firstly, a distinction was made between cost implications and benefits, further specified into four categories.

Expense drivers (1) referred to cost implications that increase the project costs for the client, whereas expense reducers (2) pointed to effects that save costs during the design and construction. Risk management (3) related to effects on risk allocation and mitigation, while cost control (4) described the integration of costs into the design process and the accuracy of cost estimates.

In addition to the cost implications, the benefits were considered. Project processes (1) related to the effects on ongoing design and construction activities and involved parties. Project results (2) referred to the final product of these activities. Innovation capabilities (3) detailed the ability of a project team to continuously transform knowledge and ideas into new products, processes, and systems. Learning (4) referred to the exchange of skills between team members and the retention and spread of knowledge acquired during the infrastructure construction project.

2.3.3. Cost implications and benefits associated with Bouwteams

An overview of the results is depicted in Table 1, categorising and listing the cost implications and benefits of Bouwteams. These effects are numbered using hashtags (e.g. #1) for reference throughout the report. These hashtags refer to the effects listed in the table without implying any order of significance. Furthermore, each effect indicates its presence in the literature related to Bouwteam or two-phase projects, collaboration and/or early contractor involvement. This is highlighted in yellow on the right side of Table 1. The numbers within these boxes correspond to the resources listed in Table 2.

Table 1 Cost implications and benefits associated with Bouwteams

Category		Nr.	Effect	Bouwteam/Two-phase	Collaboration	Early contractor involvement
Cost implications	Expense drivers (Chapter 2.3.5)	#1	Higher costs in the design phase	1 & 2		
		#2	Lack of competition in final price forming	3, 4, 5 & 6		31
		#3	Higher costs by more extensive tender procedure	7		32
		#4	Higher costs for the client-contractor relationship		15	31
		#5	Correct project administration is costly			31
	Expense reducers (Chapter 2.3.6)	#6	Prevention of conflicts resulting in savings	8	16 & 17	32 & 33
		#7	Improvement of the design	9	18	31 & 34
		#8	Increased constructability		18 & 19	31, 32, 33, & 35
	Risk management (Chapter 2.3.7)	#9	Reduction of risks	5	19 & 20	36
		#10	Improved risk allocation	10	21	31 & 37
		#11	More effective risk management		20	33, 34, 36, 37, 38 & 39
	Cost control (Chapter 2.3.8)	#12	Better accuracy of estimates	9, 10 & 11	19 & 22	31, 33, 34, 40 & 41
		#13	Reduction of additional construction costs	1 & 12		42
		#14	Costs integration into value creation process		20	43
Category		**Nr.**	**Effect**	**Bouwteam/Two-phase**	**Collaboration**	**Early contractor involvement**
Benefits	Project processes (Chapter 2.3.9)	#15	Improved working conditions and safety	3		31 & 40
		#16	Improved flexibility and responsiveness	5	18 & 23	36
		#17	Increased sharing of information and expertise	3	23	44
		#18	Improved relationship and trust	1, 5 & 10	21 & 24	31, 32, 33 & 34
		#19	Increased understanding of each other's challenges		21 & 25	
	Project results (Chapter 2.3.10)	#20	Better quality of the construction	1 & 3	18 & 21	40 & 45
		#21	Better schedule performance of construction	3, 10 & 13	17, 18 & 19	31, 42 & 44
		#22	Improved end-user satisfaction		18 & 21	
	Innovation capability (Chapter 2.3.11)	#24	Enlarged innovation by collaboration	9	18, 19, 27 & 28	35 & 36
		#25	Fostering new approaches by improved risk understanding	5 & 6		35 & 36
	Learning (Chapter 2.3.12)	#26	Contribute to mutual learning	14	25, 29 & 30	
		#27	Workers acquiring new skills		27	

Table 2 References

Nr.	Reference
1	Kleinhuis (2016)
2	Rijkswaterstaat (2023)
3	Jansen & Metsemakers (1999)
4	Dekker (1987)
5	Laeven et al. (2023)
6	Pap (2021)
7	Wielink & Luiten (2019)
8	Van Orden et al. (2022)
9	Stichting Innovatie & Arbeid (2012)
10	van den Brandhof (2009)
11	Kömürlü & Er (2023)
12	Hu & Skibnieuwski (2022)
13	Ahmad, Lamli & Osman (2021)
14	Gumbs (2023)
15	Dubois & Gadde (2010)
16	Haaskjold et al. (2019)
17	Abudayyeh (1994)
18	Bresnen & Marshall (2000)
19	Strickland (2010)
20	Zimina, Ballard & Pasquire (2012)
21	Black, Akintoye & Fitzgerald (2000)
22	Larson (1995)
23	Deakin & Wilkinson (1998)
24	Hughes, Zhaomin & Williams (2012)
25	Franco (2007)
26	Rutten, Doreé & Halman (2009)
27	Polenske (2010)
28	Gosselin et al. (2018)
29	Akintoye & Main (2007)
30	Toppinen et al. (2019)
31	Eadie et al. (2012)
32	Wondimu, Liam & Laedre (2022)
33	Finnie, Ali & Park (2018)
34	Narum et al. (2022)
35	Manley & Blayse (2004)
36	Eadie & Graham (2014)
37	Whitehead (2009)
38	Francis & Kiroff (2015)
39	Molenaar et al. (2007)
40	Rahman & Alhassan (2012)
41	Botha & Scheepbouwer (2014)
42	Rahmani, Khalfan & Maqsood (2016)
43	Gransberg (2016)
44	Song, Mohamed & Abourizk (2009)
45	Scheepbouwer & Humphries (2011)

2.3.4. Overview of the causes of the cost implications and benefits

In addition, Table 3 presents an overview of the causes of the cost implications and benefits named in the literature, following the same categorisation as detailed in Chapter 2.3.2. For each cause, the originating reference number is provided in brackets, corresponding to the references listed in Table 2.

Table 3 Causes of the effects in literature

Category		Nr.	Effects	Listed causes in the literature
Cost implications	Expense drivers (Chapter 2.3.5)	#1	Higher costs in the design phase	More effort (2) and organization prior to the works (3)
		#2	Lack of competition in final price forming	The market is sidelined (6)
		#3	Higher costs by more extensive tender procedure	More extensive tender procedure (7) and time consuming (32)
		#4	Higher costs for the client-contractor relationship	Large time and labour commitment (31)
		#5	Correct project administration is costly	-
	Expense reducers (Chapter 2.3.6)	#6	Prevention of conflicts resulting in savings	Collaboration (16 & 33), less conflicts by contract obligations (8), common commitment, mutual respect, trust and open communication (17), open book and trust (32)
		#7	Design improvement	Prevention of mistakes (9), adress need of conractor (18), collaborative project delivery (34)
		#8	Increased constructability	Collaboration (18), early consideration of contractors input (19), more informed decisions (33) and integration of design and construction (35)
	Risk management (Chapter 2.3.7)	#9	Reduction of risks	Setting the price with a well developed design (19) and lean organization (20)
		#10	Improved risk allocation	Partnering (21) and involvement of contractor (37)
		#11	More effective risk management	Collaboration in ECI using target costs (34), transparency and understanding of complexity (39)
	Cost control (Chapter 2.3.8)	#12	Better accuracy of estimates	Prevention of mistakes (9), project team expertise (10), partering (22), later setting price & less scope gaps (19), contractor knowledge (31), acountability (33), expertise (40) and input (41)
		#13	Reduction of additional construction costs	Earlier detection (1), design team skill & expertise (12), exploration of planning contractor (42)
		#14	Costs integration into value creation process	Close collaboration (20), and involvement of the contractor (43)
Category		**Nr.**	**Effects**	**Listed causes in the literature**
Benefits	Project processes (Chapter 2.3.9)	#15	Improved working conditions and safety	Contractor knowledge of design (31)
		#16	Improved flexibility and responsiveness	Collaboration (18) and sharing information and risk (23)
		#17	Increased sharing of information and expertise	Collaboration (23) and early fabricator involvement (44)
		#18	Improved relationship and trust	Collaboration (33)
		#19	Increased understanding of each other's challenges	Open and rich communication (25)
	Project results (Chapter 2.3.10)	#20	Better quality of the construction	Working together (21), contractor expertise (40), early involvement (45)
		#21	Better schedule performance of construction	Schedule control (17), overlapping of design and construction (31) and integrating construction knowledge (44)
		#22	Improved end-user satisfaction	Collaboration (21)
	Innovation capability (Chapter 2.3.11)	#23	Enlarged innovation by knowledge transfer	Better use of market input (3), Contractor knowledge(31), knowledge transfer (35) and contractor input (45)
		#24	Enlarged innovation by collaboration	Collaboration (9) on design and production (27), strong relationships (28), and ''culture of collaboration'' (35) and collaborative relationship (36)
		#25	Fostering new approaches by improved risk understanding	Reducing risks (5), equitable allocation of risk (35) and understanding risk (36)
	Learning (Chapter 2.3.12)	#26	Contribute to mutual learning	Early involvement of a third party (14) and collaboration (29)
		#27	Workers acquiring new skills	Collaboration (27)

2.3.5. Expense drivers

Higher costs in the design phase (#1)

According to Kleinhuis *(2016)*, Bouwteams could have incurred higher costs and required more before the works. Similarly, Rijkswaterstaat (2023) noted that a two-phase approach involves increased efforts and expenses during the initial phase.

Lack of competition in final price forming (#2)

Jansen & Metsemakers (1999) noted that competition is estimated for the final price formation in Bouwteams. Laeven et al. (2023) concur, and Dekker (1987) described this as difficult for many clients. Eadie et al. (2012) also pointed out the lack of price competition when using early contractor involvement. Additionally, using interviews Pap (2021) confirmed there is less competition as the market is sidelined.

Resource consuming tender (#3)

Jansen & Metsemakers (1999) and Wielink & Luiten (2019) pointed to the extensive tender procedure in Bouwteams. Wondimu, Lium, & Laedre (2022) noted that while the tender may be better, it is also more time-consuming.

Higher costs for the client-contractor relationship (#4)

Contrary to the direct beneficial effects illustrated, Dubois, and Gadde (2010) described considerable costs for developing high-involvement relationships. Eadie et al. (2012) also noted that such relationships demand substantial time and labour commitments from both the client and the contractor.

Costly project administration (#5)

Eadie et al. (2012) pointed out that using early contractor involvement can result in expensive project administration.

2.3.6. Expense reducers

Prevention of conflicts (#6)

Orden et al. (2022) found that using a Bouwteam can prevent conflicts through contractual obligations. Similarly, Abudayyeh (1994) found potential claim reduction and improved conflict resolution stemming from common commitment, mutual respect, and trust. Besides, Haaskjold et al. (2019) revealed through interviews that collaboration increases the ability to prevent and resolve conflicts. Wondimu, Lium, & Laedre *(2022)* found open book and trust leading to avoiding conflicts and Finnie, Ali, & Park *(2018)* agree on the reduced potential of conflicts and disputes connected to collaboration.

Improvement of the design (#7)

There are fewer mistakes in the design in Bouwteams according to Stichting Innovatie & Arbeid (2012). Furthermore, Bresnen & Marshall (2000) found that the design team can better address the information need of the contractor, resulting in cost savings. Eadie et al. *(2012)* also noted that the contractor's knowledge improved the construction phase's productivity. In addition, Narum et al. *(2022)* found that collaborative project delivery with early contractor involvement and target cost helps ensure improved design. Eadie et al. *(2012)* also confirmed that there is improved design quality.

Increased constructability (#8)

Strickland (2010) described how design efforts can be more efficient in an integrated and collaboration-focused approach. This efficiency is achieved by considering the contractor’s input before the design team commits to a specific approach, making the constructability input more valuable. Similarly, Bresnen & Marshall (2000) agree that collaboration can enhance buildability. Eadie & Graham (2014) revealed improved buildability through an online survey and case studies on early

contractor involvement. Finnie, Ali, & Park (2018), Wondimu, Lium, & Laedre (2022) and Eadie et al. (2012) supported this finding.

2.3.7. Risk management

Reduction of risks (#9)

Laeven et al. (2023) suggested that Bouwteams can reduce risks and failures. Similarly, Zimina, Ballard and Pasquire (2012) found collaborative decision-making can lead to risk reduction due to lean organisation and operation systems, as demonstrated in their research on the target value design. Strickland (2010) illustrated how using cost expertise from the contractor and setting the price with a further developed design can reduce risks. Eadie & Graham (2014) confirmed that early contractor involvement helps to mitigate risks.

Improved risk allocation (#10)

Van de Brandhof (2009) found that clients appreciate the division of responsibilities. Similarly, Black, Akintoye, & Fitzgerald (2000) surveyed clients, design team members, and contractors and revealed that collaboration leads to benefits such as risk sharing and reduced risk exposure. Likewise, Eadie et al. (2012) found that there is a clear definition and allocation of risks. Also, Whitehead (2009) pointed out that improved risk management can be achieved through the contractor's involvement, due to an early understanding of the project risks profiles, so that they can be appropriately allocated and shared.

More effective risk management (#11)

Zimina, Ballard and Pasquire (2012) emphasised that greater efficiency is achieved by incorporating engineering principles and practices, particularly in collaborative decision-making on risk management. Eadie & Graham (2014) found that early contractor involvement contributes to effective risk management in large schemes. Finnie, Ali, & Park (2018) noted that risk management is used in the first phase already and Francis & Kiroff (2015) reported improved risk management. Next to that, Narum et al. (2022) described how collaborative project delivery with early contractor involvement and target cost ensures effective risk management. Molenaar et al. (2007) found that early contractor involvement leads to increased transparency and understanding of project complexity and associated risks for all stakeholders. Similarly, Eadie et al. (2012) found that early contractor involvement enhances risk management.

2.3.8. Cost control

Better accuracy of estimates (#12)

Stichting Innovatie & Arbeid (2012) found that using Bouwteams can lead to greater certainty in pricing. Van de Brandhof (2009) revealed that more expertise on prices is available in the project team. Larson (1995) analysed a set of construction projects and revealed that partnering on projects shows superior results in terms of controlling costs. Similarly, Strickland (2010) illustrated how using cost expertise from the contractor, and setting the price with a well-developed design can enhance cost certainty. Furthermore, Strickland (2010) illustrated how contractors define the scope and will not feel competitive pressure to ignore or omit potential scope. Early contractor involvement has been widely recognised as helping with accurate cost estimations, as described by Narum et al. (2022). Rahman & Alhassan (2012) added that the expertise of the contractor can be used in the design phase to improve cost control, and Eadie & Graham (2014) and Finnie, Ali, & Park (2018) showed similar findings. Botha & Scheepbouwer (2014) explained how contractor input about construction contributes to price certainty. Kömürlü & Er (2023) found that two-phase projects using open book cost estimates after bidding have the lowest likelihood of variations.

Reduction of additional construction costs (#13)

Hu and Skibniewski (2022) suggested that design team skill and expertise contribute to fewer deviations, leading to a reduction in additional construction costs. Kleinhuis (2016) added that early detection results in fewer added works. Additionally, Rahmani, Khalfan, and Maqsood (2016) found that early contractor involvement reduces rework through the contractor's exploration of planning.

Costs integration into value creation process (#14)

Zimina, Ballard and Pasquire (2012) found that a close collaboration during the design can help to integrate the cost information into the value creation process and prevent budget overruns. Similarly, Gransberg (2016) noted improved cost control during the design process.

2.3.9. Project processes

Improved working conditions and safety (#15)

Jansen & Metsemakers (1999) pointed out that there can be improved working conditions and safety. Rahman & Alhassan (2012) found that early contractor involvement can improve safety and site conditions by using the contractor's expertise during the design phase. Eadie et al. (2012) found that the contractor's knowledge improved health and safety performance.

Improved flexibility and responsiveness (#16)

Laeven et al. (2023) revealed better flexibility working in Bouwteams. Furthermore, Deakin & Wilkinson (1998) point out that collaboration can improve dynamic efficiency by sharing information and risk. Similarly, Bresnen & Marshall (2000) found that collaboration can lead to greater responsiveness. Additionally, Eadie & Graham (2014) revealed higher flexibility during the construction phase.

Increased sharing of information and expertise (#17)

Jansen & Metsemakers (1999) identified better information sharing between clients and contractors as an advantage of Bouwteams. Deakin & Wilkinson (1998) pointed out that collaboration is connected to the sharing of information and risk. Lastly, Song, Mohamed, & Abourizk (2009) found that early fabricator involvement stimulates information.

Improved relationship and trust (#18)

Laeven et al. (2023) provided that in a Bouwteam, parties can shape collaboration together. Kleinhuis (2016) also found an improved relationship. Van den Brandhof (2009) found the Bouwteam agreement can form a basis for collaboration through interviews. In their survey, Black, Akintoye, & Fitzgerald (2000) added that collaboration can lead to less adversarial relationships. Additionally, Hughes, Zhaomin, & Williams (2012) found that collaboration is initiated to increase stability. Furthermore, the improved relationship between the contractor and client is connected to better collaboration in early contractor involvement by Finnie, Ali, & Park (2018), trust and sharing of goals by Wondimu, Lium, & Laedre (2022), increased trust and understanding by Eadie et al. (2012), and commitment and team building by Narum et al. (2022).

Increased understanding of each other's challenges (#19)

Franco (2007) identified two positive effects of problem structuring methods for collaboration in construction projects. Firstly, these methods enabled participants to engage in open and rich communication, resulting in mutual understanding of each other and the problem domain. Similarly, Black, Akintoye, & Fitzgerald (2000) revealed collaboration can lead to a better understanding of each other in their survey amongst clients, design team members and contractors.

2.3.10. Project results

Better quality of the construction (#20)

In general, Kleinhuis (2016) emphasised that better preparation leads to better quality. Jansen & Metsemakers (1999) supported this notion by illustrating that a focus on functional quality results in better designs. Both Bresnen & Marshall (2000) and Black, Akintoye, & Fitzgerald *(2000)* identified improved quality. Additionally, early contractor involvement can support project results and quality, as Scheepbouwer & Humphries (2011) and Rahman & Alhassan (2012) noted. Scheepbouwer & Humphries (2011) suggested this improvement may be attributed to early contractor involvement. Similarly, Rahman & Alhassan (2012) attribute it to the contractor's expertise during the design phase.

Better schedule performance of construction (#21)

Jansen & Metsemakers (1999) and van den Brandhof (2009) concurred that the use of Bouwteams can lead to time advantages. Bresnen & Marshall (2000) identified improved timing, and Strickland (2010) found improved schedule performance. Similarly, Black, Akintoye, & Fitzgerald (2000) revealed that the benefits associated with collaboration would result in better timescales. Abudayyeh (1994) highlight improved timing due to schedule control. Furthermore, Rahmani, Khalfan, & Maqsood (2016) found improved schedule performance with early contractor involvement. Song, Mohamed, & Abourizk (2009) reported similar results stemming from the integration of construction knowledge. Eadie et al. (2012) also shared these findings and noted time savings due to overlapping of design and construction. Ahmad, Lamli, & Osman (2021) detailed that the procurement process can be sped up using two-phase contracts by allowing the architect and contractor to begin work on the project as soon as possible.

Improved end-user satisfaction (#22)

Bresnen & Marshall (2000) identified improved user satisfaction. Similarly, Black, Akintoye, & Fitzgerald (2000) revealed that collaboration would increase customer satisfaction in their survey.

2.3.11. Innovation capability

Enlarged innovation by knowledge transfer (#23)

In addition to its direct impact on projects, Bouwteams can also help to foster innovations. For instance, Jansen & Metsemakers (1999) noted the underutilised potential of creativity and innovations from the market. Similarly, Rutten, Doreé and Halman (2009) found a connection between network coordination factors like knowledge exchange and planning of work and the technological innovativeness of projects. Manley & Blayse (2004) concurred knowledge transfer can facilitate innovations. Also, Eadie et al. (2012) emphasised that contractor knowledge can lead to innovation within the design phase. Scheepbouwer & Humphries (2011) also found that asset owners can take advantage of the innovation that contractors can bring to project design and delivery.

Enlarged innovation by collaboration (#24)

Stichting Innovatie & Arbeid (2012) suggested that collaborative efforts in problem-solving provide room for innovation. Abudayyeh (1994) further asserted that collaboration creates a more considerable opportunity to innovate, attributing this to open communication. Polenske (2010) illustrated that collaboration can accelerate innovation. Similarly, Bresnen & Marshall (2000) found collaboration contributes towards greater innovation. Gosselin et al. (2018) found that innovations require strong relationships in studying innovative timber structure adaptation. Eadie & Graham (2014) also highlighted how collaborative relationships encourage innovation. Manley & Blayse (2004) found a ‘culture of collaboration’ to conduce innovation.

Fostering new approaches by improved risk understanding (#25)

Bouwteams contracts offer a better environment for innovation as they provide a better risk profile for contractors according to Laeven et al. (2023). Also, Manley & Blayse (2004) discovered that

improved risk assessment can help to facilitate innovations. Similarly, Eadie & Graham (2014) emphasised that understanding risks brings innovative approaches forward. Also, Pap (2021) found that fostering innovation in two-phase contracts can be achieved through improved risk allocation, fostering a sense of equality, and allowing sufficient time for discussing innovations using interviews.

2.3.12. Learning

Contribute to mutual learning (#26)

Gumbs (2023) emphasised knowledge is retained in the Bouwteam by the early involvement of a third party. Additionally, Akintoye and Main (2007) suggested that learning can be achieved and drawn upon in future collaborations. Also, a better integration and dissemination of learning among the partners is revealed by Franco (2007). Similarly, Toppinen et al. (2019) found that collaboration stimulates mutual learning effects.

Workers acquiring new skills (#27)

Polenske (2010) pointed out that through collaboration, workers acquire new skills.

2.4. Cost trends in construction projects

2.4.1. Design costs

Despite exhaustive searches, no literature was discovered on the ex-post evaluation of engineering costs in traditional or integrated Dutch infrastructure projects. However, specific guidelines for engineering costs in cost estimations were identified. For example, the province of Zuid Holland adopted a standard of 16.2% of the total project costs for sketch designs in mobility projects (Provinicie Zuid-Holland, 2024). Additionally, DACE (s.d.) suggested that engineering costs for new construction works in infrastructure projects typically ranged from 5% to 30%, while for modifications, the range was between 5% and 50%. These sources did not specify differences between traditional or integrated projects.

2.4.2. Cost overruns

Cantarelli (2009) detailed average cost overruns in infrastructure projects as the difference between realised and estimated costs, expressed as a percentage of the estimated costs post-decision to build. Analysing 84 projects in Dutch transportation infrastructure, an average cost overrun of 10.3% was calculated, with a standard deviation of 28.8% and a not-specified average contract sum. However, it was noted that the data did not represent a random sample. In a subsequent study, Cantarelli et al. (2012) observed average cost overruns of 16.5% with a standard deviation of 40%, analysing 78 projects completed between 1991-2009 within the Dutch transportation infrastructure and an average contract sum of €86M (million). Analysing 55 projects, D. Monninkhof (2015) found an average additional cost of -3.0%, with standard deviation of 31.8%, and an average contract sum of €9M.

In a more recent study, Verweij, van Meerkerk & Leendertse (2020) examined the additional cost incurred during the realisation phase compared to the contract value in integrated design and construction projects. Analysing 49 design and construct projects, they found an average additional cost of 24.7%, with a standard deviation of 24.3% and an average contract sum of €76M. These findings align with Wolbers et al. (2017), who reported additional costs of 23% in integrated projects with the 'Room for the River' program. Analysing 22 design and construct projects, D. Monninkhof (2015) found an average additional cost of 10.5%, with a standard deviation of 43.3%, and an average contract sum of €19M.

2.4.3. Risk reserves

No literature specifically detailing average risk reserves in the Dutch construction sector could be found. However, according to the SSK (Standard form for cost estimations) from CROW (Cleven, 2019), there are some standard bandwidths for risk reserves across various project phases. Typically, risk reserves decrease as the project advances. For instance, during the provisional design phase, the risk reserve typically accounts for 14-18% of the estimated costs. This decreases to 6-12% from the middle of the definitive design phase through to the execution design phase.

2.5. Discussion

2.5.1. Interpretations

The literature review of Bouwteams' characteristics revealed they revolve around collaboration, using a two-phase approach, and early contractor involvement to manage project complexity, addressing research question 1.a. These characteristics distinguish Bouwteams from competitively procured projects.

Subsequently, these characteristics were used to explore the cost implications and benefits associated with Bouwteams according to literature, addressing research question 1.b. While using Bouwteams can introduce some unfavourable cost implications, it also contributes to a more efficient design, better risk management, more accurate cost estimates, various process improvements, and better project results, and fosters innovation and learning. Additionally, the causes of these cost implications and benefits have been identified in the literature, mostly considering collaboration and early contractor involvement, addressing sub-questions 1.c.

The benefits of using Bouwteams are evident in both the design and realisation phases. Concerning cost implications, it appears that the expense drivers dominate the design phase, while the expense reducers become apparent in the realisation phase. Therefore, initial investments may be higher, but subsequent returns can be realised over time.

The literature review on cost trends in construction projects primarily highlighted cost overruns in the sector, including integrated projects, addressing sub-question 3.c. Unfortunately, limited data on design costs and risk reserves throughout the projects appeared to be available.

2.5.2. Validity and quality assurance

Following a review of the literature study with the senior tender and contract advisor, the conclusion generally was that the method employed was suitable. His expertise in contracts enabled him to assess the content of the work. Additionally, it ensured that differences in interpretation by the researcher and the intended message of the papers were addressed. The results appeared to align with practical experiences. However, there was a recommendation to enhance the linkage between the table outlining the cost implications and benefits and the subsequent text. Consequently, each effect has been numbered and referenced in the text accordingly.

2.5.3. Limitations

Despite the use of various search queries and a wide range of resources consulted, it is essential to acknowledge the limitations of this literature review.

While conducting a literature review, it was important to realise the possibility of differences between the author's written message and the reader's interpretation. Such differences in interpretation could have led to inadequate referencing of the literature. One effect of working in Bouwteams was initially misinterpreted. At first, the researcher understood ‘controlling costs’ as Larson (1995) described as

management costs. However, revisiting the literature made it apparent that it referred to cost controlling during the design and execution phases.

The scarcity of papers focussing on Bouwteams posed a challenge. As a result, the content primarily relied on integrating information from three guiding documents. Two documents referred to two-phase contracts, while only one directly addressed Bouwteams. A similar limitation emerged during the identification of Bouwteams' effects, as it became apparent that the literature consulted could have contained uncertainties due to its limited scientific value. Specifically, regarding Bouwteams, literature was scarce, with approximately half of the documents being either thesis reports or course/symposium reports. Furthermore, it is noted that some resources may not consider Bouwteams in the context of infrastructure projects.

Notably, some more critical voices were also present in the literature. For instance, Laeven et al. (2023) highlighted the need for changes in behaviour, attitude and division of tasks and roles in Bouwteams before it can be as successful. Similarly, Franco (2007) pointed out that not all participants fully realise the potential of Bouwteams, citing complexities and challenges such as managing ambiguity and dynamics, developing a shared identity, and balancing power asymmetries.

Furthermore, some scholars doubted whether the reported benefits can be directly attributed to Bouwteams. Bresnen & Marshall (2000) suggested that performance gains may be influenced by indirect factors rather than solely by the collaboration. Similarly, Polenske (2010) noted that success in collaboration is influenced by non-market forces such as trust and learning. Additionally, Akintoye and Main (2007) pointed out that collaboration should be carefully considered to ensure alignment with the business plan and address potential failure factors.

There has been an ongoing debate regarding the cost efficiency of adding value to projects through early contractor involvement. Eadie & Graham (2014) suggested that it is most relevant for larger projects. Narum et al. (2022) found that early contractor involvement applies to complex projects and Farrell & Sunindijo (2020) and Wondimu, Lium, & Laedre (2022) concurred its unsuitability for all projects. Rahmani (2020) described challenges in demonstrating value for money, cultural barriers, and inequalities in remuneration employing interviews from the client’s perspective. Farrell & Sunindijo (2020) agreed to the challenge in culture and highlighted hurdles in practice and intellectual property. Botha & Scheepbouwer (2014) asserted that despite the good early contractor involvement input into design and price development, procurement practices and project management techniques are still required for success.

At times, the literature review encountered contradictions. For instance, instead of reporting a better accuracy of estimates (#12) Nijhuis (2019) reported larger cost deviations in Bouwteam projects compared to competitively procured projects. Similarly, van den Brandhof (2009) noted shortcomings such as lack of technical support and proactive attitude by the contractor, as well as the possibility of additional construction time and costs.

Lastly, some of the findings of the literature review were excluded from the framework due to lack of clarity or relevance. For instance, Toppinen et al. (2019) described benefits such as increased sustainability awareness and marketing gains resulting from cooperation, but they also noted that a sustainability-driven culture is still weak in the construction business. Since no other resources supported these findings, they were excluded. Similarly, Polenske (2010) pointed out that collaboration can impact an organisation's long-term position, lower costs, and help obtain capital investments. However, these effects were not accepted due to uncertainty regarding their

applicability to Bouwteams, particularly considering constraints imposed by public procurement legislation and internal budgets. Furthermore, Wondimu, Lium, and Laedre (2022) suggested the potential for optimising the construction. However, this was deemed too vague, as it was unclear whether optimisation referred to the construction phase itself or reaching specific optimisations, and thus it was disregarded.

Additionally, benchmark data for engineering costs and risk reserves were limited. Fortunately, a few studies were available to compare cost trends. Although the historical data on project costs was somewhat dated, Cantarelli et al. (2012) found no correlation between the year of completion and the cost overruns, suggesting this data would still be relevant.

2.5.4. Implications

The literature's primary contribution has been to establish an overview of the cost implications and benefits of Bouwteams, forming a hypothesis that these effects may also be present in Bouwteam projects within the Dutch infrastructure construction. Currently, some of the effects described in relation to collaboration and early contractor involvement are not described in the context of Bouwteams, indicating a gap in understanding.

Additionally, the review identified a gap in the literature regarding the causality of the cost implications. While naming collaboration and early contractor involvement cause significant effects, the causality remains uncertain.

Lastly, the analysis of cost trends in construction projects revealed a lack of ex-post project evaluation of Bouwteams, despite recommendations for such evaluations. This points to a research gap. Cost trends in the construction sector and in integrated projects are available, enabling comparisons with Bouwteams.

2.6. Conclusions

Collaboration and early contractor involvement played a prominent role in causing the cost implications and benefits associated with using Bouwteams. Table 1 provided the basis for the conceptual framework, which is summarised in Figure 5.

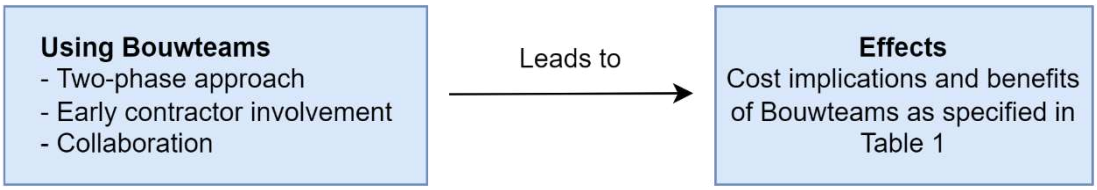

Figure 5 Conceptual framework

2.7. Recommendations

It will be advantageous to consult a broader range of written works to identify and substantiate the cost implications and benefits of Bouwteams. To improve the literature research, it may be beneficial to include search terms such as 'cooperation', 'public-private', and 'PPS' and explore search engines beyond Google Scholar.

Moreover, further exploration of the identified research gaps regarding the cost implications and benefits of Bouwteams and their causality will be beneficial. Addressing the knowledge gap concerning ex-post project evaluation on the cost trends in Bouwteams could also prove highly valuable.

3. Methodology

This chapter starts with an overview of the research design. Then, it elaborates on the three data collection methods: the expert survey, case study, and project survey. It explains each method's selection and details data collection and analysis.

3.1. Research design

A global overview of the research activities which were employed to answer the posed research questions further can be found in Figure 6. First, a conceptual framework was established, as detailed in the last chapter. Empirical research was then employed to further address the literature review recommendations. The research activities are listed in the blue boxes, and a reference to the associated research question is included between brackets.

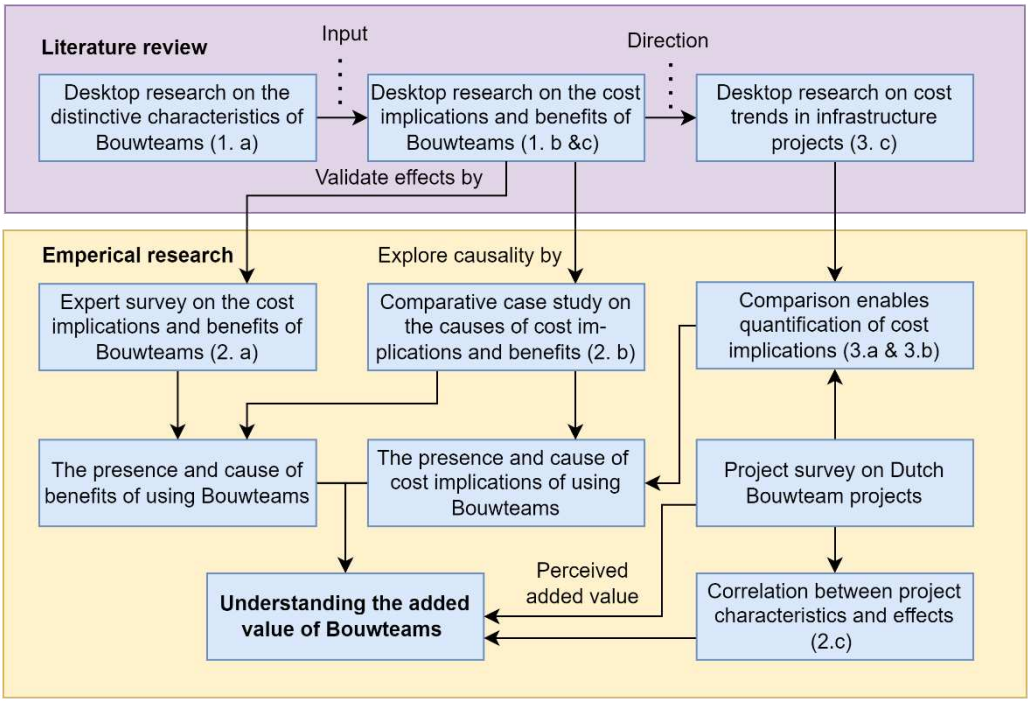

Figure 6 Research Methodology

The cost implications and benefits, as lined out in the conceptual framework, were validated using an expert survey on the cost implications and benefits. A comparative case study was also employed to investigate the causality of using Bouwteams and the cost implications and benefits. A project survey was employed to quantify the cost trends in Bouwteam projects. By comparing the cost trends of Bouwteam projects and the cost trends in the sector, the cost implications of using Bouwteams were derived. Lastly, data from the project survey was used to identify possible correlations between project characteristics and effects. Ultimately, these steps have contributed to understanding the added value of Bouwteams.

Resource triangulation was employed to validate findings and increase their reliability. The results from the expert survey were used to validate the cost implications derived from the project survey. Also, the results from the project survey were used to validate the benefits found in the expert survey. The correlation analysis between project data and characteristics was used to validate the causal diagram from the case study.

3.2. Expert survey

3.2.1. Selection research method

The literature study identified the cost implications and benefits associated with Bouwteams. An expert survey was then used to collect expert opinions. This approach helped ascertain that the effects listed in the literature align with the perceived cost implications and benefits in Bouwteam projects, which thereby addressed research question 2.a.

The main advantage of the survey was that it allowed for the investigation of a more extensive range of participants and enabled the generalisation of knowledge (Verschuren & Doorewaard, 2007). Even though the expert survey could achieve good generalisability, it had limited depth.

3.2.2. Data collection and analysis

Participants were asked to rate statements to evaluate the cost implications and benefits of using Bouwteams. The target audience of the expert survey included individuals in the construction industry who worked with Bouwteams in their daily practice, such as project managers, contract managers or tender advisors. The expert survey aimed to be easily understandable and user-friendly, with each statement reflecting one of the cost implications or benefits of Bouwteams. The numbering of the statements corresponded to the numbering of the effects in the literature review. Statements were formulated as: 'The use of Bouwteams leads to…' followed by a cost implication or benefit. Participants rated each statement on a five-step Likert scale ranging from 'totally disagree' to 'totally agree'. Finally, the chance of a cost implication or benefits occurring was calculated based on the average and standard deviation of the sample, assuming a Gaussian distribution. The invitation handout, computation of the number of participants and the expert survey can be found in Appendix C.

3.3. Comparative case study

3.3.1. Selection research method

Another method is used to explore the reasons behind the cost implications and benefits manifestation to address the limited depth of the expert survey. Namely, a comparative case study was conducted, in which two cases were investigated to ensure the generalisability of the results. The results of two case studies were compared to understand why Bouwteams leads to cost implications and benefits, addressing sub-question 2.c.

The case study was particularly suitable for developing a deep understanding of a specific domain, and a strategic sample was used to generate qualitative data. This approach is especially beneficial for practice-oriented projects, as it helps to achieve an integral image (Verschuren & Doorewaard, 2007). An additional advantage is that minimal prior structuring is needed, increasing flexibility (Verschuren & Doorewaard, 2007). Furthermore, the results were likely to be accepted in the field compared to findings from other data collection methods. However, a primary disadvantage of the case study was its lack of external validity, which made it difficult to generalise the findings (Verschuren & Doorewaard, 2007).

3.3.2. Data collection and analysis

Each case study consisted of two interviews and one project visit. One interview was conducted with a client representative, while the other was held with the contractor. These interviews were conducted in person and lasted approximately 60 minutes each. The topic list for the case study interview was designed to explore how the use of Bouwteams imposes cost implications and benefits

identified in the literature review. The topic list for the case study interview can be found in Appendix D. The interviews were recorded and transcribed for analysis and are confidential.

3.4. Project survey

3.4.1. Selection research method

In the literature, an ex-post evaluation of Bouwteams' cost-efficiency was recommended. Therefore, a more quantitative approach is employed to explore whether the use of Bouwteams correlates with changes in cost patterns across projects in the Dutch infrastructure sector.

Surveys offer the advantage of investigating a wide range of projects and facilitating the generalisation of findings (Verschuren & Doorewaard, 2007). It was recommended that the research includes at least 40 Bouwteam projects, as using fewer units may result in unreliable results (Verschuren & Doorewaard, 2007). A cross-sectional expert survey-based survey was selected, with data collected from a subset of one group over a single period.

While surveys offered advantages, such as broad data collection, they also had limitations. One drawback was their limited depth. Additionally, careful design of the method for data collection was essential (Verschuren & Doorewaard, 2007). Another challenge was that ex-post surveys could not directly capture added value (Verweij, Koppenjan, & Hombergen, 2023). To address this, an alternative approach could involve comparing benchmark data from competitively procured projects (Verweij, Koppenjan, & Hombergen, 2023).

Finally, the survey results on Bouwteam projects were analysed. This analysis examined project characteristics, cost trends and benefits to determine if there was a correlation between these elements, addressing sub-question 2.b and validating the case study results.

3.4.2. Data collection and analysis

Using a survey, which can be found in Appendix E, the cost trends in Bouwteam or two-phase projects were gathered. The project characteristics, based on the literature review, were addressed at the start of the survey. For each project, participants were asked about the type of collaboration, solution space, the project phases in which the Bouwteam took place, the contract utilised, and the approximate project turnover.

Secondly, the survey explored the cost throughout the projects. Initially, the claim of higher costs in the design phase (#2) was examined by inquiring about the proportion of the total spending used in the Bouwteam phase. Additionally, respondents were asked to assess the magnitude of the risk reserves compared to the total estimated costs both at the start and the end of the Bouwteam phase to ascertain risk reduction (#9). Lastly, a comparison between realised costs at the initiation and conclusion of the Bouwteam phase was conducted.

Thirdly, the participants were asked to indicate whether the cost implications and benefits align with their project experiences. They were provided with checkboxes to mark if they perceived the statements as applicable. Additionally, participants were invited to rate the cost-efficiency of using Bouwteams to create added value within their projects using a seven-step Likert scale.

Target projects survey

In greater detail, the project eligible for participation in the study must have met specific criteria. Surprisingly, the project did not necessarily have to use a Bouwteam agreement; any other contract emphasising collaboration, featuring two distinct phases, and involving early contractor involvement, was also accepted. The target group consisted of Bouwteam or two-phase projects that had

completed the design phase. No further constraints were applied regarding these projects' magnitude or completion date. Although further demarcation of these specifications might have helped to eliminate other influences, obtaining data on more specific projects was deemed too challenging. Additionally, reasons for cost overruns were collected, allowing for the filtering of time-dependent influences, such as fluctuation of material costs. Furthermore, the results were generalised, and these project characteristics were stored and could be used to identify possible outliers.

Target Audience survey

This survey was held under one member of the management staff involved in one Bouwteam or two-phase projects. Participants in the survey were selected through a random sample and identified through connections and snowball sampling within the researcher's network.

Correlations in project survey

Analysis of the Dutch Bouwteam projects' cost implications and benefits could help reveal which aspects are related. Therefore, the characteristics, cost implications and benefits have been analysed using the Pearson correlation test to check whether relationships could be found.

4. Results

This chapter presents the findings from the expert survey, case study and project survey.

4.1. Expert survey

Of the 92 individuals who received an invitation to participate in the expert survey, 26 completed the form, resulting in a 28% response rate. The experience and employer of the participants are detailed in Figure 7 and Figure 8 respectively. Notably, all participants had more than five years of experience, with the majority working at municipalities, contractors, or engineering firms.

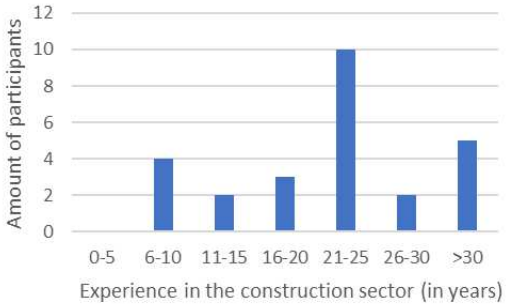

Figure 7 Experience participants

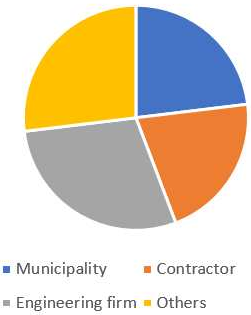

Figure 8 Employer of the participants

The results of the expert survey are presented in Table 4 below, which shows the cost implications, benefits and their average ratings, standard deviation, and chance of presence calculated based on an assumed Gaussian distribution as detailed in Appendix F. The effects are sorted in descending order.

Table 4 Expert survey results

Nr	Effect	Average (-2 to 2)	Standard deviation	Probability (sorted descending)
#7	Improvement of the design	1.54	0.51	1.00
#26	Contribute to mutual learning	1.19	0.40	1.00
#17	Increased sharing of information and expertise	1.38	0.50	1.00
#13	Reduction of additional construction costs	1.38	0.57	0.99
#6	Prevention of conflicts resulting in savings	1.42	0.64	0.99
#8	Increased constructability	1.54	0.71	0.99
#9	Reduction of risks	1.38	0.70	0.98
#19	Increased understanding of each other's challenges	1.27	0.67	0.97
#18	Improved relationship and trust	1.19	0.69	0.96
#11	More effective risk management	1.35	0.80	0.95
#10	Improved risk allocation	1.38	0.85	0.95
#12	Better accuracy of estimates	1.08	0.89	0.89
#27	Workers aqcuiring new skills	0.77	0.65	0.88
#20	Better quality of the construction	0.96	0.82	0.88
#16	Improved flexibility and responsiveness	0.92	0.80	0.88
#24	Enlarged innovation by collaboration	0.81	0.80	0.84
#22	Improved end user satisfaction	0.77	0.86	0.81
#23	Enlarged innovation by knowledge transfer	0.69	0.79	0.81
#21	Better schedule performance of construction	0.65	0.80	0.79
#15	Improved working conditions and safety	0.69	0.88	0.78
#14	Costs integration into value creation process	0.62	0.94	0.74
#25	Fostering new approaches by improved risk understanding	0.54	0.90	0.72
#5	Higher costs in the design phase	0.04	0.92	0.52
#1	Lack of competition in final price forming	-0.31	1.16	0.40
#4	Correct project admistration is costly	-0.96	0.92	0.15
#2	Higher costs by more extensive tenderprocedure	-1.04	0.82	0.10
#3	Higher costs for the client-contractor relationship	-1.04	0.77	0.09

4.2. Comparative case study

Two cases have been studied. This section will describe the two cases and their findings.

4.2.1. Case study 1

Description case

In the first case study, a municipality commissioned a redesign of a location surrounded by residential areas and businesses. The project aimed to redevelop public space to improve the area's attractiveness and accommodate green and water storage. Construction involved underground works, such as earthmoving, cables, pipelines, and sewage, as well as above-ground works, including road construction, installation of streetlights, and landscaping. The municipality's maintenance budget financed the project, supplemented with credits and subsidies.

The project was awarded using a tender with a 100% rating on quality, assessing aspects such as the establishment of the Bouwteam, environmental management, risk management, budget and quality management and stimulation of chances and innovation. During the Bouwteam phase, the design and scope were developed until an execution design was finalised. The execution phase was carried out under UAV with building specifications. Integrated collaboration was employed, with a small solution space for above-ground works and a wider solution space for the works underground, the effects of which became evident during the project:

> *"Since we had a definite design for the above-ground works, there was limited room for innovations and optimisations in the Bouwteam in this area. However, the provisional design for the underground works allowed exploring new solutions."*

Two notable findings emerged for this project. Firstly, several innovations were successfully implemented, including using an earth depot for soil reuse, using Building Information Modelling for subsoil infrastructure location and crane navigation, and constructing a sustainable road with a longer lifespan and pavement that emitted fewer emissions. These innovations could be reached due to the early involvement of the contractor and the use of a risk file. Secondly, it was observed that using fixed markup percentages was less favourable for the contractor, as it was perceived that working in a competitively procured project could be more profitable. However, despite this concern, the contractor expressed satisfaction with the project due to enlarged collaboration and job satisfaction. According to the interviewee's assessment, the Bouwteam was deemed beneficial and provided added value, as the benefits outweighed the costs.

> *''It is not that we saved money using a Bouwteam, but it surely contributed to long-term value creation."*

Findings

During the interviews, it was evident that each of the effects listed in the literature was noticed to some extent in the project, except for the expense-driving cost implications. The reasons for these, as explained by the interviewees, will be provided for each category of cost implications and benefits in the following paragraphs.

Regarding the expense drivers, the increased costs during the design phase (#1) were attributed to the contractor's active participation. However, the lack of competition on the final price (#2) was not confirmed. Higher costs in the tender procedure (#3) appeared on the contractor's side, as they felt

they needed to prepare their tender response more extensively. Higher costs for the relationship (#4) and more project administration costs (#5) were not confirmed.

Transparency, trust, and using a risk file with clear risk allocation perceivably prevented conflicts (#6). Bouwteams notably influenced the efficiency of the design effort, with design improvements (#7) due to collaboration, incorporation of sustainability, development of risks, and consultation of the environment. Also, increased constructability (#8) was achieved by the contractor's involvement and further detailing of the design.

Risk management also demonstrated improvements, with collaboration and using a risk file leading to reduced risks (#9) and enhanced risk allocation (#10). Furthermore, the suitable allocation of risks and sharing of risk-reductive thought contributed to more effective risk management (#11).

Then, the cost control witnessed an improvement in the accuracy of estimates (#12) due to the reduction of additional construction costs (#13) and the prevention of conflicts (#6). During the design, Trade-off matrixes were used to support design decisions, with cost being a crucial consideration, thus highlighting cost integration into the value-creation process (#14).

Several effects were observed throughout the project processes. Firstly, there were noticeable improvements in working conditions and safety (#15) due to the influence and expertise of the contractor, as well as the provision of space within the risk reserves to address safety issues. Additionally, greater flexibility and responsiveness (#16) were evident, driven by a shared interest in achieving project goals. The sharing of information and expertise (#17) and an improved relationship and trust (#18) between the client and the contractor became apparent due to increased collaboration in the Bouwteam. These factors also facilitated an increased understanding of each other’s challenges (#19).

Additionally, two new benefits of the project were observed. First, working in Bouwteams has been reported to lead to a reduction in environmental nuisance (#A1), focussing on minimising hindrance and sound emissions. This was achieved by using the contractor's expertise and adopting a collaborative decision-making process. Secondly, there was an observed increase in job satisfaction (#A2), attributed to more learning, collaboration, sharing of successes and problems, involvement of multiple disciplines and better risk division.

The use of Bouwteams has also demonstrated various impacts on the project results. Primarily, the quality of the construction (#20) was improved by optimising supply chain efficiency, facilitated by the collaboration of designers and the job executor. In this project, particular emphasis was placed on schedule performance (#21), a goal achieved by using the expertise of the contractor and the collaborative management of the complex environment. Consequently, there was improved end-user satisfaction (#22).

All innovations in the project were introduced in collaboration with the contractor, who had the necessary autonomy to do so. The collaborative nature and effective risk allocation provided the right environment for these innovations. This confirmed the statements that there is enlarged innovation by knowledge transfer (#23), collaboration (#24) and risk understanding (#25).

Finally, mutual learning (#26) is stimulated within the project, as the client and the contractor have a better understanding of each other’s work and challenges. Collaboration also fosters acquiring new skills (#27) among personnel.

4.2.2. Case study 2

Description case

The second case study considered a large dike reinforcement project using a two-phase approach. The construction works considered renovating and heightening the dike. Notably, the project was defined by its complexity, as various stakeholders in the neighbourhood interacted with the construction activities.

The project employed a tender procedure involving collaboration, discussion of multiple plans, and conversation rounds. During the Bouwteam phase, the design was collaboratively developed from a sketch design into an execution design under a self-drawn-up contract. The execution of the works took place under the UAV-GC. Throughout the Bouwteam, there was a shift in collaboration.

> *''In the sketch design, the client was in the lead, while we (the contractor) played a role in controlling and advising on practical matters. (…) We tended towards coordinated cooperation during this phase to provide expert input. However, when we took the lead in the definite and execution design, the approach shifted towards a more integral one.''*

One notable finding in this project was the need to ensure market conformity, a requirement imposed by the subsidy provider. This issue also corresponds to the lack of competition in the final price formation (#4). Therefore, this project adopted an approach with predetermined overhead, profit, and risk percentages. Additionally, the contractor handled the procurement of materials, offering three alternatives to the client. Moreover, lessons learned from previous projects by the contractor heavily influenced the design of the dike and the selection of materials for the project. Also, it became evident that the sequence of design activities and soft skills are essential.

> *''The sequence of the design activities is vital to a Bouwteam. (…) Working is a people business, so the team's continuity is crucial. (…) Trust is the most important, transparency and keeping each other's interest in mind is key.''*

This also appears to be the case for conflict resolution and contract management:

> *''During an argument, it is all about the conversation, not about what the contract says. Considering each other's interest leads to a solution to which both parties can agree.''*

> *''When there is too much focus on the systems and contract management, it could be that the operation is a success, but the patient dies.''*

Findings

In this project, higher costs were observed in the design phase (#1) due to increased resource consumption resulting from contractor involvement in the early project phase. The lack of competition in final price formation (#2) was also evident, particularly in the indirect costs, attributed to the contractor's establishment of a rather large project organisation. The higher costs by a more extensive tender procedure (#3) were not observed in this project. While interviewees acknowledged costs incurred for plan development and participation in conversations, savings could also be realised as no calculations were necessary. Therefore, higher costs for the extensive tender procedure (#4) could not be confirmed. Correct project administration (#5) was not applicable in this project, as the trust among parties even reduced administrative duties.

An improved client-contractor relationship prevented conflicts, resulting in savings (#6). The contractor's expertise in construction works facilitated increased constructability (#8) through design improvement (#7). For instance, feedback from previous project executors on constructability was sought at various stages of the design process.

Some differences became apparent in terms of risk management. Namely, the risk file was enriched with the contractor's input. Also, collaboration in the allocation (#10) of risks leads to a reduction of risks (#9). Furthermore, collaboration on risk mitigation led to more effective risk management (#11).

The contractor's expertise in improving the design leads to less added work (#13), thereby increasing the accuracy of the estimates (#12). Cost integration varied depending on the project's phase and parts.

The project processes identified in the literature and observed during the first case study were mostly confirmed in the second case study. However, the improved working conditions and safety (#15) were not observed. A collaborative mindset facilitated improved flexibility and responsiveness (#16) during the construction phase. Transparency and early involvement of the contractor were believed to contribute to the sharing of information and expertise (#17), improved relationships and trust (#18), and increased understanding of each other's challenges (#19). Also, the reduction of environmental nuisance (#A1) and increased job satisfaction (#A2) were caused by collaboration and early contractor involvement.

Better quality of the construction (#20) was evident due to the early involvement of the contractor, which also facilitated a manageable execution of the works and resulted in better schedule performance of construction (#21). Additionally, involving locals contributed to improved user satisfaction (#22).

Enlarged innovation was observed due to the contractor's input on the lessons learned from a previous project, reflecting knowledge transfer (#23). Collaborative design sessions facilitated the contractor's input into the design process, which led to improved innovation through collaboration (#24). However, fostering new approaches through improved risk understanding was not evident in this project (#25).

Contribution to mutual learning (#26) was widely observed. For instance, the client and contractor organisations engaged in inter-project learning, and lessons were exchanged with other client organisations. However, workers acquiring new skills (#27) did not become apparent in the project.

4.3. Project survey

The survey results are presented in the following three subsections. The first section details the characteristics of the respondents. The second section focuses on the cost trends using Bouwteams. Lastly, the cost-efficiency of Bouwteams in adding value will be discussed.

Characteristics of the participating projects

In total, the survey yielded data from 31 Bouwteam or two-phase projects. The project details are summarised in the infographic presented below in Figure 9. The turnover of the projects amounts to an average of €108M.

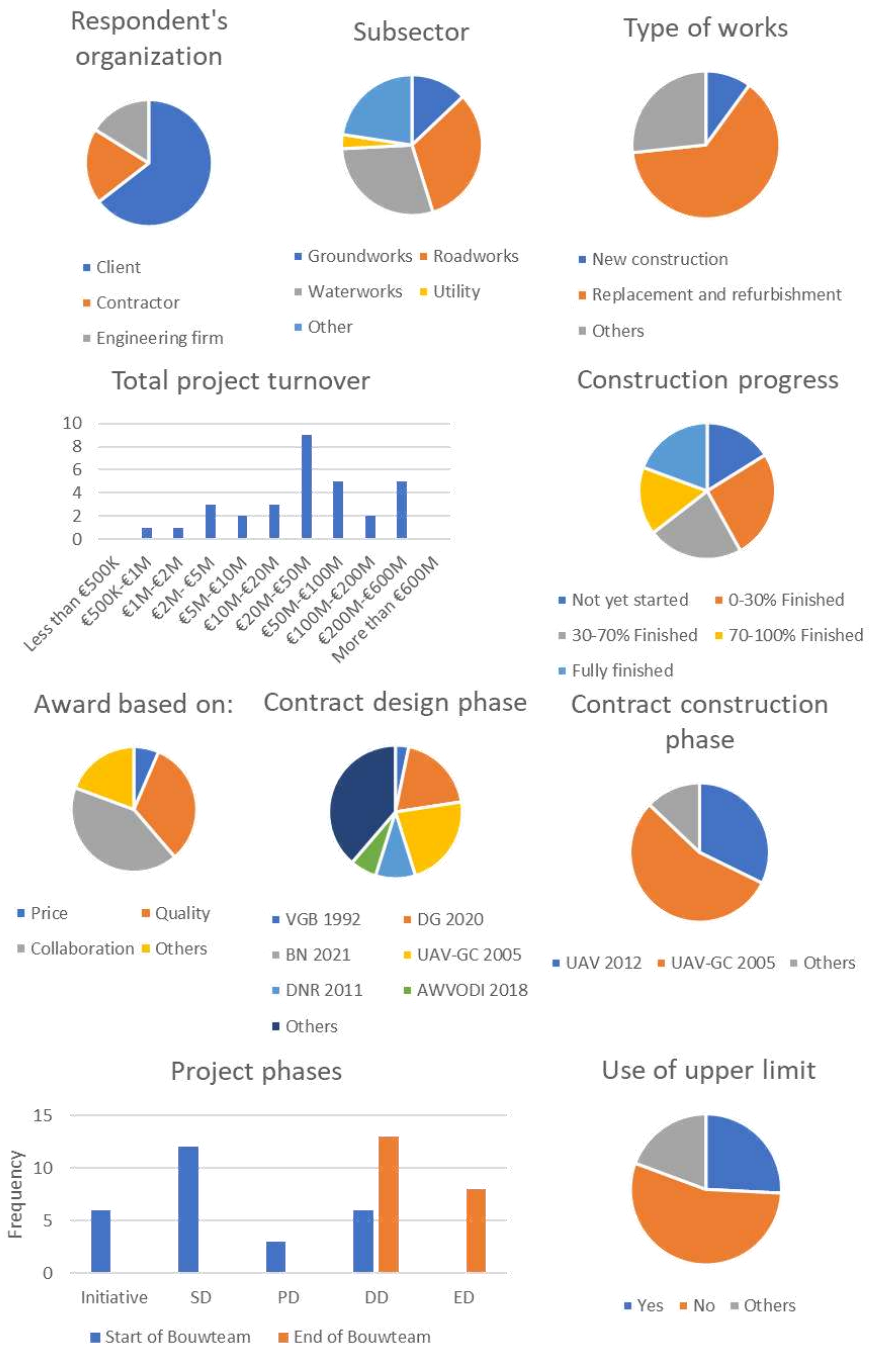

Figure 9 Infographic project characteristics

Among the 31 unique projects, most used an integral collaboration with a wide solution space, as illustrated in Figure 10. The numbers on the dots in the figure represent the number of projects at this location in the matrix.

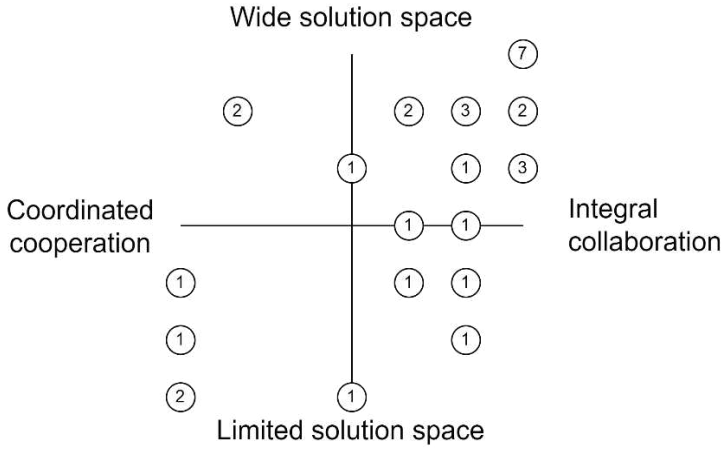

Figure 10 Projects on the solution space - collaboration quadrant of CROW (2020)

Cost trends in Dutch Bouwteam or Two-phase projects

In Figure 11 the cost trends through Dutch Bouwteams or Two-phase projects are depicted. An average cost of 15.5% (with a standard deviation, or σ, of 10.0%, based on 29 results) out of the total costs for the design and construction of the works was allocated to activities in the Bouwteam phase.

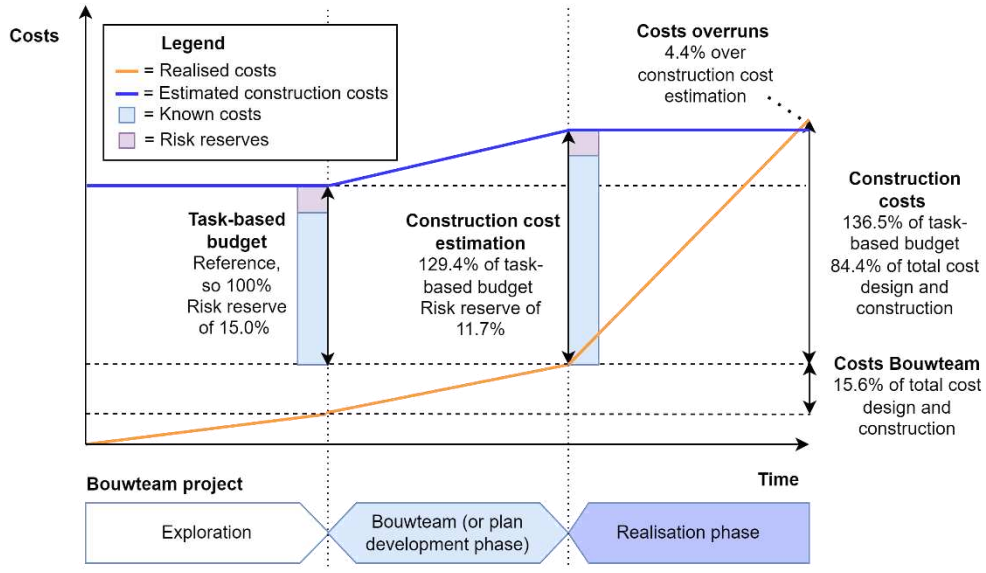

Figure 11 Cost trends in Bouwteam or Two-phase projects

On average, the construction cost estimation towards the end of the Bouwteam phase, when the design activities have (partly) progressed, amounted to 129.4% (σ being 52.0%, based on 24 results, vagueness) of the task-based budget. The task-based budget served as a reference in the figure, representing the budget for realising the works at the beginning of the Bouwteam phase. The realised cost showed a cost overrun of 4.4% (σ being 11.3%, based on 20 results) to the construction cost estimation. Projects not starting the realisation phase were excluded from determining the cost overruns. The risk reserve at the start of the Bouwteam averaged 15.0% (σ is 12.4%, based on 20

results) of the task-based budget and 11.7% (σ being 7.2%, based on 23 results) at the beginning of the realisation phase. Thereby, the monetary risk reservation developed from 15.0% at the start of the Bouwteam to 15.1% at the end of the Bouwteam, both relative to the task-based budget.

Reasons for cost overruns

In the survey, the participants were allowed to specify the three primary causes of cost overruns in their projects. Approximately two-thirds of the participants used this space, citing the following main reasons for cost overruns in descending order: scope changes (in 9 projects), rising costs for labour, material, and equipment due to economic circumstances (in 7 projects, the war in Ukraine being most frequently mentioned), setbacks in the current situation (in 5 projects, subsoil obstacles being most frequently cited), environmental concerns (3 projects), and the quality of cost estimations (in 2 project).

Cost implications and benefits in Dutch Bouwteam or Two-phase projects

In the survey concerning Dutch infrastructure projects using Bouwteam or two-phase projects, participants were asked to indicate whether they observed Bouwteams leading to cost implications or benefits in their project. They selected multiple boxes from a list of effects they observed. The findings are presented in Table 5, showing the ratio of projects where each cost implication or benefit was observed.

Table 5 Cost implications and benefits of Bouwteams in projects

Category		Nr.	Effect	Presence in projects
Cost implications	Expense drivers	#1	Higher costs in the design phase	0.43
		#2	Lack of competition in final price forming	0.70
		#3	Higher costs by more extensive tender procedure	0.07
		#4	Higher costs for the client-contractor relationship	0.23
		#5	Correct project administration is costly	0.00
	Expense reducers	#6	Prevention of conflicts resulting in savings	0.67
		#7	Improvement of the design	0.60
		#8	Increased constructability	0.73
	Risk management	#9	Reduction of risks	0.70
		#10	Improved risk allocation	0.70
		#11	More effective risk management	0.43
	Cost control	#12	Better accuracy of estimates	0.67
		#13	Reduction of additional construction costs	0.63
		#14	Costs integration into value creation process	0.20
Category		**Nr.**	**Effect**	**Presence in projects**
Benefits	Project processes	#15	Improved working conditions and safety	0.33
		#16	Improved flexibility and responsiveness	0.63
		#17	Increased sharing of information and expertise	0.70
		#18	Improved relationship and trust	0.63
		#19	Increased understanding of each other's challenges	0.63
	Project results	#20	Better quality of the construction	0.33
		#21	Better schedule performance of construction	0.40
		#22	Improved end-user satisfaction	0.47
	Innovation capability	#24	Enlarged innovation by collaboration	0.47
		#25	Fostering new approaches by improved risk understanding	0.27
	Learning	#26	Contribute to mutual learning	0.67
		#27	Workers acquiring new skills	0.13

Cost-efficiency of Bouwteams in creating added value

The participants from projects had the opportunity to express their opinions on the cost-efficiency of their projects, which were generally positive, as presented in Figure 12. The participants reported a positive effect on the cost-efficiency of adding value in 79% of their projects.

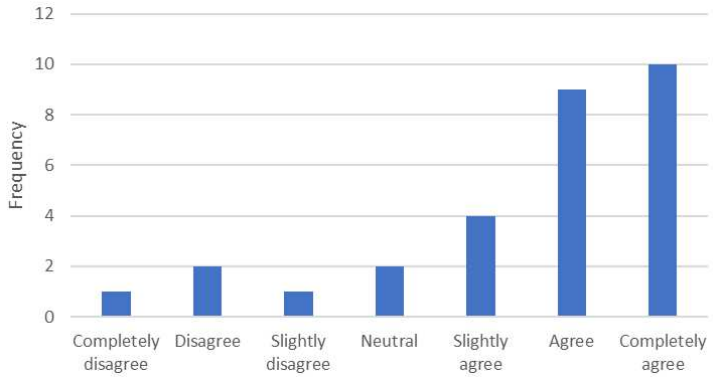

Figure 12 Participants ratings of the cost efficiency of Bouwteams in adding value in their projects

Correlation analysis

The Pearson correlation coefficient describes the correlation between two values on a scale of -1 to 1. When there is a Pearson correlation coefficient of 0-0.3, there is a weak correlation, 0.3-0.7 indicates a mediocre correlation, 0.7-1 points towards a strong correlation, and negative values represent a negative correlation.

Notably, there is a mediocre correlation of 0.46 between the type of collaboration and the cost-efficiency in creating added value. Also, a strong relationship existed between the start phase and the solution space of projects at -0.71, meaning a later starting phase implies a small solution space. Also, there was a mediocre correlation between the type of collaboration and the solution space at 0.63, where a wider solution space correlates with a more integral collaboration. However, there was a weak correlation between the type of collaboration (coordinated/integral) and the number of benefits at 0.07. No correlation could be found between the turnover of the project and the number of benefits at 0.05 or the efficiency in reaching added value at -0.07. There are weak correlations between the efficiency in adding value and the use of a price cap at -0.19, or efficiency in adding value and the solution space at 0.26.

When examining the factors related to the benefits themselves, several showed moderate correlations. Collaborative risk allocation (#10) demonstrated a mediocre correlation with the reduction of risks (#9) at 0.35, effective risk management (#11) at 0.35, and fostering new approaches (#25) at 0.43. Similarly, there was a mediocre correlation between improvement of the design (#7) and increased constructability (#8) at 0.39. Increased constructability (#8), in turn, correlated moderately with the reduction of additional construction costs (#13) at 0.43. Additionally, a moderate correlation of 0.56 was observed between the increased understanding of each other's challenges (#19) and the contribution to mutual learning (#26). There was a strong correlation between the perceived relationship and trust (#18) and the appearance of other benefits at 0.73.

5. Discussion

This chapter interprets the results presented in the previous chapter. Additionally, the implications of the findings are explained, their validity and quality are assessed, and the limitations of the employed research methodologies are outlined. Finally, recommendations for future research directions are offered. Literature on the cost implications and benefits of Bouwteams is indicated using hashtags followed by a number, referring to the effects and accompanying literature references as listed in Table 2 and Table 3 on page 14.

5.1. Interpretations

5.1.1. Expert survey

Key findings

The cost implications and benefits associated with Bouwteams were validated through an expert survey conducted among experts in the Dutch infrastructure sector. The results of this survey are presented in Table 6. The column labelled' opinion' indicates the perceived likelihood of each effect according to expert opinion.

Table 6 Expert survey results categorised

Category		Nr.	Effect	Chance occurance
Cost implications	Expense drivers	#1	Higher costs in the design phase	0.52
		#2	Lack of competition in final price forming	0.40
		#3	Higher costs by more extensive tender procedure	0.10
		#4	Higher costs for the client-contractor relationship	0.09
		#5	Correct project administration is costly	0.15
	Expense reducers	#6	Prevention of conflicts resulting in savings	0.99
		#7	Improvement of the design	1.00
		#8	Increased constructability	0.99
	Risk management	#9	Reduction of risks	0.98
		#10	Improved risk allocation	0.95
		#11	More effective risk management	0.95
	Cost control	#12	Better accuracy of estimates	0.89
		#13	Reduction of additional construction costs	0.99
		#14	Costs integration into value creation process	0.74
Category		**Nr.**	**Effect**	**Chance occurance**
Benefits	Project processes	#15	Improved working conditions and safety	0.78
		#16	Improved flexibility and responsiveness	0.88
		#17	Increased sharing of information and expertise	1.00
		#18	Improved relationship and trust	0.96
		#19	Increased understanding of each other's challenges	0.97
	Project results	#20	Better quality of the construction	0.88
		#21	Better schedule performance of construction	0.79
		#22	Improved end-user satisfaction	0.81
	Innovation capability	#24	Enlarged innovation by collaboration	0.84
		#25	Fostering new approaches by improved risk understanding	0.72
	Learning	#26	Contribute to mutual learning	1.00
		#27	Workers acquiring new skills	0.88

These results indicated a reserved opinion on the expense drivers. For instance, opinions varied concerning the higher costs in the design phase (#2). Conversely, there was a clear consensus on expense reducers and improvements for risk management, with respondents consistently scoring at least 0.95. Similarly, the benefits of Bouwteams on cost control were also clearly reflected in the respondents' answers.

The use of Bouwteams could significantly influence project processes. However, its impact on project outcomes appeared less definitive. Similarly, its effect on innovation capability was not prominently apparent. Nevertheless, there were advantages of using Bouwteams for learning purposes, as evidenced by their contribution to mutual learning (#26) and the acquisition of new skills (#27).

Table 7 summarises the benefits of employing Bouwteams in Dutch construction projects, categorised into process and product benefits. These benefits are classified according to their relevance to the design or construction phase and arranged in descending order based on their likelihood of occurrence per expert opinion. Only the benefits perceived to be present in more than 80% of the cases are included.

Table 7 The benefits witnessed in Dutch infrastructure projects using Bouwteam or two-phase projects

<table>
<tr><th>Type</th><th>Benefits in the design phase</th><th>Benefits in the construction phase</th></tr>
<tr><td>Product</td><td>Improvement of the design</td><td>Increased constructability
Better quality of the construction
Enlarged innovation by collaboration
Improved end-user satisfaction
Enlarged innovation by knowledge transfer</td></tr>
<tr><td rowspan="3">Process</td><td>Increased sharing of information and expertise
Collaborative risk allocation</td><td>Prevention of conflicts
Improved flexibility and responsiveness
More effective risk management
Improved working conditions and safety</td></tr>
<tr><td colspan="2">Benefits through both the design and the construction phase</td></tr>
<tr><td colspan="2">Contribute to mutual learning
Increased understanding of each other’s challenges
Improved relationship and trust</td></tr>
</table>

Comparison with the literature

The expense drivers present in the literature did not fully align with the findings from the expert survey. While the increased cost in the design phase (#1) and lack of competition in the final price formation (#2) were partly supported by the findings from the expert survey, the participants did not recognise other expense drivers. The expert survey’s findings could not confirm the higher cost in the tender procedure (#3) or the higher the cost of the client-contractor relationship (#4), as pointed out by Haaskjold et al. (2019) and Eadie et al. (2012) or the costly correct project administration (#5) as described by Eadie et al. (2012).

All the other cost implications and benefits associated with Bouwteams in the literature review were acknowledged in the expert survey, with probabilities exceeding 72%. Additionally, certain cost implications and benefits associated with collaboration or early contractor involvement were first found to be relevant to Bouwteams, rather than collaboration or early contractor involvement. These included increased constructability (#8), effective risk management (#11), cost integration into the value creation process (#14), increased understanding of each other’s challenges (#19), improved end-user satisfaction (#22) and workers acquiring new skills (#27).

5.1.2. Comparative case study

Key findings

A comparative case study was conducted to identify the causes of the cost implications and benefits in Bouwteams. The integration of elements discussed during the interviews in the case study results in a causal diagram, depicted in Figure 13.

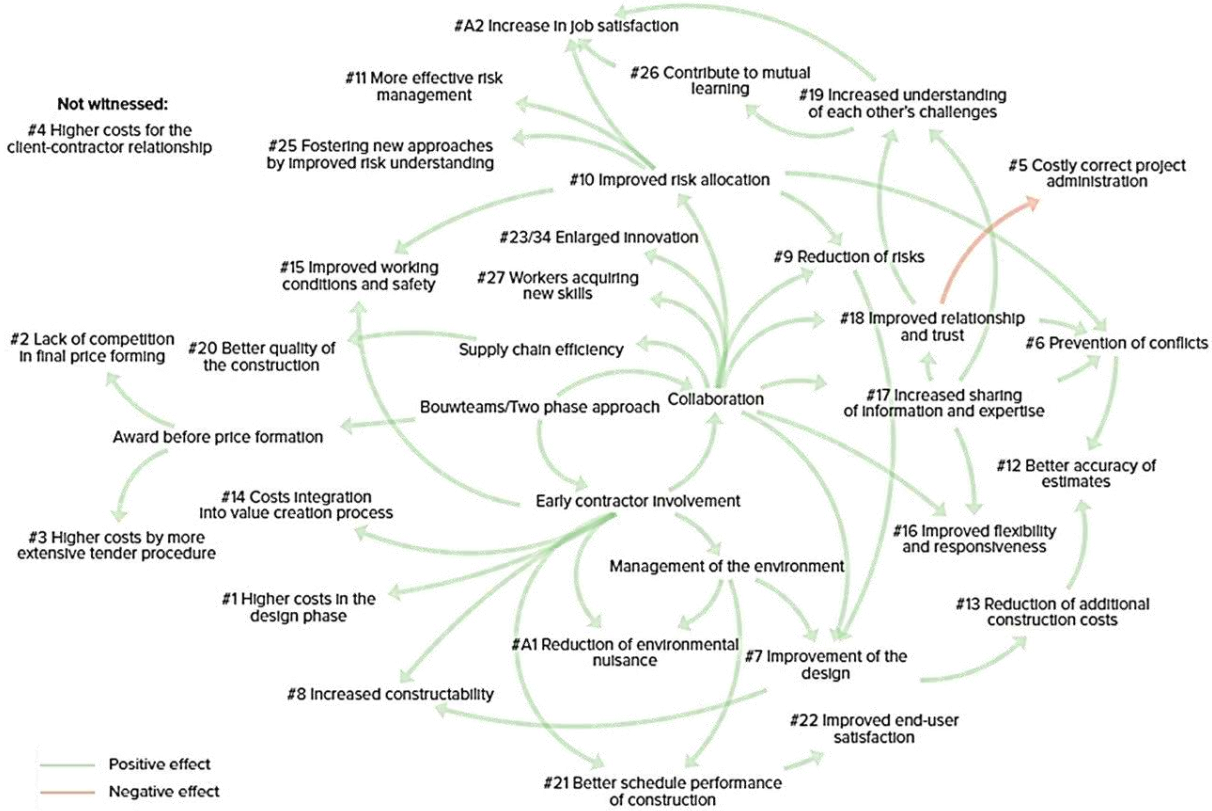

Figure 13 Causal diagram

The study revealed that early contractor involvement, collaboration, transparency, and collaborative risk allocation form the foundation for Bouwteams' benefits. Also, the findings suggest an overlap between the enlarged innovation by collaboration (#23) and risk reduction (#24).

Comparison with the literature

The causal diagram illustrated more interrelationships compared to the causes of the cost implications and benefits described in the literature. While the literature underscored the importance of collaboration, early contractor involvement, and transparency, it offered limited insights into the connections among benefits.

Furthermore, most cost implications and benefits identified in the literature review were confirmed in the case study, with two exceptions: the higher costs for the client-contractor relationship (#4), which were not observed, and an unexpected decrease in correct project administration costs due to increased trust (#5) found in the case study. Additionally, the two new effects emerged. These are reduced environmental nuisance (#A1) and increased job satisfaction (#A2), contributing to the existing body of literature on the subject.

5.1.3. Project survey

Key findings

The quantitative analysis of cost trends in Bouwteam or two-phase projects provided valuable insights into cost implications. Survey results indicated that nearly half (43%) of the projects experienced increased costs in the design phase (#1), and a majority (70%) lacked competition in the final price formation. Only 7% of cases reported higher costs due to an extended tender procedure (#3), while 24% observed increased costs related to the client-contractor relationship. Interestingly, there were no reported instances of increased project administration costs (#5). Therefore, the main cost implications would be the increased costs in the design phase and the lack of competition in the final price formation.

Correlation analysis revealed that using an integral collaboration correlates with the efficiency of the Bouwteam in achieving added value. However, no correlation was found between turnover and the benefits or efficiency in achieving added value.

Comparison with the literature

Comparing Bouwteams' cost trends with benchmark data derived from the literature review could reveal the cost implications of using them. Regrettably, the literature review did not provide precise data on engineering costs, so comparisons with competitive projects could not be made.

When comparing the development of costs through the project, Bouwteams showed a larger average increase in costs (at cumulative 35%) from the initial design phase to the realisation costs compared to integrated projects (at 25%) and the sector (17%), as illustrated in Figure 14. This is in line with the expectations. However, this difference was not statistically significant based on a two-sample t-test with α=0.05.

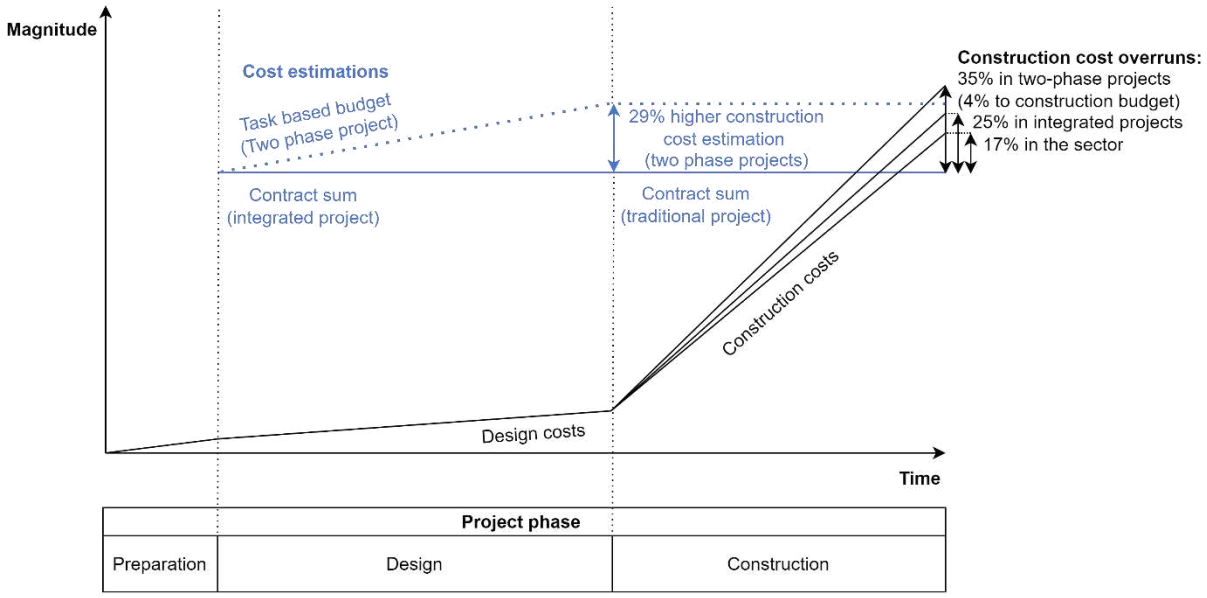

Figure 14 Average cost trends in Bouwteams compared to competitively procured projects

The average cost overruns of integrated projects, as found by Verweij, van Meerkerk & Leendertse (2020) was selected for comparison because the average contract sum is closest to one of the project surveys, shows the lowest standard deviation, and is based on most measurements. The findings from Cantarelli et al. (2012) were used to compare against average cost overruns in the sector, as their average contract sum was closest to the project survey's.

Examining the risk reserves (15.9%) at the start of the Bouwteam phase revealed no significant deviations compared to the risk reserves at the beginning of the design phase in the sector (14-18%). Similarly, an analysis of the risk reserves (11.5%) in Bouwteams at the end of the design phase showed no substantial variances compared to the risk reserves towards the end of the definitive design and at the execution design in the sector (6-12%). However, it appeared to be on the higher end.

The realised construction costs in Bouwteams averaged 104.1% (σ of 11.09% and skewness of 2.49) of the construction cost estimation. Meanwhile, the realised construction costs averaged 116.5% (σ of 40%) of the budget at the decision to build in the construction sector, as illustrated in Figure 15.

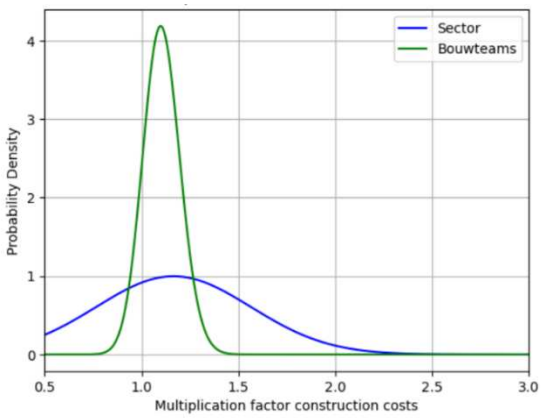

Figure 15 Accuracy cost estimations before and after the Bouwteam phase

This difference was not statistically significant according to a two-sample t-test with α=0.05. Nevertheless, these findings aligned with the reduction of additional construction costs (#13), observed in 63% of the projects. Additionally, the construction cost estimation after the completion of the Bouwteam was more accurate, with a standard deviation of 11.3%, compared to the initial estimation, which had a standard deviation of 52%. This suggests that the increased accuracy of the estimates (#12) mostly applies to the estimation after the completion of the Bouwteam. The findings are summarised in Figure 16.

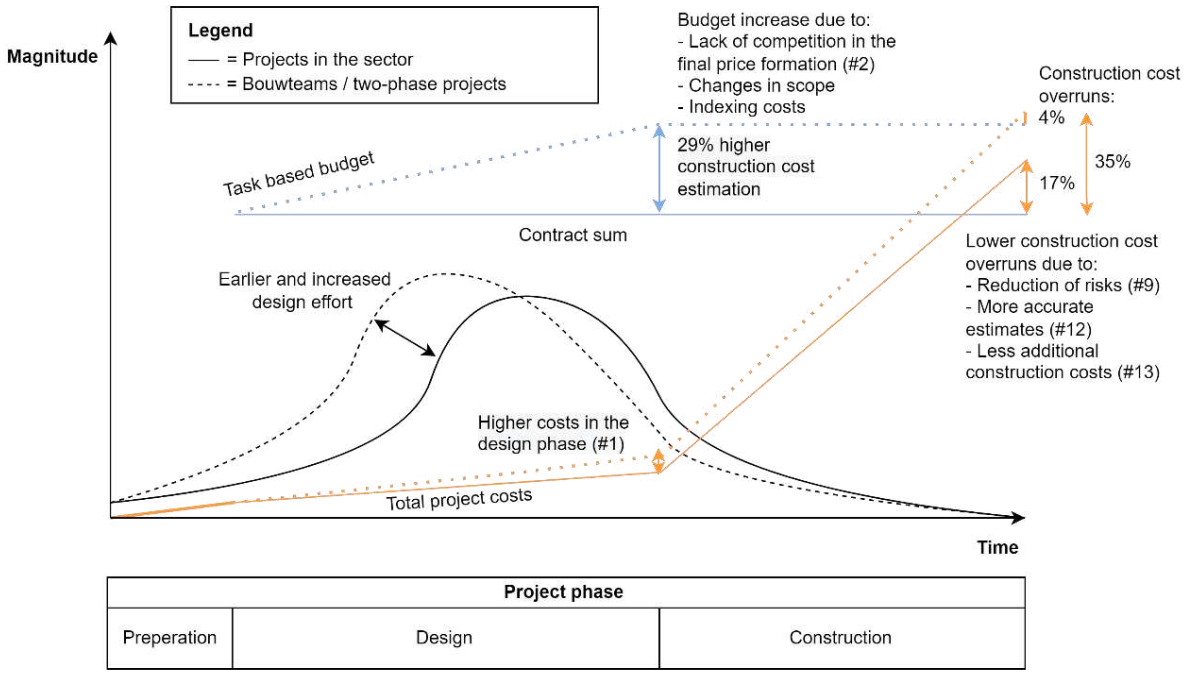

Figure 16 Cost implication of Bouwteams

5.2. Comparative analysis

While the previous findings are derived from the most appropriate research methods available, comparing the results could be helpful. Resource triangulation enhances reliability by mitigating bias and supporting the robustness of the findings.

Table 8 presents a comparative analysis of findings from the expert survey, case study, and project survey. The numbers in the column 'Expert survey' indicate the probability of an effect occurring in a project according to experts. In the 'Case study' column, the ratio represents the proportion of case studies where the effect was observed. The 'Project survey' column details the percentage of cases in which the effect was observed.

Table 8 Comparison of the cost implications and benefits of Bouwteams through different methods of data collection

Category		Nr.	Effect	Expert survey	Case study	Project survey
Cost implications	Expense drivers	#1	Higher costs in the design phase	0.52	1.00	0.43
		#2	Lack of competition in final price forming	0.40	0.50	0.70
		#3	Higher costs by more extensive tender procedure	0.10	0.50	0.07
		#4	Higher costs for the client-contractor relationship	0.09	0.00	0.23
		#5	Correct project administration is costly	0.15	0.00	0.00
	Expense reducers	#6	Prevention of conflicts resulting in savings	0.99	1.00	0.67
		#7	Improvement of the design	1.00	1.00	0.60
		#8	Increased constructability	0.99	1.00	0.73
	Risk management	#9	Reduction of risks	0.98	1.00	0.70
		#10	Improved risk allocation	0.95	1.00	0.70
		#11	More effective risk management	0.95	1.00	0.43
	Cost control	#12	Better accuracy of estimates	0.89	1.00	0.67
		#13	Reduction of additional construction costs	0.99	1.00	0.63
		#14	Costs integration into value creation process	0.74	1.00	0.20
Category		**Nr.**	**Effect**	**Expert survey**	**Case study**	**Project survey**
Benefits	Project processes	#15	Improved working conditions and safety	0.78	0.50	0.33
		#16	Improved flexibility and responsiveness	0.88	1.00	0.63
		#17	Increased sharing of information and expertise	1.00	1.00	0.70
		#18	Improved relationship and trust	0.96	1.00	0.63
		#19	Increased understanding of each other's challenges	0.97	1.00	0.63
		#A1	Reducing environmental nuisance	N.A.	1.00	0.43
		#A2	Having more fun at work	N.A.	1.00	0.63
	Project results	#20	Better quality of the construction	0.88	1.00	0.33
		#21	Better schedule performance of construction	0.79	1.00	0.40
		#22	Improved end-user satisfaction	0.81	1.00	0.47
	Innovation capability	#24	Enlarged innovation by collaboration	0.84	1.00	0.47
		#25	Fostering new approaches by improved risk understanding	0.72	0.50	0.27
	Learning	#26	Contribute to mutual learning	1.00	1.00	0.67
		#27	Workers acquiring new skills	0.88	0.50	0.13

The expense-driving effects of using Bouwteams were not so strongly indicated by the expert survey, with only the higher cost in the design phase and the lack of competition in final price formation showing more than a 15% likelihood of occurrence in Bouwteam projects. In the case studies, the higher design costs were the most convincingly demonstrated effect. The project survey yielded similar results, highlighting the lack of competition in the final price formation as the most prominent issue, observed in 70% of the projects. Additionally, higher costs in the client-contractor relationship were noted in 23% of the projects. However, the expert survey and case studies did not clearly confirm this, suggesting its contribution is less evident.

All the data collection methods clearly confirmed the expense reducers. Similarly, improvements in risk management were validated, though more effective risk management (#11) was less apparent in

the project survey. Improvements in cost control were identified, but the project survey did not clearly confirm cost integration into the value-creation process.

The three data collection methods confirm most of the improvements in the project processes. However, improved working conditions and safety (#15) were less convincingly represented, appearing in only one-third of the projects. The newly identified effects, reducing environmental nuisance (#A1), and having more fun at work (#A2), were observed in 43% and 63% of Dutch projects, respectively.

The expert survey and case study confirmed the positive impact of employing Bouwteams on project results, while the project survey findings were less convincing. Improved construction quality was observed in only 33% of the projects. A similar trend was observed in innovation capability, which was generally well-confirmed in the expert survey but was seen in only one project in the case study and 27% of the projects in the project survey.

Bouwteams' contribution to mutual learning was consistently emphasised across all three data collection methods. The expert survey prominently showcased workers' acquisition of new skills. However, this was not as well represented in the project survey, as it was observed in only 13% of the projects.

From the findings of the correlation analysis, it became clear that the causal relationships identified in the case study were mostly supported by moderate correlations between these factors. For example, there was a moderate correlation of 0.39 between the improvement of design (#7) and increased constructability (#8). Additionally, a correlation coefficient of 0.56 indicated a moderate relationship between the increased understanding of each other's challenges (#19) and the contribution to mutual learning (#26).

Overall, participants expressed a positive opinion regarding the cost-efficiency of using Bouwteams to create value in projects, with 79% of projects showing favourable views. This aligns with findings from CROW (2018), which reported that 85% of Bouwteams users are (very) satisfied.

The correlation analysis indicated that integral collaboration within Bouwteams correlates with efficiency in achieving added value, which is consistent with findings from the case study. However, it was notable that no correlation was observed between project turnover and the amount of benefits or efficiency of achieving added value.

The cost trends observed in the project survey were in line with the expectations from the expert survey. Namely, it was confirmed that there are higher costs in the design phase. Additionally, a significant jump in budget was found between the start and the end of the Bouwteam phase. Lower cost overruns were also in line with the expectations.

5.3. Implications

This section will present the broader significance that the findings have for existing theories and the conceptual framework on the cost implications and benefits leading to added value in Bouwteam projects. Additionally, the practical implications will present the applications of research findings in real-life Bouwteam projects.

5.3.1. Theoretical implications

Firstly, the research contributed to a further understanding of the presence and causes of cost implications and benefits of Bouwteams. The higher cost in the design phase (#1), as discussed in relation to Bouwteams by Kleinhuis (2016) and two-phase contracts by Rijkswaterstaat (2023) was partially confirmed, as it was observed in 42% of the projects in the project survey. The lack of competition in the final price formation (#2) was strongly confirmed, evident in 70% of the projects, concurring with the literature as named by Jansen & Metsemakers (1999), Laeven et al. (2023), Dekker (1987) and Pap (2021).

Conversely, the expert survey did not convincingly observe other anticipated cost implications, such as the higher cost of a more extensive tender procedure (#3). The project survey indicated that this factor only impacts 10% of the projects. Thereby, these findings could not confirm previous studies of Wielink & Luiten (2019) and Wodimu, Lium & Laedre (2022) which suggested a more extensive and time-consuming tender procedure with Bouwteams and early contractor involvement. Insights from the case study suggest that while the tender procedure might incur higher costs, savings are also realised as no bids need to be submitted.

The higher cost for the client-contractor relationship (#4) could not be confirmed. It might be that the 'large time and labour commitment required from the client and contractor' has been misinterpreted. Additionally, the costly correct project administration (#5) could not be confirmed. The costly correct project administration was found in 42.8% of the projects using early contractor involvement by Eadie et al. (2012) but was not observed in Bouwteams or two-phase projects in the project survey.

The expert survey robustly affirmed the benefits of Bouwteams, as indicated in the literature, with each receiving a rating of at least 0.74. However, certain benefits, such as cost integration into the value creation process (#14) and workers acquiring new skills (#27), did not show a strong presence in the project survey, with occurrences of 20% and 13%, respectively.

Interestingly, several cost implications and benefits that were not explicitly mentioned in relation to Bouwteams in the literature were confirmed through the survey, validating their presence in Dutch Bouwteam projects. These included increased constructability (#8), more effective risk management (#11), understanding of each other's challenges (#19), and improved end-user satisfaction (#24), thus expanding upon the existing body of literature on Bouwteams.

Furthermore, one discrepancy in the literature can be resolved. Contrary to the prevailing literature, Nijhuis (2019) reported larger cost deviations in Bouwteam projects. This can be explained by the fact that while there are indeed larger deviations from the initial stages of the Bouwteam, more accurate estimations follow in the subsequent phase of the project.

The case study's findings confirm causal relationships found in the literature while providing a comprehensive overview of these findings for the first time. This addresses the concerns of Bresnen and Marshall (2000), suggesting that indirect factors may influence performance gains. Additionally, two new benefits have emerged: reduced environmental nuisance (#A1) and increased job satisfaction

(#A2). These newly identified benefits were also observed in the project survey, with presence in 43% and 63% of the projects, respectively, thus validating these novel findings.

Finally, the results from the project survey shed light on the cost trends of Bouwteams projects, introducing new insights into existing literature. It became apparent that there was a budget increase during the Bouwteam phase due to the lack of competition in final price formation, scope changes and indexing costs.

Additionally, fewer cost overruns in the realisation phase were observed due to reduced risks, minimised additional construction works, and more effective risk management. Furthermore, it was confirmed that the higher initial investment costs are perceived to be outweighed by the benefits of using Bouwteams, thereby creating added value in Bouwteams or two-phase projects, as found in the project survey.

5.3.2. Practical implications

Bouwteams offer advantages in complex projects, such as those involving large risks or sustainability concerns. Clients and policymakers should carefully consider the type of collaboration and the solution space to ensure that the project goals are met efficiently. Additionally, the correlation analysis of project data revealed that Bouwteams using integrated collaboration tend to be more efficient at realising added value.

While the Bouwteam phase often sees an increase in construction budgets due to the absence of competition in final price formation, scope changes, and indexing costs, it is crucial for project and contract managers to adopt a strategic approach. By acknowledging that these initial investments can yield substantial overall project benefits, managers can confidently employ Bouwteams, knowing that these investments are crucial in minimising cost overruns, enhancing constructability, and fostering innovation and knowledge sharing.

Project managers should allocate sufficient budget and resources to the design phase, considering the higher costs associated with Bouwteam projects. Cost control measures throughout the design phase are crucial for maintaining budgetary oversight and ensuring cost efficiency. These steps could help optimise project outcomes and mitigate budgetary challenges.

Most Bouwteam projects in the survey consider integral collaborations. Clients should recognise that a Bouwteam entails mutual effort and requires organisational changes. They should allocate sufficient personnel and ensure their continuity. Moreover, they should understand that effective risk management requires a new approach to risk allocation. This includes developing a joint risk register and clearly defining responsibilities for risk management.

The lack of competition in the final price formation has shown to be a significant concern. While advocating for increased competition could be a natural response, insights from the case study suggest that a relationship-focused approach and transparent communication might be more effective. Clients are encouraged to participate in price negotiations at the end of the Bouwteam, considering the challenges faced by all parties involved and aiming to reach a mutually agreeable price. Establishing benchmarks for using Bouwteams can help set clear expectations and help continuously improve the Bouwteam approach.

5.4. Validity and quality assurance

The research methodology and results were validated through discussions with the university's supervisors, a senior contract advisor, and a cost advisor. Additionally, two panel discussions were conducted: one involving four contract advisors and another with five cost advisors. The feedback on each of the research activities is presented in this section.

5.4.1. Expert survey

Testing the expert survey with a senior tender and contract advisor ensured its quality. Feedback from the senior tender and contract advisor indicated that the expert survey had clear statements and a suitable layout. The implicit choice to avoid comparing Bouwteams to UAV/UAV-GC but compare against competitive-based projects was not identified as an issue. However, some suggestions for improvements were made. These included adding contact details and explaining the goal of the expert survey. Additionally, some textual remarks were made, all of which have been addressed.

A mid-level cost advisor reviewed the results, concurring with them and acknowledging the identification of expense drivers and reducers. However, they found it remarkable that respondents did not acknowledge the additional administrative costs of using Bouwteams. The results were also reviewed in the panel discussion with the contract advisors, who generally confirmed the results but felt the opinions might favour Bouwteams.

5.4.2. Comparative case study

First, two supervisors from the University of Twente reviewed the topic list, which served as the interview protocol. The supervisors agreed that recording the interview and anonymising participants would help ensure honest responses. They also noted that the interview contained too many questions. It was assumed that answering one question would take about two minutes, resulting in 30 questions in the body of the interview, aside from the introduction and the conclusion.

However, it was advised to limit the number of questions to a maximum of 16. A mid-level costs advisor also evaluated the topic list and reinforced the recommendation to shorten the survey. Consequently, the number of questions was reduced to 14 in the main body of the interview. The case study results were reviewed in the panel discussion with contract advisors, who found the results logical.

5.4.3. Project survey

First, a mid-level cost advisor could test the terminology and diagrams utilised in the expert survey. Additionally, a senior tender and contract advisor reviewed the entire expert survey. Finally, the results were validated through panel discussions involving cost experts and contract advisors.

Upon reviewing the diagrams in the survey with a cost advisor, they recommended using SSK terminology. Additionally, examining the expert survey with a senior tender and contract advisor revealed the need for further adjustments. Specifically, they suggested distinguishing between the design and construction phases in a Bouwteam sharper and explaining some of the terms related to costs.

The results from the project survey were discussed in the panel discussion with cost advisors. They remarked that the lack of competition in the final price formation might cause risk-avoiding design, resulting in higher costs. Also, they highlighted that negotiations might be tricky as the client seldom uses their power to stop after the first phase to limit transaction costs and reputational damage.

The cost advisors pointed out that while the reasons for an increase in the budget during the Bouwteam were logical, they missed the influence of increased collaboration and risk-averse designing. They found it remarkable that these reasons were not often listed in the project survey.

Finally, they agreed on the cost implications and pointed out that the increased cost for the relationship between the client and the contractor (#4) is captured in the increased costs in the design phase (#1). The cost advisors found the cost trends recognisable. They suggested more clearly representing the construction cost overruns, which have been addressed.

5.5. Limitations

5.5.1. Expert survey

One significant discussion point centred around the participants' responses, particularly regarding the concern over the moderate response rate and the relatively small participant pool. A larger sample size would mitigate the impact of extreme opinions, thereby enhancing the robustness of the findings. Despite the ability to skip statements when uncertain, all participants completed the entire survey. Notably, only one participant provided additional comments at the conclusion of the expert survey, elaborating on their reasoning for statement 9. They agreed with the statement, although risks may be budgeted higher due to broader contractor involvement. Their rationale emphasised that while more risks were identified, these were deemed manageable, reducing the overall presence of unknown risks.

Another point to consider was the participants' backgrounds. The respondents represented a diverse range of highly experienced employers, with most having between 21 and 25 years of experience. In the expert survey, negative formulations of the statements were included to mitigate bias by presenting both positive and negative perspectives. However, the sample of professionals at the congress may still have a positive bias. This bias could stem from the participants voluntarily attending the congress, indicating a potential pre-existing positive attitude towards Bouwteams. For example, the likelihood of a lack of competition in the final price formation (#2) in a presence was found at 40% in the expert survey but was observed in 70% of the projects.

It was noted that using a five-point Likert scale and converting it to numeric values has some drawbacks. For probability computation, it was assumed that the responses follow a normal distribution, which may not be accurate. This assumption might limit the validity of the computed likelihoods. However, this approach was justified as it allows for the deviation in the results to be considered. A more significant deviation from the mean could indicate differing participant opinions or an unclear effect. Therefore, assessing the means and using a probabilistic approach helps to better understand the magnitude of the cost implications and benefits of Bouwteams.

5.5.2. Comparative case study

The case studies effectively identified the causal relationships between the characteristics, cost implications, and benefits of using Bouwteams. However, some remarks were made on the procedure and results obtained.

First, the application of case studies lacked generalisability as it focused on a limited domain. Furthermore, there were several areas where the interview itself could have been improved. The interviewer had some experience with structured interviews, having conducted about ten interviews in previous research projects, but was not an expert in this field. Interviewing in person allowed the interviewer to interpret the participant's body language. However, involving more interviewers could have reduced the risk of interpretation difficulties. Additionally, the interviewer could have been more

critical in questioning the responses. Although participants had the opportunity to discuss additional points in the last five minutes, this might not have been sufficient. Allowing more time may have achieved further valuable insights.

5.5.3. Project survey

First, some remarks can be made on the accuracy of the results. Since the survey invitation specified that two-phase projects under construction can participate, this might introduce some constraints on the validity of the results. However, considering only completed projects would result in insufficient data. Also, some participants provided vague answers, using terms like 'certainly less than x %' and ranges like 100%-120%. This vagueness could be mitigated by averaging the span, potentially resulting in minor errors. Performing a sensitivity analysis with the extremes of these ranges indicates that this vagueness could lead to deviations of at most ± 43% in the project turnover, ± 1.5% in the cost ratios and at most ± 4% in the risk reserves compared to the current results. Another source of uncertainty in the data could be the fragmented flow of finance. For instance, employees from contractors or engineering firms filling out the survey might not have been able to provide the additional costs in the design phase for the client in the project. This limitation is relatively minor as it only applies to 35% of the respondents, as client representatives filled in the remainder.

Data availability could be improved. Only 33 projects participated, resulting in 31 unique projects after identifying and removing two duplicates. Additionally, failing to meet the target of 40 projects could have decreased the reliability of the findings. Furthermore, skewness in the data became noticeable, particularly in the deviations of the construction cost compared to the task budget and construction cost estimates.

Two projects were identified, where the survey was completed by both the client and the contractor, allowing for an analysis of measurement error based on the comparison of results. In the first project, most answers provided by both respondents were consistent, except for differences in the selection of award criteria and the identification of cost implications and benefits. The first respondent selected 20 out of 30 options, while the second respondent selected 25, of which 20 overlapped, so five additional effects were selected. Both respondents rated the cost efficiency of Bouwteams similarly. In the second project, there were disparities in the ratio between the task-based and construction cost budgets, with the client reporting a 20% higher ratio due to reserved budget allocation for specific risks. Additionally, while the first participant reported 20 cost implications or benefits in the project, the second participant reported 22, with all but one overlapping with the first. These differences could be attributed to varying perspectives and vagueness in responses, but they did not appear to influence the results significantly.

In discussions and from the feedback received at the end of the survey, it was evident that participants understood the survey well. However, it was noted that they took longer than anticipated to complete the form. Unfortunately, one participant discontinued filling out the survey, resulting in the loss of their data. Additionally, the vagueness was primarily due to participants not knowing the precise answer.

Comparing the cost trends of Bouwteams with benchmark data presented its challenges. Benchmark data for engineering costs was limited. Fortunately, a few studies were available to compare cost overruns. Although the historical benchmark data for the cost overruns in the sector was somewhat dated, Cantarelli et al. (2012) found no correlation between the year of completion and the cost overruns, suggesting this data would still be relevant. Cost overruns differed per project turnover (Cantarelli, 2009). Therefore, it was strived to match the turnover of the benchmark data with the one

from the data set. Matching the project phases between Bouwteam and traditional projects showed some difficulties.

Analysing the correlation between the cost implications and benefits of Bouwteam infrastructure projects helped validate the case study research. However, applying Pearson correlation to this relatively small data sample has limitations. Firstly, effects with low presence, such as the contribution to the acquisition of skills by personnel (#27), could not be adequately analysed as there were only four data points. Next, the overall certainty of the correlation analysis could be improved with a larger dataset.

Threats to external validity, such as sampling bias, were mitigated by including a diverse range of sampled projects from various subsectors and involving participants from different organisations. Additionally, no projects were excluded from participation, and no outliers were disregarded, further enhancing the reliability of the findings. However, Bouwteams might have been more commonly applied to complex projects, potentially affecting the results.

5.6. Recommendations

While the research has successfully provided insights into Bouwteams' cost implications and benefits, some areas could benefit from further exploration. First, the recommendations per research method are presented, after which overall recommendations are included.

5.6.1. Method specific recommendations

Expert survey

Firstly, it is recommended that the number of respondents is increased, as this would enhance the reliability of the results. Additionally, a larger dataset would enable better generalisation of the results to theory. To address the potential bias in the expert survey results, conducting the same survey amongst a random sample of experts in the field would be beneficial. Furthermore, it would be great to test the opinion on the cost-efficiency of Bouwteams in creating added value.

Case studies

Although the panel discussion with contract advisors and the project data correlation analysis have been used to validate the findings, the case study could benefit from further validation. As its main limitation is its limited generalisability, it could be recommended to employ a research strategy that allows for the validation of these results.

Project survey

Addressing some of the project survey's limitations could enhance its reliability. For instance, collecting data on finished projects from the client would be beneficial, reducing uncertainty due to unfinished projects and the fragmented flow of finance. Also, collecting more projects would increase the reliability of the cost implications and the correlation analysis.

Exploring the cost patterns in Bouwteams revealed significant deviations between the task-based budget and construction cost estimations. Further investigation into the reason and magnitude of these differences will probably provide valuable insights. Additionally, there appears to be a correlation between staying within budget and using a price cap, suggesting a potential area for further research.

5.6.2. Overall recommendations

Next, topics related to the research can also profit from further investigation. For instance, exploring macroeconomic impacts stemming from collaborative tendering or the application of Bouwteams will

offer insights into broader economic implications. Additionally, examining whether there should be a focus on ‘competitive’ or ‘fair’ pricing of works warrants further exploration.

Furthermore, providing further recommendations on utilising Bouwteams compared to an integrated approach can enhance decision-making. Results from the case study point out that using a Bouwteam may help mitigate contractors' risks, thereby preventing tender failures.

The research highlights discrepancies between the anticipated benefits of Bouwteams, as suggested by experts’ opinions in the expert survey, and their realisation of projects. For instance, the integration of costs through the design process is not widely materialised. It would be valuable to see whether this discrepancy is due to unused potential or misidentification.

Further studies could address some of the questions beyond this research's scope or help clarify the current findings. For instance, conducting more ex-post project evaluations is recommended. Investigating the engineering costs in traditional projects and analysing cost overruns across different types of projects would be beneficial. Additionally, quantifying the benefits of using Bouwteams would be beneficial. For example, exploring how Bouwteams impact schedule performance would be helpful. Another critical topic is the reasons for cost overruns. It would be valuable to investigate the extent of these cost overruns per cause and when they manifest.

Further investigation into the differences between Bouwteams, using the quadrant on solution space and collaboration outlined by CROW (2020) in Chapter 3.2.4 will be beneficial. Case study results suggest that integrated collaboration may lead to decreased controlling costs and increased benefits but also requires a large solution space. Also, project results revealed a correlation between the use of integrated collaboration and the efficiency in adding value. Conversely, coordinated collaboration might be more suitable for optimising or innovating within a specific area while involving the contractor. Exploring whether mirrored or integrated project teams are predominantly used for coordinated and integrated collaboration will provide valuable insights. Additionally, examining the effects of formal control versus a relational focus on social control and trust could offer further understanding of Bouwteam dynamics.

In addition, investigating the adaptation costs associated with Bouwteams can provide valuable results. Given that Bouwteams is a relatively new collaboration model, organisations may incur higher internal costs to reconfigure their organisational processes and address challenges to accommodate Bouwteams. For instance, the increased costs observed during the Bouwteam phase might partly stem from these adaptation costs. Therefore, exploring whether these adaptation costs diminish as Bouwteams become a more established alternative would be worthwhile.

The research primarily focuses on Bouwteams as individual projects. However, using Bouwteams within a framework agreement could yield different outcomes than using them on a project-by-project basis. For instance, when all projects in a region are procured using a framework agreement, contractors may be compelled to participate in a collaborative approach. A Bouwteam demands a suitable mindset from the client and the contractor (de Koning, 2024). Once parties are forced to work in Bouwteams, difficulties adopting them could hamper the outcome of their application. Therefore, it would be interesting to see if using Bouwteams in a framework agreement impacts the cost implications, benefits, and overall added value.

6. Conclusion

In contrast to the traditional competitive procurement methods in the construction industry, adopting Bouwteams brings a more collaborative approach. Using Bouwteams aims to address the growing complexity of projects. Issues commonly observed in competitively procured projects, such as strategic short-sightedness, adversarial relationships, and a lack of innovation, could be mitigated using Bouwteams. There was a growing need to gather insights from past experiences with Bouwteams to inform future projects and support decision-making.

Intending to reveal the added value of Bouwteams, this study has examined both the cost implications and benefits of Dutch infrastructure projects. As a starting point, a conceptual framework was set up. Literature research showed there could be various cost implications, including drivers of expenses, such as increased design costs and lack of competition in the final price formation. Conversely, factors were identified that mitigate costs, such as conflict prevention and facilitating a more efficient and constructible design. Furthermore, the consulted literature highlighted better risk and cost management, benefits regarding the project processes, the built product, innovation, and learning.

The study utilised an expert survey to examine whether these cost implications and benefits are observed at Bouwteams in the Dutch construction sector. Findings indicated varied opinions on the cost implications, while participants unanimously affirmed the benefits of using Bouwteams. For example, slightly over half of the participants acknowledged that using Bouwteams results in heightened design costs, whereas all participants agreed that Bouwteams enhances design, collaboration, and learning.

A comparative case study was conducted to explore the causes of the cost implications and benefits of using Bouwteams. The study confirmed that collaboration, transparency, and collaborative risk allocation serve as the foundation for realising the benefits of Bouwteams. Furthermore, two new benefits were revealed: increased job satisfaction and improved environmental management, reducing nuisance.

A project survey was conducted to explore the cost implications of Bouwteams further. Data on cost trends and perceived benefits across 31 Bouwteam or two-phase projects were gathered. These cost trends were compared with benchmark data from competitively procured projects, including figures from the sector and specifically integrated projects.

On the one hand, it was found that using Bouwteams leads to some negative cost implications. Initially, there are higher design efforts due to the contractor's involvement. Also, there is an average budget increase of 29% between the task-based budget at the start of the Bouwteam phase and the construction budget at the end of the Bouwteam phase. This rise is primarily due to a lack of competition in the final price formation, changes in scope and increased labour, materials, and equipment prices.

On the other hand, there are several advantages during the realisation of the project. Investing in the design and collaborative allocation of risks appeared to lower budget overruns. Additionally, the enhanced constructability of the design results in fewer additional construction costs. Projects in the sector typically experience a 17% cost overrun compared to the estimation at the decision to build, and integrated projects show an average increase in the realised costs of 25% compared to the contract sum, whereas Bouwteams exhibit only a 4% cost overrun compared to the construction cost estimation. This suggests that using Bouwteams enhances the predictability of the construction phase

and improves the accuracy of cost estimations. Participants acknowledged that Bouwteams seemed a cost-efficient way of adding value to their projects.

A deeper understanding of the cost implications and benefits of using Bouwteams in adding value to infrastructure projects would benefit the debate on its cost-efficiency. This research offers theoretical contributions by identifying and substantiating the cost implications and benefits of using Bouwteams.

Furthermore, the research provides practical guidance for advisors, clients, contractors, project and contract managers, and policymakers. Using Bouwteams in complex projects, particularly for managing large risks or sustainability concerns, offers significant advantages. Clients and policymakers should recognise that Bouwteams can enhance value creation despite increased design effort and initial budget allocations. These investments can help mitigate cost overruns, improve constructability, enhance end-user satisfaction, and stimulate innovation and knowledge sharing.

Finally, further research is recommended to evaluate the use of Bouwteams. It would be valuable to conduct more ex-post project evaluations. Likewise, more quantitative support can be gathered on the effects of using Bouwteams on design costs, cost overruns, adaptation costs, and schedule performance. Also, the findings suggest that Bouwteams employing an integrated collaboration is more cost-efficient. So, further enquiries are recommended on the effects of the type of collaboration and solution space of a Bouwteam on its cost implications and benefits, influencing added value.

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Declaration of use large language models

In this report, the writing has been enhanced using AI language models. Namely ChatGPT (3.5), and Grammarly (v1.2.81.1481) were used. The author carefully reviewed all suggestions made by these tools.

8. Appendices

Appendix A – Data collection literature review

In the following subsections, the data collection for the literature review are provided. A methodology was carefully developed and executed to increase the reproducibility of the literature review. Each of the sections used the same approach where various search queries are employed in in Google Scholar to search relevant resources. For each query, the first 50 results were considered. Initially, the title and abstract were assessed on relevance. If promising, the entire paper was skimmed to identify relevant elements and the conclusion was reviewed. The following subsections provide more detail on the data collection and used Google Scholar search queries.

Characteristics of the Bouwteam

Literature research on the distinctive characteristics of Bouwteams was conducted by comparing key documents*'Handreiking Bouwteams'* (Laeven, et al., 2023) , *'Handreiking 2-fasen aanpak bij RWS projecten'* (Rijkswaterstaat, 2023) and *'Handreiking aanbesteding van twee fasen contracten'* (CROW, 2020). These documents were sourced from authoritative bodies with experience in Bouwteams/Two-phase projects within the Dutch infrastructure sector. Additionally, a Google Scholar search was conducted using the queries 'competition OR collaboration OR cooperation AND construction' and 'opportunistic behaviour AND Bouwteams'.

Theoretical cost implications and benefits of Bouwteams

Cost implications and benefits of using Bouwteams were explored using diverse search terms, considering the characteristics of Bouwteams, and using both Dutch and English terms, as detailed in Table 9. A paper was accepted if it at least names one cost implication or benefit.

Table 9 Search queries cost implications and benefits of Bouwteams

Topic	Google Scholar search query
Cost implications of collaboration	competition AND collaboration AND costs competition AND collaboration AND construction costs
Benefits of collaboration	added value OR benefits AND Collaboration added value OR benefits OR advantages AND collaboration AND Construction
Cost implications of Bouwteams	bouwteam EN kosten bouwteam OR construction team OR design team AND costs
Beneftis of Bouwteams	bouwteam EN voordelen OF meerwaarde bouwteam OR construction team OR design team AND added value OR meerwaarde
Cost implications of Two Phase projects	two phase contracts AND costs OR construction costs two stage tender AND costs OR construction costs twee fasen contract EN kosten
Benefits of Two Phase projects	two phase contracts AND added value OR benefits two stage tender AND added value OR benefits twee fasen contract EN voordelen OF meerwaarde
Cost implications of early contractor involvement	early contractor involvement OR ECI AND costs
Benefits of early contractor involvement	early contractor involvement OR ECI AND benefits OR added value

Benchmark data cost trends

The cost trends of competitive traditional and integrated projects were explored as a starting point through a literature review. Specifically, the examination included design costs, cost overruns and risk development through competitive Dutch infrastructure projects' design and construction phases. Ideally, benchmark data from Dutch projects was to be used. This selection was motivated by the variance in cost performance observed in Dutch transport infrastructure projects compared to global findings (Cantarelli, 2011). A literature search was conducted using Google Scholar, utilising the search terms outlined in Table 10.

Table 10 Literature review search terms

Chapter	Subtitle	Google Scholar search term
5 . 2 . 2	Design costs	Kosten EN infra EN engineering OF ontwerp Kosten EN infra OF constructie EN verdeling
5 . 2 . 3	Cost overruns	Kosten OF budget EN overschrijdingen EN infrastructuur OF GWW Kosten OF budget EN overschrijdingen EN UAV OF bestek Kosten OF budget EN overschrijdingen EN geïntegreerd
5 . 2 . 4	Risk reserves	Risico EN reservering EN infra OF GWW Onvoorzien EN reservering EN infra OF GWW

Appendix B – Ambition web

Public bodies seek to serve societal goals, like enabling free transport, recreation, and maintenance of current infrastructure whilst limiting negative side effects like noise pollution or environmental damage. As there is a wide variety of public bodies' projects, they could apply the overarching ambition web to a specific project. In their approach towards sustainable ground, water and road works, the CROW developed a digital ambition web, as illustrated in Figure 17. This web helps to set a realistic ambition within the constraints of specific projects, such as available budget, time, and human resources. Laeven et al. (2023) also recommend using a project compass, like the ambition web.

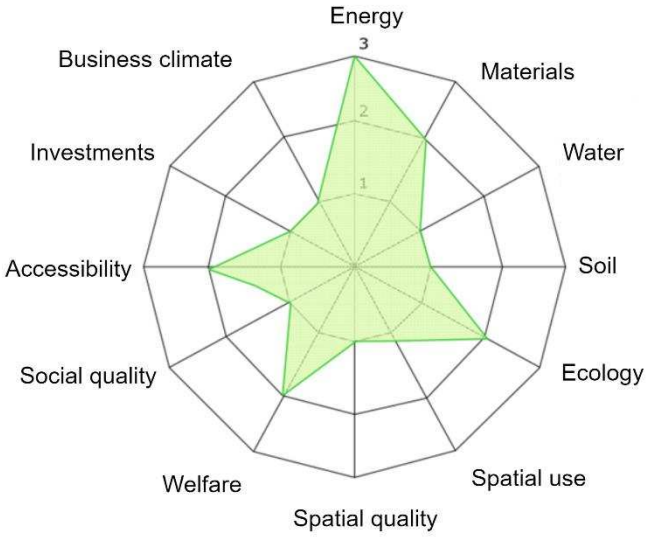


Figure 17 Ambition web Infrastructure (Translated and modified from CROW, 2023)

In this ambition web, a starting point is provided for use in projects in the infrastructure domain. The ambition web provides visual guidance depicting the project's goals, relating to process and outcome, on three levels. Namely, it provides insights into the effects of sustainability measures, sets concrete project goals, and describes the maximal effort to unlock the most feasible added value for one theme (PIANOo, sd). The ambition web can help to provide clear and measurable goals for public projects suited to the scope and budget available for the projects. For each of the twelve themes subthemes, goals and indicators are provided.

Laeven et al. (2023) add that also the demand for knowledge should be considered to suit the Bouwteam. Here, the uncertainty in construction and price, complexity, learning or development tasks, like innovation, circularity or sustainability and the interest of the neighbourhood can be considered.

Appendix C – Implementation expert survey cost implications and benefits of Bouwteams

For the survey, it is decided to invite the participants to a session during a knowledge-sharing session about Bouwteams. Testing whether this would yield enough responses can be achieved by the following computation (Cochran, 1977).

$$n_o = \frac{z^2 * p * (1-p)}{e^2}$$

Where:
$n_o = ideal\ sample\ size$
$z = z\ value$
$e = desired\ level\ of\ percision$
$p = fraction\ of\ population\ which\ displays\ attribute$

Likewise, one can compute the required sample size for a 20% fraction, with a z-value associated with a two-tailed 90% confidence interval and a desired level of precision of 0.1, providing that the sample size should be 44, as detailed in the following calculation.

$$n_o = \frac{1.645^2 * 0.2 * (1-0.2)}{0.1^2} = \frac{2.706 * 0.16}{0.01} = 43.29 \approx 44\ sample\ size$$

As 80 was expected to be the sample size, this would be sufficient. Therefore, it was decided to continue setting out the expert survey at the congress session.

The session host kindly requested that the participants fill out the expert survey. At the end of the session, the participants received a flyer from the researcher, which served as an invitation to participate in the research. The paper handout is the one presented below.

UNIVERSITY OF TWENTE.

Onderzoek over de voor- en nadelen van bouwteams

Help mee door het invullen van de enquête. Deze enquête duurt ongeveer 5 minuten en is te vinden door de onderstaande QR Code te scannen.

Toelichting

Vanuit de opleiding Constructie Management & Engineering aan de Universiteit Twente is Jip Scheper bezig met een master thesis over de meerwaarde van bouwteams. Als onderdeel van hiervan, wordt deze enquête afgenomen.

Once an invitee in the session decides to participate in the expert survey, they can scan the QR code, which will lead to an online expert survey. The setup for the online expert survey is presented below. The expert survey results other than those described in the main text are confidential.

Enquête over de voor- en nadelen van bouwteams

In de eerste plaats dank voor je deelname. Deze enquête is onderdeel van het afstudeeronderzoek van Jip Scheper vanuit de Universiteit Twente en zal gaan over jouw mening over de voor- en nadelen van Bouwteams ten opzichte van het traditionele aanbesteden van projecten. Het doel van deze vragenlijst is om de effecten van het werken in bouwteams volgens de literatuur te toetsen.

Met deze enquête zal je ongeveer 5 minuten bezig zijn. Het invullen van de enquête is anoniem. Daarnaast zullen in het verslag enkel statistieken over de resultaten worden gedeeld, welke niet zijn terug te herleiden tot de gegevens van één persoon.

Mocht je contact willen opnemen kan dit via j.h.c.scheper@student.utwente.nl.

Jouw ervaring

Om een beeld te krijgen van de deelnemers van de enquête, wordt je verzocht onderstaande vragen over jouw werkzaamheden en ervaring te beantwoorden. Mocht je een vraag niet kunnen beantwoorden, kan je deze open laten.

Bij welke organisatie ben jij werkzaam?

Markeer slechts één ovaal.

- ◯ Rijkswaterstaat
- ◯ Provincie
- ◯ Gemeente
- ◯ Waterschap
- ◯ Adviesbureau
- ◯ Aannemer
- ◯ Anders: _____

Hoeveel jaar ervaring heb je in de constructie sector?

Markeer slechts één ovaal.

- 0-5 jaar
- 6-10 jaar
- 11-15 jaar
- 16-20 jaar
- 21-25 jaar
- 26-30 jaar
- meer dan 30 jaar

Stellingen

Onderstaand vind je verschillende stellingen over jouw mening over de effecten van Bouwteams ten opzichte van het traditionele aanbesteden van projecten. Met het traditionele aanbesteden van projecten wordt gedoeld op een aanbesteding waarin werken worden gegund op basis van prijs. Er is dus sprake van competitie en de biedingen zijn gebaseerd op eisen en/of het ontwerp vanuit de opdrachtgever bij de traditionele aanpak.

Je kan de stellingen beoordelen op een schaal van 'Helemaal oneens' tot 'Helemaal eens'. Mocht je een antwoord niet weten, kan je deze open laten.

1. Werken in een bouwteam leidt tot meer conflicten tussen betrokken partijen

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

2. Werken in een bouwteam leidt tot hogere kosten in de ontwerpfase

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

3. Werken in een bouwteam leidt tot een tekort aan competitie in de uiteindelijke prijsvorming

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

4. Werken in een bouwteam leidt tot hogere kosten door een uitgebreidere aanbestedingsprocedure

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

5. Werken in een bouwteam leidt tot hogere kosten door de toegenomen inspanning voor de relatie tussen opdrachtgever en opdrachtnemer

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

6. Werken in een bouwteam leidt tot hogere kosten voor projectadministratie

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

7. Werken in een bouwteam leidt tot verbetering van het ontwerp

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

8. Werken in een bouwteam leidt tot verbeterde bouwbaarheid van het ontwerp

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

9. Werken in een bouwteam leidt tot meer risico's

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

10. Werken in een bouwteam leidt tot een verbeterde risicoverdeling tussen opdrachtgever en opdrachtnemer

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

11. Werken in een bouwteam leidt tot effectiever risicomanagement

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

12. Werken in een bouwteam leidt tot een nauwkeurigere kostenraming

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

13. Werken in een bouwteam leidt tot een toename van de hoeveelheid meerwerk

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

14. Werken in een bouwteam leidt tot betere controle van kosten gedurende het ontwerpproces

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

15. Werken in een bouwteam leidt tot verbeterde werkomstandigheden en veiligheid tijdens de uitvoering

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

16. Werken in een bouwteam leidt tot meer flexibiliteit en reactievermogen van betrokken partijen

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

17. Werken in een bouwteam leidt tot meer delen van informatie en expertise tussen opdrachtgever en opdrachtnemer

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

18. Werken in een bouwteam leidt tot een betere relatie en vertrouwen tussen de opdrachtgever en opdrachtnemer

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

19. Werken in een bouwteam leidt tot meer onderling begrip van de uitdagingen van de betrokken partijen

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

20. Werken in een bouwteam leidt tot betere kwaliteit van het bouwwerk

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

21. Werken in een bouwteam leidt tot betere tijdigheid van uitvoeringswerkzaamheden

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

22. Werken in een bouwteam leidt tot meer tevredenheid van de eindgebruiker van het bouwwerk

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

23. Werken in een bouwteam leidt tot meer innovatie door kennisoverdracht

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

24. Werken in een bouwteam leidt tot meer innovatie door samenwerking

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

25. Werken in een bouwteam leidt tot meer innovaties door beter begrip van risico's

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

26. Werken in een bouwteam leidt tot meer wederzijds leren tussen de opdrachtgever en opdrachtnemer

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

27. Werken in een bouwteam leidt tot het beter verwerven van nieuwe vaardigheden onder het personeel

Markeer slechts één ovaal.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

Verdere benadering

Onderstaand wordt gevraagd of je benaderd zou willen worden voor verder onderzoek over de kosten in bouwteamprojecten of het verslag over de meerwaarde van bouwteams wanneer deze afgerond is. Het verdere onderzoek is wederom een enquête en gaat over één specifiek bouwteam project. Hierin zullen onder andere de fasering, gebruikte contracten en percentuele kosten aan bod komen. Van deze onderwerpen zullen enkel statistieken over de resultaten worden gedeeld, welke niet zijn terug te herleiden tot de gegevens van één project. Deelname zou erg helpen om de trends van kosten in Bouwteams inzichtelijk te maken.

30. Wil je per e-mail verder benaderd worden?

Markeer slechts één ovaal.

- ◯ Ja graag, ik sta open om benaderd te worden voor verder onderzoek over de kosten in bouwteamprojecten
- ◯ Ja graag, ik zou graag het verslag over de meerwaarde van bouwteams willen ontvangen (rond juni)
- ◯ Ja graag, benader mij voor zowel het verdere onderzoek als het verslag
- ◯ Nee dankje, geen intresse *Ga naar vraag 32*

Opgave e-mail voor benadering

31. Wat is je e-mail adres?

Met het opgeven van jouw e-mailadres geef je toestemming om benaderd te worden voor verder onderzoek en/of het uiteindelijke verslag, afhankelijk van je voorkeur.

_____

Afsluiting

Hartelijk dank voor het succesvol afronden van deze enquête!
Hiermee levert je een mooie bijdrage aan het onderzoek over de voor- en nadelen van bouwteams. Klik op 'verzenden' om deze in te leveren.

Mocht je nog contact willen opnemen kan dit via j.h.c.scheper@student.utwente.nl.

32. Ruimte voor opmerkingen

Mochten er nog opmerkingen zijn, kunnen deze hier geplaatst worden.

_____

_____

_____

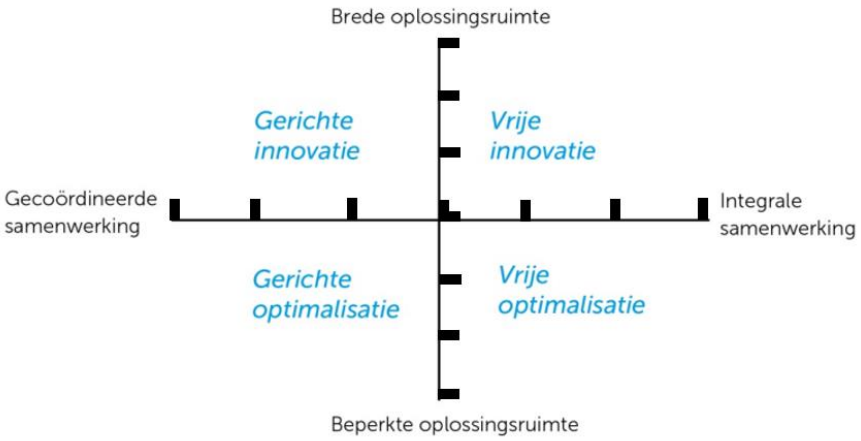
_____

Appendix D – Topic list interviews

Find the topic lists for the interviews of the case study below. The figure used stems from 'Handreiking aanbesteden van twee fasen contracten' (CROW, 2020) and is edited. The interviews' subscripts are confidential, enabling the participants to speak freely about the project.

Basis voor het documenteren van interviews voor de casestudy - Duur: 60 minuten

1. Inleiding (tot 5 min)
    a. Kennismaking en beknopte toelichting van het interview
    b. Zou dit interview mogen worden opgenomen zodat deze later kan worden verwerkt? En zouden de resultaten (anoniem) in het verslag mogen worden benoemd?
    c. Kan je een korte beschrijving geven van wat het project op hoofdlijnen probeerde te bereiken?
2. Project karakteristieken (tot 10 min)
    a. Kan je een korte beschrijving geven van wat de projectdoelen waren?
    b. Kan je kort beschrijven hoe de aanbesteding van het project eruitzag en welke criteria er zijn gebruikt voor het krijgen van een geschikte samenwerkingspartner?
    c. Kan je het project indelen op de volgende matrix?



    d. In welke fase begon de Bouwteamfase en wanneer eindigde deze?
    e. Welke contracten zijn gebruikt in de Bouwteam en uitvoeringsfase?

VGBouw 1992, DG2020, BN2021, UAV, UAV-GC

3. Directe kosten (tot 15 min)
    a. Kun je vertellen welk effect het gebruik van Bouwteams heeft gehad op de kosten in het project?
        - Conflicten, hogere kosten in ontwerpfase, aanbesteding, finale prijsvorming, relatie OG/ON
4. Efficiëntie ontwerpinspanning (tot 20 min)
    a. Heeft het gebruik van een Bouwteam gehad op het ontwerp en waarom?
        - De kwaliteit en de bouwbaarheid van het ontwerp, optimaliseren
5. Risicomanagement (tot 25 min)
    a. Kan je vertellen hoe een het gebruik van een Bouwteam invloed heeft gehad op de omgang met risico's en waarom?

b. Zie je ook veranderingen in de verdeling van risico's en waarom?

6. Kostenbeheersing (tot 30 min)

a. Kan je iets vertellen over de impact van het gebruik van een Bouwteam op de kostenbeheersing en waarom?
    - Nauwkeurigheid ramingen, hoeveelheid meerwerk en beheersbaarheid tijdens ontwerpproces

7. Processen in het project (tot 35 min)

a. Welk effect heeft het gebruik van een Bouwteam gehad de processen tijdens het ontwerp, en waarom?
    - Delen van informatie en expertise, relatie en het vertrouwen tussen opdrachtgever en opdrachtnemer, het begrip van uitdagingen van anderen betrokken partijen, werkplezier
b. Welk effect heeft het gebruik van een Bouwteam gehad de processen tijdens de uitvoering en waarom?
    - Werkomstandigheden en veiligheid, flexibiliteit en reactievermogen van betrokken partijen, omgevingshinder,

8. Projectresultaten (tot 40 min)

a. Heeft het gebruik van een Bouwteam impact gehad op de tijdigheid en kwaliteit van de constructie en waarom?
b. Kan je wat vertellen van de impact van een Bouwteam op de tevredenheid van de eindgebruiker en waarom?

9. Innovatie in het project (tot 45 min)

a. Welk effect heeft het gebruik van Bouwteams gehad op nieuwe werkmethodes en waarom?
b. Heeft het gebruik van Bouwteams impact gehad op productinnovatie in het project en waarom?

10. Leren in het project (tot 50 min)

a. Hoe heeft het gebruik van Bouwteams impact gehad op het leren van elkaar en het verwerven van nieuwe vaardigheden onder het personeel en waarom?

11. Algemene reflectie op het gebruik van Bouwteams (tot 55 min)

a. Heb je de indruk dat Bouwteams een kostenefficiënte aanpak is gebleken voor het creëren van meerwaarde in dit project en waarom?
b. Heeft het gebruik van Bouwteams bijgedragen aan het behalen van de projectdoelen en waarom?

12. Afsluiting (tot 60 min)

a. Zijn er nog andere effecten van het gebruik van een Bouwteam die je als prettig of onprettig hebt ervaren en die nog niet in het gesprek aan bod zijn gekomen?
b. Bedanken voor deelname
c. Mag ik nog contact met je opnemen en een transcriptie ter toetsing voorleggen?

Appendix E – Survey costs and added value in Dutch Bouwteams/Two-phase projects

Below, the list of question for the survey on costs and benefits in Dutch Bouwteams/Two-phase projects can be found. The results other than described in the body text are confidential.

Vragenlijst - kosten en meerwaarde bij een Bouwteam/Twee fase project

B I U

In de eerste plaats dank voor deelnemen aan deze vragenlijst over de kosten en meerwaarde van een specifiek Bouwteam of twee fase project. Dit onderzoek zal ongeveer 10-15 minuten duren en maakt deel uit van de Master Thesis van Jip Scheper over de kostenimplicaties en meerwaarde van Bouwteams, uitgevoerd voor de studie Construction Management & Engineering aan de Universiteit Twente.

Eerst zullen er een paar vragen gesteld worden over jouw rol en ervaring, waarna verschillende vragen zullen volgen over één specifiek bouwteam/twee fase project waarvan de uitvoeringswerkzaamheden zijn begonnen of afgerond. Hierin zullen onder andere project karakteristieken, kostenratio's en de meerwaarde worden behandeld.

De gegeven antwoorden zullen vertrouwelijk worden verwerkt. Daarnaast zullen in het rapport enkel statistieken over de resultaten worden gedeeld, welke niet terug te zijn herleiden tot de gegevens van één project. Mocht je een vraag niet kunnen beantwoorden, kan deze overgeslagen worden. Als je het antwoord zou willen opzoeken kan je de vragenlijst sluiten en later afronden, zolang je met hetzelfde e-mailadres in google aangemeld bent. Aan het einde is er ruimte voor opmerkingen.

Jouw ervaring

Om een beeld te krijgen van de deelnemers van de enquête, wordt je verzocht onderstaande vragen over jouw werkzaamheden en ervaring te beantwoorden.

Voor welke organisatie ben jij werkzaam?

- ○ Rijkswaterstaat
- ○ Provincie
- ○ Gemeente
- ○ Waterschap
- ○ Adviesbureau
- ○ Aannemer
- ○ Anders...

Hoeveel jaar ervaring heb je in de constructie sector?

- ○ 0-5 jaar
- ○ 6-10 jaar
- ○ 11-15 jaar
- ○ 16-20 jaar
- ○ 21-25 jaar
- ○ 26-30 jaar
- ○ meer dan 30 jaar

Karakteristieken van het Bouwteamproject

In dit onderdeel zal worden gevraagd naar de wat specificaties van jouw bouwteam of twee fase project.

Wat is de naam van het project?

Mocht je deze uit veiligheidsoverwegingen niet willen delen, dan kan je dit veld open laten.

Korte antwoordtekst

Tot welke deelmarkt behoort het project hoofdzakelijk?

- Grondbouw
- Wegenbouw
- Waterbouw
- Utiliteitsbouw
- Anders...

Valt het project binnen nieuwbouw of V&R?

- Nieuwbouw
- Vervanging en renovatie
- Anders...

Hoe ver schat je dat de uitvoering van het project onderweg is?

- ○ De uitvoering is nog niet begonnen
- ○ 0-30% afgerond
- ○ 30-70% afgerond
- ○ 70-100% afgerond
- ○ Het project is volledig afgerond

Wat is de globale omvang van het totale project?

- ○ Minder dan €200K
- ○ €200K-€500K
- ○ €500K-€1M
- ○ €1M-€2M
- ○ €2M- €5M
- ○ €5M-€10M
- ○ €10M-€20M
- ○ €20M-€50M
- ○ €50M-€100M
- ○ €100M-€200M
- ○ €200M-€600M
- ○ Meer dan €600M

Wat was het zwaarst wegende aspect bij de gunning van het project?

- ○ Prijs
- ○ Kwaliteit
- ○ Samenwerking
- ○ Anders...

Is er sprake van een plafondbedrag?

Met plafondbedrag wordt geduid op een absolute maximale kostprijs voor de realisatie van het hele project, dus de bouwteam en de uitvoering. Wanneer er sprake is van een target of taakstellend budget wordt dus 'nee' gekozen, omdat daar nog ruimte is voor wijzigingen van het budget.

- ○ Ja
- ○ Nee
- ○ Anders...

Is er binnen het project sprake van een beperkte of brede oplossingsruimte?

Bij een project met een beperkte oplossingsruimte zijn de belangrijke keuzes al gemaakt, en er wordt beoogd de uitvoeringservaring van de aannemer in te zetten. Bij een brede oplossingsruimte ligt er nog veel ruimte voor de keuze van oplossingsrichtingen.

	1	2	3	4	5	6	7	
Beperkte oplossingsruimte	○	○	○	○	○	○	○	Brede oplossingsruimte

Is er binnen het project sprake van een gecoördineerde of integrale samenwerking?

Bij een project met een gecoördineerde samenwerking wordt er uitgegaan van een duidelijke rolverdeling en een duidelijke inbreng in het project. De trekkersrol ligt bij de opdrachtgever. In een integrale samenwerking wordt gestreefd naar gelijkheid en beide partijen leveren inbreng bij ontwerpkeuzes.

	1	2	3	4	5	6	7	
Gecoördineerde samenwerking	○	○	○	○	○	○	○	Integrale samenwerking

Wat was het detailniveau van het ontwerp bij het begin van de Bouwteamfase/planuitwerkingsfase?

- ○ Initiatieffase
- ○ Schetsontwerp
- ○ Voorlopig ontwerp
- ○ Definitief ontwerp
- ○ Anders...

Welke contract is gebruikt in de Bouwteam fase/eerste fase?

- ☐ VG Bouw 1992
- ☐ Duurzaam Gebouwd 2020
- ☐ Bouwend Nederland 2021
- ☐ UAV-GC 2005
- ☐ DNR 2011
- ☐ Anders...

In welke fase van het project eindigde de Bouwteam fase/eerste fase?

- ○ Voorlopig ontwerp
- ○ Definitief ontwerp
- ○ Uiteindelijk ontwerp
- ○ Anders...

Welk contract is gebruikt in de uitvoeringsfase?

- ○ UAV 2012
- ○ UAV-GC 2005
- ○ Anders...

Kostenimplicaties

In het volgende deel worden zes vragen gesteld over het verloop van kosten in jouw Bouwteam project. De verkregen resultaten over de kosten worden in ratio uitgevraagd zodat er geen bedragen in euro's gedeeld hoeven te worden.

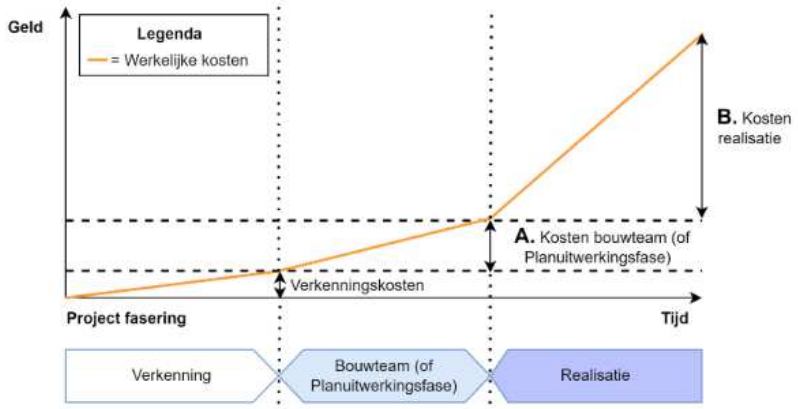
Zoals reeds aangegeven worden deze percentages niet per project bekend gemaakt, in het verslag wordt enkel gekeken naar de statistieken over de verkregen waarden.

Ratio werkelijke kosten

Onderstaande grafiek toont een versimpelde illustratie van de verloop van werkelijke bestede kosten (in oranje) door drie fasen van het project. Dit zijn de verkenningsfase, het bouwteam (of de planuitwerkingsfase) en de realisatiefase.

Daarnaast zijn twee parameters voor de werkelijke bestede kosten aangegeven:
A - kosten bouwteam fase (of planuitwerkingsfase)
B - kosten realisatiefase
De kosten gaan over de totale som van de directe en indirecte kosten beide de fases. Wanneer bekend mogen dus eventuele onderzoeken en kosten opdrachtgever hierin ook worden meegenomen. Vastgoedkosten zijn uitgesloten. Als laatste mag de uitputting van de risicovoorzieningen worden meegenomen voor de uitvoeringsfase.

Illustratie verloop van kosten



Wat is de ratio tussen de werkelijke kosten voor de bouwteamfase (A) en realisatie (B)?

Stel de gerealiseerde kosten in (A), dus het bouwteam of de planuitwerkingsfase, bedragen €1M en de kosten in fase 2 (B) bedragen €10M, dan is de ratio (A) / (B) = €1M / €10M = 0.1 = **10%.**

Kies het vakje 'anders:' en noteer daar het percentage. Als je deze niet precies weet kan je dat aangeven. Als het project nog niet volledig is afgerond, neem dan het geschatte eindbedrag voor de realisatie op basis van de laatst gemaakte inschatting.

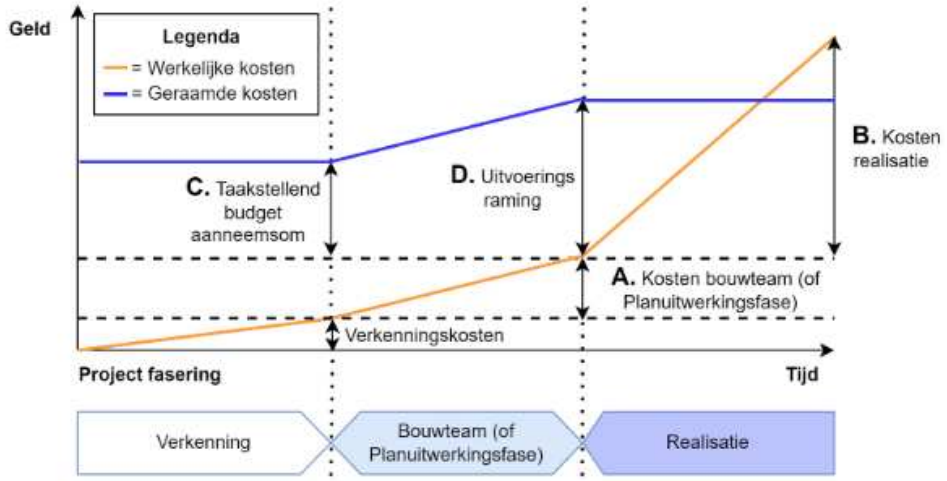
- ○ Dat weet ik niet precies
- ○ Anders...

Ratio realisatie en uitvoeringsraming

Onderstaande grafiek toont een versimpelde illustratie van de verloop van werkelijke (oranje) en nu ook de totale geraamde kosten (blauw) door drie fasen van het project.

Daarnaast zijn ramingen op twee ijkpunten aangegeven:
C - Taakstellend budget aanneemsom (vastgesteld na verkenning, incl. risicoreservering)
D - Uitvoeringsraming (vastgesteld na de bouwteam- of planuitwerkingsfase, incl. risicoreservering)

Illustratie verloop van kosten



Wat is de ratio tussen de werkelijke kosten voor de realisatie (B) en de uitvoeringsraming (D)?

Stel de werkelijke kosten voor de realisatie (B) zijn €11M en de uitvoeringsraming (D) is €10M en dan is de ratio (B) / (D) = €11M / €10M = 1.1 = **110%** (noteer het percentage). De kosten van de uitvoeringsfase zijn inclusief uitputting van de risicoreservering.

Mocht het project nog niet zijn volledig zijn uitgevoerd neem dan de kosten voor realisatie en uitvoeringsraming tot de werkzaamheden die tot zover zijn uitgevoerd en bekend zijn.

Kies het vakje 'anders:' en noteer daar het percentage. Als je deze niet precies weet kan je dat aangeven.

- ○ Dat weet ik niet precies
- ○ Anders...

Redenen kostenwijzigingen

Kan je heel beknopt maximaal drie factoren opgeven welke volgens jou de meeste kostenwijzigingen in de uitvoering veroorzaakt hebben?

Factor 1

Tekst lang antwoord

Factor 2

Tekst lang antwoord

Factor 3

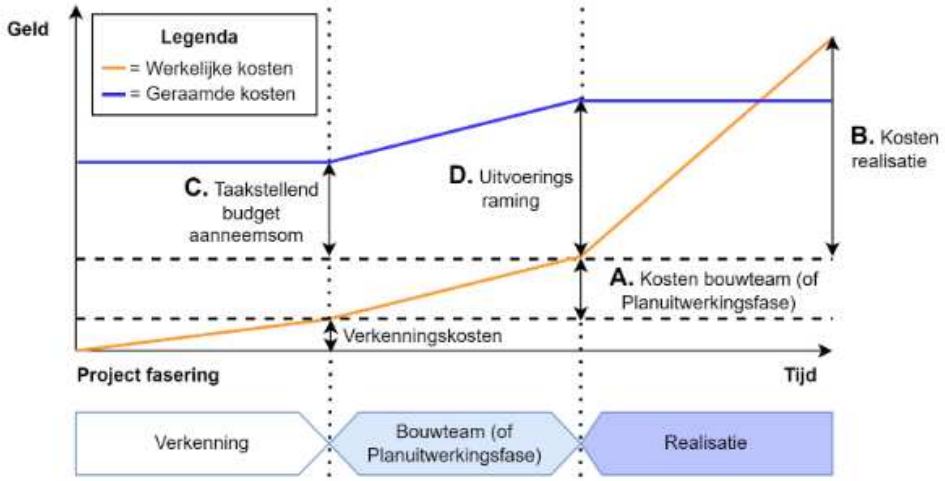
Tekst lang antwoord

Ratio uitvoeringsraming en taakstellend budget aanneemsom

Onderstaande grafiek toont een versimpelde illustratie van de verloop van werkelijke (oranje) en nu ook geraamde kosten (blauw) door drie fasen van het project.

Daarnaast zijn ramingen op twee ijkpunten aangegeven:
C - Taakstellend budget aanneemsom (vastgesteld na verkenning, incl. risicoreservering)
D - Uitvoeringsraming (vastgesteld na de bouwteam- of planuitwerkingsfase, incl. risicoreservering)

Illustratie verloop van kosten



Wat is de ratio tussen de uitvoeringsraming (D) en het taakstellend budget aanneemsom (C) ?

Stel totale uitvoeringsraming (D), incl. risicoreservering, is €10M en het taakstellend budget aanneemsom (C), incl. risicoreservering is €8M dan is de ratio (D)/(C) €10M/€8M = 1.25 = **125%**

Kies het vakje 'anders:' en noteer daar het percentage. Als je deze niet precies weet kan je dat aangeven.

- ○ Dat weet ik niet precies
- ○ Anders...

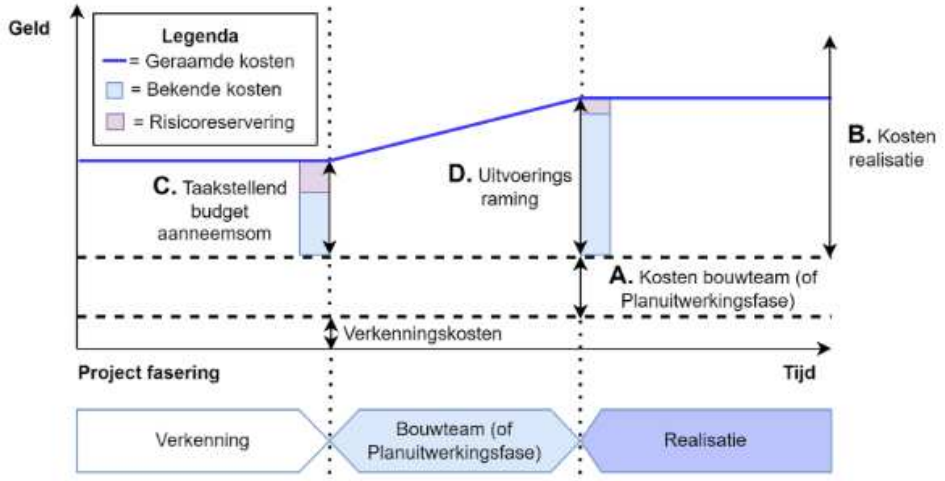
Ratio risico opslag - Taakstellend budget

Onderstaande grafiek toont een versimpelde illustratie van het verloop van de geraamde kosten (blauw) door drie fasen van het project.

Daarnaast zijn ramingen op twee ijkpunten aangegeven:
C - Taakstellend budget aanneemsom (vastgesteld na verkenning, incl. risicoreservering)
D - Uitvoeringsraming (vastgesteld na de bouwteam- of planuitwerkingsfase, incl. risicoreservering)

Ook is per raming toegevoegd hoe deze is opgebouwd, beide ramingen bestaan uit bekende en onbekende kosten met daaroverheen een risicoreservering. Met de risicoreservering wordt gedoeld op het effect maal de kans voor uiting van het effect en ongespecificeerd risico welke ten koste komt voor opdrachtgever of opdrachtnemer.

Afbeeldingstitel



Wat is de ratio tussen de risicoreservering in het taakstellend budget aanneemsom en het totale taakstellend budget aanneemsom (C)?

Stel de risico reservering in het totale taakstellend budget aanneemsom (C) is €1M en de totale het totale taakstellend budget aanneemsom incl. risicoreservering (C) is €8M dan is de ratio €1M/€8M = 0.125 = **12.5%** (noteer het percentage)

N.B. hier wordt niet gevraagd naar de percentuele risico-opslag of R, dit is een ander getal. Stel deze is 12.5% dan is de ratio 12.5%/112.5%(uitvoeringsraming incl. risicoreservering) =11.1%

Kies het vakje 'anders:' en noteer daar het percentage. Als je deze niet precies weet kan je dat aangeven.

- ○ Dat weet ik niet precies
- ○ Anders...

Ratio risico opslag - Uitvoeringsraming

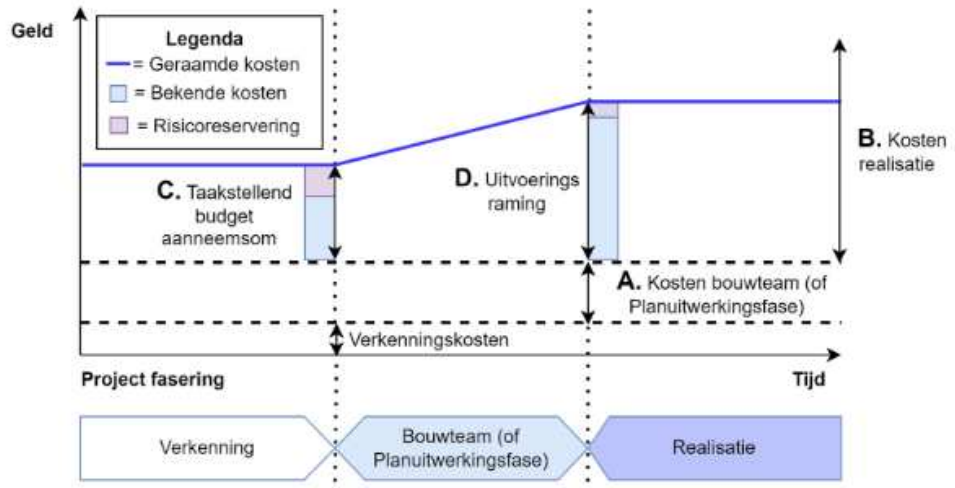
- Herhaling -

Onderstaande grafiek toont een versimpelde illustratie van het verloop van de geraamde kosten (blauw) door drie fasen van het project.

Daarnaast zijn ramingen op twee ijkpunten aangegeven:
C - Taakstellend budget aanneemsom (vastgesteld na verkenning, incl. risicoreservering)
D - Uitvoeringsraming (vastgesteld na de bouwteam- of planuitwerkingsfase, incl. risicoreservering)

Ook is per raming toegevoegd hoe deze is opgebouwd, beide ramingen bestaan uit bekende en onbekende kosten met daaroverheen een risicoreservering. Met de risicoreservering wordt gedoeld op het effect maal de kans voor uiting van het effect en ongespecificeerd risico welke ten koste komt voor opdrachtgever of opdrachtnemer.

Afbeeldingstitel



Wat is de ratio tussen de risicoreservering in de uitvoeringsraming en de totale uitvoeringsraming (D)?

Stel de risico reservering in de uitvoeringsraming is €1M en de totale uitvoeringsraming (incl. risicoreservering) (D) is €10M dan is de ratio €1M/€10M = 0.1 = **10%**

N.B. hier wordt niet gevraagd naar de percentuele risico-opslag of R, dit is een ander getal. Stel deze is 10% dan is de ratio 10%/110%(uitvoeringsraming incl. risicoreservering) =9.1%

Kies het vakje 'anders:' en noteer daar het percentage. Als je deze niet precies weet kan je dat aangeven.

- ○ Dat weet ik niet precies
- ○ Anders...

Meerwaarde bij het project

Onderstaand vind je 30 verschillende stellingen. De statement begint met 'Het gebruik van een Bouwteam/twee fase aanpak heeft in dit project geleid tot...' waar het gebruik van een bouwteam/twee fase aanpak wordt afgezet tegen traditionele projecten. Met traditionele projecten wordt gedoeld op een project dat wordt gegund onder competitie met biedingen die zijn gebaseerd op eisen en/of het ontwerp vanuit de opdrachtgever.

Je mag alle opties aanvinken die jij van toepassing vindt voor jouw specifieke project. Daarna volgt een stelling waarvan je gevraagd wordt om deze te beoordelen van 'helemaal oneens' tot 'helemaal eens'.

Het gebruik van een bouwteam/twee fase aanpak heeft in dit project geleid tot...

- [ ] 1. Minder conflicten tussen betrokken partijen
- [ ] 2. Hogere kosten in de ontwerpfase
- [ ] 3. Een tekort aan competitie bij de uiteindelijke prijsvorming
- [ ] 4. Hogere kosten in de aanbesteding wegens een uitgebreidere procedure
- [ ] 5. Hogere kosten als gevolg van de toegenomen inspanning voor de relatie tussen opdrachtgever en opd...
- [ ] 6. Hogere kosten voor projectadministratie
- [ ] 7. Verbetering van het ontwerp
- [ ] 8. Verbeterde bouwbaarheid van het ontwerp
- [ ] 9. Minder risico's in de uitvoeringsfase
- [ ] 10. Een betere risicoverdeling tussen opdrachtgever en opdrachtnemer
- [ ] 11. Effectiever risicomanagement
- [ ] 12. Een nauwkeurigere kostenraming vooraf aan de realisatiefase
- [ ] 13. Een afname van de hoeveelheid meerwerk in de uitvoeringsfase
- [ ] 14. Betere controle van kosten gedurende het ontwerpproces
- [ ] 15. Verbeterde werkomstandigheden en veiligheid tijdens de uitvoering
- [ ] 16. Meer flexibiliteit en reactievermogen van betrokken partijen

- [ ] 17. Meer delen van informatie en expertise tussen de opdrachtgever en opdrachtnemer
- [ ] 18. Een betere relatie en vertrouwen tussen de opdrachtgever en opdrachtnemer
- [ ] 19. Meer onderling begrip van de uitdagingen van de betrokken partijen
- [ ] 20. Betere kwaliteit van het bouwwerk
- [ ] 21. Betere tijdigheid van uitvoeringswerkzaamheden
- [ ] 22. Meer tevredenheid van de eindgebruiker van het bouwwerk
- [ ] 23. Meer innovatie door kennisoverdracht
- [ ] 24. Meer innovatie door samenwerking
- [ ] 25. Meer innovaties door beter begrip van risico's
- [ ] 26. Meer wederzijds leren tussen de opdrachtgever en opdrachtnemer
- [ ] 27. Het beter verwerven van nieuwe vaardigheden onder het personeel
- [ ] 28. Vermindering van omgevingshinder
- [ ] 29. Meer werkplezier gedurende het bouwteam/de planuitwerkingsfase
- [ ] 30. Het bereiken van optimalisaties van het ontwerp

Stelling: Het gebruik van een bouwteam/twee fase aanpak is een kosten-efficiënte aanpak gebleken voor het creëren van meerwaarde in dit project.

	1	2	3	4	5	6	7	
Helemaal oneens	○	○	○	○	○	○	○	Helemaal eens

Afsluiting

Beschrijving (optioneel)

Zou je het eindverslag per e-mail willen ontvangen?

Onderstaand heb je de optie om je e-mail in te vullen (in het keuzevakje) zodat het verslag hiernaar opgestuurd kan worden als deze af is (eind juni) Participanten die al elders hun e-mail hebben achter gelaten mogen deze vraag overslaan.

- ○ Nee dank, geen intresse
- ○ Anders...

Hartelijk dank voor het succesvol afronden van deze vragenlijst!

Hiermee levert u een mooie bijdrage voor het onderzoek over de kosten en meerwaarde bij bouwteams en twee fase projecten. Klik op 'verzenden' om deze in te leveren.

Mocht je nog contact willen opnemen kan dit via j.h.c.scheper@student.utwente.nl.

Ruimte voor opmerkingen

Mochten er nog opmerkingen zijn, kunnen deze hier geplaatst worden.

Tekst lang antwoord

Appendix F – Computation of the likelihood in the expert survey

The likelihood of the emergence of a cost implication or benefits has been computed with the following formula:

$$p = 1 - \int_{-\infty}^{0} \left(\left(\frac{1}{\sqrt{2\pi} * \sigma} \right) * e^{-\left(\frac{\mu^2}{2\sigma^2} \right)} \right)$$

Where:

$p = likelihood\ of\ emergence$

$\sigma = standard\ deviation\ of\ the\ sample$

$\mu = mean\ of\ the\ sample$

Appended paper

The paper 'The Added Value of Bouwteams: An Analysis of Its Costs and Benefits in Dutch Infrastructure Projects' is provided on the following pages.

The Added Value of Bouwteams: An Analysis of Its Costs and Benefits in Dutch Infrastructure Projects

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Dr. J.T. (Hans) Voordijk & Drs. Ing. J. (Hans) Boes

3rd of July 2024

Words: 5733

Abstract: There is traditionally a project-oriented and competitive focus in the infrastructure sector. Despite its ability to optimise costs in the short term, this approach tends to overlook the added value that alternative approaches like Bouwteams can create. Bouwteams promote a collaborative and transparent way of working in which the contractor is involved early in the design process. More experiences with Bouwteams must be collected and shared for advice and decision-making. This study aims to investigate their cost implications and benefits. A literature review and subsequent questionnaire have revealed divergent perspectives on project cost drivers. However, benefits such as process and project improvement and stimulating learning and innovation are unequivocally confirmed. A comparative case study indicates that collaboration, transparency, and collaborative risk allocation form the foundation of these benefits. Furthermore, the study analyses the cost implications and benefits of 31 Dutch infrastructure projects utilising a two-phase approach. During the Bouwteam phase, increased costs are found due to contractor involvement. Additionally, changes in scope, indexing costs, and lack of competition in the final price formation significantly elevated the construction budget during the Bouwteam. In the realisation phase, these initial investments result in increased predictability of construction, with reduced cost overruns due to reduction of risks and additional construction costs. Using Bouwteams in complex projects, especially for managing large risks or sustainability concerns, yields substantial benefits. Clients and policymakers should consider Bouwteams' ability to increase value creation despite requiring increased design effort and initial budget allocations. These investments can help mitigate cost overruns, improve constructability, enhance end-user satisfaction, and stimulate innovation and knowledge sharing.

Keywords: Bouwteam; Two Phase; Cost implications; Benefits; Added Value; Early Contractor Involvement; Procurement; Contracts; Collaboration.

Introduction

Traditionally, infrastructure projects are tendered to contractors primarily based on price through public procurement. Due to the construction industry's project-based and site-specific nature, companies often focus on financial control and decentralised decision-making for individual projects. While this project-oriented approach may be favourable for achieving the lowest costs, it may not foster a healthy industry.

Several parties in the Dutch construction industry have adopted a two-phase approach using Bouwteams to address infrastructure projects' growing complexities and risks. This aims to tackle societal challenges and move away from self-interest, acting reactively, opportunistic behaviour [1] and adversarial relationships [2].

Despite the rising popularity of Bouwteams, more practical and theoretical research remains needed to understand their benefits and costs fully, thereby supporting informed decision-making. Rijkswaterstaat emphasises the importance of gathering experiences to advise about follow-up projects [3]. Lagemaat [4] points out that clients struggle to quantify the benefits of using Bouwteams compared to the lack of competition. Furthermore, Verweij, Koppenjan, & Hombergen [5] recommend selecting a suitable evaluation strategy for Bouwteams and collecting data on the total cost efficiency of projects as it can be an important basis for improving decision making over coming projects.

Two-phase construction projects

In contrast to competitively procured projects, a Bouwteam project adopts a two-phase approach. Specifically, the client and contractor divide the design and the construction of works into two distinct phases [6]. It is emphasised this phase aims to establish a robust project plan through an iterative process [3]. Additionally, risk management and cost estimations can be performed [7].

Cost implications and benefits in relation to added value

Throughout a construction project, value can be understood as the degree to which the societal and project goals are achieved relative to project costs. The benefits of using Bouwteams include their impact on realising project and societal goals compared to competitively procured projects. These effects may be harder to monetise. Cost implications refer to the financial consequences of adopting Bouwteams compared to

competitively procured projects. The added value of Bouwteams is reached when the value in Bouwteam projects exceeds the value in competitively procured projects.
There is a more significant ability to impact project cost and functional capabilities early in the project [8], enabling the creation of added value. Additionally, as the project progresses, the level of risk and uncertainty declines [7], while the cost of implementing design changes increases [8]. Furthermore, using integrated project delivery, the design effort occurs earlier in the project [8].

Literature review

The literature study identified several cost implications and benefits associated with Bouwteams or the two-phase construction project, early contractor involvement and collaboration as presented in Table 1 on the next page. For each effect, the resources and associated search terms can be found. The methodology of the literature study is detailed in Appendix A. Categorization of the identified cost implications, and benefits is partly based on project aims as illustrated by Laeven et al. [7].
While using Bouwteams can introduce some unfavourable cost implications, it also brings various benefits. Additionally, the causes of these cost implications and benefits have been identified in the literature, mostly considering collaboration and early contractor involvement, and addressing sub-questions 1.c.
The literature review of Bouwteams' characteristics revealed they revolve around collaboration, using a two-phase approach, and early contractor involvement to manage project complexity. These characteristics distinguish Bouwteams from competitively procured projects.
The literature review on cost trends in construction projects primarily highlighted cost overruns in the sector, and particularly in integrated projects. Unfortunately, limited data was available on design costs or the development of risk reserves throughout the projects. Cantarelli et al. [9] observed average cost overruns of 16.5% with a standard deviation of 40% in an analysis of 78 projects completed between 1991 and 2009 within the Dutch transportation infrastructure. More recently, Verweij, van Meerkerk & Leendertse [5] found the additional cost from the decision to build to average 124.7% of the contract sum in integrated design and construction projects with a standard deviation of 24.3%.

Table 1 Cost implications and benefits associated with the use of Bouwteams according to literature

Category		Nr.	Effect	Bouwteam or Two-phase	Collaboration	Early contractor involvement
Cost implications	Expense drivers	#1	Higher costs in the design phase	[10] & [3]		
		#2	Lack of competition in final price forming	[11], [12], [7]& [13]		[14]
		#3	Higher costs by more extensive tender procedure	[15]		[16]
		#4	Higher costs for the client-contractor relationship		[17]	[14]
		#5	Correct project administration is costly			[14]
	Expense reducers	#6	Prevention of conflicts resulting in savings	[18]	[19]& [20]	[16] & [21]
		#7	Improvement of the design	[22]	[23]	[14] & [24]
		#8	Increased constructability		[23] & [25]	[14], [16], [21], & [26]
	Risk management	#9	Reduction of risks	[7]	[25] & [27]	[24]
		#10	Improved risk allocation	[28]	[29]	[14] & [30]
		#11	More effective risk management		[27]	[21], [24], [24], [30], [31] & [32]
	Cost control	#12	Better accuracy of estimates	[22], [28] & [33]	[25] & [34]	[14], [21], [24], [35] & [36]
		#13	Reduction of additional construction costs	[10] & [37]		[38]
		#14	Costs integration into the value creation process		[27]	[39]
Category		**Nr.**	**Effect**	**Bouwteam or Two-phase**	**Collaboration**	**Early contractor involvement**
Benefits	Project processes	#15	Improved working conditions and safety	[11]		[14] & [35]
		#16	Improved flexibility and responsiveness	[7]	[23] & [40]	[24]
		#17	Increased sharing of information and expertise	[11]	[40]	[41]
		#18	Improved relationship and trust	[10], [7] & [28]	[29] & [42]	[14], [16], [21] & [24]
		#19	Increased understanding of each other's challenges		[29] & [43]	
	Project results	#20	Better quality of the construction	[10] & [11]	[23] & [29]	[35] & [44]
		#21	Better schedule performance of construction	[11], [28] & [45]	[20], [23] & [25]	[14], [38] & [41]
		#22	Improved end-user satisfaction		[23] & [29]	
	Innovation capability	#24	Enlarged innovation by collaboration	[22]	[23], [25], [46]& [47]	[26] & [48]
		#25	Fostering new approaches by improved risk understanding	[7] & [13]		[26] & [48]
	Learning	#26	Contribute to mutual learning	[49]	[43], [50] & [51]	
		#27	Workers acquiring new skills		[46]	

Discussion

Interpretations

The literature review of Bouwteams' characteristics revealed they revolve around collaboration, using a two-phase approach, and early contractor involvement to manage project complexity. These characteristics distinguish Bouwteams from competitively procured projects.

Thereafter, these characteristics have been used to explore the cost implications and benefits associated with Bouwteams, according to the literature.

The literature review on cost trends in construction projects primarily highlighted cost overruns in the sector and for integrated projects. Unfortunately, limited data was available on design costs or the development of risk reserves throughout the projects.

Limitations

While conducting a literature review, it was important to realise the possibility of differences between the author's written message and the reader's interpretation.

Also, it is noteworthy that some more critical voices were present in the literature. For instance, Laeven et al. [7] highlighted the need for changes in behaviour, attitude and division of tasks and roles in Bouwteams before it can be as successful. Similarly, Franco [43] pointed out that not all participants fully realise the potential of Bouwteams, citing complexities and challenges such as managing ambiguity and dynamics, developing a shared identity, and balancing power asymmetries.

Furthermore, some scholars doubted whether the reported benefits can be directly attributed to Bouwteams. Bresnen & Marshall [23] suggested that performance gains may be influenced by indirect factors rather than solely by the collaboration. Similarly, Polenske [46] noted that success in collaboration is influenced by non-market forces such as trust and learning. Additionally, Akintoye and Main [50] pointed out that collaboration should be carefully considered to ensure alignment with the business plan and address potential failure factors.

Furthermore, there is ongoing debate regarding the efficiency of adding value to projects through early contractor involvement. Eadie & Graham [48] suggested that it is most relevant for larger projects. Narum et al. [52] found that early contractor involvement applies to complex projects and Farrell & Sunindijo [53] and Wondimu, Lium, & Laedre

[16] concurred its unsuitability for all projects. Rahmani [54] described challenges in demonstrating value for money.

Implications and recommendations

The literature's primary contribution has been to establish an overview of the cost implications and benefits of Bouwteams, forming a hypothesis that these effects may also be present in Bouwteam projects within the Dutch infrastructure construction. Currently, some of the effects described in relation to collaboration and early contractor involvement are not described in the context of Bouwteams, indicating a gap in understanding. Additionally, the review identified a gap in the literature regarding the causality of the cost implications.

Lastly, the analysis of cost trends in construction projects revealed a lack of ex-post project evaluation of Bouwteams, despite recommendations for such evaluations. Therefore, further investigation into these topics is recommended.

Methodology

A global overview of the research activities employed can be found in Figure 1. First, a conceptual framework was established, as detailed in the last chapter. Then, empirical research is employed to address the literature review recommendations further.

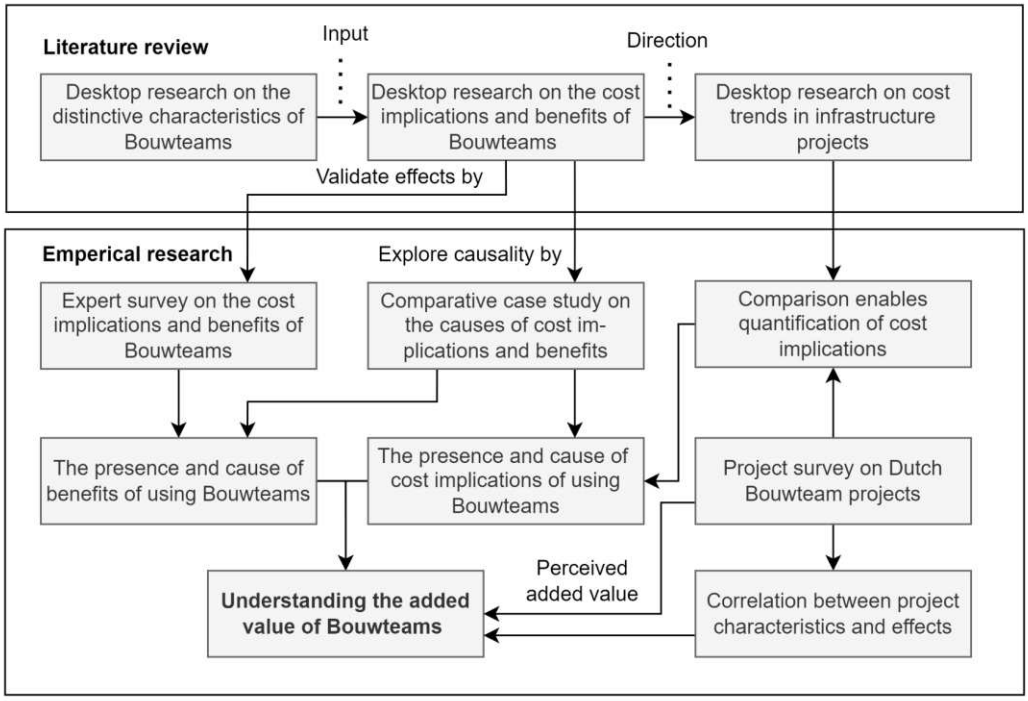

Figure 1 Research Methodology

Implementation

The cost implications and benefits, as lined out in the conceptual framework, were validated using an expert survey on the cost implications and benefits. A comparative case study was also employed to investigate the causality of using Bouwteams and the cost implications and benefits. A project survey was employed to quantify the cost trends in Bouwteam projects. By comparing the cost trends of Bouwteam projects and the cost trends in the sector, the cost implications of using Bouwteams were derived. Lastly, data from the project survey was used to identify possible correlations between project characteristics and effects. Ultimately, these steps have contributed to understanding the added value of Bouwteams.

Resource triangulation was employed to validate findings and increase their reliability. The results from the expert survey were used to validate the cost implications derived from the project survey. Also, the results from the project survey were used to validate the benefits found in the expert survey. The correlation analysis between project data and characteristics was used to validate the causal diagram from the case study.

Results

Of the 92 individuals who received an invitation to participate in the expert survey, 26 completed the form, resulting in a 28% response rate. Notably, all participants had more than five years of experience, with the majority working at municipalities, contractors, or engineering firms. The results of the expert survey are presented in Table 2 below, which shows the cost implications, benefits, average rating, standard deviation, and chance of presence calculated based on an assumed Gaussian distribution. The effects are sorted in descending order.

Table 2 Expert survey results

Nr	Effect	Average (-2 to 2)	Standard deviation	Probability (sorted descending)
#7	Improvement of the design	1.54	0.51	1.00
#26	Contribute to mutual learning	1.19	0.40	1.00
#17	Increased sharing of information and expertise	1.38	0.50	1.00
#13	Reduction of additional construction costs	1.38	0.57	0.99
#6	Prevention of conflicts resulting in savings	1.42	0.64	0.99
#8	Increased constructability	1.54	0.71	0.99
#9	Reduction of risks	1.38	0.70	0.98
#19	Increased understanding of each other's challenges	1.27	0.67	0.97
#18	Improved relationship and trust	1.19	0.69	0.96
#11	More effective risk management	1.35	0.80	0.95
#10	Improved risk allocation	1.38	0.85	0.95
#12	Better accuracy of estimates	1.08	0.89	0.89
#27	Workers acquiring new skills	0.77	0.65	0.88
#20	Better quality of the construction	0.96	0.82	0.88
#16	Improved flexibility and responsiveness	0.92	0.80	0.88
#24	Enlarged innovation by collaboration	0.81	0.80	0.84
#22	Improved end-user satisfaction	0.77	0.86	0.81
#23	Enlarged innovation by knowledge transfer	0.69	0.79	0.81
#21	Better schedule performance of construction	0.65	0.80	0.79
#15	Improved working conditions and safety	0.69	0.88	0.78
#14	Costs integration into the value creation process	0.62	0.94	0.74
#25	Fostering new approaches by improved risk understanding	0.54	0.90	0.72
#5	Higher costs in the design phase	0.04	0.92	0.52
#1	Lack of competition in final price forming	-0.31	1.16	0.40
#4	Correct project administration is costly	-0.96	0.92	0.15
#2	Higher costs by more extensive tender procedure	-1.04	0.82	0.10
#3	Higher costs for the client-contractor relationship	-1.04	0.77	0.09

Comparative case study

Two cases have been studied. This section will briefly present both cases, more detailed findings can be found in Appendix B.

Case study 1

In the first case study, a municipality commissioned a redesign of a location surrounded by residential areas and businesses. The project aimed to redevelop public space to improve the area's attractiveness and accommodate green and water storage. Construction involved underground works, such as earthmoving, cables, pipelines, and sewage, as well as above-ground works, including road construction, installation of streetlights, and landscaping. The municipality's maintenance budget financed the project, supplemented with credits and subsidies.

Two notable findings emerged for this project. Firstly, several innovations were successfully implemented, including using an earth depot for soil reuse, using Building Information Modelling for subsoil infrastructure location and crane navigation, and constructing a sustainable road with a longer lifespan and pavement that emitted fewer emissions. These innovations could be reached due to the early involvement of the contractor and the use of a risk file. Secondly, it was observed that using fixed markup percentages was less favourable for the contractor, as it was perceived that working in a competitively procured project could be more profitable. However, despite this concern, the contractor expressed satisfaction with the project due to enlarged collaboration and job satisfaction.

Case study 2

The second case study considered a large dike reinforcement project using a two-phase approach. The construction works considered renovating and heightening the dike. Notably, the project was defined by its complexity, as various stakeholders in the neighbourhood interacted with the construction activities.

One notable finding in this project was ensuring market conformity, a requirement imposed by the subsidy provider. This issue also corresponds to the lack of competition in the final price formation (#4). Therefore, this project adopted an approach with predetermined overhead, profit, and risk percentages.

Project survey

The cost trends and reasons for cost overruns in Bouwteam/two-phase projects are discussed.

Cost trends

In the first phase, an average cost of 15.5% (the standard deviation, or σ, of 10.0%, based on 29 results) was allocated to activities in the Bouwteam phase out of the total costs for the design and construction of the works. On average, the construction cost estimation towards the end of the Bouwteam phase, when the design activities have (partly) progressed, amounted to 129.4% (σ being 52.0%, based on 24 results) of the task-based budget. The construction cost showed a cost overrun of 4.4% (σ being 11.3%, based on 20 results) to the construction cost estimation. Projects not starting the realisation phase were excluded from determining the cost overruns. The risk reserve at the start of the Bouwteam averaged 15.0% (σ is 12.4%, based on 20 results) of the task-based budget and 11.7% (σ being 7.2%, based on 23 results) at the beginning of the realisation phase. Thereby, the monetary risk reservation barely decreased from 15.0% at the start of the Bouwteam to 15.1% at the end of the Bouwteam, both relative to the task-based budget.

Reasons for cost overruns

In the survey, the participants were allowed to specify the three primary causes of cost overruns in their projects. Approximately two-thirds of the participants used this space, citing the following main reasons for cost overruns in descending order: scope changes (in 9 projects), rising costs for labour, material, and equipment due to economic circumstances (in 7 projects, the war in Ukraine being most frequently mentioned), setbacks in the current situation (in 5 projects, subsoil obstacles being most frequently cited), environmental concerns (3 projects), and the quality of cost estimations (in 2 project).

Cost implications and benefits in Dutch Bouwteam or Two-phase projects

In the survey concerning Dutch infrastructure projects using Bouwteams, participants were asked to indicate whether they observed Bouwteams leading to cost implications or benefits in their project. They selected multiple boxes from a list of effects they observed. The findings are presented in Table 3, showing the rate of projects where each cost implication or benefit was observed.

Table 3 Cost implications and benefits of Bouwteams in projects

Category		Nr.	Effect	Project survey
Cost implications	Expense drivers	#1	Higher costs in the design phase	0.43
		#2	Lack of competition in final price forming	0.70
		#3	Higher costs by more extensive tender procedure	0.07
		#4	Higher costs for the client-contractor relationship	0.23
		#5	Correct project administration is costly	0.00
	Expense reducers	#6	Prevention of conflicts resulting in savings	0.67
		#7	Improvement of the design	0.60
		#8	Increased constructability	0.73
	Risk management	#9	Reduction of risks	0.70
		#10	Improved risk allocation	0.70
		#11	More effective risk management	0.43
	Cost control	#12	Better accuracy of estimates	0.67
		#13	Reduction of additional construction costs	0.63
		#14	Costs integration into value creation process	0.20
Category		**Nr.**	**Effect**	**Project survey**
Benefits	Project processes	#15	Improved working conditions and safety	0.33
		#16	Improved flexibility and responsiveness	0.63
		#17	Increased sharing of information and expertise	0.70
		#18	Improved relationship and trust	0.63
		#19	Increased understanding of each other's challenges	0.63
		#A1	Reducing environmental nuisance	0.43
		#A2	Having more fun at work	0.63
	Project results	#20	Better quality of the construction	0.33
		#21	Better schedule performance of construction	0.40
		#22	Improved end-user satisfaction	0.47
	Innovation capability	#24	Enlarged innovation by collaboration	0.47
		#25	Fostering new approaches by improved risk understanding	0.27
	Learning	#26	Contribute to mutual learning	0.67
		#27	Workers acquiring new skills	0.13

Furthermore, project participants could express their opinions on Bouwteams' cost efficiency, and their responses were generally positive. 78% of participants indicated that Bouwteams contributes to an efficient way of creating added value in their project.

Notably, a Pearson correlation analysis revealed a moderate correlation of 0.46 between the type of collaboration and the cost-efficiency of creating added value.

Discussion

Interpretations

The results revealed a rather modest opinion on the expense drivers. For instance, opinions were varied concerning the statement that there are higher costs in the design phase (#2). In contrast, the expense reducers and improvements for risk management were evident, with respondents scoring at least 0.95. Regarding cost control, the benefits were also clearly reflected in the respondents' answers.

Table 7 summarises the benefits of employing Bouwteams in Dutch construction projects. The benefits are split into process and product benefits, categorised based on their association with the design or construction phase and listed in descending order based on their chance of occurrence according to experts' opinion. Only the benefits perceivably present in more than 80% of the cases are included.

Table 4 Benefits witnessed in Dutch infrastructure projects using Bouwteams

Type	Benefits in the design phase	Benefits in the construction phase
Product	Improvement of the design	Increased constructability Better quality of the construction Enlarged innovation by collaboration Improved end-user satisfaction Enlarged innovation by knowledge transfer
Process	Increased sharing of information and expertise Collaborative risk allocation	Prevention of conflicts Improved flexibility and responsiveness More effective risk management Improved working conditions and safety
	Benefits through both the design and the construction phase	
	Contribute to mutual learning Increased understanding of each other's challenges Improved relationship and trust	

A comparative case study was conducted to identify the causes of the cost implications and benefits in Bouwteams. Linking the elements discussed during the interviews in the case study reveals the causal diagram as illustrated in Figure 2.

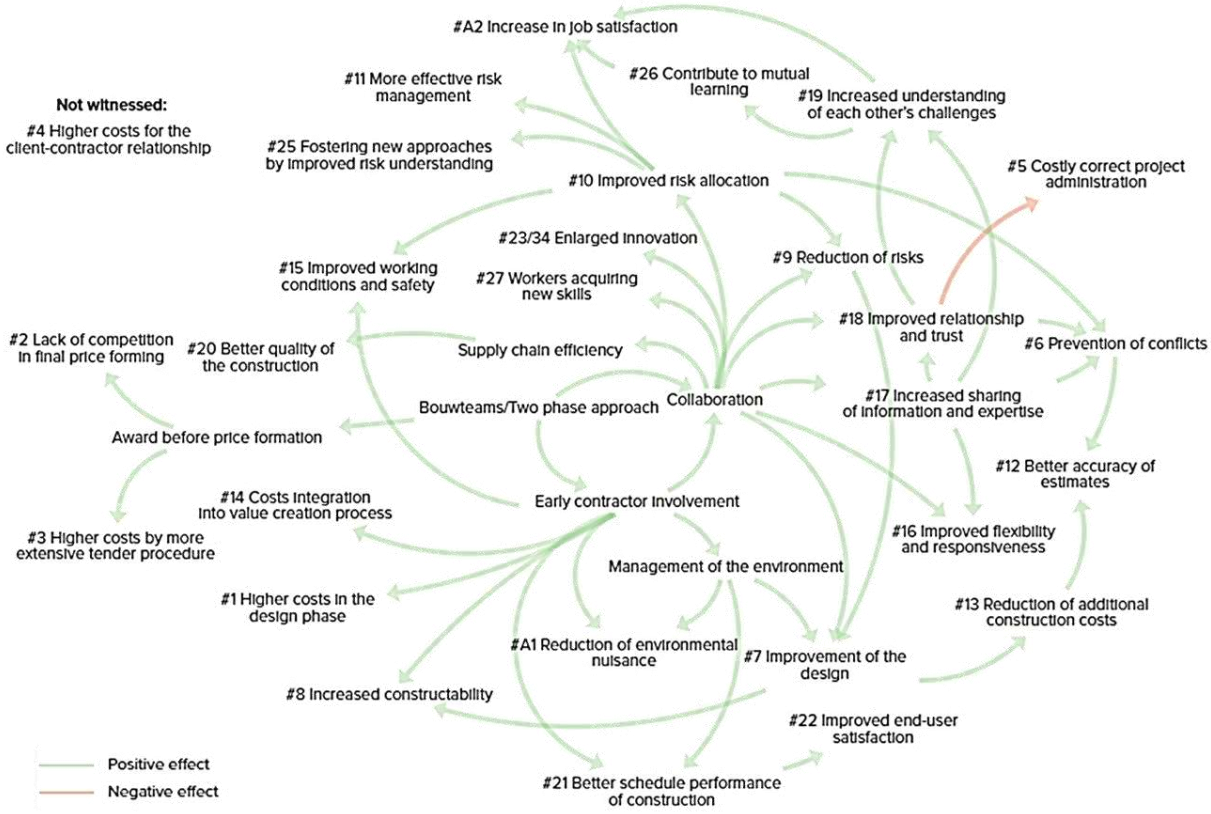

Figure 2 Causal diagram

The study revealed that early contractor involvement, collaboration, transparency, and collaborative risk allocation form the foundation for Bouwteams' benefits. Additionally, two new benefits have been revealed: reduced environmental nuisance (#A1) and increased job satisfaction (#A2).

The project survey allowed for a comparison of the cost developments. Bouwteams exhibited a larger average increase in costs (at cumulative 135%) from the initial design phase to the realisation costs compared to integrated projects (at 125%), as illustrated in Figure 14. However, this difference was not statistically significant based on a two-sample t-test with α=0.05.

The realised construction costs in Bouwteams averaged 104.1% (σ of 11.09% and skewness of 2.49) of the construction cost estimation. Meanwhile, the realised construction costs averaged 116.5% (σ of 40%) in the construction sector, as illustrated in Figure 15.

However, this difference was not statistically significant either, based on a two-sample t-test with α=0.05. Nevertheless, these findings confirmed the reduction of additional construction costs (#13), observed in most (63%) of the projects. Additionally, it became

evident that the improved accuracy of estimates (#12) applies specifically to the construction cost estimation after the completion of the Bouwteam phase.

Comparative analysis

While the current results are derived from the most appropriate research methods available, comparing the results could be helpful. Resource triangulation enhances reliability by mitigating bias and supporting the robustness of the findings.

Table 8 presents a comparative analysis of findings from the expert survey, case study, and project survey. The numbers in the column 'Expert survey' indicate the probability of an effect occurring in a project, according to experts. In the 'Case study' column, the ratio represents the proportion of case studies where the effect was observed. The 'Project survey' column details the percentage of cases in which the effect was observed.

Table 5 Cost implications and benefits of Bouwteams according to several methods

Category		Nr.	Effect	Expert survey	Case study	Project survey
Cost implications	Expense drivers	#1	Higher costs in the design phase	0.52	1.00	0.43
		#2	Lack of competition in final price forming	0.40	0.50	0.70
		#3	Higher costs by more extensive tender procedure	0.10	0.50	0.07
		#4	Higher costs for the client-contractor relationship	0.09	0.00	0.23
		#5	Correct project administration is costly	0.15	0.00	0.00
	Expense reducers	#6	Prevention of conflicts resulting in savings	0.99	1.00	0.67
		#7	Improvement of the design	1.00	1.00	0.60
		#8	Increased constructability	0.99	1.00	0.73
	Risk management	#9	Reduction of risks	0.98	1.00	0.70
		#10	Improved risk allocation	0.95	1.00	0.70
		#11	More effective risk management	0.95	1.00	0.43
	Cost control	#12	Better accuracy of estimates	0.89	1.00	0.67
		#13	Reduction of additional construction costs	0.99	1.00	0.63
		#14	Costs integration into value creation process	0.74	1.00	0.20
Category		**Nr.**	**Effect**	**Expert survey**	**Case study**	**Project survey**
Benefits	Project processes	#15	Improved working conditions and safety	0.78	0.50	0.33
		#16	Improved flexibility and responsiveness	0.88	1.00	0.63
		#17	Increased sharing of information and expertise	1.00	1.00	0.70
		#18	Improved relationship and trust	0.96	1.00	0.63
		#19	Increased understanding of each other's challenges	0.97	1.00	0.63
		#A1	Reducing environmental nuisance	N.A.	1.00	0.43
		#A2	Having more fun at work	N.A.	1.00	0.63
	Project results	#20	Better quality of the construction	0.88	1.00	0.33
		#21	Better schedule performance of construction	0.79	1.00	0.40
		#22	Improved end-user satisfaction	0.81	1.00	0.47
	Innovation capability	#24	Enlarged innovation by collaboration	0.84	1.00	0.47
		#25	Fostering new approaches by improved risk understanding	0.72	0.50	0.27
	Learning	#26	Contribute to mutual learning	1.00	1.00	0.67
		#27	Workers acquiring new skills	0.88	0.50	0.13

The expense-driving effects of using Bouwteams were not so strongly indicated by the expert survey, with only the higher cost in the design phase and the lack of competition in final price formation showing more than a 15% likelihood of occurrence in Bouwteam projects. In the case studies, the higher design costs were the most convincingly demonstrated effect. The project survey yielded similar results, highlighting the lack of competition in the final price formation as the most prominent issue, observed in 70% of the projects. Additionally, higher costs in the client-contractor relationship were noted in 23% of the projects. However, the expert survey and case studies did not clearly confirm this, suggesting its contribution is less evident.

All the data collection methods clearly confirmed the expense reducers. Similarly, improvements in risk management were validated, though more effective risk management (#11) was less apparent in the project survey. Improvements in cost control were identified, but the project survey did not clearly confirm cost integration into the value-creation process.

The three data collection methods confirm most of the improvements in the project processes. However, improved working conditions and safety (#15) were less convincingly represented, appearing in only one-third of the projects. The newly identified effects, reducing environmental nuisance (#A1), and having more fun at work (#A2), were observed in 43% and 63% of Dutch projects, respectively.

The expert survey and case study confirmed the positive impact of employing Bouwteams on project results, while the project survey findings were less convincing. Improved construction quality was observed in only 33% of the projects. A similar trend was observed in innovation capability, which was generally well-confirmed in the expert survey but was seen in only one project in the case study and 27% of the projects in the project survey.

Bouwteams' contribution to mutual learning was consistently emphasised across all three data collection methods. The expert survey prominently showcased workers' acquisition of new skills. However, this was not as well represented in the project survey, as it was observed in only 13% of the projects.

From the findings of the correlation analysis, it became clear that the causal relationships identified in the case study were mostly supported by moderate correlations between these factors. For example, there was a moderate correlation of 0.39 between the improvement of design (#7) and increased constructability (#8). Additionally, a correlation coefficient

of 0.56 indicated a moderate relationship between the increased understanding of each other's challenges (#19) and the contribution to mutual learning (#26).

Overall, participants expressed a positive opinion regarding the cost-efficiency of using Bouwteams to create value in projects, with 79% of projects showing favourable views. This aligns with findings from CROW [55], which reported that 85% of Bouwteams users are (very) satisfied.

The correlation analysis indicated that integral collaboration within Bouwteams correlates with efficiency in achieving added value, which is consistent with findings from the case study. However, it was notable that no correlation was observed between project turnover and the benefits or efficiency of achieving added value.

The cost trends observed in the project survey were in line with the expectations from the expert survey. Namely, it was confirmed that there are higher costs in the design phase. Additionally, a significant jump in budget was found between the start and the end of the Bouwteam phase. Lower cost overruns were also in line with expectations.

Theoretical Implications

Firstly, the research contributed to a further understanding of the presence and causes of cost implications and benefits of Bouwteams. The first two cost implications, the higher cost in the design phase (#1), as discussed in relation to Bouwteams by Kleinhuis [56] and two-phase contracts by Rijkswaterstaat [3] were partially confirmed. They were observed in 42% of the projects in the project survey. The lack of competition in the final price formation (#2) was strongly confirmed, evident in 70% of the projects, concurring with the literature as named by Jansen & Metsemakers [11], Laeven et al. [7], Dekker [12] and Pap [13].

Conversely, the expert survey did not convincingly observe other anticipated cost implications, such as the higher cost of a more extensive tender procedure (#3). The project survey indicated that this factor only impacts 10% of the projects. Thereby, these findings could not confirm previous studies of Wielink & Luiten [15] and Wodimu, Lium & Laedre [16] which suggested a more extensive and time-consuming tender procedure with Bouwteams and early contractor involvement. Insights from the case study suggest that while the tender procedure might incur higher costs, savings are also realised as no bids need to be submitted.

The higher cost for the client-contractor relationship (#4) could not be confirmed. It might be that the 'large time and labour commitment required from the client and contractor' has been misinterpreted. Additionally, the costly correct project administration (#5) could not be confirmed. The costly correct project administration is found in 42.8% of the projects using early contractor involvement by Eadie et al. [57] but not observed in Bouwteams in the project survey.

The expert survey robustly affirmed the benefits of Bouwteams, as indicated in the literature, with each receiving a rating of at least 0.74. However, certain benefits, such as cost integration into the value creation process (#14) and workers acquiring new skills (#27), did not show a strong presence in the project survey, with occurrences of 20% and 13%, respectively.

Interestingly, several cost implications and benefits that were not explicitly mentioned in relation to Bouwteams in the literature were confirmed through the survey, validating their presence in Dutch projects. These included increased constructability (#8), more effective risk management (#11), understanding of each other's challenges (#19), and improved end-user satisfaction (#24), thus expanding upon the existing body of literature on Bouwteams.

Furthermore, one discrepancy in the literature can be resolved. Contrary to the prevailing literature, Nijhuis [58] reported larger cost deviations in Bouwteam projects. This can be explained by the fact that while there are larger deviations from the initial stages of the Bouwteam, more accurate estimations follow in the subsequent phase of the project.

The case study's findings confirm causal relationships found in the literature while providing a comprehensive overview of these findings for the first time. This addresses the concerns of Bresnen and Marshall [23], suggesting that indirect factors may influence performance gains. Additionally, two new benefits have emerged: reduced environmental nuisance (#A1) and increased job satisfaction (#A2). These newly identified benefits were also observed in the project survey, with presence in 43% and 63% of the projects, respectively, thus validating these novel findings.

Finally, the results from the project survey shed light on the cost trends of Bouwteams projects, introducing new insights into existing literature. It became apparent that the budget increase during the Bouwteam phase was due to the lack of competition in final price formation, scope changes and indexing costs.

Additionally, fewer cost overruns in the realisation phase were observed due to reduced risks, minimised additional construction works, and more effective risk management. Furthermore, it was confirmed that the higher initial investment costs are perceived to be outweighed by the benefits of using Bouwteams, thereby creating added value in the Bouwteams or two-phase projects in the project survey.

Practical implications

While the Bouwteam phase often sees an increase in construction budgets due to the absence of competition in final price formation, scope changes, and indexing costs, it is crucial for project and contract managers to adopt a strategic approach. By acknowledging that these initial investments can yield substantial overall project benefits, managers can confidently employ Bouwteams, knowing that these investments are crucial in minimising cost overruns, enhancing constructability, and fostering innovation and knowledge sharing.

Project managers should allocate sufficient budget and resources to the design phase, considering the higher costs associated with Bouwteam projects. Cost control measures throughout the design phase are crucial for maintaining budgetary oversight and cost-effectiveness. These steps could help optimise project outcomes and mitigate budgetary challenges.

Limitations

One significant discussion point on the expert survey centred around the participants' responses, particularly regarding the concern over the moderate response rate and the relatively small participant pool. A larger sample size would mitigate the impact of extreme opinions, thereby enhancing the robustness of the findings.

The respondents represented a diverse range of highly experienced employers, with most having between 21 and 25 years of experience. However, during a panel discussion on the results, a senior cost advisor suggested that the findings might be overly optimistic.

The application of case studies lacked generalizability as it focused on a limited domain. Additionally, the interviewer could have been more critical in questioning the responses. Although participants had the opportunity to discuss additional points in the last five minutes, this might not have been sufficient. Allowing more time could have achieved further valuable insights.

Since the project survey invitation specified that two-phase projects under construction can participate, this might introduce some constraints on the validity of the results. However, considering only completed projects would result in insufficient data.

The comparison with benchmark data presented its own set of challenges. Benchmark data for engineering costs was limited. Fortunately, there were a few studies available to compare cost trends. Although the historical benchmark data was somewhat dated, Cantarelli et al. [9] found no correlation between the year of completion and the cost overruns, suggesting this data would still be relevant. Nonetheless, having cost trends specifically for traditional projects would have been beneficial, as the sector mainly comprises traditional projects. Matching the project phases between Bouwteam and traditional showed some difficulties as well.

Analysing the correlation between the cost implications and benefits of Bouwteam infrastructure projects helped validate the case study research. However, applying Pearson correlation to this relatively small data sample has limitations.

Recommendations

Providing further recommendations on utilising Bouwteams compared to an integrated approach can enhance decision-making. Results from the case study point out that using a Bouwteam may help mitigate contractors' risks, thereby preventing tender failures.

The research highlights discrepancies between the anticipated benefits of Bouwteams, as suggested by experts' opinions in the expert survey, and their realisation of projects. For instance, the integration of costs through the design process is not widely materialised. It would be valuable to see whether this discrepancy is due to unused potential or misidentification.

Further studies could address some of the questions that were beyond this research's scope or help clarify the current findings. For instance, conducting more ex-post project evaluations is recommended. Investigating the engineering costs in traditional projects and analysing cost overruns across different types of projects would be beneficial. Additionally, quantifying the benefits of using Bouwteams would be beneficial. For example, exploring how Bouwteams impact schedule performance would be useful. Another important topic is the reasons for cost overruns. Investigating the extent of these cost overruns per cause and when they manifest would be valuable.

Further investigation into the differences between Bouwteams, using the quadrant on solution space and collaboration will be beneficial. Case study results suggest that integrated collaboration may lead to decreased controlling costs and increased benefits but also requires a large solution space. Also, project results revealed a correlation between the use of integrated collaboration and the efficiency in adding value. Conversely, coordinated collaboration might be more suitable for optimising or innovating within a specific area while involving the contractor. Exploring whether mirrored or integrated project teams are predominantly used for coordinated and integrated collaboration will provide valuable insights. Additionally, examining the effects of formal control versus a relational focus on social control and trust could offer further understanding of Bouwteam dynamics.

In addition, investigating the adaptation costs associated with Bouwteams can provide valuable results. Given that Bouwteams is a relatively new collaboration model, organisations may incur higher internal costs to reconfigure their organisational processes and address challenges to accommodate Bouwteams.

Conclusions

In contrast to the traditional competitive procurement methods in the construction industry, adopting Bouwteams brings a more collaborative approach. Using Bouwteams aims to address the growing complexity of projects. Issues commonly observed in competitively procured projects, such as strategic short-sightedness, adversarial relationships, and a lack of innovation, could be mitigated using Bouwteams. There was a growing need to gather insights from past experiences with Bouwteams to inform future projects and support decision-making.

Intending to reveal the added value of Bouwteams, this study has examined both the cost implications and benefits of Dutch infrastructure projects. As a starting point, a conceptual framework was set up. Literature research showed there could be various cost implications, including drivers of expenses, such as increased design costs and lack of competition in the final price formation. Conversely, factors were identified that mitigate costs, such as conflict prevention and facilitating a more efficient and constructible design. Furthermore, the consulted literature highlighted better risk and cost management, benefits regarding the project processes, the built product, innovation, and learning.

The study utilised an expert survey to examine whether these cost implications and benefits are observed at Bouwteams in the Dutch construction sector. Findings indicated varied opinions on the cost implications, while participants unanimously affirmed the benefits of using Bouwteams. For example, slightly over half of the participants acknowledged that using Bouwteams results in heightened design costs, whereas all participants agreed that Bouwteams enhances design, collaboration, and learning.

A comparative case study was conducted to explore the causes of the cost implications and benefits of using Bouwteams. The study confirmed that collaboration, transparency, and collaborative risk allocation serve as the foundation for realising the benefits of Bouwteams. Furthermore, two new benefits were revealed: increased job satisfaction and improved environmental management, reducing nuisance.

A project survey was conducted to further explore their cost implications by gathering data on the cost trends and perceived benefits across 31 Bouwteam or two-phase projects. These cost trends were compared with benchmark data from competitively procured projects, including sector-wide and specially integrated projects.

On the one hand, it was found that using Bouwteams leads to some negative cost implications. Initially, there are higher design efforts due to the contractor's involvement. Also, there is an average budget increase of 29% between the task-based budget at the start of the Bouwteam phase and the construction budget at the end of the Bouwteam phase. This rise is primarily due to a lack of competition in the final price formation, changes in scope and increased labour, materials, and equipment prices.

On the other hand, there are several advantages during the realisation of the project. Investing in the design and collaborative allocation of risks appeared to lower budget overruns. Additionally, the enhanced constructability of the design results in fewer additional construction costs. Integrated projects typically experience a 24% cost overrun compared to the contract sum, whereas Bouwteams exhibit only a 4% cost overrun compared to the construction cost estimation. This suggests that using Bouwteams enhances the predictability of the construction phase and improves the accuracy of cost estimations. Participants acknowledged that Bouwteams seemed a cost-efficient way of adding value to their projects.

The ongoing debate on the cost-efficiency of Bouwteams in adding value to infrastructure projects stands to benefit from a deeper understanding of the cost implications and

benefits. Therefore, this research offers theoretical contributions by identifying and substantiating the cost implications and benefits of using Bouwteams.

Furthermore, the research provides practical guidance for advisors, clients, contractors, project and contract managers, and policymakers. Using Bouwteams in complex projects, particularly for managing large risks or sustainability concerns, offers significant advantages. Clients and policymakers should recognise that Bouwteams can enhance value creation despite increased design effort and initial budget allocations. These investments can help mitigate cost overruns, improve constructability, enhance end-user satisfaction, and stimulate innovation and knowledge sharing.

Finally, further research is recommended to evaluate the use of Bouwteams. It would be valuable to conduct more ex-post project evaluations. Likewise, more quantitative support can be gathered on the effects of using Bouwteams on design costs, cost overruns, adaptation costs, and schedule performance. Also, the findings suggest that Bouwteams employing an integrated collaboration is more cost-efficient. So, further enquiries are recommended on the effects of the type of collaboration and solution space of a Bouwteam on its cost-efficiency and benefits.

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Appendices

Appendix A – Data collection literature review

The following subsections provide the data collection for the literature review. A methodology was carefully developed and executed to increase the reproducibility of the literature review. Each section used the same approach, using various search queries in Google Scholar to search relevant resources. For each query, the first 50 results were considered. Initially, the title and abstract were assessed on relevance. If promising, the entire paper was skimmed to identify relevant elements and the conclusion was reviewed. The following subsections provide more details on the data collection and use of Google Scholar search queries.

Characteristics of the Bouwteam

Literature research on the distinctive characteristics of Bouwteams was conducted by comparing key documents *'Handreiking Bouwteams'* [7] , *'Handreiking 2-fasen aanpak bij RWS projecten'* [3] and *'Handreiking aanbesteding van twee fasen contracten'* [6]. These documents were sourced from authoritative bodies with experience in Bouwteams/Two-phase projects within the Dutch infrastructure sector. A Google Scholar search was also conducted using the queries 'competition OR collaboration OR cooperation AND construction' and 'opportunistic behaviour AND Bouwteams'.

Theoretical cost implications and benefits of Bouwteams

Cost implications and benefits of using Bouwteams were explored using diverse search terms, considering the characteristics of Bouwteams, and using both Dutch and English

Topic	Google Scholar search query
Cost implications of collaboration	competition AND collaboration AND costs competition AND collaboration AND construction costs
Benefits of collaboration	added value OR benefits AND Collaboration added value OR benefits OR advantages AND collaboration AND Construction
Cost implications of Bouwteams	bouwteam EN kosten bouwteam OR construction team OR design team AND costs
Beneftis of Bouwteams	bouwteam EN voordelen OF meerwaarde bouwteam OR construction team OR design team AND added value OR meerwaarde
Cost implications of Two Phase projects	two phase contracts AND costs OR construction costs two stage tender AND costs OR construction costs twee fasen contract EN kosten
Benefits of Two Phase projects	two phase contracts AND added value OR benefits two stage tender AND added value OR benefits twee fasen contract EN voordelen OF meerwaarde
Cost implications of early contractor involvement	early contractor involvement OR ECI AND costs
Benefits of early contractor involvement	early contractor involvement OR ECI AND benefits OR added value

terms, as detailed in Table 6. A paper was accepted if it at least names one cost implication or benefit.

Benchmark data cost trends

The cost trends of competitive traditional and integrated projects were explored as a starting point through a literature review. Specifically, the examination included design costs, cost overruns and risk development through competitive Dutch infrastructure projects' design and construction phases. Ideally, benchmark data from Dutch projects was to be used. This selection was motivated by the variance in cost performance observed in Dutch transport infrastructure projects compared to global findings [59]. A literature search was conducted using Google Scholar, utilising the search terms outlined in Table 7.

Table 7 Literature review search terms

Chapter	Subtitle	Google Scholar search term
5 . 2 . 2	Design costs	Kosten EN infra EN engineering OF ontwerp Kosten EN infra OF constructie EN verdeling
5 . 2 . 3	Cost overruns	Kosten OF budget EN overschrijdingen EN infrastructuur OF GWW Kosten OF budget EN overschrijdingen EN UAV OF bestek Kosten OF budget EN overschrijdingen EN geïntegreerd
5 . 2 . 4	Risk reserves	Risico EN reservering EN infra OF GWW Onvoorzien EN reservering EN infra OF GWW

Appendix B – Findings case study

Findings case study 1

The project was awarded using a tender with a 100% rating on quality, assessing aspects such as the establishment of the Bouwteam, environmental management, risk management, budget and quality management and stimulation of chances and innovation. During the Bouwteam phase, the design and scope were developed until an execution design was finalised. The execution phase was carried out under UAV with building specifications. Integrated collaboration was employed, with a small solution space for above-ground works and a wider solution space for the works underground, the effects of which became evident during the project:

> "Since we had a definite design for the above-ground works, there was limited room for innovations and optimisations in the Bouwteam in this area. However, the provisional design for the underground works allowed exploring new solutions."

According to the interviewee's assessment, the Bouwteam was deemed beneficial and provided added value, as the benefits outweighed the costs.

''It is not that we saved money using a Bouwteam, but it surely contributed to long-term value creation."

During the interviews, it was evident that each of the effects listed in the literature was noticed to some extent in the project, except for the expense-driving cost implications. The reasons for these, as explained by the interviewees, will be provided for each category of cost implications and benefits in the following paragraphs.

Regarding the expense drivers, the increased costs during the design phase (#1) were attributed to the contractor's active participation. However, the lack of competition on the final price (#2) was not confirmed. Higher costs in the tender procedure (#3) appeared on the contractor's side, as they felt they needed to prepare their tender response more extensively. Higher costs for the relationship (#4) and more project administration costs (#5) were not confirmed.

Transparency, trust, and using a risk file with clear risk allocation perceivably prevented

conflicts (#6). Bouwteams notably influenced the efficiency of the design effort, with design improvements (#7) due to collaboration, incorporation of sustainability, development of risks, and consultation of the environment. Also, increased constructability (#8) was achieved by the contractor's involvement and further detailing of the design.

Risk management also demonstrated improvements, with collaboration and using a risk file leading to reduced risks (#9) and enhanced risk allocation (#10). Furthermore, the suitable allocation of risks and sharing of risk-reductive thought contributed to more effective risk management (#11).

Then, the cost control witnessed an improvement in the accuracy of estimates (#12) due to the reduction of additional construction costs (#13) and the prevention of conflicts (#6). During the design, trade-off matrixes were used to support design decisions, with cost being a crucial consideration, thus highlighting cost integration into the value-creation process (#14).

Several effects were observed throughout the project processes. Firstly, there were noticeable improvements in working conditions and safety (#15) due to the influence and expertise of the contractor, as well as the provision of space within the risk reserves to address safety issues. Additionally, greater flexibility and responsiveness (#16) were evident, driven by a shared interest in achieving project goals. The sharing of information and expertise (#17) and an improved relationship and trust (#18) between the client and the contractor became apparent due to increased collaboration in the Bouwteam. These factors also facilitated an increased understanding of each other’s challenges (#19).

Additionally, two new benefits of the project were observed. First, working in Bouwteams has been reported to lead to a reduction in environmental nuisance (#A1), focussing on minimising hindrance and sound emissions. This was achieved using the contractor's expertise and a collaborative decision-making process. Secondly, there was an observed increase in job satisfaction (#A2), attributed to more learning, collaboration, sharing of successes and problems, involvement of multiple disciplines and better risk division.

The use of Bouwteams has also demonstrated various impacts on the project results. Primarily, the quality of the construction (#20) was improved by optimising supply chain efficiency, facilitated by the collaboration of designers and the job executor. In this project, particular emphasis was placed on schedule performance (#21), a goal achieved

by using the expertise of the contractor and the collaborative management of the complex environment. Consequently, there was improved end-user satisfaction (#22).

All innovations in the project were introduced in collaboration with the contractor, who had the necessary autonomy to do so. The collaborative nature and effective risk allocation provided the right environment for these innovations. This confirmed the statements that there is enlarged innovation by knowledge transfer (#23), collaboration (#24) and risk understanding (#25).

Finally, mutual learning (#26) is stimulated within the project as the client and the contractor better understand each other's work and challenges. Collaboration also fosters the acquisition of new skills (#27) among personnel.

Findings case study 2

The project employed a tender procedure involving collaboration, discussion of multiple plans, and conversation rounds. During the Bouwteam phase, the design was collaboratively developed from a sketch design into an execution design under a self-drawn-up contract. The execution of the works took place under the UAV-GC. Throughout the Bouwteam, there was a shift in collaboration.

> ''In the sketch design, the client was in the lead, while we (the contractor) played a role in controlling and advising on practical matters. (…) We tended towards coordinated cooperation during this phase to provide expert input. However, when we took the lead in the definite and execution design, the approach shifted towards a more integral one.''

Additionally, the contractor handled the procurement of materials, offering three alternatives to the client. Moreover, lessons learned from previous projects by the contractor heavily influenced the design of the dike and the selection of materials for the project. Also, it became evident that the sequence of design activities and soft skills are essential.

> ''The sequence of the design activities is vital to a Bouwteam. (…) Working is a people business, so the team's continuity is very important. (…) Trust is the most important, transparency and keeping each other's interest in mind is key.''

This also appears to be the case for conflict resolution and contract management:

> ‘’During an argument, it is all about the conversation, not about what the contract says. Considering each other’s interest leads to a solution to which both parties can agree.’’

In this project, higher costs were observed in the design phase (#1) due to increased resource consumption resulting from contractor involvement in the early project phase. The lack of competition in final price formation (#2) was also evident, particularly in the indirect costs, attributed to the contractor's establishment of a rather large project organisation. The higher costs by a more extensive tender procedure (#3) were not observed in this project. While interviewees acknowledged costs incurred for plan development and participation in conversations, savings could also be realised as no calculations were necessary. Therefore, higher costs for the extensive tender procedure (#4) could not be confirmed. Correct project administration (#5) was not applicable in this project, as the trust among parties even reduced administrative duties.

An improved client-contractor relationship prevented conflicts, resulting in savings (#6). The increased constructability (#8) through design improvement (#7) was facilitated by the contractor’s expertise in construction works. For instance, feedback from previous project executors on constructability was sought at various stages of the design process.

Some differences became apparent in terms of risk management. Namely, the risk file was enriched with the contractor's input. Also, collaboration in the allocation (#10) of risks leads to a reduction of risks (#9). Furthermore, collaboration on risk mitigation led to more effective risk management (#11).

The contractor's expertise in improving the design leads to less added work (#13), thereby increasing the accuracy of the estimates (#12). Cost integration varied depending on the project’s phase and parts.

The project processes identified in the literature and observed during the first case study were mostly confirmed in the second case study. However, the improved working conditions and safety (#15) was not observed. A collaborative mindset facilitated improved flexibility and responsiveness (#16) during the construction phase. Transparency and early involvement of the contractor were believed to contribute to the sharing of information and expertise (#17), improved relationships and trust (#18), and increased understanding of each other’s challenges (#19). Also, the reduction of environmental nuisance (#A1) and increased job satisfaction (#A2) were caused by collaboration and early contractor involvement.

Better quality of the construction (#20) was evident due to the early involvement of the contractor, which also facilitated a manageable execution of the works and resulted in better schedule performance of construction (#21). Additionally, involving locals contributed to improved user satisfaction (#22).

Enlarged innovation was observed due to the contractor's input on the lessons learned from a previous project, reflecting knowledge transfer (#23). Collaborative design sessions facilitated the contractor's input into the design process, leading to improved innovation through collaboration (#24). However, fostering new approaches through improved risk understanding was not evident in this project (#25).

Contribution to mutual learning (#26) was widely observed. For instance, the client and contractor organisations engaged in inter-project learning, and lessons were exchanged with other client organisations. However, workers acquiring new skills (#27) did not become apparent in the project.