In Pursuit of Success

Evaluating the Management of Engineering Projects, Cross-Sectoral Analysis of Project Management Efforts

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Summary

Projects can be regarded as the vehicle for providing value, monetary or non-monetary, to the organisations or society as a whole. Successful delivery of projects is therefore the ultimate goal of many organisations. A lot of attention is already devoted, both in practice and literature, to what factors drive a successful project. What is observed in practice, however, is that projects do not usually follow what is recommended in literature. Moreover, the dynamic nature of projects calls for continuous adjustments regarding the required project management practices contributing to performance.

In this research the interplay between the three main underlying concepts is considered: project management practices as success factors, project performance as project success, and industry sector as project context. The scope of research includes two main industry sectors: construction (including infrastructure) and process industry. The research deals with assessing and identifying project management practices required for a specific sector and compares those practices across these sectors. This dissertation is about improving the management of engineering projects by evaluating the current practices and applied methods contributing to high performance. Project evaluation with the aim of learning and performance improvement lies at the heart of this research.

The objective of this thesis is twofold. The first objective is to evaluate the current practice of managing engineering projects and make a cross-sectoral analysis of project management practice in order to investigate potential learning points. The second objective is to contribute to the development of suggested improvements by providing practical recommendations.

The main research question to be answered by this study is:

What practices and applied methods can be extracted from completed projects in different project contexts with the aim of improving the performance of future projects?

After laying the foundation for the dissertation in Chapter 1, the rest of the research is performed in three main parts to answer this question: identifying and aligning the viewpoints (Chapters 2 and 3), exploring the current practice (Chapters 4, 5, and 6), and feeding back to practice (Chapters 7 and 8).

Part I: Identifying and aligning the viewpoints

The first part starts with reviewing literature on the potential factors influencing project performance which serves as the basis for the empirical study, Q-study. The initial framework to be explored is a list of 33 factors as presented in Chapter 2. The reason for choosing Q-study was that it identifies the perspective of the practitioners on the importance of factors for managing projects successfully. In the first step,

practitioners' perspectives within the construction sector (urban development, real estate, and infrastructure) are investigated. The aim is to explore whether the practitioners in a specific sector do share the same viewpoint regarding success factors. Based on the Q-sorting of 34 practitioners from consultant companies four distinctive perspectives were identified: seeking the best match, being adaptive and open, keeping the team focused, and preparing for opportunities. Although the practitioners acknowledge the importance of soft factors such as competences of the project teams (client and contractor) and the way they interact with each other, the traditional view of managing projects by closely monitoring them still exists. Based on the findings no link could be found between the identified perspectives and the sectors, suggesting that a broader view on the sector should be taken.

In Chapter 3, the Q-study is extended to 108 respondents including three datasets: dataset 1, same dataset used in Chapter 2, (construction-consultant), dataset 2 (construction-client), and dataset 3 (process industry- contractor). Four distinctive perspectives were identified for each dataset which were further compared across the datasets for determining differences and similarities in the practitioners' viewpoints. A major difference between the sectors was found: practitioners in the process industry and construction sector considered the integration and its importance for performance differently. The practitioners in the process industry perceive a broader definition of integration involving the key parties and end users. For the construction industry this integration, even in the narrow sense within the project team including client and contractor, is not acknowledged. Due to the nature of construction projects, that are mainly publicly commissioned, the emphasis is on procurement. This might imply that in such projects, the tendency is more towards giving the majority of responsibility to the contractor rather than working in an integrative manner. Another difference was the importance given by the practitioners in the process industry regarding health and safety considerations. Such focus can also stem from the fact that safety plays a crucial role in the process industry projects.

Six shared themes were found across the datasets: client emphasis, traditional approach, team focus, end user focus, procurement focus, and opportunity focus. Moreover, adaptive project management was not recognised in practice by the practitioners in both sector groups.

Part II: Exploring the current practice

In part II of the thesis a survey study was performed using data from 104 engineering, mainly Dutch, projects in three different sectors: 26 from construction, 35 from infrastructure, and 43 from process industry. The survey questions were based on the framework used in part I of the research considering only 25 factors. The factors considered were divided into two main aspects: front-end activities and project management principles. The reason for such division was that the nature of those factors is different. Front-end activities can be measured by the intensity of application, whereas project management principles were mainly measured qualitatively. For measuring these factors multi-item measurement scales were used.

In Chapter 4, the survey results on the application of the items of front-end activities and project management principles were analysed. Looking into data, it was observed that some front-end activities and project management principles are not commonly applied in practice. Examples of such "not commonly applied" front-end activities are environmental impact assessment, checking deliverables against the business case, training programs tailoring to the project requirements, and performance assessment with the aim of continuous improvement. In the same vein, some project management principles are not acknowledged by the current practice: use of an integrated contract, considering the technical skills, and project management skills of the contractor. These findings suggest that usually contractors are not involved in the early phases. Some front-end activities are well-known in a specific sector. For instance, joint lessons learned with client and contractor and HSE management are mainly applied in the process industry and not in the construction and infrastructure projects.

After filtering data, based on these "not commonly applied" practices, 39 items were considered for further analysis: 15 front-end activities and 24 project management principles. Next, multivariate data analysis was applied on these remaining items, to reduce the number of variables in the next steps. This resulted in the identification of 12 factors: five front-end activities (risk management, monitoring and quality management, embracing and capturing lessons learned, team building, and setting expectations) and seven project management principles (collaboration between client and contractor, project manager competency, setting project goals, top management support, client competency, information sharing, and client involvement).

Later in Chapter 4, the application of these front-end activities and project management principles is compared across the sectors. It was revealed that the process industry is more mature in terms of the application of front-end activities compared to the construction and infrastructure sectors. This provides a learning point for the construction and infrastructure sectors. The project management standards within the construction and infrastructure sectors require more strict requirements which could facilitate the integration between the parties, setting project goals, and agreeing upon them. Comparing the results of the Q-study and the survey study on the application of those considered factors, it was observed that practitioners believe that they should move towards a more open and integrative approach. In practice, however, the main focus is still on the traditional approach, by monitoring and performing the project by the parties separately rather than in an integrated team.

Chapter 5 adopts Necessary Condition Analysis (NCA) for exploring the relationship between the identified 12 factors and project performance. Analysing the answers on project performance criteria, four indicators were considered in this research: within budget, within schedule, within specifications, and client satisfaction. Broader aspects of performance such as contractor satisfaction, safety, and flawless start-up were not considered in the analysis because the respondents did

not provide an answer for these criteria. This might suggest that practitioners do not acknowledge these indicators in their projects providing some food for thought. The findings revealed that four conditions were necessary for high level of performance: collaboration between the client and contractor, top management support, information sharing, and technical competencies of the client representative in the front-end. The latter has an important implication for the construction and infrastructure sector where the client usually seeks the technical skills and competencies merely from the contractor. The reason might be that having the technical skills as such by the client representative during the front-end phase facilitates the formulation of clear project goals and provides a basis for better collaboration between the client and contractor. The absence of those necessary conditions cannot be compensated by additional application of other activities.

In Chapter 6, the analysis of data gathered from the survey continues. The aim is to explore the configuration of the practices which could explain high performance in each sector. First, using multiple regression analysis, four conditions that most strongly contribute to project performance were selected. The following four conditions were considered for further analysis: setting expectations, collaboration between client and contractor, information sharing, and setting aligned goals. Next, Qualitative Comparative analysis (fsQCA) was used to identify sufficient conditions for high levels of performance in each sector. From this study, the first observation was that no single condition is sufficient, independent from other conditions, for the intended level of project performance. Analysis of the sufficiency configurations also showed that a high degree of team collaboration (client and contractor) and a high level of open information sharing appear to be constantly present in the sufficient configurations for very high performance across the sectors. All these conditions were present in the most empirically important configurations in each sector. Per sector, high performance can be explained differently. In the construction sector, a combination of high-level collaboration and high-level information sharing among the parties is crucial when the level of goal setting is low. In infrastructure projects, however, alignment on goals among the stakeholders together with a high level of collaboration between the team members and smooth information exchange could lead to high performance. In the process industry, the results suggested that playing down the application of expectation management across the team members (establishing roles and responsibilities and giving feedback on individual or team performance) could explain those projects with high performance. This does not imply that expectation management should be ignored in such projects, rather it suggests parties should take a more collaborative approach in performing project management efforts. Another conclusion was that in all those configurations for explaining high performance, support from the top management, at both client and contractor side, was significantly high.

Part III: Feeding back to practice

In the last part, the results of the practitioners' perspectives on project performance are combined with the findings of the survey study from the previous chapters. In the survey, the respondents were asked to give some recommendations for the improvement of their future projects. Overall, analysing their answers revealed that practitioners would focus more on the following practices: team building, client involvement, contract management, monitoring and quality management, and risk management.

All findings from previous sub-studies provides a basis for proposing an agenda for improving the management of engineering projects in Chapter 7 which contributed to the development of the Nexcess model. The model consists of two main sections and 12 core project management practices, see Figure 1:

I. Proven practices - Based on the findings of Chapters 5 and 6, six proven practices include three sets: necessary conditions, necessary and sufficient conditions, and sufficient conditions. Necessary conditions are shared among projects irrespective of their context, whereas sufficient conditions are specific for a sector. Necessary and sufficient conditions lie at the intersection of these two practices.
II. Suggested practices - Based on the results of Chapters 3, 4, and 7, six practices are suggested. Practice (13) was added to the model for the construction and infrastructure sectors reflecting the importance of integration between various key stakeholders in such projects.

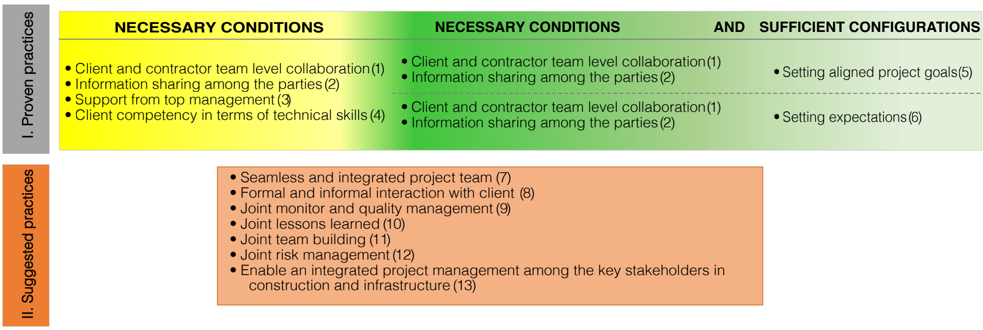


Figure 1: Nexcess model of core project management efforts in engineering projects

To enhance the applicability of the model in practice, the model was evaluated separately by the experts in the construction sector and process industry. Overall, the experts largely agreed on the application of the proven practices. There was, however, a major difference of opinion between the experts in the construction and infrastructure sectors and the process industry regarding the provision of a seamless and integrated project team. Experts in the construction industry found that organising such an integrated team is challenging. Moreover, the experts believed that such an integrated approach, presented by the suggested practices, can be merely enabled (or hampered) by the factors outside the project (such as politics and contractual arrangements) or inside the project (such as individual leadership of project team members).

The Nexcess model was further adapted based on the results of these evaluation sessions resulting in the final model. The final model is accompanied by a roadmap, presented in Table 1, which helps practitioners to improve the performance of their projects. The roadmap describes the actions taken when a high level of project performance is desired. The roadmap consists of two steps:

- **Step 1:** The focus should be given to the proven practices and the underlying items for each factor by ensuring that they are realised in the project. These practices should be discussed among the participants to guarantee that they are implemented in the project.
- **Step 2:** In this step, the extent to which those activities can be stimulated by or integrated with each other can be discussed. Project boundaries affecting the implementation of the suggested practices in terms of political influence and contractual arrangements should be discussed in this step.

The roadmap can be discussed between the main project parties, including client, contractor and consultant, during the project kick-off. Any potential point of disagreements between the parties concerning the exact and concrete definition of the proven and suggested practices can be discussed during preliminary sessions

Table 1: Roadmap for the application of core project management practices to be discussed between parties

Steps		Core project management practices	Implementation guide
Step 1: Establish the consensus on the definition of the proven practices and agree on the actions to be undertaken	Proven practices	Practice 1: boost team level collaboration between client and contractor	1. Client and contractor team level collaboration 1.1 Sense of belonging to the team 1.2 Sharing a belief that they perform their roles and protect the interests of each other 1.3 Helping and supporting each other in carrying out their tasks 1.4 Putting best on joint efforts 1.5 Commitment to the team tasks 1.6 Motivation to maintain the team
		Practice 2: leverage open information sharing	2. Open information sharing 2.1 In-time distribution of the required information by the parties 2.2 Presence of clear communication channels
		Practice 3: Enhance top management support from both sides, client and contractor	3. Top management support 3.1 Showing trust towards project team 3.2 Showing honesty and openness in the interactions 3.3 Commitment to the project and supporting the project team 3.4 Closely collaborate with the project management 3.5 Delegation of authority to project manager
		Practice 4: Assign client representative with the right technical skills	4. Technical skills of the client representative during front-end
		Practice 5: Ensure that aligned goals are set	5. Aligned goal setting 5.1 Organise a clear project performance measurement system 5.2 Prioritised of aligned project goals 5.3 Clearly definition of goals among the stakeholders involved
		Practice 6: Establish expectations among the team members	6. Expectation management 6.1 Establishing of roles and expectations of the team members 6.2 Feedback on individual/team performance
Step 2: Investigate the requirements for applying the suggested practices	Suggested practices *	Practice 7: Organise a single integrated team	7. Provide the requirements for organising a single integrated project team
		Practice 8: Formal and informal interaction with client	8. Agree on the intensity of formal interactions and enable the possibilities for informal interactions with client
		Practice 9: Joint monitoring and quality management	9. Agree on the intensity joint monitoring and quality management
		Practice 10: Joint lessons learned	10. Agree on the intensity of joint lessons learned activities
		Practice 11: Joint team building	11. Agree on the intensity of joint team building activities
		Practice 12: Joint risk management	12. Agree on the intensity of joint risk management activities
		Practice 13 (construction and infrastructure): Enable an integrated project management among the key stakeholders	13. Identify the key stakeholders and establish an integrated project management among them

* Discuss what project boundaries affect the implementation of the suggested practices in terms of political influence and contractual arrangements

The practical relevance of the study covers two main aspects. First, by providing a cross-sectoral analysis of the applied methods, the study facilitates a knowledge base for comparing project management practice and what can be learned across the sectors. In this regard, findings suggest that the process industry seems to be ahead in the application of project management practices, compared to the construction sector. Thus, more structure is required for the applied standards and project management practices within the construction sector. These project management practices have already been well set up in the process industry. Secondly, the proposed roadmap can help practitioners to improve the performance of their projects. The Nexcess model encourages the practitioners to check for those practices which absence hinders the achievement of high level of performance. In addition, it offers a space for interaction in which practitioners can understand the extent to which they can contribute positively to the performance by promoting an integrated approach.

Finally, this dissertation concludes two general implications for project practitioners:

- Incorporate a collaborative approach in contracts as an agreement for fostering integration: collaborative contractual arrangements such as early contractor involvement, integrated project delivery, and alliance are recommended as a strategy for successful integration practices.
- A bottom-up approach as a stimulus for adopting an integrated approach: The behaviour of the people at the operational level can stimulate the provision of an open and collaboration environment. Application of suggested practices starts with the behaviour of the team itself.

The study was merely focused on front-end activities applied in the engineering projects. It is suggested that such analysis is extended to explore how the (intensity of) application of those activities evolves during the execution phase. The scope of the research included projects within the construction, infrastructure, and the process industry. In Chapters 3 and 7, the construction and infrastructure sectors were considered as one overarching industry sector. Although they share some characteristics, the analyses performed in Chapters 4 and 6, revealed some differences between the two sectors regarding the application of project management practices. Therefore, future research can focus on more data gathering to explicitly compare these sectors.

Samenvatting

Projecten kunnen gezien worden als een middel om geldelijke of niet-geldelijke waarde te verschaffen aan organisaties of de gemeenschap in haar geheel. Succesvolle oplevering van projecten is daarom het ultieme doel van veel organisaties. Veel aandacht, zowel in de praktijk als literatuur, is reeds gewijd aan welke factoren tot een succesvol project leiden. In de praktijk zien we echter dat projecten gewoonlijk niet lopen zoals gewenst. Bovendien vraagt de dynamische aard van projecten om continue aanpassingen van projectmanagement activiteiten.

In dit onderzoek wordt gekeken naar de interactie tussen drie onderliggende concepten: front-end activiteiten en projectmanagementprincipes als succesfactor(en), projectprestatie als projectsucces en de industriesector als project situatie. De scope van het onderzoek omvat twee hoofdsectoren van de industrie: bouw (inclusief infrastructuur) en procesindustrie. Het onderzoek is gericht op de beoordeling en identificering van de praktijk van projectmanagement in een specifieke sector, en vergelijkt deze sectoren. Dit proefschrift gaat derhalve over de verbetering van het managen van engineering projecten door middel van evaluatie van de huidige praktijk van projectmanagement en de identificatie van toegepaste methoden die positief bijdragen aan projectprestaties. Projectevaluatie, met als doel leren en prestatieverbetering, vormt het hart van dit onderzoek.

De doelstelling van deze thesis is tweeledig. Ten eerste het evalueren van de huidige praktijk van het managen van engineering projecten en het maken van een sector-overstijgende analyse van de projectmanagement praktijk teneinde mogelijke leerpunten te vinden. De tweede doelstelling is een bijdrage leveren aan het verbeteren van projectprestaties door het geven van praktische aanbevelingen.

De voornaamste onderzoeksvraag is:

Welke methoden worden in verschillende projecten gebruikt die kunnen bijdragen aan verbetering van de prestaties van toekomstige projecten?

Na het leggen van de fundering voor de dissertatie in hoofdstuk 1 wordt de rest van het onderzoek uitgevoerd in drie delen: identificeren van perspectieven (hoofdstuk 2 en 3), onderzoeken van de huidige praktijk (hoofdstuk 4,5 en 6) en de terugkoppeling naar de praktijk (hoofdstuk 7 en 8).

Deel I: Identificatie van de perspectieven

Het eerste deel begint met literatuuronderzoek naar de mogelijke factoren die projectprestaties beïnvloeden en dient als basis voor de empirische studie, Q-studie. Het initiële raamwerk is een lijst van 33 succesfactoren zoals gepresenteerd in hoofdstuk 2. Er is gekozen voor Q-studie omdat deze methode perspectieven op het belang van factoren om projecten succesvol te managen kan identificeren. In de eerste stap wordt het perspectief van professionals in de bouwsector

(stedelijke ontwikkeling, onroerend goed en infrastructuur) onderzocht. Het doel is om na te gaan of professionals in een bepaalde sector hetzelfde standpunt delen betreffende succesfactoren. In een Q-studie met 34 professionals, afkomstig uit consultancy bedrijven, werden vier karakteristieke perspectieven geïdentificeerd: de beste match zoeken, adaptief en open zijn, het team gefocust houden en voorbereiden op kansen. Hoewel de professionals het belang van zachte factoren, zoals competenties van de projectteams (opdrachtgever en opdrachtnemer) en de manier waarop zij met elkaar communiceren, erkennen, blijft de traditionele blik op het managen van projecten “door hen nauwgezet te monitoren” nog steeds bestaan. Gebaseerd op de bevindingen kon tussen de geïdentificeerde perspectieven en de sectoren geen verband gevonden worden en dat zou veronderstellen dat er met een bredere blik naar de sector gekeken zou moeten worden.

In hoofdstuk 3 wordt de Q-studie uitgebreid tot 108 geënquêteerden, verdeeld over 3 datasets: dataset 1, dezelfde dataset als in hoofdstuk 2 (bouw-consultant), dataset 2 (bouw-opdrachtgever) en dataset 3 (procesindustrie – opdrachtnemer). Vier kenmerkende perspectieven werden geïdentificeerd in elke dataset en de perspectieven in de verschillende datasets werden met elkaar vergeleken. Een belangrijk verschil werd gevonden tussen de sectoren: professionals in de procesindustrie en in de bouwsector kijken verschillend aan tegen ‘integratie’ en het belang daarvan voor het verbeteren van projectprestaties. Voor professionals in de procesindustrie gaat integratie over het betrekken van sleutelfiguren en eindgebruikers. In de bouwindustrie wordt deze integratie niet herkend, zelfs niet in nauwe zin binnen het projectteam van opdrachtgever en opdrachtnemer. Door de publieke aard van bouwprojecten ligt de nadruk op aanbesteding en inkoop. Dit zou kunnen impliceren dat in dergelijke projecten meer aandacht is voor het geven van verantwoordelijkheid aan de aannemer, dan voor werken op een geïntegreerde manier. Een ander verschil was het belang dat door de professionals in de procesindustrie werd gehecht aan gezondheid en veiligheidsoverwegingen. Een dergelijke focus kan ook voortkomen uit het feit dat veiligheid een cruciale rol speelt in de procesindustrie.

Verdeeld over de dataset werden zes gemeenschappelijke thema’s gevonden: nadruk op de opdrachtgever, traditionele benadering, focus op team, focus op eindgebruiker, focus op inkoop en focus op kansen. Adaptief projectmanagement werd door de professionals van beide sectorgroepen niet herkend in de praktijk.

Deel II: Onderzoek naar de huidige praktijk

In deel 2 van deze thesis werd middels een online enquête data verzameld van 104, voornamelijk Nederlandse, engineering projecten in drie verschillende sectoren: 26 uit de bouw, 35 uit de infrastructuur en 43 uit de procesindustrie. De enquêtevragen werden gebaseerd op het raamwerk dat is ontwikkeld in deel I van het onderzoek, waarbij 25 factoren zijn meegenomen. De factoren werden verdeeld in twee hoofdaspecten: front-end activiteiten en projectmanagementprincipes. De reden voor een dergelijke verdeling was het verschil in de aard van de factoren.

Front-end activiteiten kunnen gemeten worden via de intensiteit van de toepassing, terwijl projectmanagementprincipes voornamelijk kwalitatief gemeten worden. Om deze factoren te meten werd gebruik gemaakt van schalen met meerdere items per factor.

In hoofdstuk 4 werden de onderzoeksresultaten met betrekking tot de front-end activiteiten en projectmanagementprincipes geanalyseerd. De data liet zien dat sommige front-end activiteiten en projectmanagementprincipes in de praktijk niet algemeen worden toegepast. Voorbeelden van niet algemeen toegepaste front-end activiteiten zijn: milieueffectrapportage, checken van de producten ten opzichte van de businesscase, trainingsprogramma's toegespitst op het project en prestatiebeoordeling met als doel continue verbetering. Enkele projectmanagementprincipes worden niet teruggevonden in de huidige praktijk: de toepassing van een geïntegreerd contract, technisch inhoudelijke kennis en projectmanagementvaardigheden van de opdrachtnemer. De bevindingen suggereren dat aannemers gewoonlijk niet in een vroege fase betrokken worden. Enkele front-end activiteiten zijn beter bekend in een specifieke sector: gezamenlijk opgedane lessen door opdrachtgever en opdrachtnemer en HSE-management worden grotendeels toegepast in de procesindustrie en niet in de bouw- en infrastructuurprojecten.

Na filtering van de data, waarbij de “niet algemeen toegepaste” front-end activiteiten en projectmanagementprincipes zijn verwijderd uit de dataset, kwamen 39 items in aanmerking voor verdere analyse: 15 front-end activiteiten en 24 projectmanagementprincipes. Een multivariate data-analyse werd toegepast op deze resterende items om het aantal variabelen verder te reduceren. Dit resulteerde in de identificatie van 12 factoren: vijf front-end activiteiten (risicomanagement, monitoring en kwaliteitsmanagement, aandacht voor opdoen en gebruik van geleerde lessen, teambuilding en het vaststellen van verwachtingen) en zeven projectmanagementprincipes (samenwerking tussen opdrachtgever en opdrachtnemer, competentie van de projectmanager, vaststellen projectdoelstelling, steun van het topmanagement, competenties van de opdrachtgever, het delen van informatie en betrokkenheid van de opdrachtgever).

De toepassing van deze front-end activiteiten en projectmanagementprincipes wordt vergeleken over de sectoren. Vergeleken met de bouw- en infrastructuursectoren bleek de procesindustrie meer volwassen wat betreft de toepassing van front-end activiteiten. Dit resulteerde in een leerpunt voor de bouw- en infrastructuursectoren. De projectmanagementstandaarden binnen de bouw- en infrastructuursectoren zouden meer aandacht moeten hebben voor het bevorderen van de integratie tussen de partijen en het vaststellen en overeenkomen van projectdoelstellingen. Uit de resultaten van de eerdere Q-studie bleek dat de professionals geloven dat zij naar een meer open en integratieve aanpak zouden moeten gaan. Uit de enquête blijkt echter dat in de praktijk de voornaamste focus nog steeds de traditionele benadering is, gericht op monitoring en het uitvoeren van een project door de afzonderlijke partijen en niet in een geïntegreerd team.

In hoofdstuk 5 wordt de Necessary Condition Analysis (NCA) gebruikt om het verband tussen de 12 geïdentificeerde factoren en projectprestatie te onderzoeken. Bij de analyse van de antwoorden op projectprestatie criteria werden in dit onderzoek vier indicatoren bekeken: binnen budget, op tijd, volgens specificatie en klanttevredenheid. Bredere prestatieaspecten als aannemer tevredenheid, veiligheid en vlekkeloze startup werden in de analyse niet beschouwd, omdat de ondervraagden geen antwoord gaven op deze prestatieaspecten. Dit zou erop kunnen duiden dat professionals deze indicatoren niet erkennen in hun projecten, hetgeen stof tot nadenken geeft. Uit de bevindingen bleek dat vier condities noodzakelijk waren voor projectprestaties op hoog niveau: samenwerking tussen opdrachtgever en opdrachtnemer, steun van het topmanagement, het delen van informatie en technische competentie bij de vertegenwoordiger van de opdrachtgever in de vroege projectfase. Dit laatste heeft een belangrijke implicatie voor de bouw- en infrastructuursector waar de opdrachtgever de technische vaardigheden en competenties gewoonlijk bij de aannemer zoekt. Het hebben van dergelijke technische vaardigheden bij de vertegenwoordiger van de opdrachtgever zou het formuleren van heldere projectdoelstellingen in de beginfase vergemakkelijken en zodoende een betere basis bieden voor de samenwerking tussen opdrachtgever en opdrachtnemer. De afwezigheid van deze noodzakelijke condities kan niet gecompenseerd worden door extra toepassing van andere activiteiten.

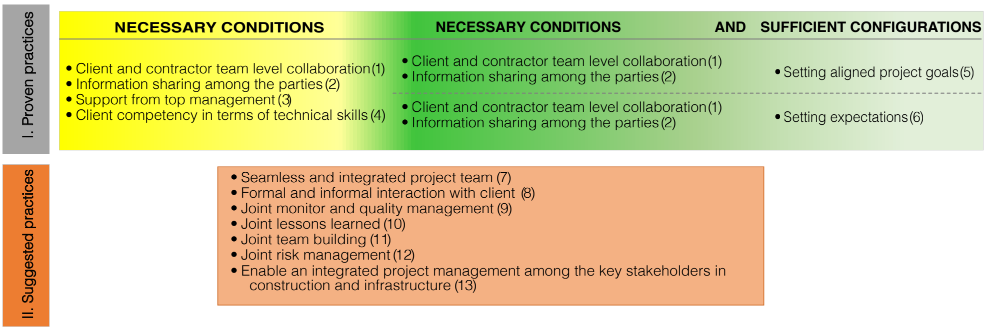
In hoofdstuk 6 gaat de analyse van enquêtedata verder. Het doel is om de configuraties van de front-end activiteiten en projectmanagementprincipes te onderzoeken die de hoge prestatie in elke sector zou kunnen verklaren. Gebruikmakend van meervoudige regressieanalyse werden eerst vier condities geselecteerd die het sterkst bijdragen aan de projectprestatie. De volgende vier condities werden aangemerkt voor nadere analyse: vaststellen van verwachtingen, samenwerking tussen opdrachtgever en opdrachtnemer, het delen van informatie en het vaststellen van afgestemde doelen. Vervolgens werd Qualitative Comparative Analysis (fsQCA) gebruikt om voldoende condities te identificeren voor hoge prestatieniveaus in elke sector. De eerste observatie in deze studie was dat niet één enkele conditie voldoende is voor het beoogde niveau van projectprestatie. Analyse van de configuraties die wél voldeden toonde dat een hoge mate van teamsamenwerking (opdrachtgever en opdrachtnemer) en een hoog niveau van het openlijk delen van informatie in deze configuraties aanwezig bleek te zijn. Deze configuraties zorgden voor goede prestaties in alle sectoren. Per sector kan een hoge prestatie verschillend uitgelegd worden. In de bouwsector is een combinatie van samenwerking en het delen van informatie tussen de partijen cruciaal als het niveau van het vaststellen van het doel laag is. In infrastructuurprojecten echter kan het afstemmen van doelen tussen de belanghebbenden tezamen met een goede samenwerking tussen de teamleden en vlotte informatie-uitwisseling leiden tot goede prestatie. De resultaten in de procesindustrie suggereren dat minder nadruk op de toepassing van verwachtingsmanagement bij de teamleden (vastleggen van rollen en verantwoordelijkheden en terugkoppeling geven over individuele of teamprestatie) de goede prestatie van deze projecten zouden kunnen verklaren. Dit impliceert niet dat verwachtingsmanagement genegeerd zou moeten worden in zulke projecten, maar suggereert dat partijen een meer op samenwerking gerichte benadering moeten kiezen bij het uitvoeren van projectmanagement. Een andere observatie was dat in alle configuraties die leiden tot goede prestaties steun van het topmanagement hoog scoorde zowel aan de kant van de opdrachtgever als aan de kant van de opdrachtnemer.

Deel III: Terugkoppeling naar de praktijk

In het laatste deel worden de perspectieven van de professionals op projectprestatie gecombineerd met de bevindingen uit de enquête. De geënquêteerden werd gevraagd om aanbevelingen te geven voor verbetering van hun volgende project. Hun antwoorden analyserend bleek dat professionals zich meer wilden richten op de volgende aspecten: teambuilding, betrokkenheid van de opdrachtgever, contractmanagement, monitoring en kwaliteitsmanagement en risicomanagement.

Alle bevindingen uit voorgaande sub-studies bieden een basis om een agenda voor te stellen voor verbetering van de prestatie van engineering projecten in hoofdstuk 7, dat bijdroeg aan de ontwikkeling van het Nexcess model.

Het model bestaat uit twee hoofdsecties en 12 kern front-end activiteiten en projectmanagementprincipes, zie Figuur 1.



Figuur 1: Nexcess model voor kern front-end activiteiten en projectmanagementprincipes in engineering projecten

I. Bewezen front-end activiteiten en projectmanagementprincipes: Gebaseerd op de bevindingen in hoofdstuk 5 en 6, omvatten zes bewezen front-end activiteiten en projectmanagementprincipes drie sets voorwaarden: noodzakelijke voorwaarden, noodzakelijke en voldoende voorwaarden, en voldoende voorwaarden. Noodzakelijke voorwaarden worden gedeeld tussen projecten ongeacht de context, terwijl voldoende voorwaarden specifiek zijn voor een sector. Noodzakelijke en voldoende voorwaarden liggen op het kruispunt van deze twee.

II. Voorgestelde front-end activiteiten en projectmanagementprincipes: Gebaseerd op de resultaten van hoofdstuk 3, 4 en 7 worden zes front-end activiteiten en projectmanagementprincipes voorgesteld. Projectmanagementprincipe (13) werd toegevoegd aan het model voor de bouw- en infrastructuursectoren vanwege het belang van de integratie tussen de voornaamste belanghebbenden in dergelijke projecten.

Om de toepasbaarheid van het model in de praktijk te verbeteren werd het model door experts in de bouwsector en procesindustrie afzonderlijk geëvalueerd. In het algemeen waren de experts het grotendeels eens over de toepassing van de bewezen front-end activiteiten en projectmanagementprincipes. Er was echter een belangrijk verschil van mening tussen de experts in de bouw- en infrastructuursectoren en die uit de procesindustrie betreffende het leveren van een naadloos geïntegreerd projectteam. Experts in de bouwindustrie vonden het organiseren van een dergelijk, geïntegreerd team lastig. Bovendien geloofden de experts dat een dergelijke geïntegreerde aanpak, zoals voorgesteld, alleen tot stand kan komen (of belemmerd wordt) door factoren buiten het project (zoals politieke en contractuele afspraken) of binnen het project (zoals individueel leiderschap van projectleden).

Het Nexcess model is vervolgens aangepast, gebaseerd op de resultaten van deze evaluatiesessies wat heeft geresulteerd in het definitieve model. Het model wordt vergezeld van een routekaart, zie Tabel 1, die professionals helpt om de prestatie van hun projecten te verbeteren. De routekaart beschrijft de te nemen acties wanneer een hoog niveau van projectprestatie gewenst is. De routekaart bestaat uit twee stappen:

- **Stap 1:** de focus moet gericht zijn op de bewezen front-end activiteiten en projectmanagementprincipes en de onderliggende items voor elke factor door te verzekeren dat zij gerealiseerd worden in het project. Deze front-end activiteiten en projectmanagementprincipes zouden besproken moeten worden tussen de deelnemers teneinde te garanderen dat zij geïmplementeerd worden in het project.

- **Stap 2:** In deze stap wordt besproken in hoeverre deze activiteiten gestimuleerd of geïntegreerd kunnen worden, en door wie. Projectgrenzen die de implementatie van de voorgestelde front-end activiteiten en projectmanagementprincipes beïnvloeden, denk aan politieke invloed en contractuele afspraken, zouden ook in deze stap besproken moeten worden.

De routekaart kan bij de aftrap van het project besproken worden tussen de voornaamste projectpartijen: opdrachtgever, opdrachtnemer en consultant. Elk mogelijk verschil van inzicht tussen de partijen betreffende de exacte en concrete definitie van de bewezen en voorgestelde front-end activiteiten en projectmanagementprincipes kan besproken worden in voorbereidende sessies.

Tabel 1: Routekaart voor de toepassing van de belangrijke front-end activiteiten en projectmanagementprincipes, om te bespreken met de partijen

Steps		Core project management practices	Implementation guide
Step 1: Establish the consensus on the definition of the proven practices and agree on the actions to be undertaken	Proven practices	Practice 1: boost team level collaboration between client and contractor	1. Client and contractor team level collaboration 1.1 Sense of belonging to the team 1.2 Sharing a belief that they perform their roles and protect the interests of each other 1.3 Helping and supporting each other in carrying out their tasks 1.4 Putting best on joint efforts 1.5 Commitment to the team tasks 1.6 Motivation to maintain the team
		Practice 2: leverage open information sharing	2. Open information sharing 2.1 In-time distribution of the required information by the parties 2.2 Presence of clear communication channels
		Practice 3: Enhance top management support from both sides, client and contractor	3. Top management support 3.1 Showing trust towards project team 3.2 Showing honesty and openness in the interactions 3.3 Commitment to the project and supporting the project team 3.4 Closely collaborate with the project management 3.5 Delegation of authority to project manager
		Practice 4: Assign client representative with the right technical skills	4. Technical skills of the client representative during front-end
		Practice 5: Ensure that aligned goals are set	5. Aligned goal setting 5.1 Organise a clear project performance measurement system 5.2 Prioritised of aligned project goals 5.3 Clearly definition of goals among the stakeholders involved
		Practice 6: Establish expectations among the team members	6. Expectation management 6.1 Establishing of roles and expectations of the team members 6.2 Feedback on individual/team performance
Step 2: Investigate the requirements for applying the suggested practices	Suggested practices *	Practice 7: Organise a single integrated team	7. Provide the requirements for organising a single integrated project team
		Practice 8: Formal and informal interaction with client	8. Agree on the intensity of formal interactions and enable the possibilities for informal interactions with client
		Practice 9: Joint monitoring and quality management	9. Agree on the intensity joint monitoring and quality management
		Practice 10: Joint lessons learned	10. Agree on the intensity of joint lessons learned activities
		Practice 11: Joint team building	11. Agree on the intensity of joint team building activities
		Practice 12: Joint risk management	12. Agree on the intensity of joint risk management activities
		Practice 13 (construction and infrastructure): Enable an integrated project management among the key stakeholders	13. Identify the key stakeholders and establish an integrated project management among them

* Discuss what project boundaries affect the implementation of the suggested practices in terms of political influence and contractual arrangements

De praktische relevantie van de studie omvat twee hoofdaspecten. Door een sector-overschrijdende analyse van de praktijk van projectmanagement faciliteert de studie een kennisbank om deze praktijk te vergelijken en te kijken naar wat er geleerd kan worden over de sectoren heen. De bevindingen suggereren dat de procesindustrie voor lijkt te lopen in de toepassing van projectmanagement, ten opzichte van de bouwsector. Er is daarom meer structuur vereist in de standaarden en front-end activiteiten en projectmanagementprincipes binnen de bouwsector. Deze front-end activiteiten en projectmanagementprincipes zijn al goed opgezet in de procesindustrie. Ten tweede kan de voorgestelde routekaart de professionals helpen om de prestatie van hun projecten te verbeteren. Het Nexcess model moedigt de professionals aan om die front-end activiteiten en projectmanagementprincipes na te gaan, waarvan het afwezig zijn het bereiken van een hoog prestatieniveau belemmert. Daarnaast biedt het model ruimte voor interactie waaruit professionals kunnen begrijpen in hoeverre ze positief kunnen bijdragen aan de prestatie door het bevorderen van een geïntegreerde aanpak.

Tenslotte benoemt dit proefschrift twee algemene implicaties voor project projectproffessionals:

- Neem een overeenkomst over de samenwerkingsaanpak op in contracten om integratie te bevorderen: contractuele samenwerkingsovereenkomsten zoals het vroegtijdig betrekken van de aannemer, geïntegreerde projectuitvoer en het vormen van allianties worden aanbevolen als strategieën voor succesvolle integratiepraktijken.

- Een bottom-up aanpak als stimulans voor een geïntegreerde aanpak: het gedrag van de mensen op de werkvloer kan een open en samenwerkingsgerichte omgeving stimuleren. Toepassing van de voorgestelde front-end activiteiten en projectmanagementprincipes begint met het gedrag van het team zelf.

De studie was alleen gericht op front-end activiteiten toegepast in engineering projecten. Voorgesteld wordt dat deze studie wordt uitgebreid om te onderzoeken hoe de (intensiteit van) toepassing van deze activiteiten evolueert tijdens de uitvoeringsfase. De scope van het onderzoek omvatte projecten in de bouw, infrastructuur en procesindustrie. In hoofdstuk 3 en 7 werden de bouw- en infrastructuursectoren beschouwd als een overkoepelende industriesector. Hoewel zij enkele kenmerken delen toonden de analyses uit hoofdstuk 4 en 6 enkele verschillen tussen de twee sectoren betreffende de toepassing van front-end activiteiten en projectmanagementprincipes. Daarom kan toekomstig onderzoek zich richten op het verzamelen van meer data om deze sectoren expliciet te kunnen vergelijken.

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List of abbreviations used

BRN	BouwRegieNetwerk
CII	Construction Industry Institute
FsQCA	Fuzzy set QCA
IPA	Independent Project Analysis
NAP	Nederlands Apparatenbouw en Procesindustrie
NCA	Necessary Condition Analysis
PCA	Principal Component Analysis
PMBOK	Project Management Body of Knowledge
QCA	Qualitative Comparative Analysis
VIP	Value Improving Practice

Chapter 1

Laying the foundation

Abstract

The first chapter of this thesis includes a brief introduction of the research topic. The study aims at providing a basis for evaluating current project management practice within engineering projects in the construction sector and the process industry. The ultimate purpose of the study is to contribute to the improvement of project performance of such projects. To achieve this goal, this chapter lays the foundation for the further steps of this research. It starts with the research background in Section 1.1 in which the main concepts used in the study including project management practices, project context, and project performance are elucidated. In Section 1.2, generalization and contextualization as two extremes in the project evaluation and how the current dissertation is situated in this spectrum are discussed. Next, the research objectives are presented followed by the research questions in Section 1.3. Different stages of the research design are defined in Section 1.4. Subsequently, Section 1.5 gives the position of this research in the field of project management research. In Section 1.6, the scientific and practical relevance of the study is presented. The chapter ends with the outline of the dissertation in Section 1.7.

1.1 Setting the scene

Projects are crucial for the success of any company or organisation and they are considered as the managerial environment to combine activities for providing new products or services, improving procedures, implementing and developing new businesses (Berjis, Shirouyehzad, & Jouzdani, 2020; Shenhar, Dvir, Levy, & Maltz, 2001). Successful projects can have various advantages either to the organisations or society: increase the profit, improve quality, reduce costs, customer and end user satisfaction (Salazar-Aramayo, Rodrigues-da-Silveira, Rodrigues-de-Almeida, & de Castro-Dantas, 2013) and direct and indirect social, economic and environmental benefits (Fahri, Biesenthal, Pollack, & Sankaran, 2015; Lehtonen, 2014). To put it simply, projects can add value to organisations and society as a whole.

Project success has been an interesting topic in the project management literature for a long time (de Wit, 1988; Fahri et al., 2015; Kerzner, 1987; Mir & Pinnington, 2014; Shenhar et al., 2001; Turner & Zolin, 2012; Westerveld, 2003). The International Project Management Association (IPMA) defines project management success as "***the appreciation of the project management results by the relevant interested parties***" (IPMA, 2006, p. 16). More specifically, the literature focuses on how the success of a project is judged (Al-Tmeemy, Abdul-Rahman, & Harun, 2011; Atkinson, 1999; Diallo & Thuillier, 2004; Shenhar, Tishler, Dvir, Lipovetsky, & Lechler, 2002) and how success can be achieved (Chua, Kog, & Loh, 1999; Cooke-Davies, 2002; Fortune & White, 2006; Pinto & Slevin, 1987)

Assessment of project success and related success factors is one of the most popular research topics in project management literature (Belassi & Tukel, 1996; de Wit, 1988; Fortune & White, 2006; Pinto & Slevin, 1987; Yang, Huang, & Wu, 2011). The concept of project success is dependent on the perception of the players involved in the project. Various studies propose that the perception of success both in terms of the importance of criteria (that respectively affect the perception of the project performance) and success factors (how this success can be achieved) might differ per stakeholder (Davis, 2014; Turner, Zolin, & Remington, 2009). Some literature defines project success as an unidimensional concept, whereas others perceive it as a complex multi-dimensional construct where the elements interrelate with each other (Müller & Jugdev, 2012). It is important to distinguish success **criteria** and success **factors**: success criteria define what to measure and success factors define how to achieve the success criteria (Koops, Bosch-Rekveldt, Coman, Hertogh, & Bakker, 2016). Success criteria are the descriptive measures of success or failure of a project or business with respect to the defined goals (Rodríguez-Segura, Ortiz-Marcos, Romero, & Tafur-Segura, 2016). Based on the definition of Rockart (1980), "***critical success factors are the relatively small number of truly important matters on which a manager should focus her attention***". Lehtiranta, Kärnä, Junnonen, and Julin (2012) view project success as the aggregation of the success of various participants' coordinated actions and discipline-specific success factors help in identifying critical management areas.

Despite the large amount of research on project success and the advances in project management, projects still fail to meet their objectives (Andersen, Birchall, Arne Jessen, & Money, 2006). In addition, projects not only become more complex (Williams, Jonny Klakegg, Walker, Andersen, & Morten Magnussen, 2012), but also the dynamic nature of project context requires continuous adjustments (Hertogh, Baker, Staal-Ong, & Westerveld, 2008). The interrelationship between project context (industry sector), project organisation or success factors (project management practices), and project success (project performance) as investigated in the current thesis is presented in Figure 1.1.

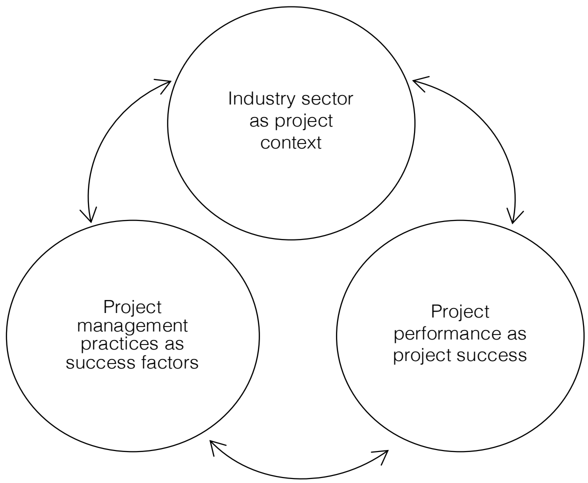

Figure 1.1: Conceptual model adjusted from Hertogh et al. (2008)

The current dissertation is built on this model; therefore these concepts are elucidated next.

1.1.1 Project management practices as success factors

After more than four decades of research on the concept of project success factors, the point of emphasis has been gradually extended to consider broader aspects of projects (Fossum, Binder, Madsen, Aarseth, & Andersen, 2019). In the beginning, studies merely presented anecdotic lists or frameworks of success factors focusing on the hard aspects of project management (Ika, 2009). For years, these lists or frameworks have been replicated without introducing new factors (Davis, 2014). Since the beginning of the 21st Century, more emphasis has been put on the soft skills such as communication and the importance of the involvement of sponsor and owner (Peled & Dvir, 2012). When looking at the evolution of project success factors, the understanding of these factors has shifted from focusing only on implementing the project and handing it over, to a more strategic and holistic view (Jugdev & Müller, 2005). In other words, the advances in the project management research have resulted into the development of more inclusive and rhetoric frameworks.

Hobbs and Besner (2016) made a distinction between "success factors" and "best project management practices". They argued that the former may include some contextual conditions surrounding the project which are not under the direct control of a project manager, such as top management support, whereas the latter can be directly managed and controlled by a project manager.

In literature, project management practices are usually defined at two levels (Hobbs & Besner, 2016): aggregated level of methodologies and knowledge areas or individual tools and techniques. Regarding the aggregated level of these practices, 10 Knowledge areas are distinguished for any type of project and in different project phases in the sixth edition of ***A Guide to the Project Management Body of Knowledge***, PMBOK (PMI, 2017): Project Integration Management, Project Scope Management, Project Schedule Management, Project Cost Management, Project Quality Management, Project Resource Management, Project Communications Management, Project Risk Management, Project Procurement Management, and Project Stakeholder Management. Various studies are available that have been focused on the clusters of knowledge areas for investigating their impact on project performance and project success (Chou & Yang, 2012), focusing on specific knowledge areas for identifying its attributes (Badewi, 2016; Demirkesen & Ozorhon, 2017), or even go beyond these (traditional) knowledge areas to meet the demands of our modern world such as the knowledge areas required for green construction projects (Hwang & Ng, 2013).

When focusing more into details, several studies examined a comprehensive list of individual tools and techniques to identify the extent to which these are applied in practice (Besner & Hobbs, 2006; White & Fortune, 2002), to find the most useful tools and techniques providing high benefits to project management performance (Fernandes, Ward, & Araújo, 2013), to explore the groups of specific tools and techniques affecting the project performance in different contexts (Hobbs & Besner, 2016), or to find a pattern for the importance of such tools and techniques in different sectors and project phases (Tereso, Ribeiro, Fernandes, Loureiro, & Ferreira, 2019).

Overall, the two terms 'best project management practices' and 'success factors' are used interchangeably in the project management literature and they can be defined as the daily routines, norms, traditions, rules, and practices (Blomquist, Hällgren, Nilsson, & Söderholm, 2010). If an empirical study can prove that the application of project management practices can have a significant effect on project performance, they can be considered as success factors (Hobbs & Besner, 2016).

In order to systematically investigate those factors contributing to project performance, this study presents an extensive literature review (see Section 2.3). These success factors, however, might not be applied to a large extent in practice. The empirical study would determine the applicability of those factors in terms of practices and applied methods (see Section 4.5). Further, this study identifies the relation between the level of application of those factors and project performance.

In the next subsection, project performance as an indicator of project success is explained.

1.1.2 Project performance as project success

The concept of project success has attracted the attention of many scholars in the field of project management. Generally, it is defined as the extent to which pre-determined project goals are achieved (Lim & Mohamed, 1999). Traditionally, three determinants are used to assess the project success: time, cost, and quality (de Wit, 1988). Given the arising complexities, however, many scholars have reached a consensus that merely focusing on classical judgment of projects is too narrow and cannot meet the needs of today's complex projects (Dainty, Cheng, & Moore, 2003; Serrador & Turner, 2015; Shenhar & Dvir, 2007; Turner & Zolin, 2012). Thus, much broader impact of a project should be considered when assessing project success (Jugdev & Müller, 2005; Munns & Bjeirmi, 1996). A distinction can be made between three categories of project success (Al-Tmeemy et al., 2011): project management success (meeting schedule, budget and quality targets, project success), project/product success (customer satisfaction, meeting functional requirements and/or technical specifications), and consistent business success (revenue and profit, market share, reputation, competitive advantage).

The more recent literature on project success, from the start of the 21st Century, emphasizes the importance of stakeholders on achieving the short-term project goals (Turner et al., 2009). Combining the views for achieving the short-term goals with those of the long-term (wider organisation), however, still remains a challenge (Davis, 2014). In assessing the success of the project, the research of Shenhar et al. (2001) is remarkable, where they distinguish four dimensions of project success: project efficiency (iron triangle), impact on the customer, business case, and preparing for the future. In more recent research, the concept of project success has been extended to the whole project lifecycle, taking into account the effect of the project months and years after its completion (Turner & Zolin, 2012). Earlier studies only considered the project manager's view of success, which has limited the achievement of stakeholder satisfaction by not considering the owner's view. To broaden the view of project success, Davis (2014) examined the literature to find how success can be perceived by different internal/external stakeholders of an organisation (e.g. senior management, contractor or the external environment). An examination of the perception of the project managers also suggests that even within the same stakeholder groups measuring project success is subjective and it is also highly dependent on whose point of view is considered (Koops et al., 2016). In the same vein, Williams (2016) characterizes project success by five aspects:

1. Efficiency (well managed project)
2. Effectiveness (project outcome meeting project goals)
3. Relevance (alignment of project goals with the needs of the organisation)
4. Impact (anticipated/unintended effects of the project on the organisation)
5. Sustainability (Long-term positive impacts of the project)

To broaden the concept of project success, Lehtiranta et al. (2012) show that, based on empirical research in the construction industry, multi-firm project participants' satisfaction with each other can also affect the client satisfaction. As a result, they conclude that satisfaction of the project participants, namely designers, consultants and contractors can also be a determinant of the project success. And even, using a systems thinking approach, the performance outcome assessment can be dynamic due to the interdependencies between various elements (Zhu & Mostafavi, 2017). Despite these advances in the research on project success, still many aspects of success measures are translated to the traditional dimensions of time and cost performance (Kloppenborg, Manolis, & Tesch, 2009).

Measuring project performance is one of the important aspects of project management (Toor & Ogunlana, 2010). Project performance can also be a representative of project success in its wider definition (Zaman, Jabbar, Nawaz, & Abbas, 2019). Chou and Yang (2012) used three measurement constructs in their empirical study: project performance, customer satisfaction, and project success. For assessing project performance, Chou and Yang (2012) employed six indicators: cost performance, schedule performance, quality performance, safety performance, rework, and change order. Customer/client satisfaction, in their study, measures specifically the aspects relating to the client's expectations and objectives of the project. Project success entails broader aspects including both project performance and client satisfaction. Further, their result showed that project performance can positively affect the client satisfaction and as client satisfaction enhances, the project success improves. In another study, Demirkesen and Ozorhon (2017) consider also client satisfaction together with other indicators (time, cost, quality, safety) for measuring the project management performance.

Given the above explanations, the current study aims at measuring the project performance as a representative of project success. The approach to project success and performance, however, depends on the project context such as objectives, stakeholders, environment and risks, which requires various combinations of success criteria and factors (Cserháti & Szabó, 2014). Therefore, the project context is discussed next.

1.1.3 Industry sector as project context

Although contingency theory is widely applied in the organisational research since the 1950s, it has been only three decades since it caught the attention of scholars in project management research (Hanisch & Wald, 2012). Since then, the contingency view became a popular lens of theory in the project management body of literature. Contingency theory suggests that projects should be managed based on their given characteristics and context (Sauser, Reilly, & Shenhar, 2009). More specifically, using contingency theory, it can be explored how one variable (an independent variable) can affect another variable (a dependent variable) while depending on a context variable (Joslin & Müller, 2015).

Hobbs and Besner (2016) used a wide range of contextual variations such as type of project (engineering & construction, IT and telecom, software development, business & financial services), public vs. private sector, project complexity, participation of the project manager in the front-end, availability of competent personnel, precision of project definition, and organisational structure. The results of this study reflect that project management practices should be adapted based on their context. This echoes the findings of Ramalingam, Laric, and Primrose (2014), who suggest to use the term “best fit” instead of “best practice”.

Following this contingency view, industry sector can be considered as one of those contextual factors affecting the application of project management practices. Apart from other contextual factors, projects within one industry sector might share some characteristics, such as technological characteristics and market needs (Artto, Gemünden, Walker, & Peippo-Lavikka, 2017), which influence the application and importance of those practices in that specific sector. Zwikael (2009) highlighted the role of the industry type on the application of PMBOK knowledge areas and how they could affect project success. For instance, the results of his study suggest that Integration Management and Cost Management have the largest impact on project success in construction and engineering projects. When comparing engineering projects with other project types, Müller and Turner (2007a) found that, in high performing projects, the overall success of ICT and organisational change projects was significantly higher than of engineering projects.

In order to investigate the relationship between the three concepts presented in this section (project management practices as success factors, project performance as project success, and industry sector as project context), the current research seeks to explore the current practice by evaluating how engineering projects are actually managed. Although Hobbs and Besner (2016) emphasise the multidimensional nature of context, considering a wide range of contextual variables is only possible in large-N datasets. In the current study, the focus is merely on the industry sector as the leading contextual factor on evaluating the practice and specifically the application of project management practices. The ultimate objective is to learn from practice and improve the project performance. In the next section, project evaluation as observed in previous studies is elucidated.

1.2 Generalization and contextualization in project evaluation

In pursuit of improving the performance of projects, project evaluation is considered one of the important prerequisites for learning and improvement within and across organisations (Fahri et al., 2015). In the literature on project evaluation, two extremes can be distinguished: generalization versus contextualization (Verweij, 2015b). The former implies little attention to the project environment, whereas the latter implies considering its context. Generalization, which is conducted through large-N analysis, does allow for identifying generic patterns, however, it neglects the idiosyncratic nature of projects.

An example of the variable-oriented study aiming at generalizing the results is the research of Cantarelli, Flyvbjerg, and Buhl (2012a) in which the causes of cost overruns of the infrastructure projects (N=806) were examined through a statistical generalization. The main objective of their study is to increase the accuracy of cost estimates by comparing them with similar completed projects. In this large N-study, the influence of context is also considered. Three independent variables are considered in this study: project type (road, rail, and fixed link projects), project size (measured in terms of estimated costs), and the length of the project implementation phase. In addition, they also explored whether those independent variables affecting the cost overrun are different in the context of Dutch transport infrastructure projects compared to that in other countries (Cantarelli, Van Wee, Molin, & Flyvbjerg, 2012b). A main conclusion from their study is that optimism bias and strategic misrepresentations negatively affect the cost performance.

Regarding the effect of project context in such large N-studies, Zwikael (2009) showed that the type of industry affects the relationship between the application of the Knowledge areas of the PMBOK and project success (N=783). More specifically, application of those Knowledge areas during the project planning is industry-dependent. Fossum et al. (2019) also investigated the relationship between organisational support practices and project management success in Global projects (N=1170) that are applied across different nations and cultures.

Another large-N study is the project evaluation done by the Independent Project Analysis (IPA), a private international construction benchmarking and metrics corporation headquartered in the US founded in 1987. In 2018, the main database of IPA has a large amount of input from capital projects (N= 20,000) mainly from the process industry, however, data from these projects is not publicly available (IPA, 2020). One important conclusion which was made from data analysis within IPA is that bridging the gap between the business and technical professionals is crucial (Merrow, 2011, p. 126). Another conclusion is that the business objectives of projects should be justified during the shaping process. Project team formation and the importance of team integration are other remarkable findings of these evaluations. IPA suggests that team leadership is an important factor for project success and the continuity of project leadership can be one of the factors, which absence (turnover of project director) is highly likely leading to failure. Their results also highlight the importance of front-end loading and good project preparation by developing and following a stage-gated front-end loading process (Merrow, 2011).

All in all, such large-N studies are powerful indications of how a generalized pattern for the “best practices” can be identified. They are, however, unable to identify the underlying reasons behind the successful implementation of the project.

The contextualization approach assumes that projects are sensitive to their context by exploring the “why” of success or failure (Verweij, 2015b). When considering the context for project evaluation, some literature on evaluation and eventually learning focuses on identifying organisational and managerial practices leading to either success (Kwak, Walewski, Sleeper, & Sadatsafavi, 2014) or failure and lessons learned in a single case study (Venugopal & Suryaprakasa Rao, 2011). Other scholars identified some contextual patterns contributing to different aspects of success in the planning and execution of projects by studying several projects (Brookes, Locatelli, & Mikic, 2015; Dimitriou, Ward, & Wright, 2011; Hertogh et al., 2008; Verweij, 2015b). These evaluation studies are briefly explained in the following.

The Megaproject Cost Action provided an intergovernmental framework aiming at improving the effectiveness of megaprojects (Brookes et al., 2015). This study identified the learning across megaprojects which could improve the performance. This can be achieved by developing transferable mechanisms for linking the characteristics (independent variables) of megaprojects to their performance (dependent variables) and further apply these mechanisms to identify the critical characteristics that could affect the performance of European megaprojects (Brookes, 2015). The megaprojects characteristics are mainly derived from brainstorming and therefore the perception of project practitioners. In addition, only the presence or absence of these characteristics are investigated without considering the intensity of these characteristics in different contexts (Locatelli, Mikic, Kovacevic, Brookes, & Ivanisevic, 2017). Another criticism of this mainly quantitative approach of Megaproject Cost Action is that it is not clear whether these characteristics are the complexity factors or the success factors.

OMEGA is an international research programme at University College London (UCL) that has studied 30 mega transport projects (MTPs) in ten developed countries worldwide since 2006. Besides contributing to their research objectives, OMEGA Centre also provides consultancy and advisory services to large projects in different sectors. The research addresses much wider considerations for a successful mega transport project in the 21st century than merely time, cost and compliance with specifications. It also explores how the context of the project affects judgments regarding: (a) what a successful project is; (b) how well and to what extent risks, complexities and uncertainties have been addressed. In this research, special attention is paid to the contextual elements of the project such as geographical, political and economic climate and project timelines of key decisions (Dimitriou, Ward, & Wright, 2013). Some of the main generic conclusions from this study for improvement of future projects include effective and early engagement of the stakeholders, perform post-project evaluation and systematic lessons learned practices, and institutional, policy and legislative support. Moreover, the recommendations and findings in this research might apply to megaprojects only. Although these megaprojects might be regarded as important drivers for the society and economic changes, there are not many of such projects in that large scale (Mišić & Radujković, 2015). This might limit the application of the lessons and recommendations from such studies.

Another evaluation study is the research of NETLIPSE, a European network for sharing knowledge on different aspects of management and organisation of large infrastructure projects (LIPs) among the client organisations, universities and other research institutes. Their main objective is to assess the management quality with regard to such projects, including the agreed objectives at the beginning of the project (Hertogh et al., 2008). Project assessment by NETLIPSE is performed in different phases in the project such as on ex-ante evaluation or gate reviews, ex-post evaluation, during the project execution in order to monitor the progress, and to benchmark the projects. The target groups for this research network include primary and secondary groups. The former groups consist of client/sponsor project delivery organisations and parent organisations. The latter comprise public and private financiers, the European commission and research institutes. Some of the recommendations of their study based on those project evaluations include early approval of finalising the scope and definition of requirements, existence of a sound business plan at the outset of the project with adequate financial setup, and early formation of the project delivery organisation. Furthermore, it was concluded that the "hard" factors and "control" aspects of the projects are better managed than the "soft" factors and "open and adaptive parts" (Staal-Ong, Kremers, Karlsson, & Baker, 2016). One of the limitations of this study, however, is that the focus is mostly on the client or sponsor project organisation, which might limit its application by other stakeholders involved such as the contractor. The tool developed by NETLIPSE for project evaluation is the same for all the target groups and it is not sensitive to which view is taken. Moreover, those project evaluations seem to be subjective to the assessors' views and their experience.

Verweij (2015b) focused on the implementation phase of Public Private Partnership (PPP) projects in the Netherlands. In total, this study evaluated 29 transport infrastructure projects which is considered a medium-N study. For assessing the project success, only the (presence or absence of) satisfaction is considered. Although there is not a single correct way to respond to unforeseen events during the implementation phase, the study presents a set of recommendations based on the project evaluations. Irrespective of the project context, the findings suggest that the following management responses are associated with high satisfaction in such projects: open and external-oriented (together with different stakeholders involved) responses to social events and internal-oriented response by the client or jointly by the public and private partners. Next, this research also considered three contextual factors: type of contract, project scope, and project size (Verweij, 2015c). Overall, the results highlight the importance of external-oriented management and closer cooperation between public and private parties in achieving satisfactory outcome in infrastructure projects.

Some of the main examples of the evaluation studies in the process industry and the construction sector mentioned in this section with the aim of improving the performance of future projects either with a generalization or contextualization approach are listed in Table 1.1. In addition, their purpose (commercial or research), the main industry sector in which these studies are performed, their main themes and conclusions, and the number of projects included in these evaluation studies are also presented in this table.

To sum up, each of the generalization and contextualization approaches would shed light on different aspects of project management and have their own advantages and disadvantages. Although contextualization provides an in-depth and detailed insight into the unique characteristics of each project under study, it is unable to identify the general patterns from different situations. Without doubt different projects in various contexts call for a different project management approach (Bosch-Rekveldt, 2011; Shenhar & Dvir, 2007). Evaluation, however, with the aim of identifying similarities and differences across different contexts could add value. Determining a general pattern as well as a context-dependent pattern could still contribute to the improvement of performance of future projects. As observed from the studies presented in this section, even in the evaluation studies where the focus is mostly on the contextualization, some observations are made that are not dependent on the context.

Table 1.1: Examples of the evaluation studies with the purpose of learning from projects and project performance improvement in the process industry and the construction sector

	Name of the study/ database	Purpose	Industry sector	Main themes and conclusions	Number of projects studied in the study/database	Contextualization or generalization
1	IPA (IPA, 2020; Merrow, 2011)	Commercial	Process industry	Proper preparation and front-end loading, continuity of project leadership, align the goals and objectives of the client and the contractor by using the proper contractual structure, assessing the basis for business objectives, identifying and understanding stakeholders, megaproject team building, team integration (clients and contractors) and client involvement, megaproject governance and accountability, controlling project risks.	20,000 international capital projects	Generalization
2	Reference Class Forecasting (Cantarelli et al., 2012a)	Research	Transport infrastructre (mainly road, rail and fixed links)	Optimism bias and startegic misrepresentations negativey affect the cost performance, increasing the accuracy of cost estimates by comparing it with similar completed projects, cost performance is affected by the project size, location and project phase.	806 international transport infrastructure projects	Mainly generalization
3	NETLIPSE (Hertogh et al., 2008; Staal-Ong et al., 2016)	Research	Infrastructure	Early approval of finalising the scope and definition of requirements, existence of a sound business plan at the outset of the project with adequate financial setup, early formation of the project delivery organisation at an early stage, existence of adequate procedures for legal consents, highly professional project director, systematic stakeholder management with an open culture of communication, assessment of changes which might affect the scope, incorporating opportunities in the risk assessments, finding a balance between control and interaction.	15 European large infrastucture projects	Generalization and contextualization
4	OMEGA (Dimitriou et al., 2013)	Research/ commercial	Infrastructre	Treatment of risks, uncertainties with the special attention to the context, changes in the project objectives (emergent objectives) should be negotiated with all key stakeholders involved, political influence as a key contexutal driver, the power of context and how this colours judgements about perception of success over different time periods, effective and early engagement with key stakeholders, exploit the opportuinites that might arise, project-based lesson learning and sharing, trust and transparency in engaging the stakeholders, sustainable development as an ultimtate vision.	30 International mega tranport projects	Mainly contextualization
5	Cost Action Megaproject (Brookes et al., 2015; Locatelli et al., 2017)	Research	Energy, transport and cross-sectoral projects	Managing the stakeholders (specially external stakeholders), proper project governanace, identifying risks in the front-end phase, and learning across European megaprojects within and across the sectors.	50 European megaprojects	Generalization and contextualization
6	Verweij (2015b)	Research	Transport infrastrucutre (PPP projects)	Internally-oriented management strategy cooperatively or by the public partner in project implementation, open and externally-oriented management strategy by interaction with stakeholders for finding solutions for the unforseen events, cooperation between the punlic and private parties. i.a. with regard to stakeholder management	29 Ducth trasnportation infrastrucutre projects	Mainly contexutalization

Given the above introduction, the current research explores how engineering projects are managed in practice. As explained in Subsection 1.1.3, the industry sector is considered as the key contextual factor affecting the application of the project management practices. More specifically, the study provides an in-depth understanding regarding how projects in the construction industry and process industry are managed. The results of such analysis also provide a basis for cross-industry knowledge sharing which can further enrich our knowledge of project management. Thus, the study pursuits project success by evaluating the current practices and applied methods contributing to high project performance. This is done by highlighting the commonalities between projects in two industry sectors (generalization) and it studies a medium-N of projects per sector for finding the differences across these sectors in the application of those practices (contextualization).

In order to map the connection between project management practices and project performance within and across the industry sectors, the next section sets out the objective of the research and based on that the research questions are formulated.

1.3 Research objective and research questions

As explained in Section 1.1, there is an abundant research on improving the project performance. Combining different research methods by exploring what project management practices have been performed in practice across different sector groups and the interrelation of these practices with performance has rarely been studied. To address this research gap and contribute to the improvement of management of engineering projects, this research explores projects in two main sectors, construction (including infrastructure) and process industry. Thus, the objective of this research is twofold (see Figure 1.2):

1. Evaluate the current practice of managing engineering projects and make a cross-sectoral analysis of project management practice in order to investigate potential learning points.
2. Contribute to the development of suggested improvements by providing practical recommendations.

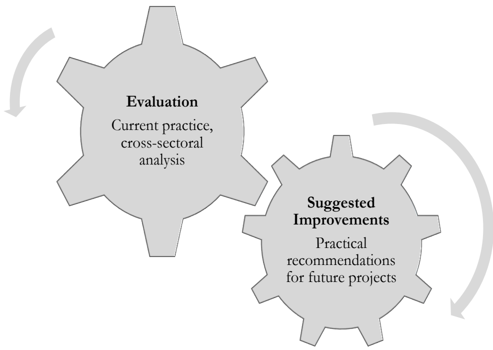

Figure 1.2: Main research objectives

The following main research question is formulated in order to achieve the overarching researchgoal.

What practices and applied methods can be extracted from completed projects in different project contexts with the aim of improving the performance of future projects?

This main research question is further decomposed in the following seven sub-questions enabling the identification of different aspects of the topic under investigation. In answering these research sub-questions, this dissertation is grouped into three parts:

Part I: Identifying and aligning the viewpoints

RQ1: What are practitioners' views on obtaining good project performance?

RQ2: How do the perceptions of the practitioners on obtaining good project performance differ across construction sector and process industry?

Part II: Exploring the current practice

RQ3: Which front-end activities and project management principles are typically applied in engineering projects?

RQ4: What differences and similarities do appear in the intensity of application of front-end activities and level of project management principles across construction, infrastructure and process sectors?

RQ5: Which combinations of intensity of application of front-end activities and level of project management principles are necessary for achieving good project performance?

RQ6: Which combinations of such project management efforts produce high project performance in each sector?

Part III: Feeding back to practice

RQ7: What are the building blocks for improving the management of engineering projects?

In Section 1.7, the outline of the dissertation is presented in which Figure 1.3 presents an overview of the content of the chapters indicating which research question(s) is dealt with in each chapter. But first the research design is elaborated in the next section.

1.4 Research design

In social sciences, such as project management, theoretical ideas can be created on the basis of empirical data (Timmermans & Tavory, 2012). The research in project management, however, cannot only be based on empirical evidence, it should have some drivers from theory (Söderlund, 2004). A theory can be defined in different ways. For instance, Abend (2008) defined the theory as the "*overall perspective from which one sees and interprets the world*". It can be also viewed as a "*system of constructs and variables in which the constructs are related to each other by propositions and the variables are related to each other by hypotheses*" (Bacharach, 1989). In order to position the research within existing research as well as practice, a research design is established. The research design provides a guide for selecting types of information required, preparing a plan for answering the research question, shaping the framework for determining the relationship between the variables under study, and developing an outline for research activities (Cooper & Schindler, 2014). Blaikie (2009) suggests that for developing a research design following steps should be applied: research objective and questions, research strategies, research paradigms, and data collection techniques. The research objective and questions are presented in Section 1.3. The rest of the research design steps followed in this dissertation are explained in this section. First, the research strategies and paradigm are determined in Subsection 1.4.1. Next, the methods used in the research are clarified in Subsection 1.4.2. It is crucial to justify these concepts before starting the research, since the research strategies, paradigm and the methods used should be suitable for answering the research question under investigation.

1.4.1 Research strategies and philosophical foundation of the research

Research paradigms, or philosophical worldviews (Creswell, 2013), are defined as "*a general organising framework for theory and research that includes basic assumptions, key issues, models of quality research, and methods for seeking answers."* (Neuman, 2002). In this sense, a research paradigm can be applied to investigate a phenomenon by understanding three constructs: ontology (the nature of being and the fundamental categories of reality), epistemology (how it is understood or what are the most valid ways to reach truth), and the research methodology which is based on a foundation of ontological and epistemological assumptions (Neuman, 2002). In another explanation, Blaikie (2009) describes the paradigms within social research as the "*traditions of some theoretical and methodological ideas*. *They are not only the source of theoretical ideas but also of ontological and epistemological assumptions".*

Six major paradigms can be identified in social and behavioural sciences: positivism, post-positivism, pragmatism, constructivism (often combining with interpretivism), critical realism, and post-modernism (Biedenbach & Müller, 2011; Creswell, 2013; Tashakkori & Teddlie, 1998). Traditional approaches, such as positivism, are unable to cope with the complexity and uncertainty in the current projects (Bredillet, 2010; Klein, Biesenthal, & Dehlin, 2015). In order to address this issue, the field of project management research has shifted from hard paradigms (positivist epistemology and mainly deductive reasoning) towards softer paradigms (interpretive epistemology, inductive reasoning). This shift highlights the importance of contextual influence and finding particular explanations rather than objectivity and investigating general explanations in the project management research (Pollack, 2007). Subjectivist approaches seem to be more promising in explaining the current complexity of the projects.

Since each part of this PhD research aims at answering a set of sub-questions, a specific research paradigm fitted to those questions should be followed. Part I of the research focuses on the subjective opinion of the practitioners, following a combination of positivist and constructivist approaches. Positivism takes a single vision and assumes there is only one reality, whereas constructivism asks for generating or inductively developing a theory or pattern of meanings by exploring the opinion of the practitioners based on their actual experience (Creswell, 2013; Tashakkori & Teddlie, 1998).

Part II takes a post-positivist approach for investigating sector-specific factors leading to the high level of performance.The post-positivist approach acknowledges that the application of these project management practices might be situation (sector) dependent (Joslin & Müller, 2016a). Part III focuses on suggesting improvements for practice in different sectors and it also uses a constructivist approach with dominant positivist aspects.

After determining the research philosophy, the research strategy is selected. Four research strategies can be distinguished: inductive, deductive, retroductive, and abductive (Blaikie, 2009; Saunders, Lewis, & & Thornhill, 2016). In the inductive approach general inferences from particular instances are developed from the observations of empirical reality, whereas deductive approach involves the development of a conceptual structure to be further tested by the observation. The retroductive research strategy is dealt with analysing in-depth underlying mechanisms, in specific contexts for producing empirical phenomena. In an abductive reasoning, the deductive and inductive approaches are followed iteratively. The aim of abductive approach is to understand and interpret the patterns to develop a conceptual framework to be further examined.

The qualitative research cannot be purely inductive or deductive (Verweij, 2015b). Thus, in part I, inductive and deductive approaches are combined. In this part, first a literature review is performed which lays the foundation for the empirical research (deductive). Next, the opinion of the practitioners is collected on which factors they perceive as the most contributing factor to performance (inductive). In part II and III inductive inference is dominantly applied. The survey questions were developed deductively, building on understanding from previous literature. Next, an inductive analysis is followed in which empirical data serves as the starting point to capture what front-end activities and practices are commonly applied in current practice. The final model is developed inductively through which it is aimed to provide a set of practice-based recommendations for improving the performance of engineering projects.

Now that the strategies and philosophical foundation of the research are elucidated, the next step in the research design is to choose the appropriate research methods.

1.4.2 Research methods

Methodological analysis can be viewed as the "rational reconstruction" of the researcher's thought process, which serves as the logical skeleton of the procedure of testing the new ideas or creating knowledge (Müller & Söderlund, 2015; Popper, 2005). Typically, three types of research approaches of inquiry can be distinguished: quantitative, qualitative and mixed methods. Quantitative methods condense the data in order to see the big picture, whereas the qualitative methods focuses on events, processes, perceptions of the people and enhancing the data (Neuman, 2002). When conducting the quantitative methods, usually the researcher has very limited contact with the people being studied, whereas in performing the qualitative methods, active involvement in the social world is needed (Blaikie, 2009). Quantitative methods entail instrument-based questions, statistical analysis, statistical interpretation, and measuring the objective facts. Qualitative methods involve open-ended questions, themes and patterns interpretation, and subjective assessment of attitudes (Creswell, 2013; Neuman, 2002). Usually data used by social researchers begins in a qualitative form and then transposes into quantifiable measures (Blaikie, 2009).

In an ideal research design, mixed methods approach is used (Creswell, 2013). In mixed methods research the qualitative and quantitative methods are integrated and complementing each other allowing for richer insights about the studied concepts (Johnson & Onwuegbuzie, 2004). Greene, Caracelli, and Graham (1989) and Tashakkori and Teddlie (1998) identify five main purposes for mixed methods designs: (1) *Triangulation*, looks for convergence, corroboration, correspondence of results from different methods; (2) ***complementarity,*** seeks elaboration, enhancement, illustration, clarification of the results from one method with the results from the other methods; (3) ***development,*** uses the methods sequentially in order to employ the results from one method to guide the other method; (4) ***initiation,*** discovers paradoxes, contradictions, new perspectives; and (5) ***expansion,*** mixed methods can be used to extend the breadth and scope of a project.

When conducting a mixed methods research three criteria should be considered (Creswell, 2013):

- The timing of the use of collected data (sequential or concurrent);
- The relative weight of qualitative and quantitative approaches (equal or unequal weight);
- The approach for mixing qualitative and quantitative data (merging data during interpretation or analysis, embedding data at the design level, or

connecting one form of data analysis to the other one).

Given the nature of each research sub-question in this dissertation, either a qualitative or quantitative research approach is used that is fitted to the objective of that specific sub-question. Therefore, a sequential mixed methods research design is followed.

Following Blaikie (2009), the next step in the development of research design is the selection of research methods and data collection techniques. The main research method used in each part is summarised in Figure 1.3 and it is explained below.

Part I: After introducing the topic in this introduction chapter, phase I of the research starts with an extensive literature review on the potential factors influencing project performance. This serves as the starting point for the empirical study using Q-methodology combining both qualitative and quantitative approaches. The aim is to understand the subjective view of the practitioners on those identified factors from the literature and how they do experience the importance of these factors in their projects. The findings of this study provide an answer to the ***first research sub-question***. In order to answer the ***second research sub-question*** and compare the practitioners' viewpoints across the construction sector and process industry, the study using Q-methodology is extended to 108 respondents. The results reveal what practitioners in each sector perceive as the focal point when managing their projects.

Part II: With the survey study performed in part II, the focus shifts from the subjective view of the practitioners to what front-end activities and project management principles are commonly performed. A link is also made between these applied project management practices and project performance. A total of 104 projects are both quantitatively and qualitatively assessed to answer the ***third sub-question*** and to identify those project management practices which are typically applied or not applied in the construction, infrastructure and process industry projects. Cross-sectoral analysis is also performed to compare the intensity of application of those practices. Thus, for answering the ***fourth sub-question***, multivariate analysis is performed. To answer the ***fifth sub-question*** Necessary Condition Analysis (NCA) was used to identify the extent to which those typically applied front-end activities and project management principles are necessary for high levels of project performance. Next, the ***sixth research sub-question*** considers how these patterns associated with high performance can be explained in the total dataset as well as per sector. For conducting this sub-study Qualitative Comparative Analysis (QCA) is used.

Part III: From the previous sub-studies, a set of observations is gathered which resulted in the development of the Nexcess model. Representatives from each sector further evaluated this model. With this model, the ***seventh research sub-question*** is addressed dealing with the applicability of the results in practice with the aim of improving the performance of engineering projects.

1.5 Research in project management

After presenting the research design followed for this dissertation based on the general research approaches in social science in Section 1.4, this section explains how the current research positions itself in the project management body of literature.

Classically, research in project management has been divided into hard systems thinking and soft-systems or multi actor approach (Winter, Smith, Morris, & Cicmil, 2006). However, some researchers (Blomquist et al., 2010), criticise that project management research does not have sufficient emphasis on practice-based approaches and there is a need to explore more in-depth what is actually being done by practitioners. Following this critique, three perspectives can be distinguished (Blomquist et al., 2010; Engwall, 2003; Jarzabkowski, 2004; Söderlund, 2002, 2004):

- **Systems thinking:** This perspective focuses on hard systems thinking, with a top-down and system-model-based approach. It emphasises systems design, tools, methods, procedures and attempts to forecast the behaviour of the practitioners in the project by providing a set of best practices, guidelines and various bodies of knowledge such as PMBOK (PMI, 2017) and PRINCE2 (TSO, 2009), Construction Industry Institute (CII, 2011) and APMBOK (APM, 2012).
- **Process-based:** This perspective mainly focuses on processes in the project and the "relationship between past, present and future". It aims at understanding projects while acknowledging and applying the organisational theories and organisational behaviour frameworks. In this sense, it considers the complexity of projects as social processes and the epistemology used in this perspective is mainly objectivist.
- **Project-as-practice:** In explaining this research perspective three concepts are considered: praxis (actions of individual actors in the project in a given situation), practitioner (person who conducts the praxis) and practices (rules, norms, traditions, or bodies of knowledge, either explicitly or implicitly, guiding the behaviour of the practitioners in a given situation). These concepts are highly interwoven with each other. Practice-based research focuses on how knowledge and action are applied in practice. It investigates how real people solve real problems and it seeks the reasons behind those actions rather than comparing their actions based on the corporate or model-based principles.

Table 1.2 (Blomquist et al., 2010; Lalonde, Bourgault, & Findeli, 2010) presents an overview of these different perspectives in project management research.

Table 1.2: Different perspectives in project management research (Blomquist et al., 2010; Lalonde et al., 2010)

Research perspective	**Systems thinking**	**Process-based**	**Project-as-practice**
Focus	Focuses on structures, tools and procedures and how they can be managed	Emphasises on the processes and how they relate to the structure	Investigates how practitioners act in their own praxis and how they translate practices and principles to their own situated circumstances
Empirical approach	Top-down	Past, present, future	Bottom-up
Ontology	Determined	Intersubjective	Intersubjectively situated
Epistemology	Objectivist, mainly positivist	Objectivist/ subjectivist	Subjectivist
Dominant methodology applied	Mostly quantitative methods	Mostly qualitative methods such as interviews and document reviews	Mostly qualitative methods such as ethnography
Theorisation	Prescriptive theories of project management practice	Interpretive framework (e.g., sociological theories of project management practice)	Situated, pragmatist theories of project management practice

The distinctions between systems thinking and process-oriented approaches can also be described as “being” versus “becoming” ontology, where the “being” ontology itself is not regarded as a wrong or unhelpful approach in project management research (Winter et al., 2006). Systems thinking only partially views and describes the reality without looking into processes, human interactions and activities (Linehan & Kavanagh, 2006). Although the process-oriented approach pays special attention to the human elements in projects, it puts emphasis on the processes without presenting a bottom-up analysis of the individual actors who actually perform the project (Blomquist et al., 2010). Hence, the modern stream of project management research focuses on the last perspective (project-as-practice) to see how practitioners actually translate the tools and processes in their own local circumstances and combine the ‘global’ and ‘local’ views. The practice perspective has a bottom-up approach and focuses on what is done and based on this observation, it creates the understanding of larger contexts (communities rather than organisational units) (Blomquist et al., 2010). Klein et al. (2015) argue that projects are social systems that non-linear and dynamic aspects of practice and human actions should be considered. This requires the application of more reflective practices and context-specific transformation of old experiences into expert action (Crawford, Morris, Thomas, & Winter, 2006; Klein et al., 2015). This new research direction in project management, where the concept of praxis and context-dependent judgements have become the focal point in the realm of actuality of a project, can be also followed in the work of other scholars (Cicmil, Williams, Thomas, & Hodgson, 2006; Crawford et al., 2006; Lalonde et al., 2010; Townsend & Gershon, 2020).

The current dissertation starts (Chapter 2, Chapter 3) and ends (Chapter 7) using a qualitative approach focusing on the individual and subjective opinion of the practitioners in their own context. Therefore, these chapters follow a “project-as-practice” approach. Part II of the study (Chapter 4, Chapter 5, and Chapter 6) focuses mostly on the project management practices performed and how they do relate to the performance. Combining qualitative and quantitative approaches to study these processes and their relationship with the project outcome resembles the “process-based” approach.

Now that the research objective, questions, research design, and position of the study in the project management research have been presented, in the next section the relevance of the study for science and practice is discussed.

1.6 Scientific and practical relevance

The study aims at providing a knowledgebase for both researchers and practitioners in the field of managing engineering projects. In this section, the contribution the current thesis intends to provide to the field of project management is presented.

In this thesis, it is not claimed that the performance of projects in the construction, infrastructure and process industry is intrinsically low. Rather, from what is observed from current practice (Chapter 5 and Chapter 6), the performance of such projects is relatively high. The aim, however, is to focus on those high performing projects to investigate what can be learned from their practices. Therefore, the starting point of this thesis is to investigate all those factors contributing to high project performance, usually tagged as success factors in the literature. Earlier studies on project success factors are, however, criticised for their lack of clarity on the exact definition of the factors, proportion of the success to be explained by these factors (Fortune & White, 2006; Zwikael & Globerson, 2006), and the binary view on merely presence or absence of these factors for interpreting the success (Joslin & Müller, 2015). Hence, the contribution of this research is to bring new methodologies in the evaluation of engineering projects. More specifically, applying NCA (Chapter 5) and QCA (Chapter 6) to the evaluation of those project management practices brings fresh perspectives. This is also in line with the argument of Müller and Söderlund (2015) advocating that the researchers move towards a more practitioner-oriented research in project management, incorporating more creative research approaches.

The practical contribution of this thesis is to apply the results of project evaluations into next projects in order to improve the performance of these next projects. In this sense, the research would follow the same line of reasoning as in the research of Verweij (2015b). In his research on infrastructure projects, he argues that projects are situated in a specific pattern of local conditions and a set of generic developments. He claims that finding these combinations can shed light on understanding “*ex-ante”* how a project should be executed and, to some extent, *“ex-post”* what leads to certain project outcomes. Projects in a specific sector also share some local conditions, which make their management unique. Therefore, in the current thesis, it is explored how project management practices in each industry sector are performed and how they link to the performance of those projects. In addition, those cross-industry evaluations facilitate a basis for the exchange of “fit practices” that are commonly applied in a specific sector and can be adapted to the other sector.

Moreover, as explained in Section 1.2, evaluation can be performed with the aim of contributing to improvement of the current practice. The current thesis also evaluates the practice to explore the extent to which it is in line with what is prescribed by the academic community. The current stream of project management research emphasises the role of integration and bringing different parties together, specifically during the front-end phase. The thesis investigates the applicability of such integration in engineering projects. The thesis enables project managers to get an overview of those project management practices required for high levels of project performance. Awareness of those practices would help in catering the practitioners to jointly understand what is needed for their projects and how they can exert a mutual effort to address them.

1.7 Outline of the dissertation

As explained in Sections 1.3 and 1.4, the dissertation consists of eight chapters, divided into three parts. The outline of the dissertation including the methods used and position of the chapters in each part, the research sub-question(s) that is dealt with in each chapter, content, and main deliverables are displayed in Figure 1.3.

Part I: The results of the literature review and the perspective of the practitioners on factors leading to performance, using the Q-methodology, is presented in Chapter 2. Further in Chapter 3, those perspectives are compared across the main two sector groups: construction and process industry.

Part II: The second part of the research comprises three chapters presenting the result of the survey study. In Chapter 4, the overall project management practices applied in the engineering projects are analysed together with a cross-sectoral analysis of those practices. Next, the relationship between the application of these practices and high project performance are explored in Chapter 5 (necessary conditions) and Chapter 6 (sufficient conditions per sector).

Part III: In Chapter 7, findings from the previous two phases are merged to develop a practical model (Nexcess model), to be used by practitioners. To enhance the practicality of the model, it is evaluated by experts, the results of which are presented in the same chapter. In the last chapter (Chapter 8), the final discussion, conclusions, and practical as well as scientific recommendations are presented.

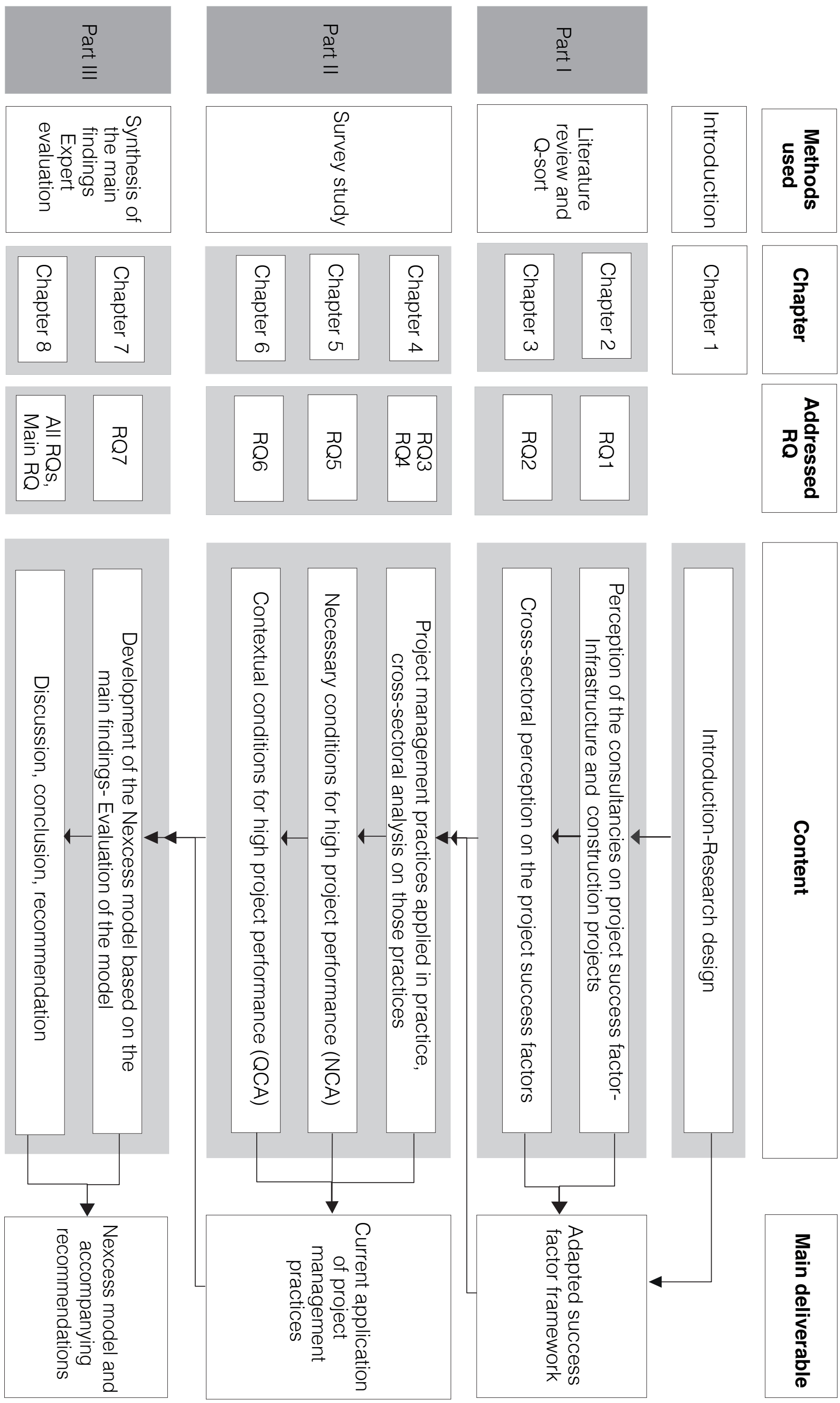

Figure 1.3: PhD research outline

Part II

Identifying and aligning the viewpoints

Chapter 2

Extending the view on project performance

This chapter is published as an article

Adm. Sci. **2019**, *9*(3), 65

Abstract

The main aim of this chapter is to gain insights into project management professionals' perception of how project success can be achieved. The Q-methodology was followed in this research. Based on an extensive literature review and validation through expert judgment, a framework consisting of 33 factors increasing the likelihood of success was developed. A total of 34 practitioners in three different sectors (real estate, urban development, and infrastructure) in the Netherlands were asked to rank the statements contributing to the success of their projects. Four different perspectives of how project success can be achieved were distinguished in this study: "seeking the best match", "being adaptive and open", "keeping the team focused", and "preparing for opportunities". The perception of different practitioners of how success can be obtained may stem from factors of project context rather than sector and complexity. This highlights further research opportunities in taking a contingency approach when investigating project performance. The study helps to grasp the subjectivity of practitioners' viewpoints regarding the potential ways to enhance project performance by understanding the similarity and differences of these viewpoints.

2.1 Introduction

Project success is among the most researched topics in project management literature. Although there is a vast amount of studies which provide an in-depth investigation of project success, there is no consensus on different aspects of it (Davis, 2016). There are different approaches in investigating project success including statistical analysis of success where success is studied objectively (Tabish & Jha, 2011; Toor & Ogunlana, 2008). Another approach is to investigate project success subjectively. Not all the stakeholder groups perceive the project's success in the same way (Davis, 2014; Turner & Zolin, 2012). Koops, van Loenhout, Bosch-Rekveldt, Hertogh, and Bakker (2017) note that different project managers working in public projects have different perceptions of how project success can be measured (i.e., success criteria). In this regard, they distinguished three perspectives: the holistic and cooperative leader; the socially engaged, ambiguous manager; and the executor of top-down imposed assignment. This research takes another step toward understanding how different perspectives of various ways to achieve project success—in other words, project success factors—can be framed. Therefore, this study aims to answer the following research question:

What are practitioners' views on obtaining good project performance?

What is often overlooked in the literature is the importance of the project context and its effect on how a project is managed. Ika and Donnelly (2017) acknowledge the awareness of the project context and claim that without that knowledge, success factors cannot be transferred properly in practice. The present study contributes to the field of project management by providing an approach to identifying different viewpoints on what factors might increase the chance of a successful project outcome. The assumption is that practitioners performing projects in the same sectoral context might have a common perspective. An earlier version of this study was presented at the IPMA world congress 2017 (Molaei, Bosch-Rekveldt, & Bakker, 2017) and it has been further advanced, resulting in the current chapter.

The chapter is structured as follows. First, the relevance of the concept of success factors is explained in Section 2.2. The procedures followed for the development of the framework used in this study are covered in Section 2.3. The methods applied in this research are explained in Section 2.4. Next, the findings of the Q-study and data analysis are explained in Sections 2.5 and 2.6. In Section 2.7 the research contributions are discussed followed by the suggested research agenda in Section 2.8. The findings provide a new approach to identifying how achieving a successful project is perceived by practitioners.

2.2 Literature review

The questions of how project success can be measured (success criteria) and how success can be achieved (success factors) are widely elaborated in the literature.

However, these two notions are still used interchangeably (Davis, 2017). This section presents the results of a literature review into success criteria and success factors and closes a gap regarding the inclusion of contextual factors. To investigate this gap, a success factor framework is developed in the next section.

Cooke-Davies (2002), in his study, identified 12 real success factors in projects at three different levels: project management success, success of an individual project, and consistent project success. Westerveld (2003) in his Project Excellence Model claims that success factors (or the so-called organisational areas in this model) should be tailored to the goals of the project and external factors including project manager and his team, project characteristics, parent organisation, and external environment. In addition, his model reveals the relationship between success factors and criteria.

Another remarkable article on success factors is the study of Fortune and White (2006), where 63 publications were reviewed resulting in 27 critical success factors (CSFs). They showed that little agreement on these factors existed among scientists. Among these 63 publications, the 6 most cited factors are: support from senior management, having clear and realistic project goals, efficient project plan, good communication and feedback, client involvement, and skilled and sufficient project team. This model does not explicitly incorporate success criteria, which makes it unclear what the relation is between these success factors and project success criteria.

Toor and Ogunlana (2008) categorised the critical success factors for large construction projects based on the perception of project professionals into four main groups: comprehension, competence, commitment, and communication. Cserháti and Szabó (2014) defined success criteria and factors of organisational event projects. The study revealed that success factors can be classified into five groups, namely, project management processes, project resources, project team, organisational culture, and communication and co-operation. They also analysed the relationship between these factors and success criteria.

All these studies attempt to classify the success factors either by extending the work of previous researchers or by developing a new framework which is specific to their own research (Costantino, Di Gravio, & Nonino, 2015). However, most of these studies focus on identifying success factors in one specific sector, and the role of the sector as a project contextual variable is overlooked. There is a knowledge gap in the project management literature regarding what success factors are most influential in a specific sectoral context.

Since there is a large (scientific) literature available on the factors contributing to project success, in this study we conducted an extensive literature review on this concept. Next, it is explained how the framework to be used for the Q-sorting was developed.

2.3 Framework development

SCOPUS was used as a database in order to investigate the concept of project success in a broad sense. The selection of the Scopus database was based on the fact that Scopus is one of the most comprehensive literature databases, covering a wider journal range compared to other databases such as Web of Science (Falagas, Pitsouni, Malietzis, & Pappas, 2008; Ma, Schraven, Bruijne, Jong, & Lu, 2019; Pelz, 2019). The authors explored the literature through screening the title, abstract, or keywords of the papers having the following terms: ("success factors" OR "critical success factors" OR "success determinants" OR "success criteria") AND ("project" OR "project management"). For success criteria, earlier research results were applied; however, the search results for the query on success factors did (partially) include literature on success criteria (Subsection 1.1.1).

The focus was particularly on relatively new literature in the field of project success published from 2000 onwards in order to find new developments in the area (this part of the research was performed in August 2016). These "recent" articles often referred back to older articles, which were included in the study as well if considered relevant. In this search, only journal articles were included because of their generally accepted scientific value (due to a stringent peer-review procedure). The following 9 journals were selected to ensure a broad range of various fields of managerial issues in project organising, including project management and construction management: International Journal Of Project Management (IJPM), Journal Of Management in Engineering, International Journal Of Managing Projects In Business (IJMPB), Engineering Construction And Architectural Management (ECAM), International Journal of Project Organisation And Management (IJPOM), Journal Of Construction Engineering And Management, Construction Management And Economics, Project Management Journal (PMJ), and European Management Journal (EMJ).

Initially, the database returned more than 223 hits. No refinement was made based on the number of citations. Next, the table of contents, keywords, and abstract of each of the articles were carefully reviewed. The filtering was applied, and those articles having the most relevance to success factors in the context of project management were selected. For authors who wrote several related articles, the most influential article was chosen. This filtration resulted in 78 articles. The selected articles were not limited to a specific industry nor to the methodology used in the study in order to have a comprehensive view of the concept of project success factors. Finally, inductive content analysis of the selected articles was performed to identify and code the success factors. The stages followed for the literature review are presented in Figure 2.1.

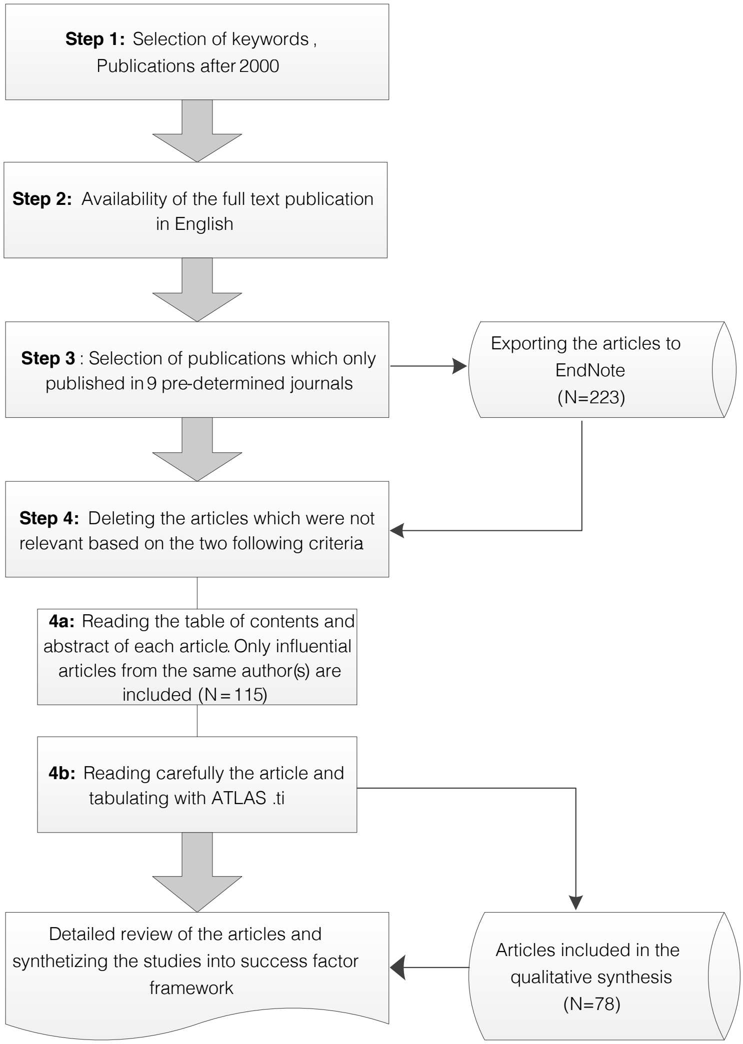

Figure 2.1: Stages followed for the literature review

In order to classify these factors, a qualitative content analysis was applied as a tool for qualitative data analysis and categorisation. The literature review yielded 153 distinctive sub-success factors. Since the literature review ignored the most recent developments, the framework was refined using expert evaluation including academic and industry experts (three from each sector). Based on this expert judgement, a category “modern project management” consisting of three factors was added to this framework, incorporating opportunity management, integrated approach, and adaptive project management. Moreover, the factor project manager early involvement and continuity (derived from the literature review) was removed, and two additional factors were incorporated: active involvement of users and active involvement of external stakeholders. Eventually, a final framework of 33 success factors clustered into 9 categories was developed, using the Project Excellent Model of Westerveld (2003) (see Table 2.1). The colour and pattern used in the third column refer to the colour and pattern per category of success factor in the figures presented in Section 2.5 (results from the Q-study).

Table 2.1: Success factors framework that resulted from a systematic literature review and expert judgment

Category of Success Factors	No.	Corresponding Colour/Pattern	Statement (Success Factor)
Project characteristics	1		Awareness of project nature
	2		Awareness of project external factors
	3		Clearly defined scope
Project management process	4		Project management methodology
	5		Level of emphasis on quality (product/process)
	6		Monitoring and control
	7		Information sharing within the project team
	8		Risk management
	9		Environmental and sustainability considerations
	10		Learning from current and past experiences
	11		Health and safety considerations
	12		organisational structure
Contracting	13		Selection of contracting strategy and tender process
	14		Contract management
	15		Proper selection of project execution resources
Leadership and team	16		Top management support
	17		Competent project manager
	18		Competent/multidisciplinary project team
	19		Collaboration between project parties
	20		Training provision
	21		Integrated project team (client and contractor)
Stakeholder engagement	22		Early involvement of project parties
	23		Active client involvement
	24		Active involvement of users
	25		Active involvement of external stakeholders
Policy and strategy	26		Clear goals
	27		Project planning
	28		Legal and administrative processes
Modern project management	29		Opportunity management
	30		Integrated approach
	31		Adaptive project management
Resources	32		Efficient use of people and resources
	33		Use of new technology

2.4 Q-methodology

In this section, the research set up for conducting the Q-sorting is elaborated. The Q-methodology was applied to learn the respondents' viewpoints regarding the factors leading to the success of their projects. Q-methodology was invented by Stephenson (1935) as a methodology for factorizing the correlations between persons. Ellis, Barry, and Robinson (2007) argue that the Q-methodology is based on both strict empirical evidence and subjectivity in respondents' viewpoints, which implies that the Q-methodology combines positivist and post-positivist approaches. The Q-methodology is defined as "a technique used for defining and describing shared positions on issues through a combination of quantitative factor analysis and qualitative interpretation" (Price, Saunders, Hinchliffe, & McDonald, 2017). However, it is still considered a qualitative approach (Forrester, Cook, Bracken, Cinderby, & Donaldson, 2015).

The Q-methodology has already been applied in research on various aspects of project management (Cuppen, Bosch-Rekveldt, Pikaar, & Mehos, 2016; Sohi, Bosch-Rekveldt, & Hertogh, 2019; Suprapto, Bakker, Mooi, & Moree, 2015b) and on implementing sustainability in different contexts, including urban planning (Lu, Lin, & Sun, 2018; Silvius, Kampinga, Paniagua, & Mooi, 2017). The Q-methodology appears to have potential in the context of project success factors, since the purpose of this study was to identify different subjective perspectives of the importance of the various success factors.

2.4.1 Q-Set Design

Watts and Stenner (2012) highlight the importance of Q-set items or statements in enabling the respondents to rank these items properly. The result of the literature review on success factors was used in order to ensure that the Q-statements were sufficiently comprehensive. In this study, the assumed influence of the project sector on the perspective of the practitioners was particularly explored. In other words, it was presumed that the sectoral background, as a contextual factor, can influence the sorting of the success factors. Maybe a set of success factors is more important in one specific sector, which also affects the perspective of the respondents in that specific sector.

2.4.2 Respondents

The interviewees were chosen from 13 different Dutch companies specializing in three major sectors: real estate, infrastructure, and urban development. All of these companies are part of BouwRegieNetwerk (BRN), a network aiming to provide a platform for sharing knowledge and experience between the public infrastructure and construction clients/owners. 16 respondents were selected from real estate, 9 from urban development, and 9 from infrastructure, resulting in 34 respondents. Given this diversity, the perspectives of the practitioners in each of these sectors could be compared. The participants were dominantly the project manager or project director (27 out of 34). The majority of them (27 out of 34) can be considered as (very) experienced practitioners with more than 10 years of experience. In the analysis, the respondents were labelled R_Nxx, where xx indicates the respondent's identification code.

2.4.3 Q-Sorting

Face-to-face Q-sort sessions were conducted, where respondents were asked to refer to a reference project that was considered successful. Next, they were provided with a list of statements (33 success factors), presented in small cards and a score sheet. The respondents were asked to sort the cards (success factors) according to their relative importance in terms of contributing to the success of the reference project using the score sheet (see Figure 2.2). The respondents had to comply with a pre-defined semi-normal distribution of the cards (Ellingsen, Størksen, & Stephens, 2010; Van Exel & De Graaf, 2005), prioritising the success factors. The scale used in the score sheet ranged from -3 (least contributing to project success), via 0 (neutral), to +3 (most contributing to project success). Moreover, in order to help to interpret the factors, the respondents were asked to explain their reason for placing the success factors on the extreme ends (±3 and ±2). In addition to ranking the statements, the respondents were asked to rate their recent project in terms of predefined success criteria.

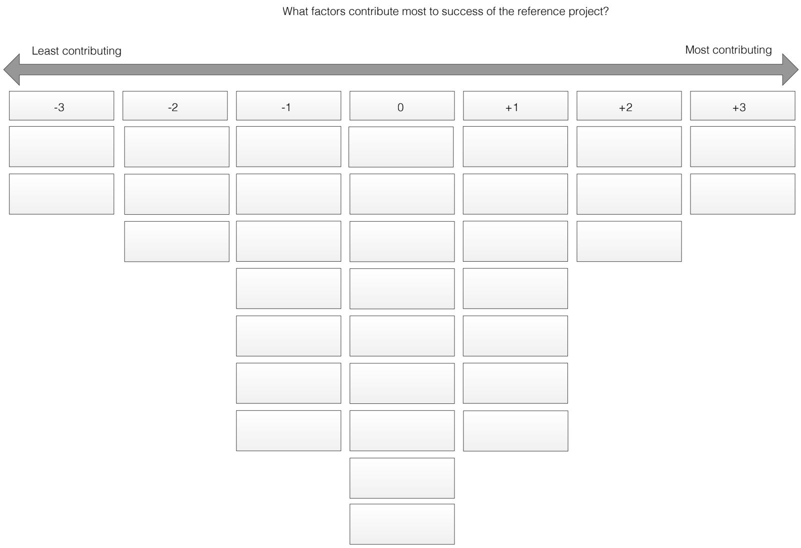

Figure 2.2: Score sheet for Q-sorting

2.5 Results from the Q-study

Before proceeding with analysing the data and extracting different perspectives among the respondents, all the data on how the respondents placed the success factors were compared. Looking at the overall ranking of the success factors, the respondents positioned three of them as the most contributing to project success: *competent project manager*, *collaboration between project parties*, and *competent/ multidisciplinary project team*.

2.5.1 Perspective extraction

The PQ Method 2.35 (Schmolck, 2014), a free analysis tool, was used for conducting factor analysis. With this program package, one to eight factors (groupings or perspectives) can be derived. Researchers have to decide on the number of meaningful factors to include in the analysis, based on two parameters (Brown, 1980; Suprapto et al., 2015b). First, the cumulative explained variance of factors should be more than 50% of the study variance. Second, there are at least two significant Q-sorts loading on the factor. A Q-sort x loads significantly at the 0.05 level (p-value) on a factor y if its factor loading is ±0.34 or more (calculated from $1.96/\sqrt{N}$, where N = 33 is the number statements) and its highest square factor loading explains more than half of the common variance. Based on the result of the analysis, four to eight factors were rotated separately. Four and five factor solutions explained 54% and 60% of the study variance, respectively.

There is no single correct number of factors, and it is up to the researcher to select the best factor solution based on four criteria (Webler, Danielson, & Tuler, 2009): simplicity, clarity, stability, and distinctiveness. "Simplicity" implies that selecting the fewer number of factors makes it easier to understand the viewpoints on each specific factor. "Clarity" means that each respondent should load only on one factor. In reality, some respondents might either load on multiple factors (confounders) or not load on any factor (non-loaders). Confounders have hybrid views, and their views cannot be totally explained by only one factor. Hence, to meet the "clarity" criteria, the number of confounders and non-loaders should be minimised. In this dataset, there were no non-loaders. In the four-factor solution, eight confounders were found, and in the five-factor solution, there were nine confounders. Following the suggestion of Webler et al. (2009) for minimizing the number of confounders, the four-factor solution was preferred. If a certain group of respondents is clustered together when investigating a different number of factors, this means that they do think similarly with regard to the statements. In a best factor solution, "stability" of these clusters should be maintained. Finally, the "distinctiveness" criterion calls for having low correlation between the factors.

The perspectives are labelled on the basis of the shared position of success factors as well as the explanations provided by the practitioners with that specific perspective. Appendix A. 4 presents the Z-scores and the corresponding positions (Q-score values) per perspective. The grey cells show the distinguishing success factors for each perspective which can be compared with the views of other respondents with other perspectives. These distinguishing success factors indicate differences with the significance thresholds of 0.05 and 0.01 p-value levels. For completeness, the factor loadings for the four-factor solution are given in Appendix A. 3 showing which respondent loaded on which factor, including confounders. These four perspectives are discussed next.

Perspective 1 (Seeking the Best Match)

Nine respondents loaded on perspective 1 (P1), which is called “seeking the best match”. Perspective 1 reflects the viewpoint that procurement is the most important factor leading to success of projects. The ranking of the success factors, including five distinguishing factors, for P1 is depicted in Figure 2.3. The respondents emphasised the importance of ***selecting the contracting strategy and tender process*** (13: Pos. +2) and ***proper selection of project execution resources*** (15: Pos. +2). As expressed by R_N16: “The content is basically not provided by the project manager but by the execution parties (advisors). They should have the knowledge and they should have the intention to collaborate effectively with each other”.

Furthermore, the importance that practitioners with this perspective gave to ***clear organisational structure*** (12: Pos. +1) is higher than for other perspectives. The importance of this factor is reflected by R_N19: “without a clear structure, people do not know where they are responsible for and they can hide or do not feel responsible”. The factor ***environmental and sustainability considerations*** (9: Pos. -3) is ranked lower in this perspective compared to P2 and P4. As expressed by R_N02, “Although the project was delivered sustainable and energy-efficient, this does not play a role in project success”.

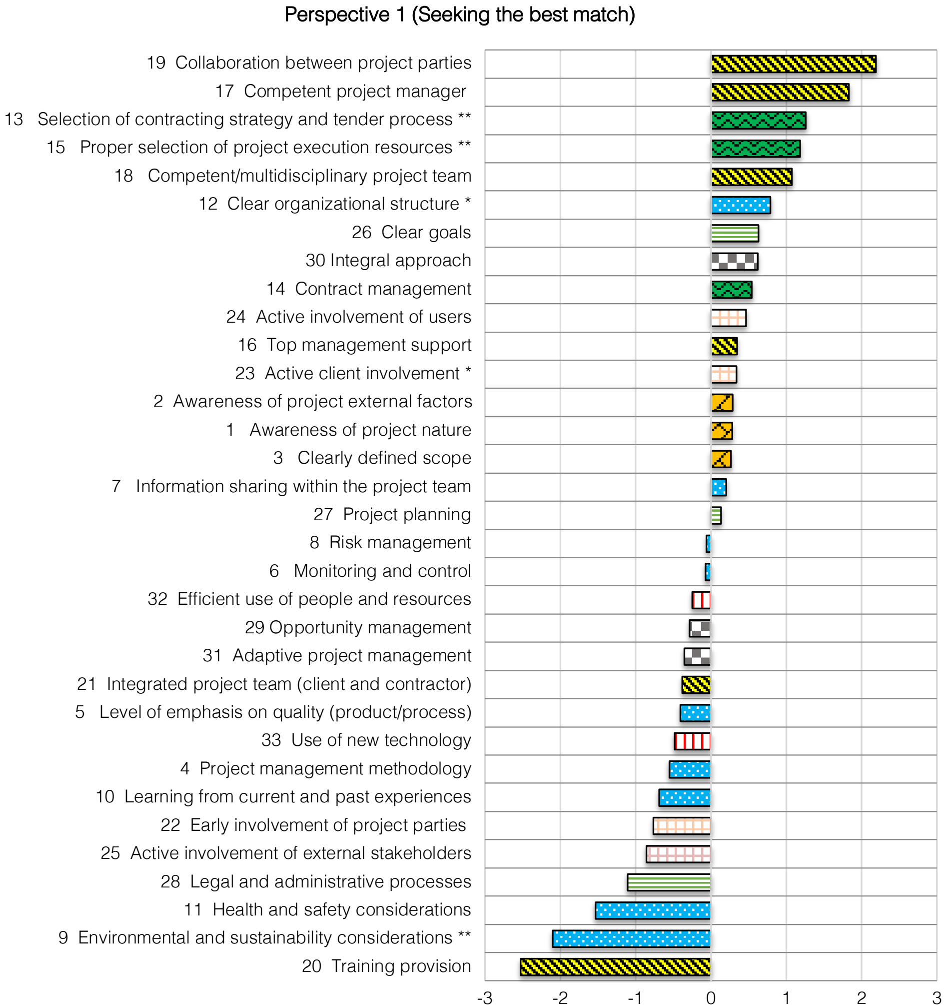

Figure 2.3: Ranking of success factors for seeking the best match perspective (P1)
* Factor is distinguishing at $p < 0.05$; ** The factor is distinguishing at $p < 0.01$.

Perspective 2 (Being Adaptive and Open)

Perspective 2 gathered the largest number of respondents (13). The focal theme of perspective 2 (see Figure 2.4) is the importance its respondents give to ***information sharing within the project team*** (7: Pos. +3) and ***adaptive project management*** (31: Pos. +2) as the enablers of project success. The following argument from R_N31 shows the importance of information sharing: “Collaboration can only be possible when the parties have the required information”. The reflection that collaboration can be enhanced by information sharing can also be inferred from the importance the respondents within this perspective placed on ***collaboration between project parties*** (19: Pos. +1). Another explanation from R_N14 showing that adaptability was a crucial success factor in a reference project is: “The complexity of the current processes and projects calls to be flexible and adaptable. As a result of changes at the organisational level and change of the goals in this project, flexibility is required".

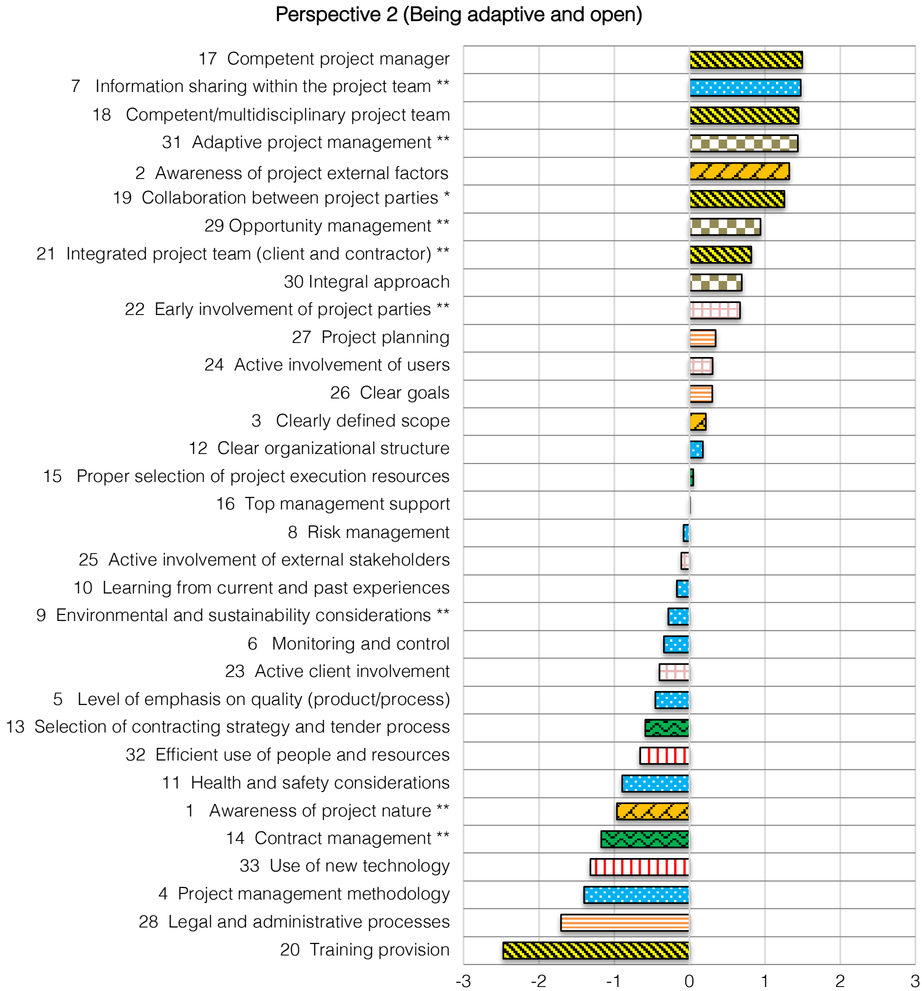

Figure 2.4: Ranking of success factors for being adaptive and open perspective (P2)
* Factor is distinguishing at $p < 0.05$; ** The factor is distinguishing at $p < 0.01$.

Perspective 3 (Keeping the Team Focused)

In perspective 3 (eight respondents), it is evident that team effort is important: a focused project team is suggested to lead to better project performance (see Figure 2.5).

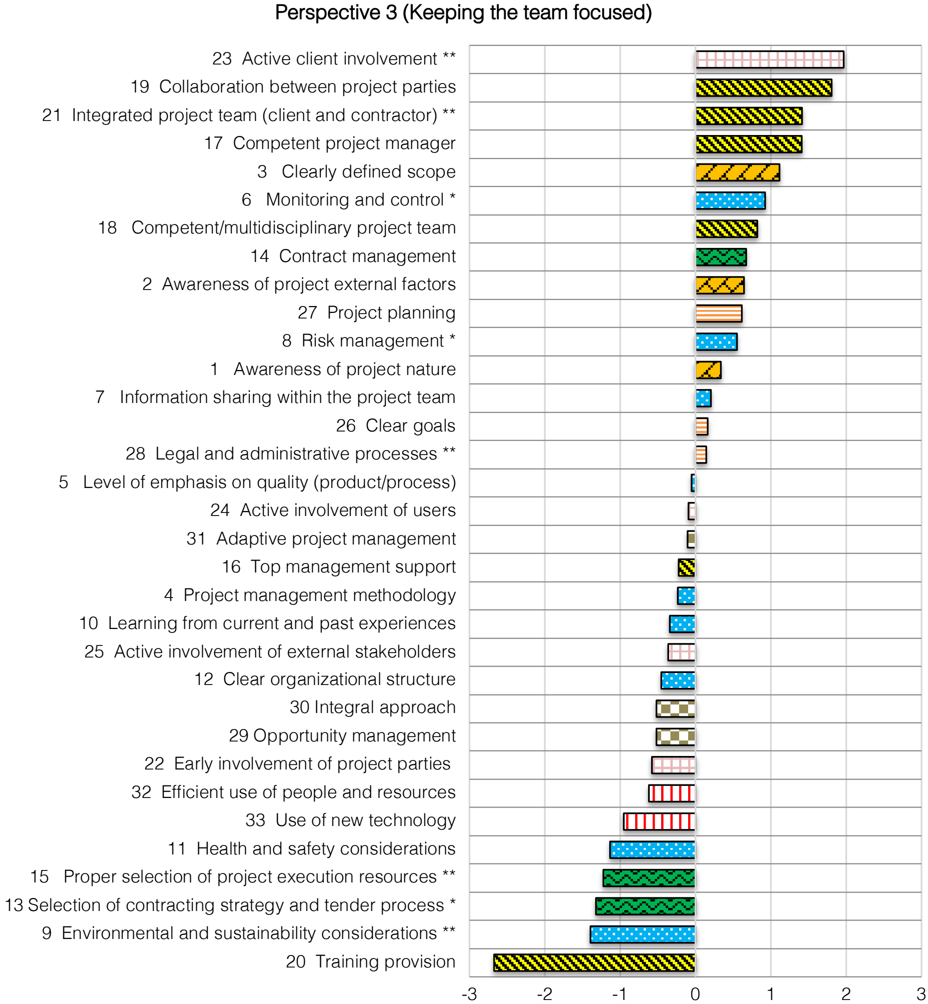

Figure 2.5: Ranking of success factors for keeping the team focused perspective (P3)
* Factor is distinguishing at $p < 0.05$; ** The factor is distinguishing at $p < 0.01$.

In contrast to, particularly, perspective 1, this perspective scored low on the contract-related success factors: ***proper selection of project execution resources*** (15: Pos. -2), ***selection of contracting strategy and tender process*** (13: Pos. -2). ***Active involvement of client*** (23: Pos. +3) and ***integrated project team*** (21: Pos. +2) are the most important success factors. Regarding the importance of the active involvement of the client, as mentioned by R_N28: "The client stands at a large distance, therefore he has no feeling of the project complexity and urgency of the solutions". R_N03 reflected on the factor ***integrated project team*** as follows: "It was important that everybody was directly affiliated with the procedures and the outcomes in order to quickly act". Another explanation was given by R_N22: "There were collaboration and joint agreements on how developments should take place and what should be done". In addition to this emphasis on the team, they believe that rigorous ***monitoring and control*** (6: Pos. +1) of the activities is needed in order to deliver a successful project.

Perspective 4 (Preparing for Opportunities)

Perspective 4 is the perspective with the smallest number of loaders, having only four respondents. This perspective is characterized by placing emphasis on ***opportunity management*** (29: Pos. +3). A practitioner shared his experience with regard to looking for potential opportunities*: "* Support from the stakeholders was very important in the project. They were very diverse and constantly looking for optimisation in that framework*"* (R_N27). Interestingly, the respondents also focused on ***monitoring and control*** activities (6: Pos. +2), which is considered as more "traditional" project management.

This, however, seems contradictory with the first distinguishing statement of ***opportunity management***. Although the factor ***monitoring and control*** scores high, the importance of ***planning*** as such scores very low (27: Pos. -3). Figure 2.6 presents the ranking of the factors given by the respondents within perspective 4. The respondents in perspective 4, in contrast to the respondents in all other perspectives, gave a considerable importance to ***ecological and sustainability considerations*** (9: Pos. +2): *"*The value of development, in terms of both monetary and intrinsic value, gave importance to the project and provided support and connection*"* (R_N17).

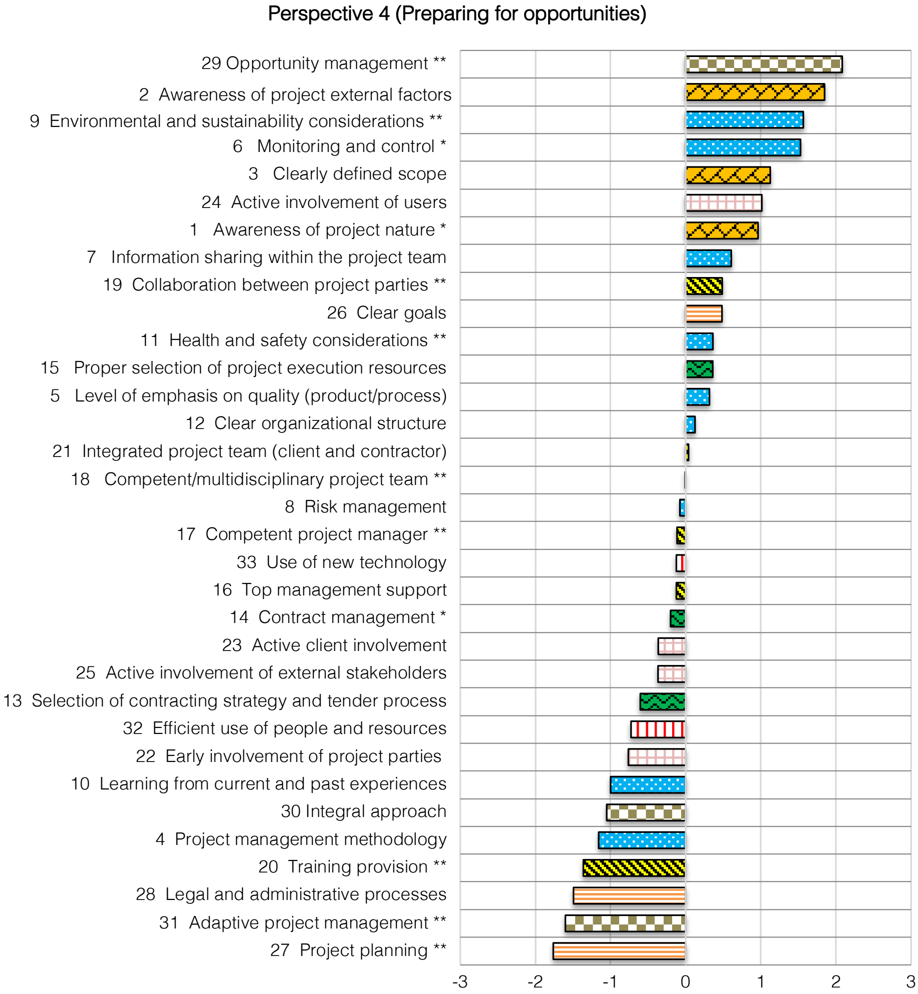

Figure 2.6: Ranking of success factors for the preparing for opportunities perspective (P4)
* Factor is distinguishing at *p* < 0.05; ** The factor is distinguishing at *p* < 0.01.

2.5.2 Relation to specific project characteristics or profile of the respondents

The delineation of the perspectives does not show that practitioners from the same sector might perceive the relative importance of success factors in the same way (see Appendix A. 1 for the profile of the respondents). Next to the project description and sector, some background information from the respondents was collected. This included educational background, years of working experience, role in the project. To further explore the significant project characteristics that might be shared across the perspectives, the respondents were asked to evaluate the performance of their projects. The project performance was measured in terms of 11 criteria or indicators. These criteria were based on the study of Yan, Elzarka, Gao, Zhang, and Tang (2018), which identified five dimensions of project success criteria based on a literature review: iron triangle, commercial success, stakeholders' satisfaction, organisational benefits, and system view. Iron triangle criteria are the most commonly used measures, which assess the project in terms of meeting time, budget, and quality constraints (de Wit, 1988). Assessing the project success merely on the basis of the iron triangle is inadequate (Turner & Zolin, 2012); therefore, the commercial profitability of the project should also be taken into consideration (Shenhar et al., 2001). The dimension of stakeholder satisfaction measures the extent to which stakeholders are satisfied with the project (Davis, 2016). The organisational benefits dimension addresses the impact which the project may have on the organisation by providing business success and strategic benefits (Shenhar et al., 2001). In the system approach, all project success dimensions are integrated by considering the interrelations between these dimensions (Yan et al., 2018).

Hence, in the current study, 11 success criteria were adopted and grouped into three categories of stakeholder satisfaction, iron triangle, and beyond iron triangle (see Appendix A. 2). The category of stakeholder satisfaction considers the satisfaction of various stakeholders including end user, client, team, contractor, and external stakeholders. The beyond iron triangle category measures the project success in terms of the criteria of safety, long-term impact, and flawless start-up.

The respondents were asked to rate these criteria based on a five-point scale (1 = Not successful to 5 = Very successful). The Kruskal–Wallis test was used to see which perspectives were significantly different from each other with regard to success criteria and working experience of the respondents with that specific perspective. The reason for choosing a non-parametric method was that these tests work on the principle of ranking the data (Field, 2009), not requiring normally distributed data. If the p-value is less than or equal to the significance level (alpha level, typically 0.05), it can be concluded that the distribution of the independent variables (here, project characteristics, background of the respondents, and performance indicators) are not the same across different samples (here, the four perspectives that we identified). The Kruskal–Wallis tests cannot indicate which set of perspectives are different from each other. As a result, Dunn–Bonferroni post-hoc method was performed, for the significant results, to compare pairs of perspectives with each other. Table 2.2 shows the significant outcomes from the pairwise comparison based on the Kruskal–Wallis test.

Table 2.2: Significant results from the pairwise comparison

Characteristics	Pairwise Comparison	Significance	Adjusted Significance
Success criteria: end user satisfaction	P2 - P4	0.004 *	0.024 *
Success criteria: end user satisfaction	P3 - P4	0.020 *	0.121
Working experience	P2 - P3	0.011 *	0.069
Working experience	P2 - P4	0.020 *	0.122

* The pairwise comparison is statistically significant at the level of 0.05.

The resulting p-values that were statistically significant were adjusted according to the Bonferroni correction which considers the influence of multiple testing (IBM, 2016). Because of the availability of only a small sample size for each perspective, the pairwise comparison for the Kruskal–Wallis test could be considered statistically significant only for one set (P2 - P4). However, the Bonferroni correction was considered rather conservative for this analysis. As a result, the characteristics were examined qualitatively by looking more in depth at all the four pairwise comparisons.

The end user satisfaction criterion was considered the lowest for P2. None of the respondents with this perspective ranked the project as very successful in terms of end user satisfaction. For P4, however, three (out of four) respondents ranked this criterion as very successful. Regarding working experience, young professionals seemed more attracted by P2 (see Appendix A. 1).

2.6 Perspectives compared

In this section, the z-scores and the corresponding position of the distinguishing success factors amongst the perspectives are compared. Figure 2.7 plots the relative importance of the success factors per perspective and compares what category of success factors is overrepresented or underrepresented in which perspective. At first glance, “contracting” is stressed by P1. When looking at P2, it ranks one factor from “modern project management”, adaptive project management (31) and one factor from “project management process”, information sharing within the project team (7), much higher than other perspectives. It appears that, from the viewpoint of P3, “contracting” is relatively less important compared to other perspectives. This perspective also puts emphasis on factors within “leadership and team”, “stakeholder engagement”, and “policy and strategy”. Finally, the last remark is that P4 focuses on the two categories of “project management process” and one factor from “modern project management”. The categories of “leadership and team” and “policy and strategy” scored relatively low for P4 compared to other perspectives. Across all four perspectives, the category of “resources” scored almost equally. Therefore, this category was further removed from the comparison of the perspectives on the position of their distinguishing success factors explained in this section.

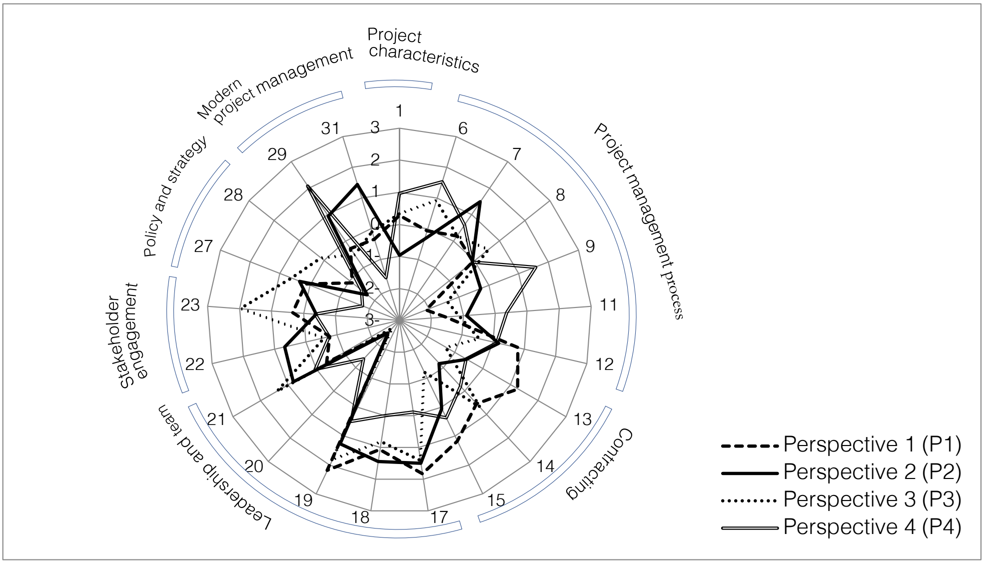

Figure 2.7: Comparing distinguishing success factors and categories across perspectives

Looking more precisely at the overall data and success factors, some observations were made. The success factor environmental and sustainability considerations (9) is the only success factor, which is distinguishing for all the identified perspectives, but its relative importance is different across perspectives. P4 ranked this factor much higher than other perspectives, which is evident in the explanation of R_N17: "Due to these considerations on the value development, project becomes important, and this provides support and connection". On the contrary, P1 and P3 ranked this factor as one of the least success enablers, and R_N10 expressed that "Sustainability was neglected due to the tight budget".

Risk management (8) scored equal, around 0, except for P2 which ranked this factor higher than other perspectives (+1). For P3, the project success can be achieved by having an integrated project team (21). Regarding the importance of this success factor, P2 had relatively the same view. R_N18 asserted that "Due to an integrated project team, the tension between the organisations was automatically eliminated by the chosen approach". P1 perceived the integrated project team as the lowest contributing success factor compared to other perspectives.

The success factor proper selection of project execution resources (13) scored the highest for P1, and this factor got the lowest rank from P3. This difference in views can be explained by the statement from R_N19: "The execution team should do the work. Even if steering is good, without proper party, success cannot be obtained". However, according to P3, collaboration within the real integrated team is more important because "the shared interest was exploited" (R_N13).

The influence of contract management (14) in achieving project success was perceived as the least important factor by P2. This is reflected in the statement of R_N33: “There was a high trust in the execution parties”. This indicates the focus on relational governance rather than on formal contracts. P1 and P3 placed this factor higher than other perspectives. Since the focus of the latter perspective is on team-related activities, one might expect that formal contract management as such might also rank low for P3. In the view of P3, relational governance cannot be substituted by formal contractual governance, although an integrated project team is important. Active client involvement (23) is another factor on which P2 and P4 agreed that it does not contribute to project success. On the other hand, P3 disagrees with P2 and P4 and underlined the role of the client.

As can be seen from Appendix A. 4, the perspectives scored three factors more or less equally in this study (from -1 to +1): top management support, having clear goals, and efficient use of people and resources. These statements do not contribute to the different viewpoints of the perspectives regarding success factors.

2.7 Discussion

This chapter provides an approach to understanding how practitioners value different success factors. Price et al. (2017) express that the application of the Q-methodology is twofold. First, different positions of the statements can be explored. Second, insights can be gained about how particular statements are perceived in relation to other statements. Even the top-ranked success factor collaboration between project parties is ranked differently by different perspectives.

The research findings provide important practical managerial insights into the field of project management. The proposed approach can be applied by the practitioners in a project team to understand what factors are regarded as important for a successful project outcome. These factors show what aspects practitioners tend to focus on. The practitioners can even use the Q-methodology as a toolbox (Cuppen et al., 2016) in different stages of the project to identify different perspectives within their own project team. Recognizing these perspectives might help the practitioners to understand the differences and similarities on key contributors to project success within the team. This will help them to better align to the value drivers of the project. In addition, as it was explained in Section 2.5, three top-ranked success factors across the perspectives were: competent project manager, collaboration between project parties, and competent/multidisciplinary project team. This results into an important managerial implication: the existence of these factors is crucial for achieving project success, irrespective of the perspectives taken. Therefore, practitioners should focus on these soft factors in their projects.

The main aim of this research was not only to explore different viewpoints on the relative importance of success factors, but also to explore sectoral differences which could not be proven on the basis of the current dataset. The research was exploratory by nature and has some limitations which suggest some directions for further research. The empirical data gathered, both success factors and success criteria, relied on the perception of the respondents (subjective data). Further research could be a survey study, collecting objective data regarding the success factors and success criteria of a project.

In this research, the respondents were asked about the overall project (lifecycle) and not specifically about what success factors are most contributing in a specific project phase. The stage of the project might affect the perspectives of success factors. Hence, it will be interesting to see how the perspectives might develop over time.

This study only focused on three sectors: real estate, urban development, and infrastructure. It would be beneficial to replicate the results of this study by extending the suggested approach to projects in other sectors. It is also suggested to examine the practitioners' views on success factors in different project contexts by considering other contextual factors rather than sector, such as project governance.

2.8 Concluding remark and next step

An extensive literature review of academic papers, published from 2000 onwards, was performed to obtain a holistic view of project success factors. This formed the basis for conducting the Q-sorting. The Q-methodology was applied to reveal the diversity of the practitioners' perspectives of the most contributing success factors in three different sectors, namely, urban development, real estate, and infrastructure. From the analysis of 34 Q-sorts, four distinctive perspectives of the relative importance of the 33 success factors were revealed: "seeking the best match", "being adaptive and open", "keeping the team focused", and "preparing for opportunities". For the first perspective, the factors relating to procurement were emphasised. The practitioners with the second perspective valued the information sharing and being adaptive. Perspective three noted that having a focused project team is more important than other factors. In the view of perspective four, identifying opportunities contributes most to project success. Overall, the findings suggest that the perspectives of success factors place more emphasis on soft factors, especially on the competences of the people who actually perform the project and on the interactions between them. Still, the traditional view of managing projects by closely monitoring them exists. However, in order to improve project performance, the practitioners dominantly tend to pay more attention to the soft aspects.

The Q-methodology not only takes into account different views of exploratory variables but also statistically provides a position of the statements (Price et al., 2017). From this study, there is no evidence that the practitioners in one specific sector might share a common perspective of how to achieve good project performance. It could be that the three sectors in this study (real estate, infrastructure, and urban development) share some characteristics such as the typical stakeholders involved or political influences. Hence, a broader cross-sectoral analysis is required to compare these sectors with other, maybe more different, contexts. This provides the basis for next chapter. Chapter 3 further investigates and compares the common patterns of project management practices contributing to success across two main industry sectors: construction and process industry.

Chapter 3

Cross sectoral analysis of project practitioners' perceptions

Part of this chapter was presented at

EURAM Conference 2018, Reykjavik, Iceland

Abstract

In this study, a cross-sectoral analysis between construction sector and process industry was performed where data was gathered from 108 practitioners divided over three datasets. Using the Q-methodology, the perspectives of the practitioners in each of these datasets were identified, followed by a meta-analysis of those identified perspectives. The findings suggest that some factors tend to be more sector-specific, such as the emphasis on health and safety aspects by the process industry, or the focus on procurement and tendering by the construction sector. There are also factors which are not sector-specific and are acknowledged by the practitioners across all the three datasets (such as collaboration between parties) or not recognized (such as training provisions). Based on the findings, it was concluded that the construction sector can learn from the process industry to incorporate a more integrated approach by promoting an integrated project team of client and contractor. Both industry sectors could evolve in the application of adaptive project management and training provisions for the project team members.

3.1 Introduction

Despite the abundant literature on project performance and the factors most contributing to that, there has been little study providing a comparison across different project contexts. Most of these studies focus on a specific context, for instance a specific sector such as defence (Dvir, Lipovetsky, Shenhar, & Tishler, 1998); Information Technology (Chow & Cao, 2008); construction (Zuo, Zhao, Nguyen, Ma, & Gao, 2018); manufacturing (Saad, Perera, Achanga, Shehab, Roy, & Nelder, 2006); or international development (Khang & Moe, 2008). Some other studies did only provide a general and holistic view without considering the effect of the sector on factors affecting the performance (Fossum et al., 2019).

Different parties involved in the project might perceive the factors contributing to performance differently (Nour & Mouakket, 2013). Davis (2014), using a systematic literature review on the studies regarding success factors, concluded that there is no consensus on the perception of success factors among different stakeholder groups, namely senior management, project core team and project recipient. This difference in views suggests that more investigation is required on the perception of other stakeholder groups across the organisations involved in a project such as clients, contractors, and consultants.

Contingency theory is a well-known concept within the project management research and has been applied to several aspects in this field (Hanisch & Wald, 2012). Specifically, since 2005, the number of project management studies that applied contingency theory has increased (Hanisch & Wald, 2012). Müller and Söderlund (2015) criticised the stream of project management research for focusing on a context specific phenomenon (i.e. related to a specific country or industry). They claim that this trend has been inspired by the well-known mantra developed by the work of Shenhar (2001) “one size does not fit all projects”. This context specificity, in the view of Müller and Söderlund (2015), has resulted in publications which are rarely useful for other researchers or practitioners within other contexts (in other countries or industries). In addition, Artto et al. (2017) criticise the existing contingency research in project management for focusing only on the internal rather than external project parameters. This is also confirmed by the bibliometric analysis of contingency theory in project management literature by Hanisch and Wald (2012), in which they suggested that specifically cross-sectoral analysis of projects would help both researchers and practitioners to broaden their understanding on factors influencing project performance.

There were some earlier studies focusing on comparing the project management practices across sectors. For instance, Bryde (2008) compared the project management maturity of the construction sector with other sectors and he concluded that construction is more mature in terms of program management and organisational support. Comparing the result of his research to the earlier studies in the construction sector, Bryde (2008) pointed out that other sectors could learn from how the construction sector has evolved on these aspects over the past years. In another cross-sectoral study, Artto et al. (2017) performed a literature review of project management research across different sectors and they provide a modular PM theory which incorporates different sector-specific modules for knowledge, concepts, and underlying assumptions. These differences confirmed that some of the project management approaches are sector-specific due to the differences in the market mechanisms, technologies and the associated capabilities.

The objective of the current chapter is to examine how practitioners perceive factors affecting the project performance in different contexts. This is done by exploring the subjective perspectives on those factors using Q-methodology. A contingency approach is followed in this study for explaining the differences in the observed patterns in the practitioners' perspectives with regard to the emphasis on factors contributing to project performance. Sector is one of the potential contextual factors affecting the project management practices. Identifying those patterns, obtained from the dominant perception of practitioners on project management practices in a specific sector, would help us to propose some sector-specific factors contributing to improved project performance. Such comparisons would help to understand the similarities and differences in the importance of project management practices across the contexts which could promote developing "universal project management knowledge" (Artto et al., 2017) or learning across sectors. Although sharing of concepts, ideas and empirical domains with other disciplines may stimulate cross-fertilization, Davies, Manning, and Söderlund (2018) challenged this view by claiming that usually there is a barrier to this learning.

Given the above explanations, the empirical study presented in this chapter answers the following research question:

How do the perceptions of the practitioners on obtaining good project performance differ across the construction sector and the process industry?

Part of the data in this chapter was presented at ***EURAM*** Conference 2018 (Bosch-Rekveldt, Molaei, & Bakker, 2018) and the study was further developed since then. This chapter is organised as follows. First, in Section 3.2, the relevance of the contingency theory in project management is presented. Next, in Section 3.3 the adopted research method is explained, followed by the results of the study in Section 3.4. In Section 3.5, the empirical findings of the study are discussed in light of previous studies and the contributions of the research are proposed. Section 3.6 summarises the conclusions of the study, the limitations, and the further research.

3.2 Industry sector as a contextual factor

In Section 2.3, the theoretical background was explained on the factors contributing to project performance. Based on a comprehensive literature review and through expert judgment a project success factor framework was developed (see Table 2.1). The same framework is used in this study, to identify context-specific success factors. In this section, the concept of contingency theory is presented which helps in understanding those context-specific factors.

Applying contingency theory in a project management environment would stimulate understanding and evaluating projects in their specific context (Verweij, 2015b).

Following the argument that there is no universal management approach for all projects (Dvir et al., 1998), classification schemes have been used in the project management literature to address this issue (Niknazar & Bourgault, 2017). Such classification schemes can be used to predict the project performance or even serve as the basis for a benchmarking system which facilitates the identification of early warning signs in projects (Haji-Kazemi, Andersen, & Krane, 2013; Sauser et al., 2009). In the context of project management research, Niknazar and Bourgault (2017) made a distinction between "classification" and "typology". The difference between these two lies in the way they contribute to the theory development in project management research. Classification concerns adopting the theories for classification, selecting the significant features as the classification criteria, constructing homogenous categories for delimiting project types, testing the hypothesis, and developing the middle-range theories which are applicable to certain project types (Niknazar & Bourgault, 2017). These middle range theories are narrower in scope. In the typology, however, the ideal types of the entity are constructed by two steps: identifying the first order and second-order constructs. Then the degree of fit between the existing dependent variable in the real situation and the ideal types is explored (Doty, Glick, & Huber, 1993). As a result, typology encompasses multiple layers of theory including the ground theory and middle-range theories (Niknazar & Bourgault, 2017). Fiss (2011) argues that in typologies there is a configuration of causes which leads to a certain outcome.

Project contingency factors are examples of classification criteria. Contingency theory has already been applied in different aspects in project management literature, such as quality management practices by considering governance mechanisms as contextual factors (Lu, Cai, Wei, Song, & Wu, 2019), project manager leadership competences in various project types (Müller & Turner, 2007b), front-end management activities contingent on project complexity (Bosch-Rekveldt, 2011), and in studies into the application of project management methodologies affected by the project governance contexts (Joslin & Müller, 2015).

The research of Crawford, Turner, and Hobbs (2004) is another example of such classification studies, where they developed a model for categorisation of projects. The main rationale behind their model is that different projects should be managed differently. Based on the study of Crawford et al. (2004), there is no single correct model for a project categorisation system. Project categorisation has two aspects: the "purpose" for developing such a categorisation and the "attribute" or characteristics used for classifying projects into groups. Sauser et al. (2009) incorporated different contingency frameworks for analysing the underlying reasons behind the failure of a NASA program. Each of these frameworks provides a rich understanding on specific contextual characteristics from different points of view showing that there is no single dominant contingency theory. If those contingency frameworks would be applied collectively, they can provide better insights into why certain management approaches did (not) provide the intended project outcome (Sauser et al., 2009). Contingency knowledge can affect the understanding of management practices in a specific context (Sousa & Voss, 2008). It can lead to the development of frameworks helping practitioners to better select a management approach that would fit their situation (Sauser et al., 2009).

Artto et al. (2017) and Hanisch and Wald (2012) suggest that the contingency view can be extended to examine the management of projects in different sectors. Some earlier studies took the sector as one of the project contextual factors affecting the project management approach. An example is the study by Bryde (2008), who performed an analysis of the project management maturity and project management performance across different project contexts and sectors, including public and private services, manufacturing, and construction. The findings of his study showed that projects in the construction sector outperform projects in other sectors. In addition, the results of their study suggested that project management practices in the construction sector are more mature, in terms of programme management and senior management commitment, than in the other studied sectors (Bryde, 2008).

Another example of such cross-sectoral analysis is the study by Artto et al. (2017), who analysed project management research across nine different sectors through literature review on the project management content of articles published in those sectors. Their literature review was only limited to sector-specific engineering and technology-focused journals in order to create a high-level structure of project management content and to extract those project management approaches which might be sector-specific. Artto et al. (2017) argued that the differences in the project management practices across the sectors stem from the technological characteristics and market needs within each sector. They found that the construction sector mainly focuses on management control through pre-planning processes. Chemical engineering, oil and gas industry (mostly known as process industry) literature was dominantly focused on modelling and management control because of their nature of business, which is investor-centred. This approach is criticised by the scholars for hindering the innovation in that sector.

The focus of this study is classification where contingency theory is adopted as the theoretical lens. Looking back at the two main aspects of project categorisation suggested by Crawford et al. (2004), the purpose of this study is to promote learning and provide an overview of the focus points in the project management practices in different project contexts. In terms of attributes of such a classification, this study is focused on the sector as a contextual factor to find out whether the perceptions of the practitioners working in the construction sector, process industry or others differ on contributing factors to project performance.

3.3 Method

In order to explore the practitioners' opinion on factors contributing to project performance, Q-methodology is used (Brown, 1980). The same Q-set design was used as explained in Subsection 2.4.1 where the Q-statements (33 success factors) are shown in Table 2.1 (Molaei, Bosch-Rekveldt, & Bakker, 2019). For this study, industry sector was used as an underlying contextual factor which might affect the application of such factors and thus practitioners' perspectives working in construction sector and process industry. In the current study, construction and infrastructure sectors are considered as one sector. Infrastructure and construction sectors are used interchangeably in the project management literature (Lloyd-Walker & Walker, 2012; Mok, Shen, & Yang, 2015). In the current study for making the cross-sectoral analysis with the process and energy sector, construction sector is used as the overarching term for the infrastructure and the construction sector. Process industry is used as the overarching term for the process and energy sector.

In order to compare the results across sectors, data was collected through three datasets. The first dataset incorporates consultant companies working in infrastructure and construction projects in the Netherlands. This was the same dataset as used in Chapter 2. The second dataset is an owner organisation acting as a public client, responsible for the development and maintenance of certain public buildings in the Netherlands. The third dataset consists of participants of a contractor organisation, an international company, mainly active in the process and energy sector. The P-set of this comparative study consisted of 34 respondents in dataset 1, 31 respondents in dataset 2, and 43 respondents in dataset 3. The characteristics of the datasets used in this study are presented in Table 3.1.

Table 3.1: Datasets used in this study for the Q-sorting

No.	Industry sector	Number of respondents per dataset	Predominant role of the organisation
Dataset 1	Construction industry	34	Consultant
Dataset 2	Construction industry	31	Client
Dataset 3	Process industry	43	Contractor
Total		**N=108**	

During the Q-sort sessions, respondents were given the 33 Q-statements each presented on small cards and a score sheet. They were asked to rank those cards based on their relative importance according to Figure 2.2 while considering one of their successful projects. The sorting question to be answered by the respondents was: “what factors contribute to the success of the reference project?”. The prioritisation of those factors might be affected by the practitioners’ subjective view (Koops et al., 2016) and their specific project context. For a more elaborate explanation on the Q-sorting followed, reference is made to Subsection 2.4.3.

3.4 Research findings

In this section, the results of the study are presented in five subsections. First in Subsection 3.4.1, the identified perspectives per dataset are discussed. Next, the overall rank of factors across all the three datasets and per dataset are presented in Subsection 3.4.2 followed by the contrasting views across the datasets in Subsection 3.4.3. A comparison is made on the distinguishing factors across the three datasets highlighting the perceived shared views in Subsection 3.4.4. Finally, in Subsection 3.4.5 the respondents’ profiles across the datasets are explored.

3.4.1 Perspectives per dataset

The perspectives identified for each dataset are explained in this section.

For each perspective, the chosen label is based on the distinguishing factors in that specific perspective.

Dataset 1 (construction sector-consultant)

The four perspectives extracted for dataset 1 are briefly summarised in this subsection (see also Chapter 2, Subsection 2.5.1 for more explanations of the perspectives for this dataset). The factor loadings for the four-factor solution and Q-set with the corresponding Z-scores for each perspective are presented in Appendix B. 3 and Appendix B. 4, respectively.

N1. Seeking the best match

The distinguishing factors for this perspective reflect the importance of procurement: *selecting the contracting strategy and tender process* (Pos. +2) and *proper selection of project execution resources* (Pos. +2). These aspects together with the emphasis on *clear organisational structure* (Pos. +1) provide the core belief of the practitioners in this perspective.

N2. Being adaptive and open

Information sharing within the project team (Pos. +3) was underlined by this perspective, which cannot be observed in other perspectives. This together with the practitioners' emphasis on *collaboration between project parties* (Pos. +1), suggest that sharing information and collaboration could enhance each other. Furthermore, this perspective considers the importance of *adaptive project management* (Pos. +2).

N3. Keeping the integrated team focused

The reason for labelling N3 as keeping the integrated team focused, is the unique emphasis that the respondents in this perspective put on team effort, specifically *integrated project team of client and contractor* (Pos. +2). This integration can also be enhanced by showing commitment from the client (*active client involvement,* Pos. +3). On the other hand, the contract-related factors are considered relatively less crucial for this perspective: *proper selection of project execution resources* (Pos. -2) and *selection of contracting strategy/tender process* (Pos. -2).

N4. Preparing for opportunities

Opportunity management (Pos. +3) was emphasised by the respondents in this perspective. These opportunities, however, needs to be in pre-defined boundaries (*monitoring and control*, Pos. +2). What distinguishes N4 from other perspectives is the importance they gave to the *ecological and sustainability considerations* (Pos. +2). In contrast to the focus given to the opportunities, practitioners seem not willing to follow an *adaptive project management approach* (Pos. -3).

Data set 2 (construction sector-client)

The four identified perspectives for this dataset are separately explained in this subsection. Factor loadings of the respondents are given in Appendix B. 3 and the factor scores of the Q-sorts per perspective are shown in Appendix B. 4.

P1. Client defined project

There were 10 respondents loading on this perspective. This perspective underlined the importance of having *clearly defined scope* (Pos. +3) and *clear goals* (Pos. +2). For instance, one respondent reflected on this factor: ***"If everyone knows where they should exactly focus and further everyone supports these goals, the quality will be higher and there will be less rework and conflict".*** On the other hand, *use of new technology* (Pos. -3) was not favoured for this perspective. This together with the focus on the scope and goal definition might imply that practitioners loading on this perspective opt for reducing the uncertainties for their projects. *Active client involvement* (Pos. +2) was also emphasised by this perspective. Given the fact that this factor was highlighted by the client itself implies that either the client would like to be the leading party in all the decision-making processes without giving the autonomy to the contractor or he wants to collaborate with the contractor in jointly making decisions. *Integrated project team of client and contractor* (Pos. 0), another distinguishing factor for this perspective, is perceived neutral: as long as the client is actively involved, the respondents are neutral to the use of an integrated team.

P2. Steering by procedures

The respondents who loaded on this perspective (9 respondents) shared the belief that procedures such as *quality management (both product and process)* (Pos. +3) and *risk management* (Pos. +2) are the focal point in order to improve the project performance. One respondent commented on the importance of quality management processes: ***"If there are clear and measurable requirements to be achieved in a project, one needs to follow quality assurance processes".*** In addition, on the importance of risk management, one of the respondents remarked: ***"risk management helps in bringing the critical aspects in the process to mind and to stimulate people to reflect on those aspects".*** In this perspective, *active involvement of users* (Pos. -1) was not perceived as a focus of attention for the practitioners.

P3. Collaborating with user and team orientation

This perspective contains 8 practitioners. The respondents in this perspective acknowledged the importance of *active involvement of users* (Pos. +3). As reflected by one of the respondents on the importance of end user involvement: "***end users should be actively involved and there should be a good interplay between architect/ contractors and the end users: they should listen to each other***". *Competent/ multidisciplinary project team* (Pos. +3) was also underlined by the respondents. Furthermore, as noted by one of the practitioners, collaboration between project parties positively contributes to the project performance because it provides a "***joint stand for the project culture. This attitude could help in solving problems even before they would be called problems!"*** To the practitioners in this perspective, *integrated team of client and contractor* (Pos. -2) was relatively less important compared to other factors. One of the respondents mentioned that this was due to the choice of traditional contract which hampers the integration of these two separate teams.

P4. Innovating in project and procurement

This perspective is represented by the smallest number of respondents in dataset 2 (only 4 respondents). In contrast to the other perspectives in dataset 2, the respondents put an emphasis on the *use of new technology* (Pos. +3) but with a focus on putting enough effort on *defining the scope clearly* (Pos. +2). In addition, *selection of contracting strategy and tender processes* (Pos. +2) was perceived relatively important. This might imply that the respondents in this perspective to a large extent outsource their project. This explanation is supported by the fact that *contract management* (Pos. +1) was perceived as relatively important.

Data set 3 (process industry-contractor)

In this subsection, the four perspectives distinguished on the successful performance among the respondents in dataset 3 are explained. More detailed information about the factor loadings of the Q-sorts and the associated Z-score per perspective are presented in Appendix B. 6 and Appendix B. 7, respectively.

R1. Keeping the client close

In total, 13 respondents loaded on this perspective. This perspective from the contractor side is characterized by an *actively involved client* (Pos. +3) because it can provide an environment for seeking the solutions better together with client, according to the respondents. *Integrative project approach* (Pos. +1) was also important to this perspective providing them with a comprehensive overview of the project. However, this integrated approach preferably is predefined: the management approach followed is not adaptive (*adaptive project management:* Pos.-1). *Learning from current and past practices* (Pos. -1) could not add value to the project suggesting that the respondents might believe that every project is unique.

R2. Co-creating with end users

According to the practitioners in this perspective (12 loaded on this perspective), this perspective is characterized by a main focus on the *future end user involvement* (Pos. +2). They strongly believe that end users have a pivotal role both in design and execution phase because "*their involvement can prevent the development of mistakes"* and at the end the project should meet their demands*. Involvement of senior management* (Pos.+1) was also highlighted by this perspective because this involvement *"is the key for success for instance, by giving the empowerment to the team". Risk management* was not a big deal for them as they put relatively less importance to risk management compared to other factors. *Contract management* (Pos. -2) was not a prime focus for this perspective. Specifically, one of the respondents reflected that: *"Contract management is much less important when an alliance or reimbursable contract is used".*

R3. Managing by conventional wisdom

This perspective gathers 11 respondents. In this perspective, aspects of traditional project management are observed focusing on *monitoring and control* (Pos. +3) with a *well-defined project scope* (Pos. +1) as a starting point. On the other hand, *active involvement of end users* (Pos. -1) and *early involvement of project parties* (Pos. -2) were perceived less important in this perspective. This resembles the emphasis on hard aspects of project management, rather than soft aspects like collaboration with end users and other project parties. Surprisingly, *adaptive project management* (Pos. +1) was considered as relatively influential to project performance for these practitioners, which seems contradictory to the strong focus on traditional aspects of project management. It seems that these practitioners would give preference to the so-called "standard management control processes", however, project circumstances, for instance a *"new type of contract"*, could shift their behaviours towards a more adaptive approach. Respondents in this perspective rank the *use of new technology* relatively low (Pos. -2).

R4. Bringing the team together with an integrated approach
This perspective (7 respondents) is all about an *integrated approach* (Pos. +3). As experienced by one of the respondents: *"the whole team consisting of all the parties involved worked in such a way that it looked like they came from the same organisation".* Compared to perspective 1, however, this perspective is less "strict": opportunities are carefully looked at (*opportunity management*, Pos. +1). Having a *competent/multidisciplinary project team* (Pos. +2) is also acknowledged as a crucial contributor to project performance. *Risk management* (Pos. +1) is considered important, maybe to compensate for the lack of importance of a *clearly defined scope* (Pos. -1).

3.4.2 Overall rank of factors across the datasets

The goal of this section is to examine whether some common views exist with regard to practices required for achieving good project performance, shared by all respondents. To achieve this goal, the overall rank of factors is calculated and compared across all three datasets as well as per dataset. This is done by averaging the Z-scores of each factor for the whole dataset and for each dataset. The comparison in this section is rather similar to the comparison in the previous section but it provides a more in-depth overview of relative priority given to the factors across the datasets. In the following, high ranked factors, low ranked factors, and contrasting views across the datasets are discussed.

High ranked factors across the datasets

The top 5 high scored success factors across the datasets are listed in Table 3.2. In the second column, the overall rank of factors across the whole dataset (N=108) is presented. As can be seen from this column, *collaboration between project parties* and having a *competent/multidisciplinary project team* are ranked as the first and second most contributing factors to project performance, respectively. According to the respondents, however, the project team competences should fit the project and also the contract type: all required knowledge and skills should be considered in advance. Next, having a *competent project manager* (third position) a *clearly defined scope* (fourth position) are the factors which are perceived as important to the project performance.

In the columns three to five in Table 3.2, the high-ranked success factors per dataset are given. In these columns, the factors which are placed commonly on the top 5 factors across all the three datasets, albeit with different order, are highlighted in grey. Again, the respondents across the datasets, shared the belief that *collaboration between project parties* and *competent/multidisciplinary project team* are the important factors for achieving the desired project performance (they are always ranked in the top 3). Practitioners in dataset 1 ranked the *competent project manager* as an essential factor for the performance (first place) by "*bringing the parties (client and contractors) together and remaining critical on them*", as noted by a respondent. In dataset 3 (contractor organisation in the process industry), *integrated project team* is perceived as a precondition for success in their projects because in such an arrangement "*the goals of the project are clearer to everyone and the differences can be solved faster".*

Table 3.2: High scored success factors

Rank	Overall rank across the whole dataset	Construction sector (consultants)	Construction sector (clients)	Process industry (contractors)
1	Collaboration between project parties	Competent project manager	Collaboration between project parties	Collaboration between project parties
2	Competent/ multidisciplinary project team	Collaboration between project parties	Clearly defined scope	Competent/ multidisciplinary project team
3	Competent project manager	Competent/ multidisciplinary project team	Competent/ multidisciswplinary project team	Integrated project team (client and contractor)
4	Clearly defined scope	Awareness of project external factors	Active involvement of users	Active client involvement
5	Clear goals	Information sharing within the project team	Integrated approach	Project planning

Grey cells indicate the factors that appeared mutually in the top 5 factors across all the three datasets.

Low ranked factors across the datasets

The bottom 5 scored success factors across the datasets are listed in Table 3.3. When looking at the ranking in the whole dataset (N=108), it can be seen that the respondents irrespective of their project context, ranked "*training provision*" as not a relevant factor contributing to project performance. According to the explanations of the respondents, often there was no time for training, the team was just asked to get the job done. Also, it was mentioned that "*learning from the experiences is more important than providing opportunities for training*". Practitioners see gained experiences of the project team and the project manager as more important for project performance than training as such: training might be the responsibility of the line organisation, not the temporary project organisation.

Next, *environmental and sustainability considerations* was ranked as one of the least contributing factors, not because they are not important, but because these are the "*normal embedded parts"* of every project. A contrasting view on this factor is that the legislative requirements regarding sustainability should be met and most of the times there is no budget or time left to experiment with these aspects and go beyond the requirements. According to the practitioners, *legal and administrative processes* are served only as a basis or hygiene factor for turning the project back but, in itself, these processes can hardly play a role. This implies that practitioners put not their principal focus on these legal and administrative processes because *"if people are very busy with those aspects, no time and energy would remain for the actual project tasks".* In the reflection of the practitioners also *use of new technology* and *active involvement of external stakeholders* are ranked at the bottom of the list. *Use of new technology* can highly depend on the client's requirements and whether he wants to bear the risk of applying a new technology or just allows application of proven technology.

Health and safety considerations is not a factor which the respondents in dataset 2 (construction projects in the client organisation) perceived as a contributing factor to the project performance. It is argued by the experts in this dataset that usually the contractor is responsible for considering health and safety measures.

Table 3.3: Low ranked success factors

Rank	Overall rank across the whole dataset	Construction sector (consultants)	Construction sector (clients)	Process industry (contractors)
29	Active involvement of external stakeholders	Use of new technology	Environmental and sustainability considerations	Use of new technology
30	Use of new technology	Active involvement of external stakeholders	Use of new technology	Legal and administrative processes
31	Legal and administrative processes	Legal and administrative processes	Legal and administrative processes	Active involvement of external stakeholders
32	Environmental and sustainability considerations	Environmental and sustainability considerations	Health and safety considerations	Training provision
33	Training provision	Training provision	Training provision	Environmental and sustainability considerations

Grey cells indicate the factors that appeared mutually in the bottom 5 factors across all the three datasets.

3.4.3 Contrasting views across the datasets

A detailed list of the overall rank of success factors across the whole dataset and per dataset, including the associated Z-score for each factor, is presented in Appendix B. 1. As can be seen from that bar chart, there are some contrasting views across the datasets. In other words, there are some factors which practitioners in a dataset ranked negatively, whereas the other dataset ranked it positively. These contrasting views are discussed here.

Integrated project team is scored negatively by the client organisation in the construction industry (dataset 2). According to the practitioners, usually the selected contracting strategy, specifically traditional contractual arrangements, do not allow for such active involvement of the client and/or end users.

According to the practitioners in dataset 3 (process industry), *awareness of project external characteristics* is perceived as a factor to least contribute to project performance compared to other factors. This awareness regarding project external characteristics, however, is more important according to the practitioners in dataset 1 and 2. An explanation for such ranking can lie in the nature of construction projects where there are many stakeholders involved. This makes it crucial to have a grip on those external project characteristics in construction projects.

Although *early involvement of parties* in the project can smoothen the processes and create trust between the parties, practitioners in dataset 1 ranked this factor more negatively compared to the practitioners in other datasets. This early involvement can add value if parties can be involved at the right moment and perform their requested task. It could also help to bring the attention to all facets of the project and provide an opportunity to understand each other's interests and challenges. With respect to the contractors as one of the key parties involved in the project, however, practitioners argued that price setting and market forces might also hinder their early involvement.

Adaptive project management was considered an important factor contributing to project performance, specifically in complex projects. This factor was only ranked positively by the practitioners working in consultancies within the construction sector who expressed that for having such an adaptive project management approach some adjustments should also be made at the organisational level. In the same vein, *organisational structure* was mostly perceived by the practitioners in dataset 1 as an important contributing factor to performance. Given the fact that many stakeholders are involved in the infrastructure and urban development sectors, it is important to have a proper structure where different levels of communication are clear. In such projects, politics play a crucial role and having an adjusted organisational structure can help in creating a "*workable business case*", according to the respondents.

Practitioners in dataset 3 valued *efficient use of people and resources* as a contributing factor to project performance compared with other practitioners in other datasets. The reason might be that contractors are more involved with such resources and their effect on project costs. Thus, smart use of such resources is crucial for making the project profitable to the contractor, for instance managing the interfaces between the sub-contractors. This seems less important for a consultant or client in our datasets.

Interestingly, the factor *health and safety considerations* was only acknowledged by the practitioners in the process industry as a vital success factor. This might be due to the nature of such projects where *"a zero-accident project positively contributes to the morale*" and it is a top priority for the client. In the process industry a project cannot be successful without the proper attention for health and safety issues.

Having explained the practitioners' perspective per dataset and the overall rank of factors across the datasets, in the next subsection the perspectives of the practitioners are compared. This enables the identification of similarities and differences on the priority given by the respondents across the sectors.

3.4.4 Comparing the perspectives across the datasets

In this subsection, the perspectives identified per dataset were compared across the datasets. For this analysis, only the distinguishing factors in each perspective were compared with each other. Based on sorting the factors according to their relative position and practitioners' explanations on those factors, the perspectives across the datasets were plotted. For instance, if a specific factor ranked +2 in a specific perspective and it is ranked +1, +2 or +3 in the other perspective we put these two perspectives together. As explained in Subsection 2.4.3, the respondents were asked to explain their answers on the extreme positions. For comparing across the datasets, if in a dataset a factor is distinguishing in more than one perspective, the perspective which has the higher z-score is selected for performing the comparison. To facilitate the comparison across the datasets, Table 3.4 summarises how the identified perspectives with their associated distinguishing factors are compared across the sectors. Six different themes can be identified from the cross analysis of the shared distinguishing factors across the datasets: I. client emphasis; II. traditional approach; III. team focus; IV. end user focus; V. procurement focus; and VI. opportunity focus. The criterion for identifying these themes was that the distinguishing factor should be common at least among two datasets.

Among these identified themes, the focus on the end user (theme IV) was not observed in dataset 1. Emphasis on managing opportunities (theme VI) was not perceived by the respondents in dataset 2. The other four themes were recognized in the perspectives in all three datasets, albeit with different relative importance. A detailed explanation of all themes is presented in the following.

I. Client emphasis

"*Active client involvement*" is acknowledged to be one of the most important contributing factors to project success, according to the respondents in all datasets (perspectives N3, P1, and R1). This factor was always ranked +2 or +3 across these perspectives. Also, in dataset 2 this was the case; the practitioners from the client organisation expressed that involving them in the project contributed positively to the project performance, possibly exaggerating their own importance. Still, client involvement is concluded to contribute to better understand the individual and shared interests of client and contractor. Changes in the project circumstances are inevitable and these in turn can cause changes in the project goals. Knowing each other's interests helps the collaboration under changing circumstances. It is therefore important that the client is closely engaged. In addition, contractor and consultant respondents believed that client commitment is crucial. By having a dialogue between client and contractor during the early phases, clients and contractor/consultant can think together effectively towards potential solutions. Having done that early in the project, there would be less change orders from the client later during the execution phase.

II. Traditional approach

The perspectives in this theme are mainly focused on defining the project goals, scope, and monitoring these project boundaries (with an inclination towards traditional project management approach). These aspects can be observed in perspectives N4, P1, and R3. For practitioners in these perspectives, it is of great importance to have a very clear scope from the very early phase. This makes it easier for everyone to understand what their role is and when they are responsible for a specific task. According to the practitioners, monitoring could help in predicting and controlling the potential deviations.

III. Team focus

The team focus is more or less observed across the datasets as a contributing factor, however, the "team" might be perceived differently across the datasets (N3, P3, and R4). Perspective N3 acknowledged the project team as an "integrated team" including both client and contractor. According to the practitioners in this perspective, in such a team, it is important that parties trust each other, give each other some space while supporting each other whenever needed. Such an arrangement would help in creating a team spirit, sharing the knowledge, and joint execution across different disciplines. As can be observed from the distinguishing factors in perspective P3, *competent/multidisciplinary project team* was considered as one of the essential factors for a successful project performance which highlights the team focus for this perspective. Interestingly, *integrated project team of client and contractor* was perceived as one of the least contributing factors to project performance in this perspective (21: Pos. -2), see Appendix B. 6. This might imply that the team (within the client organisation in the construction) is more perceived as an "internal" project team within the organisation (client). This internal team needs to interact closely with the project end users. Although practitioners in perspective R4 did not explicitly highlight the importance of an *integrated project team*, an *integrated approach* is very important to them. For practitioners holding this perspective, these two factors are the same to some extent, with the difference that *integrated approach* for them entails various parties involved, not limited to client and contractor. As said by one of the practitioners: "*Integrated approach can lead all parties to jointly work together and minimise the chance of interfaces*".

IV. End user focus

Active involvement of users seems to be more influential for the practitioners in dataset 2 (perspective P3) and dataset 3 (perspective R2) compared to those working at consultancy offices. As noted by one of the practitioners in P3, input from the end users is essential because at the end those users determine whether the project was successful or not. As mentioned earlier in this subsection, user focus was not observed in any of the perspectives of dataset 1.

V. Procurement focus

This theme highlights the importance of procurement and contracting strategies and it was mainly distinguished in dataset 1 (N1) and dataset 2 (P4), both from the construction sector. This procurement focus was found as a lesser priority for the respondents in dataset 3 (R1). Indeed, this theme is more influential for the client and consultant, compared to the contractor. Thus, the theme seems to be role dependent because usually the contractors are involved in the (pre-) tendering processes. In addition, procurement is a focal point for a public organisation compared to a private organisation. That could explain why tendering is mostly a key feature in the infrastructure and construction sector, where the client is a public organisation, and less in the process industry, where mostly private parties are involved. Interestingly, for the practitioners in P4, ***integrated approach*** and ***integrated project team of client and contractor*** were perceived relatively less important compared to the other factors. This might suggest that, to them, the focus is more on procurement and agreements and much less on an (integrated) team level.

VI. Opportunity focus

This theme is mainly focused on acknowledging the opportunities, which can only be observed among two perspectives in dataset 1 (N4) and dataset 3 (R4). One of the practitioners in N4 underlined the importance of seeking opportunities, specifically during the optimisation as a way to create support by the stakeholders. The practitioners in N4, however, tend to consider opportunities with a careful emphasis on control (6: Pos. 2). To a lesser extent, compared to N4, opportunity focus was mentioned by the respondents in R4. It seems that practitioners holding the R4 perspective, couple this emphasis on opportunity with defining a broad scope (3: Pos. -2) and incorporating an ***integrated approach*** (30: Pos. 3). Moreover, R4 has the same attention for ***opportunity management*** as for ***risk management*** (29, 8: Pos.1).

Apart from these shared themes across the datasets, some perspectives had distinctive emphasis that were not seen in other perspectives: N2, P2, and P4, see Appendix B. 8.

Table 3.4: Comparison of the perspectives on shared distinguishing project success factors across the datasets

	Dataset 1. Construction sector (consultants)				Dataset 2. Construction sector (clients)				Dataset 3. Process industry (contractors)			
	No.	**Success factor**	**Z-score**	**Pos.**	**No.**	**Success factor**	**Z-score**	**Pos.**	**No.**	**Success factor**	**Z-score**	**Pos.**
I. Client emphasis	N3. Keeping the integrated team focused				P1. Defining the project by client				R1. Keeping the client close			
	23	Active client involvement	1.97	3*	23	Active client involvement	0.95	2*	23	Active client involvement	1.69	3*
II. Traditional approach	N4. Preparing for opportunities				P1. Defining the project by client				R3. Managing by conventional wisdom			
	6	Monitoring and control	1.53	2	3	Clearly defined scope	2.17	3*	6	Monitoring and control	1.96	3*
					26	Clear goals	1.58	2*	3	Clearly defined scope	0.51	1*
III. Team focus	N3. Keeping the integrated team focused				P3. Collaborating with user and team orientation				R4. Bringing the team together with integrated approach			
	21	Integrated project team (client & contractor)	1.41	2*	21	Integrated project team (client and contractor)	-0.88	-2	30	Integrated approach	1.88	3*
					18	Competent/multidisciplinary project team	1.69	3*	18	Competent/multidisciplinary project team	1.34	2
					19	Collaboration between project parties	1.49	2*	19	Collaboration between project parties	1.04	1
IV. End user focus					P3. Collaborating with user and team orientation				R2. Co-creating with end users			
					24	Active involvement of users	2.13	3*	24	Active involvement of users	1.43	2*
V. Procurement focus	N1. Seeking the best match				P4. Innovating in project and procurement				R1. Keeping the client close			
	13	Selection of contracting strategy/tender process	1.26	2*	13	Selection of contracting strategy and tender process	1.4	2*	13	Selection of contracting strategy and tender process	0.52	1*
	15	Proper selection of project execution resources	1.18	2*								
VI. Opportunity focus	N4. Preparing for opportunities								R4. Bringing the team together with integrated approach			
	29	Opportunity management	2.08	3*					29	Opportunity management	0.96	1*

All the factors in this table represent the distinguishing statements per perspective at $p < 0.05$, the statements with * are success factors which are distinguishing at $p < 0.01$

3.4.5 Exploring respondents' profiles

Next to cross sectoral analysis of the perspectives, the profiles of the respondents per perspective were also analysed to see whether any pattern can be observed in the distribution of the respondents' experience or role. The profile of the respondents is presented in Appendix A. 1 (dataset 1), Appendix B. 2 (dataset 2), and Appendix B. 5 (dataset 3). Comparing the experience of the respondents per perspective in dataset 1, it can be concluded that the majority of the young professionals loaded on perspective N2 (being adaptive and open), see Subsection 2.5.2. Senior practitioners (with more than 20 years of experience) from perspective 2 dominantly loaded on perspective P1(client defined project) and P2 (steering by procedures). Again, Kruskal-Wallis test was performed to determine whether there are significant differences on the experience of the respondents across the perspectives in datasets 2 and 3. No significant results, however, were found for the difference between the experience of the practitioners across the perspectives at the 0.05 significant level.

For datasets 1 and 3, the majority of the respondents were "project managers or project directors". For dataset 2, there is no dominant presence of "project managers": other roles such as "member of the project team" and "other management functions" were also present in fair amounts. There was, however, no link observed between respondents' roles and their corresponding perspectives.

3.5 Discussion

There is an abundance of literature on project performance and the main contributors to that, however, this study examined the potential views on those contributing factors by taking a sector-specific approach as an element of project context. Absence of a dominant focus across the datasets might imply that some of the factors are sector specific. And some other factors were shared among the datasets implying that they are not context specific.

To discuss the findings, this section is divided into two subsections enabling us to answer the main research question: (1) sector-specific success factors and (2) general observations. Furthermore, the findings of the study are compared to the prior research in the field.

3.5.1 Sector-specific factors

The datasets in the study represent two main sectors: construction sector (datasets 1 and 2) and process industry (dataset 3). In terms of sector-specific factors contributing to project performance, based on the result of Q-sorting, three inferences can be made: *integrated approach, focus on procurement, health and safety considerations*. Each of these observations are discussed in the following.

Overall, the results suggest that an integrated approach in project management is more promoted in the process industry compared to the construction sector. Although in dataset 2, *integrated approach* was ranked among the high ranked factors, none of the four identified perspectives within this dataset specifically highlight it. This finding echoes earlier studies in the construction industry arguing that fragmentation is one of the common problems in the construction industry (Alashwal & Fong, 2015; Saini, Arif, & Kulonda, 2019). This fragmentation partly stems from the fact that selection of the construction project participants is based on their professional capability rather than their ability to integrate effectively with each other (Baiden, Price, & Dainty, 2006). Specifically, due to the characteristics of the construction projects, Fellows and Liu (2012) distinguished two dimensions of fragmentation: entities (disintegration of expertise and knowledge) and processes (common separation of design and construction works). Alashwal and Fong (2015) extended this definition of fragmentation by identifying four constructs: level of team integration; spanning knowledge across boundaries; decoupling of diversity; and professional barriers. Their results suggest that the first two constructs (level of team integration and spanning knowledge across boundaries) make a significant contribution to fragmentation. The first construct, level of team integration, indicates the extent to which the project team has autonomy in organising works (self-governing team), focus on end-user needs, and regular meetings with other parties (Alashwal & Fong, 2015). Looking at the overall ranking of the success factors per dataset, practitioners in the process industry dataset ranked ***integrated project team*** much higher than construction sector, see Appendix B. 1. Fragmentation, in terms of team integration, can be observed in both industry sectors. Capturing the perspectives of the practitioners, however, supports that practitioners in the process industry tend to focus more on team integration compared to the construction sector. The second construct of fragmentation, defined by Alashwal and Fong (2015), is spanning knowledge across boundaries including accessibility, sufficiency and management of the information among the project team. The practitioners in both sectors scored ***information sharing within the project team*** relatively high, see Appendix B. 1. As stated in Subsection 3.4.4, however, practitioners in these two sectors might perceive “team” differently. For the practitioners in the process industry, this project team includes broader parties and disciplines. The two constructs of team integration and information sharing could be interrelated. Organising team building and establishing effective communication might be used to improve the relationship between the project professionals (Alashwal & Fong, 2015). Lech (2014) suggested that in the context of IT projects, integration of the project team is required in order to facilitate the incorporation of knowledge and skills from different sources. Knowledge integration and exchange of knowledge among the stakeholders in construction projects can also contribute to project management success (Erdem & Ozorhon, 2015) and eventually sustainable success (Heising, 2012). Given the above explanations, the construction sector can also benefit from integration practices between project parties.

The focus on procurement seems to be more important for the respondents in datasets 1 and 2, compared to dataset 3, highlighting its importance in construction sector. De Araújo, Alencar, and de Miranda Mota (2017) performed a systematic literature review on papers related to project procurement processes. Their study showed that the majority of the papers published on this topic was related to the construction or infrastructure sector. Procurement and selecting the execution party is also a challenging decision-making process for the client and it is crucial for the success of construction projects (Kog & Yaman, 2016). Thus, the result of the current study might imply that the construction sector has a predominant focus on procurement compared to the process industry. This emphasis in the construction sector has to do with the fact that mostly public organisations are involved in such projects. Both sectors, however, need to move towards more collaborative procurement arrangements.

The practitioners in the process industry heavily emphasised ***health and safety considerations***. The reason for this primary focus might be that safety is an inherent operating characteristic and culture of the companies working in the process industry (Hofmann, Jacobs, & Landy, 1995; Zwetsloot, van Middelaar, & van der Beek, 2020). Compared to other industries including process industry, safety culture within construction is not mature (Boateng, Pillay, & Davis, 2019; Feng & Trinh, 2019; Misnan & Mohammed, 2007; Zou, 2011). Generally, safety culture is a social construct (Cooper, 2018) and can be defined as the shared beliefs, norms, attitudes and technical practices of the individuals and organisations relevant to managing the health and safety risks (Zou, 2011; Zwetsloot et al., 2020). This lack of formation of safety culture within the construction sector was also observed from the results of the Q-sorting where health and safety considerations are not acknowledged by the respondents from this sector. Note, however, that only client and consultant respondents, representing the client perspective from the construction sector were involved in the current study. Primarily safety should be handled by the contractor, and not the client, in the execution phase (Bakker, Hertogh, & Vrijdag, 2017). In project management research, it can be also observed that most of the existing literature on health and safety procedures, processes, and performance in the construction industry are related to the execution phase (Chi, Han, & Kim, 2013; Hardison, Behm, Hallowell, & Fonooni, 2014; Karimi, Taylor, Goodrum, & Srinivasan, 2016) showing the importance of such processes during this phase. Safety measures, however, should be considered very early in the project, otherwise it would be expensive and difficult to change the processes for safety reasons (Hurme & Rahman, 2005). Additionally, due to fragmentation in the industry, safety is merely regarded as the responsibility of the construction personnel who are directly involved in the construction processes during execution (Saunders, Kleiner, McCoy, Ellis, Smith-Jackson, & Wernz, 2017). To promote an inter-organisational safety culture in such projects, key project stakeholders such as clients, architects, engineers, construction managers, and (sub)contractors should be aware of their roles related to safety procedures, for instance by improving safety training (Saunders et al., 2017). In this regard, the construction sector can learn from safety practices applied in the process industry, specifically by aligning the stakeholders' safety attitudes and goals, to improve the safety culture.

3.5.2 General observations

Based on the identified perspectives in each dataset, similarities were observed across the sectors and roles in terms of collaboration and active client involvement.

Collaboration between project parties was the most agreed factor amongst all practitioners. The findings are consistent with the study of Suprapto, Bakker, Mooi, and Hertogh (2016) showing that collaboration between client and contractor in terms of relational attitudes and teamworking could positively affect project performance irrespective of the contract types. Looking at the overall rank of statements across the datasets, ***collaboration between project parties*** and ***competent and multidisciplinary project team*** is ranked first and second, respectively. This can be evidence for the importance of project team competences and capabilities in creating a collaborative environment fostering the success of project processes as suggested by Wen, Qiang, and An (2017). Such inter-organisational collaboration between project parties can be distinguished at two levels: project level and strategic level (Bourgault, Drouin, & Hamel, 2008). Collaboration merely at the project level without the commitment at the strategic level, however, would result in the non-aligned decision making processes within the distributed project teams (Bourgault et al., 2008). Instead, if parties invest sufficient time and communication in collaboration on strategic level, it can positively contribute to project efficiency and organisational performance (Fulford & Standing, 2014). Such collaboration at both project and strategic level calls for more collaborative procurement arrangements (Suprapto et al., 2015b).

Active client involvement was acknowledged in this study as one of the key contributing factors to project performance, irrespective of the project context (more specifically, role and sector). Active client involvement is required for identifying project demands, requirements, and goals during the front-end phase. The role of client involvement was also investigated in the studies of Campbell and Cooper (1999) and Peled and Dvir (2012), both in the context of new product development. In such projects, the client is usually referred to as customer. The study of Campbell and Cooper (1999) showed that customer involvement would mainly positively contribute to the customer satisfaction, compared to other success dimensions such as meeting profit objectives. Although client involvement is beneficial, Peled and Dvir (2012) suggested that a balance should be made between the level of client involvement, more specifically along the spectrum of involvement styles: design with (owner representative participation together with the producer personnel) and design by (direct performance of design activities by the owner representative as the project team). Their study provides a contingent approach for customer (representative) involvement based on the project characteristics and operation policies of the customer.

Chih, Zwikael, and Restubog (2019) showed another crucial factor affecting the level of client involvement is the client's professional knowledge. Their study, in the context of professional service projects, suggested that professionals should take the lead in managing the client's professional knowledge and based on that develop a contingent level of interaction strategies. These professional-client interactions can positively affect the project value creation, both in monetary and non-monetary aspects (Chih et al., 2019). Specifically, with the new shift in collaborative project procurement, finding an optimal and contingent client involvement plays an important role. Early Contractor Involvement (ECI) can be perceived as the core of such collaborative arrangements (Lahdenperä, 2012) where the contractor's knowledge and experience can be incorporated early during the development (Wondimu, Klakegg, & Lædre, 2020). In our study, we did not ask specifically whether the contractor was involved early in the front-end phase or not and if this contributed positively to project performance. Such collaborative procurement arrangements, however, might also affect the involvement strategies and the practitioners' perspective on contributing factors to performance.

There are three overall observations based on the identified perspectives in our study, irrespective of sector and organisational role, which are worth to be given some thought:

1. The dominant focus of the two industry sectors was on theme I (traditional approach) encompassing hard aspects, such as control and setting project goals, together with the focus on project team (theme II). This is in line with the previous studies suggesting that hard factors of project management are as important as the soft factors including people interactions (Clark, 2003; Gustavsson & Hallin, 2014; Larsson, Eriksson, & Pesämaa, 2018). One of the key areas of project management content identified by Artto et al. (2017) is people-focus. Their literature review of the technical papers revealed that there is no dominant focus on people-focused approaches, specifically in construction and process industry. The results of the current study, however, suggest that practitioners did acknowledge the importance of soft aspects in terms of team management.

2. The findings show that adaptive project management does not yet predominantly exist in the current opinions of project management practitioners. Adaptive project management has been advocated in earlier studies as an ability to respond to unforeseen circumstances (Koppenjan, Veeneman, Van der Voort, Ten Heuvelhof, & Leijten, 2011). There are, however, some barriers for applying adaptive project management in practice including financing, commercial and contractual arrangements, technology, and regulatory frameworks (Denicol, Davies, & Krystallis, 2020). Linking this also back to the contingency view, focusing merely on contingency factors as the internal aspects to the project can be criticised because of the short-sighted view that it would provide on project management approaches (Artto et al., 2017). Instead, an open system view broadens the contingency view by considering the management of projects as a dynamic approach. The open system view acknowledges the projects to be part of a dynamic system which calls for combining several contingency views (Sauser et al., 2009) and thus applying an adaptive project management approach (Artto et al., 2017). Future research could explore how such an adaptive project management approach can be stimulated in each sector.

   The focus on adaptive project management was only observed in perspective N2 (being adaptive and open), in which the practitioners were dominantly junior practitioners (see Subsection 3.4.5). This, however, is contrasting to what is found in the study of Bakker, Arkesteijn, Bosch-Rekveldt, and Mooi (2010), in which the results show that less experienced practitioners give more attention to traditional approaches and following pre-defined procedures. Further research could investigate whether there is any relationship between the seniority level of practitioners and their inclination towards a more adaptive approach in their projects.

3. Generally, in the opinions of the practitioners, training provisions was the least contributing factor to project performance (see Subsection 3.4.2). This is in line with the study of Abdul-Rahman, Berawi, Berawi, Mohamed, Othman, and Yahya (2006), finding that (construction) companies prefer to hire experienced personnel rather than investing in training and education. Additionally, this "explicit knowledge" of the experienced personnel cannot be properly shared because of the lack of integrative transfer tools within the companies (Aerts, Dooms, & Haezendonck, 2017). The reason for less emphasis on training might be that the companies do not directly recognize the added value of project training on their business outcomes. Moreover, regarding project management related training, it can be argued that project management is not considered a skillset as such. Thus, organisations do not consider training as an essential part of project management. In order to evaluate the added value, Lee-Kelley and Blackman (2012) suggested that it is important to define explicitly how training can benefit other staff in other projects and the organisation as a whole. Training as a means to disseminate the experiences of senior practitioners is acknowledged as one of the crucial activities leading to better organisational performance (Bakker & de Kleijn, 2018). Hence, training should be advocated and facilitated both at the strategic level and the project level.

In this study, the main focus was on the industry sector as the contextual factor affecting the practitioners' view on factors leading to project performance. Looking at the three datasets, also different roles were distinguished: consultants (dataset 1), clients (dataset 2), and contractors (dataset 3). There was, however, no dataset representing each role within one sector. Acknowledging this limitation, still three observations are distinguished with regard to role-specific factors contributing to project performance. Future research could focus on larger sample sizes including all organisational roles in multiple industry sectors.

1. Focus on procurement was mainly observed in the consultants and client perspectives (Pos. +2) and to a lesser degree in the contractor perspective (Pos. +1), which seems logical. This supports the findings of Chen (2011) who stated that usually the client-side of project management incorporates the management of project procurement. Procurement is one of the primary activities of the (public) client because it affects the financial health and production capability of the client (Zolghadri, Amrani, Zouggar, & Girard, 2011). Given the fact that the consultants in the current study represent clients in public infrastructure and construction projects (see Section 3.3), with regard to the importance of procurement, the consultants seem to hold the same opinion as the client.

2. The emphasis on quality was only identified in the client perspectives. No specific perspective focusing on quality in contractor or consultant datasets was found in the current study. This might be explained by the fact that clients usually focus on defining project quality contributing to their business objectives, whereas contractors' ultimate objective is to make profit (Mosey, 2009; Tang, Qiang, Duffield, Young, & Lu, 2009). Basu (2014) defined quality as "*the consistent conformance to customer expectations"*. Lu et al. (2019) divided quality management practices into process-related (associated with methods and tools for quality management implementation) and people-related (associated with people such as involvement of leadership, customers, and participants) practices. Their study showed a positive effect of quality management practices on project performance. By taking a contingency view, however, Lu et al. (2019) suggest that this relationship can be moderated by high-level contract governance promoting cooperative behaviour. This emphasised the importance of joint quality management practices between client and contractor, however, this joint emphasis on the quality was not observed in our study.

3. Innovation was only emphasised by the clients. An explanation might be that innovation cannot be only promoted by the consultants or contractors because it needs to be incorporated in the project requirements and as a desired project outcome (Gambatese & Hallowell, 2011). Within construction projects, Ozorhon and Oral (2017) showed that those project requirements are one of the key drivers for the innovative activities providing guidance for the contractors. This result corresponds to the findings of Peled and Dvir (2012) showing that usually the client (representatives) serve(s) as the champion for the innovation. As Merrow (2011) highlights the role of the owner in specifying the right project and the role of the contractor to follow the client's wishes, initiation of innovation seems at client's stake. Furthermore, the demonstrated commitment from the client is crucial for incorporating innovation (Gambatese & Hallowell, 2011).

   When innovation is actively promoted by the client across the whole supply chain in the infrastructure projects, Sergeeva and Zanello (2018) report that it can deliver value to both economy and society. Linking innovation back to the importance of procurement, Lloyd-Walker, Mills, and Walker (2014) argued that collaborative procurement arrangements would facilitate innovation through knowledge-sharing and creating a no-blame culture. An example in the construction sector is the early contractor involvement through which innovation can be encouraged by bringing in the technical experience and knowledge of the contractor during the early project phase (Mosey, 2009; Wondimu et al., 2020). This might support the argument of Verweij, Loomans, and Leendertse (2019) suggesting that in DBFM (Design-Build-Finance-Maintain) projects, innovation should be market-driven rather than being defined by the public client. Due to the nature of such projects the public and private management roles and responsibilities are separated. The application of such contracts, however, is criticised for not facilitating the cooperation between the public and private parties resulting in less satisfactory outcomes compared to other collaborative contractual arrangements (Verweij, Teisman, & Gerrits, 2017).

4. Team-focus was acknowledged by the practitioners across all three datasets as a convergent aspect, however, (project) team might have a different meaning to each of the roles. (Lin, Müller, Zhu, & Liu, 2019)"*Project teams bring together people from two or more discrete areas of organisational function to undertake tasks in a temporary effort*" (Lin, Müller, Zhu, & Liu, 2019; PMI, 2017). In our study, clients defined the project team mainly as the "internal" team within the (client) organisation which should work closely with the end users which is in line with the PMI (2017) definition of project team. In view of the consultants, preferably the project team is composed as an integrated team, including client and contractor. For the contractor, the project team has a much broader connotation including all involved disciplines within the client and contractor organisations, as well as the end users. The importance of an integrated team (client and contractor) can also be linked to the emphasis on an integrated approach by the process industry, see Subsection 3.4.4.

3.5.3 Implications

In this study, a contingency view was applied as the underlying theoretical lens to explain the existence of different practitioners' perspectives in different project contexts, more specifically industry sector. The study provides the contractor and consultant perceptions on the contributing factors to project performance. This is one of the contributions of this study to the literature since in project management literature the main focus is on the client view. This research provides an in-depth understanding of the collective view of the practitioners and how it can be influenced by the project context.

The nature of projects and their underlying assumptions might be different across different contexts (Artto et al., 2017). The findings of our study, however, provide some learning opportunities for practitioners through comparing the focus points of the project management practices across sectors. The process industry showed more intention towards an integrated approach compared to their counterparts from the infrastructure and construction sectors. This integrality can also be seen in the project team formation. This might be due to the political and supply chain arrangements in the construction and infrastructure sector (with mostly public clients) which make it difficult for this sector to adopt an integrated approach. Another reason might be that the pace of technological advancement and market conditions call for more integrality across the disciplines in the process industry. Each party involved has specific know-how and technical and managerial competency and it is crucial that those parties come together in an integrative manner. Overall, the results suggest that the process industry is more advanced in terms of project management practices.

In order to stimulate an integrated approach, Bakker and de Kleijn (2018) suggest that the relationship between the stakeholders should not be merely driven by formal contractual arrangements. Instead, companies should invest in establishing engagement with all stakeholders and focus on managing the collaboration with these stakeholders. This requires that practice, in both construction and process industry, gives prominence to the collaborative procurement practices. The results suggest that, in the construction sector, tendering and procurement seems to be one of the barriers for not applying an integrated approach. Although there has been a shift in the public client procurement approaches within European countries towards more collaborative arrangements, the adoption rate of such collaborative procurement strategies is still low (Eriksson, Lingegård, Borg, & Nyström, 2017). It is, however, argued that more collaborative contractual arrangements facilitate an integrated approach (Eriksson, Volker, Kadefors, Lingegård, Larsson, & Rosander, 2019). Thus, it is suggested that clients should be aware of the contractual freedom provided by the legislation to adopt those integrative collaborative procurements. Given that in the current study, the consultants together with the clients focused on the procurement aspects, consultants with their knowledge and skills can encourage and direct clients to apply such collaborative contracts. Additionally, focus on innovation was only perceived among the client respondents. This suggests that consultants and contractors can play a more proactive role in enabling an innovative climate within projects.

The results of the study also suggest a significant difference in the emphasis on health and safety considerations among the process industry and construction industry indicating major room for improvement for the construction sector to enable a safe working environment. Lastly, the importance of training and educational provisions in projects was not acknowledged by the practitioners. This suggests that companies in both sectors could give more attention towards investing in training, also on a project level.

3.6 Concluding remark and next step

The main aim of the study was to compare the focal aspects of project management practices across different project contexts by using a contingency view. More specifically, sector was selected as the contextual factor. To gain an understanding of this contextual factor influencing project performance, a qualitative approach was applied, through which data was collected in three separate datasets: construction-consultant (dataset 1), construction-client (dataset 2), and process industry-contractor (dataset 3). The perspectives of the practitioners per dataset were identified by means of Q-methodology.

By comparing the perspectives across the datasets, six shared themes were identified: client emphasis, traditional approach, team focus, end user focus, procurement focus, and opportunity focus. Also, it was observed that the emphasis on the broader definition of integration, towards involving the parties and end users, is mostly emphasised by the practitioners in the process industry. Regardless of the type of project or sector, what is important for all practitioners was the importance of client involvement in defining the project requirements and boundaries. Collaboration between project parties was acknowledged as the most important contributing factor to project performance overall.

Project context can encompass different aspects. In this research, the focus was only focused on sector as a contextual factor. Further research is suggested for identifying other contextual factors which might have an effect on the application of factors contributing to the project performance, such as political and market influence or organisational role. Another limitation of this study concerns the presence of three datasets to examine the viewpoints of the practitioners in different contexts. The missing roles in each of these sectors (contractor-construction; consultant-process; client-process) are blind spots in this study. A useful extension to this research would be to collect six datasets (one organisational role per sector) instead of three. In addition, the result of the study is based on a Dutch sample per dataset which might not represent the whole sector. Culture can be another important factor affecting the perception of contributing factors to project performance.

The presented research only studied the subjectivity of the practitioner's perspective and did not provide evidence for the causality of the relationship between selected success factors and project performance. Hence, further research can investigate such causal relationships enhancing the understanding of the influence of the project context on the importance and application of the project management practices and how such application would eventually affect project performance. In the current study, the application of those success factors was studied in the construction sector and process industry without considering a specific project phase. The importance of success factors, however, might change throughout the project and future research could address such influence. Thus, in the next chapters we focus on the front-end phase, as the main determinant of performance of engineering projects (Bosch-Rekveldt, 2011; Martinsuo & Lehtonen, 2007), to explore the causality relationships between success factors and project performance.

Part II

Exploring the current practice

Chapter 4

Project management efforts across different sectors

Part of this chapter was presented at

Project Management Congress, Research meets Practice, Towards project management 3.0*,* 2019*,* Delft University of Technology

Abstract

The purpose of this chapter is to examine the current project management practice of engineering projects. This study contributes to the evaluation and comparison of project management efforts across three industry sectors: construction, infrastructure, and process industry. The survey, developed based on the earlier literature review, collected data from 104 engineering projects in the Netherlands within the studied sectors. First, an analysis was performed to identify those activities and project management principles, which are (not) commonly applied in the project front-end. Next, multivariate analysis was carried out on those commonly applied practices, to determine if the intensity of application of those front-end activities and project management principles differs amongst the sectors. The cross-sectoral analysis presented in this chapter revealed that, to some extent, in the process industry more effort is usually put into the project front-end phase by bringing the parties together earlier and joining the efforts.

4.1 Introduction

In the previous chapter, the subjective perspectives of the practitioners on factors most contributing to project performance were compared across the construction sector and process industry. This chapter continues with in-depth evaluation of the project management practice in terms of the intensity of application of front-end activities and project management principles. Thus, the purpose of the study in this chapter is to explore what the focuses of project management are during the front-end phase of engineering projects and how they could be compared across the sectors. The research questions addressed in this chapter are as follows:

Which front-end activities and project management principles are typically applied in engineering projects?

What differences and similarities do appear in the intensity of application of front-end activities and level of project management principles across construction, infrastructure and process sectors?

In Section 3.3, construction sector was used as the overarching term for the infrastructure and the construction sector. In the survey study of this PhD research, however, we gathered enough data to make a distinction between construction and infrastructure sector. This split would enable us a more in-depth analysis of the project management practices within construction sector (urban development, real estate, etc) and infrastructure sector (transportation e.g., rail, highway). As a third focus area, process industry is used as the overarching term for the process (including food, pharma, and petrochemical) and energy sector.

The structure of this chapter is as follows. The theoretical framework used for this study is described in Section 4.2. Next, the survey setup adopted for this study is explained in Section 4.3 followed by the analysis setup in Section 4.4. Section 4.5 then presents the results of the survey study. Section 4.6 discusses the findings of the study, compares these findings to the earlier findings in Chapter 3 and based on that provides some implications for practice. Finally, Section 4.7 summarises the conclusions of this chapter.

4.2 Literature review

The concept of project success and how it can be achieved has been studied vastly in the literature, (Berssaneti & Carvalho, 2015; Carvalho & Rabechini, 2015; Cooke-Davies, 2002; Fortune & White, 2006). It is, however, still vague what the relative importance of each of those managerial endeavours is and how configurations of those activities and practices contribute to project performance. Some recent studies suggest that for understanding the concept of success factors, it would be required to consider the intensity of these factors during the project rather than applying them or not. An example is the work of Joslin and Müller (2016b) which investigated the relationship between project management methodology and project success. They suggest that the literature on project success should be “observant of the application of the success factor rather than only consider their presence” (Joslin & Müller, 2016b).

The success factor framework presented in Table 2.1 acted as the theoretical base for this study. The next step is to operationalise these factors in order to explore how they are applied in practice, based on the insights of the empirical research presented in Chapter 2 and Chapter 3. It should be noted that not all these factors can be operationalised in the same way, since some of them are different in nature. The following factors were removed from the initial theoretical framework due to their abstract level and broad definition: awareness of project nature, awareness of project external factors, project management methodology, organisational structure, early involvement of external stakeholders, project planning, adaptive project management, and efficient use of people and resources.

The intensity of the application of team building activities can be measured by asking how often they are applied in practice. Quality of the relationship between client and contractor, however, cannot be determined using such measures. Therefore, the factors in this framework are divided into two major aspects, see Table 4.1: front-end activities (that are measured by asking the frequency of application) and project management principles (that are measured by the extent to which they were present in the reference project).

Table 4.1: Applied front-end activities and project management principles framework, adapted from Table 2.1

	Applied front-end activities		Project management principles
		1.	Level of scope definition
2.	Level of emphasis on quality (product/process)		
3.	Monitoring and control		
		4.	Information sharing within the project team
5.	Risk management		
6.	Environmental and sustainability assessment		
7.	Learning from current and past experiences		
8.	Health and safety records		
		9.	Selection of proper contracting strategy and tender process
		10.	Contractual clarity
		11.	Proper selection of project execution resources
		12.	Top management support
		13.	Competent project manager
		14.	Competent/multidisciplinary project team
15.	Team building		
		16.	Collaboration between project parties (quality of collaboration among the team members involved in the project, client and contractor)
17.	Training provision		
		18.	Integrated project team (client and contractor)
		19.	Early involvement of (end) users
		20.	Active client involvement
		21.	Setting clear project goals
		22.	Legal and administrative processes
		23.	Integrated approach
24.	Opportunity management		
25.	Use of new technology		

The aim of this study is to gain insight into the actuality of the project management practice in the front-end development phase, leading to a certain project performance. The reason for focusing on the front-end development is the importance of this phase in value creation (Edkins, Geraldi, Morris, & Smith, 2013) which could result in increasing the chance of project success. This line of thought can be seen in the recent literature of project management: a study into the importance of front-end phases of major public projects (Samset & Volden, 2016) and projects in the process industry (Bosch-Rekveldt, 2011). During the front-end phase, crucial decisions are made which further determine the strategic success of the project (Kock, Heising, & Gemünden, 2015). Definitions used for the two aspects of the project management practice and which items are used in this research to measure each of these aspects are explained in the next section.

4.3 Survey setup

In this section, the setup of the survey is described in two subsections. Subsection 4.3.1 describes the measurement of constructs and the measures for the questionnaire items. In Subsection 4.3.2, data collection procedures and the profile of the survey respondents are presented.

4.3.1 Measurement of constructs

Respondents were asked to answer the questions based on their last completed project, either a finished front-end phase or a finished execution phase. The survey consisted of four parts: demographics, questions regarding the application of front-end activities, identified project management principles and project performance. The first part included questions on the respondent's experience, background, sector, project size and duration, role of the company in the project, etc. The questions in the second and third part were extracted or adapted from the underlying literature or created in order to capture the aspects of the activities and project management principles under investigation. The fourth part of the survey aimed to measure the project performance. The survey questions are presented in Appendix C.

As explained in Section 4.2, the developed success factor framework (independent variables) is divided into two main aspects: front-end activities and project management principles. Multi-item measurement scales with items extracted from either literature or practice were used for operationalising these two aspects. It is based on existing scales whenever possible, but some measurement scales had to be developed to meet our research goals. Therefore, Table 4.1 is further operationalised into items of front-end activities (Table 4.2) and project management principles (Table 4.3) and they are explained next.

Front-end activities

Front-end activities are defined as those processes applied with the aim of improving the project performance. Williams, Vo, Samset, and Edkins (2019) performed a systematic literature review on what the front-end phase entails. After setting up the preliminaries and preparing the business case at the start of the project, the following stages are followed during the front-end phase: project purpose, concept analysis and alternative analysis, assessment, and setting up project execution plan. They highlight the importance of the front-end phase on role clarity during this phase which lays the foundation for a clear project governance during project execution.

The research of the Construction Industry Institute (CII) has revealed 17 “best practices” or activities. These activities are defined as the “*process(es) or method(s) that when executed effectively lead to improved project performance*” (CII, 2011). Some other studies used the term “Value Improving Practice” (VIP) for addressing such activities especially in the projects in the process industry (Bosch-Rekveldt, 2011; McCuish & Kaufman, 2002). Examples of such VIPs are lessons learned, team building, and risk management. Use of new technology is another VIP focusing on the product innovation (Tawiah & Russell, 2008) which includes the exploration of new technologies to better prepare for future demands in the market (Eriksson & Szentes, 2017). Six VIPs were explicitly asked in the survey: technology selection, constructability review, design-to-capacity, value engineering, goal setting and alignment, and operations implementation planning. In this research, multi-item measurement scales were used to measure various aspects of these activities. Reporting health and safety is another crucial activity during the front-end phase, and especially during the execution phase. Environmental assessment and sustainability also gain prominence to be considered during the front-end phase (Williams et al., 2019). An overview of the items of front-end activities asked in the survey is given in Table 4.2.

Table 4.2: List of items of front-end activities asked in the survey

No.	Items of front-end activities
1.	Technology selection
2.	Constructability review
3.	Design-to-capacity
4.	Value engineering
5.	Goal setting and alignment
6.	Operations implementation planning
7.	Joint social events
8.	Work related informal joint activities
9.	Feedback on individual/team performance
10.	Training programs (required skills for the project, communication skills, and team development)
11.	Establishing of roles and expectations of the team members
12.	Joint problem solving/trouble shooting sessions for developing and evaluating action plans by the team members
13.	Development of risk register including mitigation plan
14.	Prioritisation of risks based on the risk assessment matrix
15.	Updating the risk register (including mitigation plan)
16.	Specific attention for opportunities in order to seize them
17.	Joint risk management sessions with client, contractor(s), and other main stakeholders
18.	Check for applicable lessons from previous projects
19.	Thorough documentation of the project for future reference
20.	Capture lessons learned from this project
21.	Organise joint lessons learned sessions both client and contractor(s)
22.	Disseminate lessons learned from this project to other projects
23.	Check deliverables against the business case
24.	Track the progress of project performance
25.	Report the overall project progress to the client
26.	Measure the project performance
27.	Quality audit with regard to design conformance (meeting the specifications of the product)
28.	Quality audit with regard to service conformance (process conformance)
29.	Self-assessment of project team members
30.	Report of health and safety records (HSE management)
31.	Environmental assessment

For the applied front-end activities, instead of asking whether a certain activity was performed or not (presence or absence of that specific activity) the intensity of each of the activities was asked and measured using a seven-point scale: (1) “none”, (2) “once”, (3) “annually”, (4) “quarterly”, (5) “monthly”, (6) “every two weeks”, (7) “weekly”.

Project management principles

Project management principles are those established processes which can guide the successful implementation of a project. Compared to front-end activities, these principles evaluate soft aspects of the project management and their presence cannot be measured through their intensity of application. The project management principles considered in the current study emphasize the generic aspects of project management such as the level of scope definition, presence of clear legal and administrative processes, setting clear and aligned project goals. These factors focus on behaviour, competence, relationship aspects of project management together with the “skills, knowledge, abilities, and behaviours required for success” (Bernthal, 2004). Soft skills of project management have been earlier addressed in literature (Ahadzie, Proverbs, & Olomolaiye, 2008). Also, Zuo et al. (2018)

showed that soft skills of project managers significantly contributed to application of project success factors and consequently project success. An example of such soft aspects or project management principles is the quality of collaboration among organisations involved in the project, like client and contractor (Suprapto, 2016). The current study is focused on the general skills and abilities for managing projects rather than individual competences. Project management principles also include the capability of the execution parties (contractors and subcontractors) and tendering and contracting procedures. An overview of the items of project management principles considered in the survey is presented in Table 4.3.

Table 4.3: List of items of project management principles asked in the survey

No.	Items of project management principles
1.	Integrated project team (client and contractor)
2.	Team members (client & contractor) had a sense of belonging to the team
3.	Team members helped and supported each other in carrying out their tasks
4.	Team members shared a belief that they will perform their roles and protect the interests of each other
5.	Team members were committed to the team tasks
6.	Project team put their best on joint efforts
7.	Members of team exhibited motivation to maintain the team
8.	The project manager exhibited leadership and managerial competencies
9.	The foreseen complexity of this project was takin into account when selecting the project manager for this project
10.	The project manager had sufficient technical skills for managing this project
11.	The project manager was committed to the project
12.	Senior management exhibited trust towards project the team
13.	Senior management expressed honesty and openness in the interactions with the project team
14.	Senior management were committed to this project and supported the project team
15.	Senior management collaborated closely with the project manager
16.	Senior management delegated authority to the project manager for decision making
17.	Percentage of the scope known at FID
18.	Using of high-quality project brief including the output specifications for the tendering processes
19.	Proportional risk sharing among the parties
20.	Comprehensive contract documentation
21.	Considering the technical capability of the (sub)contractor(s) in the selection procedures
22.	Considering the project management capability of the (sub)contractor(s) in the selection procedures
23.	Technical skills of the contractor
24.	Project management skills of the contractor
25.	Early involvement of the user in the front-end development
26.	Use of an integrated contract
27.	Required information was disseminated in time by various parties
28.	Clear communication channels were present for information sharing
29.	Use of an integrated contract
30.	Early involvement of (end) users
31.	Client/owner representatives involved regularly in the front-end development phase and in defining project goals and specifications
32.	The frequency and intensity of the interactions with client/owner representatives were sufficient
33.	Sufficient technical skills were available from the client/owner representatives involved in the project
34.	Project management skills were available from the client/owner representatives involved in the project
35.	Project goals were clearly defined
36.	A clear project performance measurement system existed
37.	Project goals were prioritised and were fully aligned
38.	Legal/regulatory framework to support the project procurement

In this research, project management principles were aggregated and operationalised in order to obtain an overall overview of those principles required for managing a project such as the support from the top management, collaboration between the parties in a project, etcetera. The majority of the survey questions about these principles used a five-point Likert-scale: (1) “strongly disagree”, (2) disagree”, (3) neutral, (4) “agree”, (5) “strongly agree”.

Not all those applied front-end activities and project management principles might be acknowledged/applied by the respondents. Therefore, two additional answer options were available: “not applicable” and “do not know” for each corresponding question. These options would help in identifying those front-end activities and project management principles which are not commonly applied in the management of engineering projects (see Subsection 4.5.1).

4.3.2 Data collection and survey sample

Data collection was conducted through an online questionnaire from late September 2017 to June 2018. The online questionnaire was developed and performed in the Collector website (an internal website formerly used by TU Delft for collecting questionnaire data). Specifically, two networks of companies (BRN and NAP) were targeted which are active in three specific industry sectors: construction, infrastructure and process industry. BRN was already approached for data collection for Q-sorting (see Section 2.4.2). NAP is a network of companies in the process industry including clients, engineering companies, suppliers, and research institutes. An invitation email with a link to the online questionnaire was sent to the companies within these networks. In order to increase the number of respondents, the respondents were asked to distribute the survey link among their colleagues in the company working on other engineering projects. Therefore, it was not possible to track the actual number of practitioners who received this invitation.

Overall, 176 potential respondents opened the link to the survey, from which 126 respondents completed the survey. Since there were some responses with more than 10% missing values, the final sample included 104 usable responses. In-depth analysis of the missing values per item was also performed setting the boundary level for the missing values at 10% (Hair, Black, Babin, & Anderson, 2010). If a specific item has more than 10% missing values, that item was removed from the analysis. This analysis suggested that some of the front-end activities or project management principles were not known/applied in specific project contexts (sectors). This filtration process is further explained in Subsection 4.5.1.

The majority of the projects was performed in the Netherlands. The sample projects were mostly executed in the public sector (around 48%), 39% in the private sector and 13% working in both public and private sectors. More than half of the respondents (55%) in this sample acted either as the owner/client or worked on behalf of the client in a reference project. The sample demographics are detailed in Appendix D.

A cross-tabulation of project size and project duration across the sectors is shown in Table 4.4. This cross-tabulation shows that more than three quarters of the projects had a size of less than 100 million Euro (77%), and only about 9% were more than 1000 million Euro. The duration of about half of the projects (53%) was less than 24 months, approximately one-fifth (21%) had a duration between 25 and 36 months, and only around 8% had a duration of more than 60 months. Infrastructure projects, however, had a longer project duration of more than 25 months (65% of infrastructure projects) compared to the construction and the process industry projects, 34% and 40% respectively.

Table 4.4: Project size and project duration cross tabulation per dataset and in the whole dataset (N=104)

Project size		< 12 months	Between 13-24 months	Between 25-36 months	Between 37-60 months	> 60 months	Total per sector
		Project duration					
<1 M€	Construction	2	2	0	0	0	4
	Infrastructure	3	0	0	0	0	3
	Process	3	2	0	0	0	5
	Total	8	4	0	0	0	12 (11.5%)
Between 1-10 M€	Construction	1	7	2	0	0	10
	Infrastructure	1	3	1	1	0	6
	Process	5	4	0	0	0	9
	Total	7	14	3	1	0	25 (24.0%)
Between 10-100 M€	Construction	1	3	4	2	1	11
	Infrastructure	2	1	5	5	2	15
	Process	2	7	4	4	0	17
	Total	5	11	13	11	3	43 (41.3%)
Between 100-1000 M€	Construction	0	1	0	0	0	1
	Infrastructure	1	1	3	2	2	9
	Process	1	0	2	2	0	5
	Total	2	2	5	4	2	15 (14.4%)
>1000 M€	Construction	0	0	0	0	0	0
	Infrastructure	0	0	0	0	2	2
	Process	1	1	1	3	1	7
	Total	1	1	1	3	3	9 (8.7%)
Total per sector	Construction	4	13	6	2	1	26
	Infrastructure	7	5	9	8	6	35
	Process	12	14	7	9	1	43
	Total	23 (22.1%)	32 (30.8%)	22 (21.2%)	19 (18.3%)	8 (7.7%)	104 (100%)

The respondents were also asked to identify which stakeholders were involved during the front-end phase, see Table 4.5. Across the sectors it can be observed that the project manager and his/her team are involved in the majority of the projects. Obviously, in the construction and infrastructure projects, local and regional government are involved. In the infrastructure projects, national government is also engaged early during the project. The involvement of contractors and suppliers in the front-end phase is typically less in the construction and infrastructure sectors compared to the projects in the process industry. From this table, it can be also observed that in more than half of the projects in each sector, future users are not involved in the front-end phase.

Table 4.5: List of stakeholders typically involved in the front-end phase per sector group

	Construction (N=26)		Infrastructure (N=35)		Process industry (N=43)	
	N	Percentage (%)	N	Percentage (%)	N	Percentage (%)
Local/reginal government	17	65.4	33	94.3	8	18.6
National government	3	11.5	17	48.6	5	11.6
Joint venture (or business) partner(s)	2	7.7	6	17.1	7	16.3
Project/finance/business developer	7	26.9	7	20	15	34.9
Line management of PM	11	42.3	15	42.9	24	55.8
Project manager and his organisation	17	65.4	24	68.6	37	86
Contractor(s)	7	26.9	7	20	20	46.5
Supplier(s)	2	7.7	7	20	21	48.8
Future users/inhabitants	10	38.5	16	46	12	27.9
NGOs	1	3.8	4	11.4	1	2.3

4.4 Analysis setup

The data collected from the survey was analysed using Statistical Package for Social Sciences, SPSS version 25.0 (IBM, 2016). Multivariate analysis was used to identify the patterns of front-end activities and project management principles most commonly applied in the management of large engineering projects. Before doing that, however, data was refined to exclude those items (of front-end activities and project management principles) with a high percentage of missing values. The percentage of the missing values can be calculated based on the "not applicable" and "do not know" answers given to each question. This allows respondents not to answer those questions that do not apply to their situation or simply they do not know the answer for (Castillo, Alarcón, & Pellicer, 2018). The inclusion of those options is twofold. First, the respondents are not forced to give an answer, which would not represent their situation. This can strengthen reliability and validity of data (Cooper & Schindler, 2014, p. 224). Second, these options would help in filtering data, providing an overview of which project management efforts are not commonly applied in managing engineering projects.

Further, it was investigated whether the mean of the intensity of application of front-end activities and the level of the project management principles varied significantly across these three sectors (groups). Thus, the data analysis in this study aims to assess the following hypothesis:

***H:** The project management effort in terms of the intensity of application of front-end activities and project management principles differs amongst the industry sectors.*

In order to evaluate this hypothesis, a Kruskal-Wallis test was performed. This test is applied to investigate the relationship between two or more variables (Kruskal & Wallis, 1952). In other words, Kruskal Wallis test is applied to examine whether sectors (nominal variables) are significantly different from each other in terms of the intensity of application of front-end activities and the level of project management principles. Kruskal-Wallis test is a non-parametric method which works on the principle of ranking the data, thus the data is not required to be normally distributed (Field, 2009; Vargha & Delaney, 1998).

4.5 Results

The results of the study are presented in three subsections. First, in Subsection 4.5.1 it is investigated which of the front-end activities and project management principles are not commonly applied in practice. Removing these items filters the variables used for the next stage of the analysis presented in Subsection 4.5.2 and further in Chapter 5 and Chapter 6. Next, in Subsection 4.5.3 the difference between the intensity of application of front-end activities and level of project management principles is investigated to determine whether this difference is statistically significant amongst the three sectors.

4.5.1 Observations regarding not commonly applied front-end activities and project management principles

In this study, we treated both "not applicable" and "do not know" responses as missing values. The aim of analysing these missing values here is twofold. First, interpretation of those missing values could give an indication of which of those studied front-end activities and project management principles are not really applied, overall as well as per case, in practice. Second, large numbers of missing data would hamper our further analysis for comparing the project management efforts made in terms of front-end activities and project management principles. Items which have more than 10% missing data are removed from the further analysis (Hair et al., 2010).

In order to calculate the missing values per item, all the "not applicable" and "do not know" responses are summed up. Figure 4.1 shows the percentage of the missing values for those items of the front-end activities, which have more than 10% missing values. The dotted line indicates the threshold of 10% missing values per item. As can be seen in Figure 4.1, 14 out of 33 items of the front-end activities had to be removed from the analysis due to the high percentage of missing values. In the majority of the items related to the front-end activities, the infrastructure sector had the highest percentage of missing values compared to other sectors (except for the activity ***process conformance***). The highest missing values (all above 30%) for the infrastructure include ***design to capacity, technology selection***, ***self-assessment of project team members***, and *HSE management, value engineering, and operation implementation planning.* More detailed information on the frequency and percentages of missing values for the application of front-end activities, overall as well as per sector, is presented in Appendix E. 1 (front-end activities), here only the main findings are summarised.

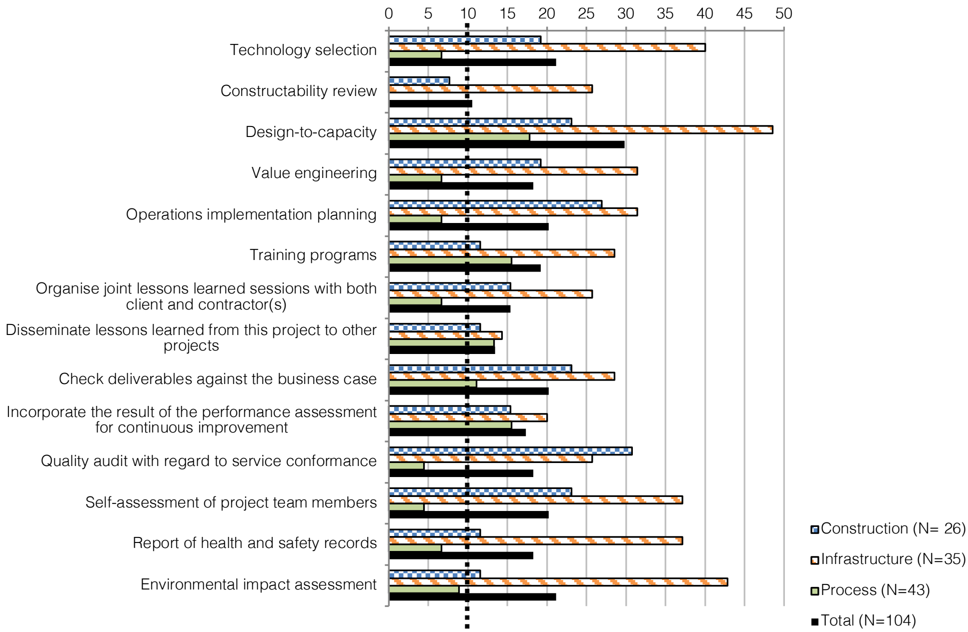

Figure 4.1: Percentage of missing data, "not applicable" and "do not know" responses, for the aspect front-end activities

The findings from Figure 4.1 are summarised as follows.

All these 14 items have a missing value higher than 10% across the whole dataset (N=104). The top three front-end activities items with a high percentage of missing values include ***design to capacity, technology selection, and environmental impact assessment. Design-to-capacity*** is considered as one of the VIPs as defined by IPA and it is defined as evaluating the maximum capacity of each major piece of equipment, and action is taken to reduce unnecessary excess capacity (McCuish & Kaufman, 2002). Even in the process industry where this activity originated from, the percentage of missing values is relatively high (17.7%). *Technology selection* and *Environmental impact assessment* are other VIPs which received less attention from the practitioners. Additionally, it can be observed that ***training programs (required skills for the project, communication skills, and team development)***, ***dissemination of lessons learned to other projects,*** and ***performance assessment for continuous improvement,*** received the highest percentages of missing values, across all sectors.

Some of the front-end activities are typically applied in projects in a specific sector. Specifically, a major difference can be observed between the applied front-end activities in the process industry and both construction and infrastructure projects. For instance, ***constructability review*** is recognized by nearly all respondents in the process industry. ***Process conformance (quality audit with regard to service conformance)***, ***organise joint lessons learned sessions with both client and*** *contractor(s),* and *self-assessment of project team members* are also applied mostly in the process industry. It can be also observed that *HSE management* is not well-established in the construction and infrastructure sectors.

Figure 4.2 gives an overview of 13 out of 43 items of the project management principles with high percentages of missing values (higher than 10%). Again, the dotted line indicates the threshold of 10% missing values per item. More detailed information on the frequency and percentage of missing values for the level of project management principles, overall as well as per sector, is presented in Appendix E. 2 (project management principles).

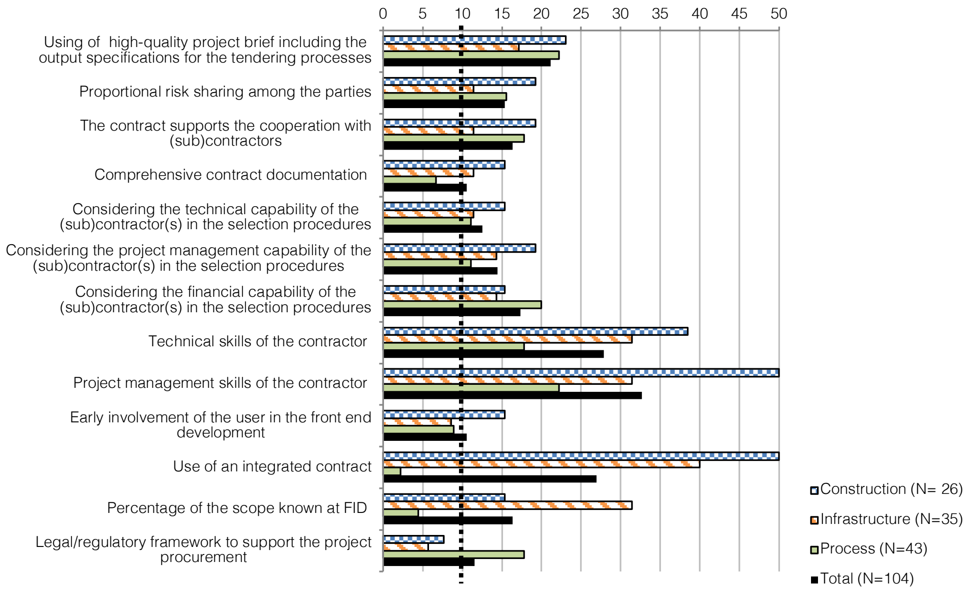

Figure 4.2: Percentage of missing data, "not applicable" and "do not know" responses, for the aspect project management principles

The findings from Figure 4.2 are summarised as follows. Not all items related to project management principles are present in practice (considering the whole dataset, N=104). Most of these items related to the following principles: ***selection of contracting strategy and tender process, contract management, and proper selection of project execution resources***. The high percentage of missing values regarding the items related to the skills of the contractor might imply that contractors are not typically involved during the front-end development in these sectors. This lack of involvement was also observed in Table 4.5. Additionally, an *integrated contract* was not applied in the majority of the projects. If the participants did not already know during the front-end phase whether an integrated contract has been used or not this implies that such a fully integrated contract was not used. An *integrated contract* was only used in 23 out of 104 projects: 4 in the construction, 7 in the infrastructure, and 12 in the process industry.

Some of the project management principles seem more sector-specific, at least during front-end development. *Legal and regulatory framework supporting the project procurement* is more evident in the construction and infrastructure sectors compared to the process industry. The reason might be that construction and infrastructure projects are more often publicly owned which makes it crucial to define such legal framework.

It should be noted that the analysis presented here is only based on the percentage of missing values per item. No conclusions can be drawn on the actual intensity of the application of front-end activities or the level of project management principles and their comparison across the industry sectors on these items.

After removing the items for which not enough data was collected in this study, the final analysis framework is refined to 42 items: 17 front-end activities and 25 project management principles (see Table 4.6). Subsection 4.5.2 concerns the grouping of these remaining items.

Table 4.6: Applied front-end activities and project management principles items refined based on the survey results

	Applied front-end activities		Project management principles
1.	Goal setting and alignment	1.	Required information was disseminated in time by various parties
2.	Measure the project performance		
3.	Report the overall project progress to the client	2.	Clear communication channels were present for information sharing
4.	Track the progress of project performance	3.	Senior management exhibited trust towards project the team
5.	Quality audit with regard to design conformance (meeting the specifications of the product)	4.	Senior management expressed honesty and openness in the interactions with the project team
6.	Thorough documentation of the project for future reference	5.	Senior management were committed to this project and supported the project team
7.	Development of risk register including mitigation plan	6.	Senior management collaborated closely with the project manager
8.	Prioritisation of risks based on the risk assessment matrix	7.	Senior management delegated authority to the project manager for decision making
9.	Updating the risk register (including mitigation plan)	8.	The project manager exhibited leadership and managerial competencies
10.	Specific attention for opportunities to seize them		
11.	Check for applicable lessons from previous projects	9.	The foreseen complexity of this project was takin into account when selecting the project manager for this project
12.	Capture lessons learned from this project	10.	The project manager had sufficient technical skills for managing this project
13.	Joint social events	11.	The project manager was committed to the project
14.	Work related informal joint activities	12.	Team members (client & contractor) had a sense of belonging to the team
15.	Joint problem solving/trouble shooting sessions for developing and evaluating action plans by the team members	13.	Team members helped and supported each other in carrying out their tasks
16.	Establishing of roles and expectations of the team members	14.	Team members shared a belief that they will perform their roles and protect the interests of each other
17.	Feedback on individual/team performance	15.	Team members were committed to the team tasks
		16.	Project team put their best on joint efforts
		17.	Members of team exhibited motivation to maintain the team
		18.	Integrated project team (client and contractor)
		19.	Client/owner representatives involved regularly in the front-end development phase and in defining project goals and specifications
		20.	The frequency and intensity of the interactions with client/owner representatives were sufficient
		21.	Sufficient technical skills were available from the client/owner representatives involved in the project
		22.	project management skills were available from the client/owner representatives involved in the project
		23.	Project goals were clearly defined
		24.	A clear project performance measurement system existed
		25.	Project goals were prioritised and were fully aligned

4.5.2 Factor analysis on the constructs of front-end activities and project management principles

Principal Component Analysis (PCA) was used to reduce the items related to the front-end activities and project management principles into meaningful and manageable factors based on the empirical data (Field, 2009). In addition, PCA is used to group these quantities of items (Liu, Li, Xue, Li, Zou, & Li, 2018) and examine for unidimensionality of each factor to check if all related items load onto a particular factor (Kock, Schulz, Kopmann, & Gemünden, 2020). Such an approach for reducing the number of individual practices into groups of practices, based on the given dataset, is also applied in other studies (Besner & Hobbs, 2012; Müller, Zhai, & Wang, 2017).

The PCA was performed on the filtered data after removing those items with missing value percentages higher than 10%, as presented in Table 4.6. PCA aims to "maximize the amount of variance described by a transformed, orthogonal set of parameters" (Nickerson & Sloan, 1999). First, the data was checked for the existence of outliers (Field, 2009). The analysis showed that none of the cases were significantly different from the other cases. PCA with direct oblimin rotation was used separately for the front-end activities and project management principles. Direct oblimin was used because of the small sample size (Yalegama, Chileshe, & Ma, 2016) and the fact that interrelationships between the factors are allowed (Field, 2009). The following questionnaire items were rejected by the PCA and removed from further analysis because they did not clearly load on a specific factor: goal setting and alignment, attention for seizing opportunities, and integrated project team of client and contractor. The former two items are related to front-end activities and the latter is related to project management principles. Goal setting and alignment in this definition, that is removed from the analysis, was considered as one of the VIPs (front end activity) which intensity can be measured. But setting project goals was also operationalised as a project management principle (see Table 4.3). Eventually, 39 items (15 front-end activities and 24 project management principles) were selected for further analysis.

The analysis resulted in five factors for the front-end activities and seven factors for the project management principles which explained 61% and 59% of the variance, respectively. The value of the Kaiser–Meyer–Olkin (KMO) indicator for both of the constructs was higher than 0.7 (0.820 and 0.826, respectively) with p=.000. This indicates that the dataset is appropriate for this analysis.

The factor loadings for the two separate aspects of front-end activities and project management principles are presented in Appendix F. 1 and Appendix F. 2. As a rule of thumb, a cut-off value of 0.4 on the rotated factor is considered to meet the minimum level for interpreting the factors (Hair et al., 2010). Tabachnick and Fidell (2007) argue that a factor loading of 0.45 is adequate for a (fair) factor analysis. However, a more stringent rule suggested by Hair et al. (2010) states that in a sample size of around 100 respondents, a factor loading of 0.55 and higher is required for identifying significant factors. All the items in this analysis met this latter threshold. The front-end activities were labelled A_x and E_x denoted project management principles. As a reference, the list of the items of front-end activities and project management principles and their associated questions in the questionnaire are presented in Table 4.7.

Table 4.7: Front-end activities and project management principles items in the survey considered in this research

	Factor	Items	ID
Front-end activities (A)	*How often did you perform the following activities in front-end development phase of this project…*		
	Risk management	Development of risk register including mitigation plan	A2
		Prioritisation of risks based on the risk assessment matrix	A1
		Updating the risk register (including mitigation plan)	A3
	Embracing and capturing lessons learned	Thorough documentation of the project for future reference	A6
		Check for applicable lessons from previous projects	A4
		Capture lessons learned from this project	A5
	Team building	Joint social events	A14
		Work related informal joint activities	A12
		Joint problem solving/trouble shooting sessions for developing and evaluating action plans by the team members	A13
	Setting expectations	Establishing of roles and expectations of the team members	A11
		Feedback on individual/team performance	A15
	Monitoring and quality managemen	Measure the project performance	A8
		Report the overall project progress to the client	A7
		Track the progress of project performance	A9
		Quality audit with regard to design conformance (meeting the specifications of the product)	A10
Project management principles (E)	*Please indicate for each statement the answer that applies best to your project…*		
	Collaboration between client and contractor	Team members (client & contractor) had a sense of belonging to the team	E2
		Team members helped and supported each other in carrying out their tasks	E3
		Team members shared a belief that they will perform their roles and protect the interests of each other	E1
		Team members were committed to the team tasks	E6
		Project team put their best on joint efforts	E5
		Members of team exhibited motivation to maintain the team	E4
	Top management support	Senior management exhibited trust towards project the team	E21
		Senior management expressed honesty and openness in the interactions with the project team	E22
		Senior management were committed to this project and supported the project team	E20
		Senior management collaborated closely with the project manager	E24
		Senior management delegated authority to the project manager for decision making	E23
	Project manager competency	The project manager exhibited leadership and managerial competencies	E7
		The foreseen complexity of this project was takin into account when selecting the project manager for this project	E9
		The project manager had sufficient technical skills for managing this project	E8
		The project manager was committed to the project	E10
	Setting project goals	Project goals were clearly defined	E11
		A clear project performance measurement system existed	E13
		Project goals were prioritised and were fully aligned	E12
	Information sharing	Required information was disseminated in time by various parties	E14
		Clear communication channels were present for information sharing	E15
	Client involvement	Client/owner representatives involved regularly in the front-end development phase and in defining project goals and specifications	E18
		The frequency and intensity of the interactions with client/owner representatives were sufficient	E19
	Client competency	Sufficient technical skills were available from the client/owner representatives involved in the project	E16
		Project management skills were available from the client/owner representatives involved in the project	E17

As explained earlier in Subsection 4.3.1, a multi-item measurement scale is used for measuring the front-end activities and project management principles. Cronbach

Alpha was calculated to check the internal consistency of the factors (Cronbach, 1951). All 12 extracted factors had acceptable reliability (Cronbach's alpha more than 0.6) (Müller et al., 2017). Thus, these factors can be used and replaced the aggregated items for the high-level analysis. The factors developed by the PCA confirm the theoretically derived items from the literature.

Table 4.8 provides the descriptive statistics of the factors. As can be seen from this table, the mean score of the front-end activities is relatively low. The factor embracing and capturing lessons learned has a minimum mean value of 2.59 (corresponding to an intensity of applying these activities between once or annually) and monitoring and quality management activities have a maximum mean value of 4.40 (intensity of application between quarterly and monthly). Team building and setting expectations also have a low frequency of application (between annually and quarterly). More detailed information on descriptive statistics of the items (mean and standard deviation) is given in Appendix F. 3.

Table 4.8: Descriptive statistics for the factors used in the research

No.	Factor	Mean	Scale	Standard deviation	Skewness	Kurtosis
1	Risk management	3.59		1.57	-0.28	-0.82
2	Embracing and capturing lessons learned	2.59		1.21	0.96	0.98
3	Team building	3.38	1 to 7	1.58	0.03	-0.95
4	Setting expectations	3.29		1.49	0.11	-0.83
5	Monitoring and quality management	4.40		1.24	-0.76	1.29
6	Collaboration between client and contractor	4.01		0.66	-0.52	0.16
7	Top management support	4.08		0.70	-0.63	-0.15
8	Project manager competency	4.23		0.66	-0.88	0.42
9	Setting project goals	3.71	1 to 5	0.72	-0.08	-0.34
10	Information sharing	3.80		0.80	-0.97	0.52
11	Client involvement	4.13		0.68	-0.88	1.34
12	Client competency	3.79		1.24	-0.85	-0.32

4.5.3 Comparison of the intensity of application of front-end activities and level of project management principles across the sectors

In this subsection, it is investigated whether there are significant differences in the intensity of application of front-end activities and level of project management principles between the three industry sectors: construction (N=26), infrastructure (N=35) and process industry (N=43). In order to do that, first the factors related to front-end activities and project management principles resulting from PCA are compared. Next, the application of items related to the factors are compared in order to identify the potential differences.

Checking for normality is important for choosing the appropriate parametric or non-parametric test (Field, 2009). The result of the Shapiro-Wilk test and visual assessment of the histograms and boxplots on the factors of front-end activities and project management principles showed that the data are not normally distributed ($p < 0.05$) (Ghasemi & Zahediasl, 2012). Therefore, Kruskal-Wallis test, which is a non-parametric test, is used to check the hypotheses of equality of means of the factors and items across the industry sectors (Field, 2009). The null hypothesis for this analysis can be formulated as: (**H_0**) "the distribution of the intensity of application of front-end activities and the level of project management principles is the same across the three groups of industry sectors". If p-value for the Kruskal-Wallis test is less than or equal to the significance level, this leads to rejection of the hypothesis of equality of means. Aguinis, Werner, Lanza Abbott, Angert, Park, and Kohlhausen (2010) suggest that the choice for the significance level can be varied in a specific research field and it should also be accompanied by a qualitative analysis. Additionally, they argue that a balance should be found between the probabilities of having Type I error (a) and Type II error (β). Kim and Choi (2019) showed that when the sample size is relatively small (N=100), a significance level of 0.11 is reasonable. Some previous studies used the significance level of 0.10 in their qualitative study when the sample size is around 100 (Bond-Barnard, Steyn, & Fabris-Rotelli, 2013; Jørgensen, 2006). Following these arguments, for the analysis presented in this subsection, a p-value (a) lower than 0.10 is considered as a significant result. Further, in order to provide more in-depth insight, these significant results are investigated qualitatively by looking at the rank of the factors or items in each sector.

For these significant results from Kruskal-Wallis test, pairwise comparison was performed to identify which pairs of groups are statistically significant from each other. The adjusted p-value according to the Bonferroni correction indicates which pairs within a family of comparisons (3 comparisons are made between three industry sectors) are significantly different considering the influence of multiple testing (IBM, 2016). Table 4.9 only summarises the outcome of pairwise comparison on the significant differences resulting from Kruskal-Wallis test. More detailed information on the Kruskal-Wallis test on the factors considering industry sectors is presented in Appendix G. 1.

Table 4.9: Summary of hypothesis test resulted from pairwise comparison of Kruskal-Wallis test significant factors differences considering industry sectors

Test factor	**Kruskal-Wallis test results**			**Pairwise comparison result**	
	Test statistics	**Mean rank**		**Sig. (P)**	**Adjusted Sig.**
Team building	5.26	Construction	Infrastructure	0.022	0.067
		41.81	59.59		
Top management support	5.98	Construction	Process	0.030	0.090
		44.77	60.97		
Setting project goals	8.59	Construction	Process	0.003	0.011
		37.04	57.95		

Overall, Table 4.9 suggests that the intensity of application of team building activities, level of top management support, and level of project goal setting is significantly different amongst the industry sectors. More specifically, a significant difference was found in the intensity of application of team building activities in the construction and the infrastructure projects. The construction projects applied team building activities only with a frequency between "once" and "annually". This is less frequent than in the infrastructure projects where such activities were applied nearly every quarter. Regarding the configuration of their project team(s), only 16 out of 104 projects indicated that an integrated project team was organised: 3 in the construction, 4 in the infrastructure, and 9 in the process industry. This might imply that those team building activities are organised separately.

The construction projects showed lower levels of top management support compared to the process industry projects. When comparing the levels of project goal setting between the construction projects and the projects in the process industry, the construction projects put considerably lower effort in defining those requirements or at least those goals were not aligned amongst the parties in the early stages of the project.

No significant differences were found on other front-end activities and project management principles, grouping the projects amongst the industry sectors. This could be because of the high-level character of this analysis. Thus, in order to perceive if the items related to front-end activities and project management principles differ significantly amongst the industry sectors, more in-depth analysis could be helpful. Again, the Kruskal Wallis test is performed on the items (see Appendix G. 2 and Appendix G. 3 for detailed results). Table 4.10 shows the significant outcomes from the pairwise comparison based on the Kruskal-Wallis test.

Table 4.10: Summary of hypothesis test resulted from Kruskal-Wallis test, significant differences of items considering industry sectors

Test item	Kruskal-Wallis test results			Pairwise comparison result	
	Test statistics	Mean rank		Sig. (P)	Adjusted Sig.
Work related informal joint activities (project team within either client or contractor team)	9.02	Construction 36.33	Infrastructure 58.23	0.003	0.008
Check for applicable lessons from previous projects	8.21	Construction 40.25	Infrastructure 60.02	0.008	0.024
		Process 46.16	Infrastructure 60.02	0.027	0.081
Report the overall project progress to the client	0.05	Infrastructure 43.62	Process 58.05	0.014	0.041
Project team (client and contractor) joint efforts	6.01	Construction 44.58	Process 60.1	0.049	0.069
Prioritised and aligned project goals	6.68	Construction 38.23	Process 55.74	0.010	0.029
Clear project performance measurement system	6.38	Construction 37.68	Process 54.51	0.012	0.036
Senior management commitment (from both sides, client and contractor) to the project and team members	6.75	Construction 42.77	Process 60.12	0.011	0.034
Considering the foreseen complexity of the project when selecting the project manager	4.79	Construction 40.69	Process 55.79	0.029	0.086

Infrastructure project teams, within their own, applied a higher intensity of informal joint activities close to quarterly application, whereas in construction projects such activities were applied mostly once during the front-end phase. Interestingly, infrastructure projects had the highest mean ranks in terms of checking lessons learned from previous projects. The intensity of retrieving those lessons learned is still relatively low (close to yearly application) but compared to the construction and process industry projects (which mostly showed a onetime application) these lessons were valued more. The process industry projects provide “monthly” or “weekly” project progress reports in order to check it against the project requirements defined by the client. In the infrastructure projects, this progress reporting was significantly less frequent applied; “quarterly” or “monthly”. A potential explanation could be the longer duration of infrastructure projects in our dataset, compared to projects in the process industry.

Project teams in the process industry agreed that they work jointly together with their counterparts, from client and contractor side. In the construction projects, however, the extent to which respondents experienced this joint effort is lower. There seems to be a greater discord between the construction and process industry projects in terms of the level of project goal alignment and clarity of the importance of those goals amongst the key stakeholders. Specifically, the majority of the respondents in the construction industry indicated that there is no project performance measurement system. The mean score for senior management commitment was high amongst the three industry sectors. Respondents in the process industry, however scored this factor relatively higher compared to the respondents in the construction industry.

Compared to the process industry, when selecting the project manager in the construction projects, less focus is given to the complexity of the project and whether the project manager is capable of managing the different aspects of project complexity. Looking into the respondent’s answers and their organisational roles, most of the respondents in the construction sector work in a consultancy firm or they were externally hired by the client to manage the project. This suggests that the organisational role can affect their project management selection. In order to check this argument, Kruskal-Wallis test and pairwise comparison were conducted to compare the extent to which the selection of project manager could vary across the sectors. The results indeed suggest that clients, compared to consultants, put more attention to select the suitable project manager for a specific project characteristic (adjusted p-value = 0.062).

4.6 Discussion and implications

This chapter investigated what project management efforts in terms of front-end activities and project management principles are applied in the current practice of managing a wide range of engineering projects. A survey study approach was adopted including qualitative and multivariate data analyses. In this section, first the observed similarities and differences on those project management practices, across the industry sectors, are discussed in Subsection 4.6.1. Next, in Subsection 4.6.2, the findings of the survey study are compared and linked with the Q-study results in Chapter 3.

4.6.1 Interpreting the observed similarities and differences among the industry sectors

The findings suggest that a number of front-end activities and project management principles are well-established in a specific sector. For instance, constructability review and value engineering as the VIPs are less recognized by the respondents in the construction and infrastructure sectors. The reason might be that such practices are less well-known in these sectors or the terminology used for these activities varies in different sectors suggesting that sector-specific project management knowledge is required (Artto et al., 2017). However, still some of those sector-specific practices can be adapted and fitted to other sectors.

The results indicate that several front-end activities and project management principles are not acknowledged to a large extent in practice, irrespective of the industry sector. These include, for instance, joint lessons learned with client and contractor, checking deliverables against the business case and performance assessment with the aim of continuous improvement. It might be logical to some extent not to track those deliverables because during the front-end the business case is still under development. This might, however, raise the question to what extent the business case is clearly defined and whether any evaluation of those goals in the business case is performed during the early project phases. Looking more in-depth into the data, it was revealed that in the majority of infrastructure (60%) and process industry (70%) projects, a business case review was performed at the end of the front-end phase. In construction, however, only 39% of the projects in our dataset had such review at FID (final investment decision), implying that in such projects the business case and the benefits expected from the project might be inadequately defined. Hertogh et al. (2008) also emphasised that there should be a sound business plan at the beginning of the (infrastructure) project containing adequate financial setup. The main purpose of the business case should be to understand whether undertaking the project could deliver promised strategic values to the organisation (Einhorn, Marnewick, & Meredith, 2019). If it is not clear what benefits are expected from the project it would be hard to track these benefits later during the execution phase (Kopmann, Kock, Killen, & Gemünden, 2015).

Another observation from our survey study was that assessing the project performance with the aim of continuous improvement and disseminating the project experiences was not sufficiently recognized in practice. Capturing and disseminating those reusable lessons and continuous improvement are closely interrelated (Carrillo, 2005) and if they are applied properly, they can positively contribute to project performance (Yap, Abdul-Rahman, & Chen, 2017). In practice, however, capturing lessons learned is disregarded (Duffield & Whitty, 2015) and even when those lessons are captured and documented, they are rarely reused in future projects (Tan, Carrillo, Anumba, Bouchlaghem, Kamara, & Udeaja, 2007) which confirms relevant literature in the field. For facilitating such learning and reusing experience, creating a collaborative culture among the project parties is crucial (Yap et al., 2017).

The cross-sectoral analysis revealed that the construction projects, to some extent, seem to be less mature in terms of application of project management practices during the front-end phase. Specifically, analysis of the survey data revealed that the construction projects put considerably less effort into aligning project goals among the key stakeholders during the front-end phase. This is crucial because those objectives and goals can direct the project in later stages (Heravi, Coffey, & Trigunarsyah, 2015). In order to contribute to project performance, those goals should be defined clearly at the very beginning of the project and further be prioritised to adopt an appropriate management approach (Scott-Young & Samson, 2008). Thus, the result of the survey data is in line with the study of Heravi et al. (2015) finding that, in the context of building construction, contractors are not usually involved early in the project. This late involvement might cause misalignments of the goals and objectives among the stakeholders which could negatively affect the project quality. Project managers in construction industry should provide more opportunities on bringing the stakeholders together where they can openly discuss where their priorities regarding the projects lie.

4.6.2 Linking the findings back to the Q-study results

In this subsection, it is discussed how the results of the current survey data analysis could be linked back to the findings of the earlier Q-study in Chapter 3. Both empirical studies provide insights into how engineering projects are managed in practice, thereby addressing the need for empirical data on the intensity of application of success factors, beyond a binary applied/not applied scale, as suggested by (Joslin & Müller, 2015). The Q-study is merely focused on the practitioners' perceptions in different industry sectors, whereas the survey data analysis presented in this chapter, took a more practice-oriented approach.

The difference observed in the level of project team joint effort may be explained, in part, by the fact that in the process industry more focus is given to the practice of integration (see Subsection 3.5.1). Such an integrated team practice could "*orchestrate a more collective action towards common goals*" (Ibrahim, Costello, & Wilkinson, 2018). For having an integrated team and enhancing team collaboration, stimulating a self-governing team is required on one hand (Alashwal & Fong, 2015), commitment from top management from both sides is on the other hand crucial for providing a governance structure (Ibrahim et al., 2018). This top management commitment is also stronger within the process industry projects in the current survey data.

The results of the survey study point out that the involvement of contractors in the early project phases is not acknowledged. This is in line with the study of Heravi et al. (2015) suggesting that usually, in building construction projects, contractors are involved late when the planning is already made or even later during the execution phase. This again highlights the extent to which early contractor involvement could facilitate collaboration (Ferme, Zuo, & Rameezdeen, 2018). Even in the context of a traditional contract, Mollaoglu-Korkmaz, Swarup, and Riley (2013) show that client commitment, timely participation of the contractor (which can be informally), and team collaboration and chemistry can contribute to the level of integration obtained.

Construction and infrastructure projects seem to be more sceptical in incorporating product related innovation by adopting new technologies. As explained in Subsection 4.5.1, selecting the best technology is widely disregarded in construction and infrastructure sector. Indeed, it would be interesting to perform more in-depth analysis on underlying barriers for incorporating innovation in construction and infrastructure projects and what can be the enablers for such innovations by stimulating collaborative environments among the parties (Eriksson et al., 2019). Linking this back to the integration approaches, it would be of value to explore how arranging such integrated project teams could stimulate the innovation adoption. More collaborative contracts and early involvement of the contractor can stimulate the incorporation of innovation (Verweij et al., 2019; Wondimu et al., 2020). When innovation in terms of new technologies is incorporated it can contribute to the improvement of project performance (Davies, MacAulay, DeBarro, & Thurston, 2014).

The study revealed that quality management practices focusing on the product-related aspects are commonly applied in practice (within the factor monitoring and quality management). Process-related and people-related aspects are to some extent implemented, albeit with different frequencies in the sectors. These practices are mostly centred around meeting specifications (product-and process-related) and requirements as defined by the client (people-related), implying that clients play an important role in such quality management practices. This is in line with the findings of the Q-study where the quality management was mostly emphasised by the client perspectives. Other aspects of the project management such as service conformance, and self-assessment of the project team members are not commonly recognized in practice across all the sectors. This suggests that people-related practices of the quality management, as explained by Lu et al. (2019), require an effective governance structure among the participants. The implication of this is that these mostly “soft” aspects of quality management need to get more attention from practitioners. This again emphasises the importance of integration between the parties to jointly perform the project management practices and the need to provide those preconditions for facilitating such integration.

As expected from the findings of the Q-study, ***HSE management*** is mostly recognized by the practitioners in process industry owing to the culture of companies active in such environment (Hofmann et al., 1995). In the survey, the respondents were asked about HSE related activities during the front-end phase. It could be expected that such activities could gain more attention later during execution. As discussed in Subsection 3.5.1, however, it would become more expensive to change those safety related activities during execution (Hurme & Rahman, 2005). The implication for construction and infrastructure projects is to put more effort into designing the required processes related to safety early during the front-end phase.

The survey results suggest that training as such is not acknowledged by the practitioners. Lack of emphasis on training provisions, such as programs for developing the necessary skills, across all sectors was also observed in the Q-study. This might imply that training receives insufficient attention in the engineering projects' practice. The study of Tabassi, Ramli, and Bakar (2012) on the construction companies, however, shows that training could enhance the teamwork performance. In the same vein, training programs as one of the organisation support practices could contribute to the project (Fortune & White, 2006) and organisational performance (Zwikael & Meredith, 2019). Hence, an implication might be that more effort should be invested in (project-related and personal) training practices, especially during the front-end phase.

4.6.3 Bringing it together

This cross-sectoral analysis provides an opportunity for practitioners in a specific sector to understand how projects are managed in other interrelated sectors. Communicating those ideas across different sectors can enhance the development of disciplines and the world of practice (Zahra & Newey, 2009). It can be concluded from this chapter that projects in the construction and infrastructure sector can learn from the process industry to make their project management practices more structured.

An integrated approach was emphasized more by the practitioners in the process industry in the Q-study. What is observed from the survey results presented in this chapter, however, is that the perception of practitioners might be different from what commonly happens in practice. This is illustrated by a relative low percentage (less than 50%) of client involvement during front-end, as a requirement for such integration, in the process industry. Still, the early involvement of the contractor is higher in the process industry compared to that in the construction and infrastructure sectors (both around 20%). This lack of early contractor involvement in the construction and infrastructure sectors can be partly explained by the fact that the legal requirements within such sectors might hinder the application of early involvement of the contractor. The message, however, here is that project management practice in the three sectors should put more effort into bringing the parties together early and focus on an integrated approach.

Q-sorting can be seen as a reflection of the subjective viewpoint of the practitioners on what factors need to be in place for a successful project, whereas the survey study explicitly examined what front-end activities and project management principles are commonly applied. By comparing the results of these two studies, it can be concluded that practitioners intend to move towards a more open and integrative approach. Looking more in-depth into the reality of project management practices in the survey, however, it can be observed that practice lags behind and remains focused on the traditional approach. Front-end activities, such as lessons learned, setting expectation, team building, and risk management are typically applied with less intensity compared to monitoring and quality management activities. Even when applied, these activities are organised within separated project teams (client and contractor). Hence, this difference between the personal viewpoint of the practitioners and daily practice provides food for thought and discussion on what the barriers are for an integrative approach and how such approach can be stimulated.

4.7 Concluding remark and next step

The main purpose of this chapter was to explore the current project management practices specifically during the front-end, and further compare them across three industry sectors: construction, infrastructure, and process industry. To address this, a survey study was performed.

Together with the results from Chapter 3 (cross-sectoral analysis of the practitioners' perceptions using Q-study), the survey study provides insights into how project management practices are applied in different sectors. When comparing those project management practices, it was concluded that (specifically) construction and infrastructure sector could enhance their project management practices in terms of more integration between the main project parties during the project front-end. This calls for more stringent requirements to be set up in the project management standards within these sectors. For instance, construction projects could benefit from providing a collaborative environment among the parties by jointly setting project goals and agreeing upon them. Having an integrated project team of client and contractor representatives can facilitate this. Arranging a real integrated project team is challenging and just a few of the projects in the current dataset have provided such an arrangement. Although it seems the business case is taken for granted in infrastructure and construction projects, the practitioners should exert more effort into preparing a sound business plan and regular checking of deliverables against the business case should be on the agenda.

The process industry seems to be more effective in terms of stimulating collaboration among the parties, even when having such an integrated team is not possible in practice. Indeed, there is no single universal approach of project management and because of the unique characteristics of each sector, specific project management practices are required.

A limitation of this study was that those items with large missing values which were not commonly applied in practice during the project front-end phase, had to be removed from the further analysis. Despite this limitation, it already conveys a message that these activities/items are not popular in practice. These practices, however, have been extracted from and are recommended by literature. The fact that they are not applied in practice shows that there is a gap in what is preached by the academic community and what is commonly practised by practitioners. Further research could explore the underlying reasons that hamper or promote the application of such practices. Further research could also investigate what other practices and tools are applied instead. Of course, it remains to be seen to what extent those project management practices could contribute to the performance of engineering projects. This is investigated and discussed in the next chapters (Chapter 5 and Chapter 6).

Chapter 5

Advancing the Research on Project Performance: A Necessity Logic approach

Part of this chapter was presented at

EURAM Conference 2019*,* Lisbon, Portugal

Abstract

The purpose of this study is to identify the role of project management efforts in terms of front-end activities and project management principles in determining the intended level of project performance. The research was performed in three sectors: construction, infrastructure, and process industry. Using survey data of 104 engineering projects in the Netherlands, 12 factors of front-end project management efforts were identified. Next, a Necessary Condition Analysis (NCA) was performed on these factors. The findings show that four factors were among the necessary conditions for good project performance: top management support, collaboration between client and contractor, information sharing among the project parties, and technical skills of the client representatives in the early project phases. The paper contributes to a better understanding of conditions, which are necessary during the front-end development of projects, irrespective of their context, for achieving high levels of project performance. Project professionals should focus on these necessary conditions, since not satisfying these conditions guarantees project failure. This research advances current project management literature by investigating a logic for finding the required level of necessary conditions for a certain level of project performance.

5.1 Introduction

Although earlier literature provided profound insights into the concept of project success and project performance (Serrador & Turner, 2015; Williams, 2016), still there is a potential for research on how project management activities and processes are commonly applied in practice. In project management literature two concepts have been vastly used: factors contributing to the success of projects or "success factors" and the indicators used for measuring the successful outcome of projects success or "success criteria" (Locatelli et al., 2017; Müller & Turner, 2010). A number of studies investigated the relation between success factors and success criteria or project success (Fortune & White, 2006; Turner & Zolin, 2012; Westerveld, 2003). Despite the wide applicability of the concepts of success factors and success criteria, they are also considered to be among the controversial topics in the project management literature.

Various research methods have already been applied in the research on project success factors. (Locatelli et al., 2017) identified three clusters of research methods to study success factors: statistical analysis of a large database, surveys with project managers and stakeholders, and case studies. They argued that each of these methods has its own advantages and disadvantages. For instance, the generalizability of the results is under pressure in case of conducting case studies. In order to incorporate the complexity of major projects and due to the nature of data in their study, they applied Fisher's exact test (FET) and machine learning (ML) techniques in order to quantify the relationships between the project characteristics of megaprojects and success criteria. Their study provides an example of using a novel approach for investigating the relationship between the project success factors and success criteria.

Summarising the above review, there is a need for taking novel research approaches to understand the causal relationships between the project management efforts and project performance. This study therefore aims at exploring how these project management efforts are applied in the engineering projects, not only if, but also to what extent. In other words, the study deals with variable values of these conditions for high levels of project performance, rather than merely focusing on their presence or absence in a binary way.

In Chapter 4, the survey data analysed to find what managerial activities are performed for managing engineering projects. In that study, the project management efforts were divided into two main aspects: front-end activities and project management principles (see Subsection 4.2). This distinction has been made to measure the established activities through their intensity of application during the front-end development. Project management principles, in nature, include a broader view on those established efforts which are harder to measure based on their intensity. Based on the data gathered, a cross-sectoral analysis was performed, in which those project management activities were compared in three sectors: construction, infrastructure, and process industry. The relation between the front-end activities and project management principles is further explored in this chapter. For measuring these project management efforts, the same survey study data, as explained in Chapter 4, has been used. The aim of this research is to investigate the intensity of the front-end activities and project management principles that affect project performance. For achieving this goal and in pursuit of applying novel methodological approaches, Necessary Condition Analysis (NCA) was used for analysing the quantitative data. Necessity logic (Dul, 2016b) has potential for better investigating the managerial mechanisms and their relation with the project performance. This method has the potential to understand the conditions (X) which are necessary for the outcome (Y) with relatively small sample sizes compared to the number of included variables (Dul, 2016b). The results of this chapter, partly, provide the building blocks for the development of the model with the aim of improving the measurable performance of engineering projects. Consequently, the research question in this chapter is formulated as:

Which combinations of intensity of application of front-end activities and level of project management principles are necessary for achieving good project performance?

This chapter is structured as follows. First, in Section 5.2, the relevance of the method used for the study and the variables used for the NCA (front-end activities, project management principles, and project performance indicators) are explained. Subsequently, in Section 5.3, the results of the study are presented. In Section 5.4, the findings providing insights into those necessary conditions in the front-end phase of projects are discussed and the theoretical and practical contribution of the research are presented. Finally, the conclusions are drawn together with the limitations of the research and paths for future research in Section 5.5.

5.2 Method

This section describes how project performance was measured using the survey and why NCA was used in this study. As discussed earlier in Section 4.2, the front-end activities and project management principles identified from the literature were used as a guideline for operationalisation of the research variables. The survey setup including the measurement of constructs for these variables and data collection are presented in Subsections 4.3.1 and 4.3.2, respectively. As stated in these subsections, the respondents were asked to measure the performance of their projects. Various researchers use the terms “project success” and “project performance” interchangeably (Lu et al., 2019). Generally, project performance is defined as accomplishment and “*achievement of pre-determined project goals*” (Zaman et al., 2019). In this study, as explained in Subsection 2.5.2, the aim is to measure the project performance using 12 indicators (including the sustainability considerations) (Berssaneti & Carvalho, 2015; Scott-Young & Samson, 2008; Suprapto et al., 2016; Yan et al., 2018): within budget, within schedule, meeting specifications, client satisfaction, no accidents (safety), contractor satisfaction, team satisfaction, end user satisfaction, flawless start-up, sustainability considerations, business success, preparing for the future. The respondents were asked to indicate the extent to which the project met the target set at the start. The project performance score was calculated as the average of the values derived for each of the performance criteria. A five-point Likert scale was used as a response format ranging from (1) "strongly disagree to (5) "strongly agree". Due to missing values on the latter eight indicators (higher than 10%), however, it was only focused on the first four performance indicators: within budget, within schedule, meeting specifications, and client satisfaction.

Table 5.1 provides more detailed information on the values per project performance criterion in the dataset. Overall, the table suggests that the projects in this dataset had relatively good performance. Specifically, in more than 90% of the projects, the quality performance scored either 4 or 5 (in a five-point Likert scale). It can be also observed that in more than 85% of the projects, the client was satisfied to a large extent (scored 4 or 5). The main difference, however, lies in the fulfilment of project schedule and budget constraints: only around 65% of projects were completed successfully within these two constraints.

Table 5.1: Performance scores per criterion in the dataset

Criterion score	**Performance criteria**			
	Within budget	Within schedule	Meeting specifications	Client satisfaction
5 (Strongly agree)	37 (35.6%)	25 (29.8%)	32 (30.8%)	31 (30.1%)
4 (Agree)	31 (29.8%)	36 (34.6%)	63 (60.6%)	57 (55.3%)
3 (Neutral)	12 (11.5%)	17 (16.3%)	8 (7.7%)	13 (12.6%)
2 (Disagree)	17 (16.3%)	20 (19.2%)	0 (0.0%)	1 (1%)
1 (Strongly disagree)	7 (6.7%)	6 (5.8%)	1 (1.0%)	1 (1%)
Total	104	104	104	103 (1 missing value)

5.2.1 Relevance of necessary condition analysis in project management research

Earlier studies in project management literature only focus on the absence or presence of project success factors (Joslin & Müller, 2015). In the same vein, Knol, Slomp, Schouteten, and Lauche (2018a) criticise the universality of the concept of success factors. Woodside (2013) argues that use of the term "success factors" may be misleading because it suggests that "the mere presence of a factor automatically leads to more success". Success factors, however, should be seen as "a necessary but not a sufficient condition for success" (Knol et al., 2018a). Given the data in the current study and the above explanations, it is expected that applying NCA could provide valuable insights compared to large N approaches such as regression analysis or Structural Equation modelling (SEM). In the following, the logic behind the NCA and its difference with other relationship testing approaches are explained.

When conducting theory-testing research, four types of propositions can be distinguished (Dul & Hak, 2007): (1) a sufficient condition (*If there is A, then there will be B*); (2) a necessary condition (*B exists only if A is present*); (3) a deterministic relation (*If A is higher, then B is higher*); and (4) a probabilistic relation (*If A is higher, then it is likely that B is higher*). A sufficient condition, such as fuzzy set QCA (fsQCA), ensures the presence of the outcome (if X=1 then Y=1), however, the intended outcome can also be present without the sufficient condition (if X=0 then Y can still be 1) (Vis & Dul, 2016). NCA distinguishes itself from the fsQCA technique by providing qualitative statements merely ***in kind***. Thus, fsQCA ignores the variation in degree, suggesting that "a condition or configuration is necessary or not for an outcome" (Vis & Dul, 2016). Linear thinking suggests that an increase in the independent variable (predictor) relates to an increase in the dependent variable (outcome), whereas NCA investigates a necessity condition both ***in kind*** and ***in degree*** (Arenius, Engel, & Klyver, 2017). A necessary condition can be defined as a constraint or a bottleneck which, if not present, blocks achieving a certain level of outcome (Dul, 2016b; Vis & Dul, 2016). Hence, causality is the central point in necessary condition analysis. In other words, "a certain level of outcome B exists only if a certain level of necessary condition A is present" (Dul & Hak, 2007). Or phrased differently: not implementing a necessary condition would guarantee failure (Karwowski, Dul, Gralewski, Jauk, Jankowska, Gajda, Chruszczewski, & Benedek, 2016).

The NCA looks for the empty space in the upper-left corner of the scatter plot and separates the area with observations from the area without observations, with the so-called "ceiling lines" (Dul, Hak, Goertz, & Voss, 2010). This is in contrast with the traditional regression which draws a line through the middle of the data (Dul, 2016b; Karwowski et al., 2016). In order to determine the validity of these ceiling lines, two additional parameters are calculated: the accuracy and the effect size (Knol et al., 2018a). ***Accuracy*** can be defined as 'the number of observations that are on or below the ceiling line, divided by the total number of observations, multiplied by 100%' (Dul, 2016b). An ***Effect size*** (d) can range from 0 to 1 and its value is context dependent. This means that a given effect size can be small in one context and large in another. Following the general benchmark suggested by Dul (2016b), an effect size between 0 and 0.1 can be categorised as a "small effect", $0.1 \leq d < 0.3$ as a "medium effect", $0.3 \leq d < 0.5$ as a "large effect", and $d \geq 0.5$ as a "very large effect". The size of this ceiling line is also important in determining the extent to which the condition is necessary for a specific level of the outcome (Dul, 2016b).

In order to find the necessary conditions using NCA, two steps should be followed. The first step is to determine the ceiling lines and the associated bottleneck tables. The next step is to calculate several NCA parameters such as accuracy of the ceiling line, the ceiling zone, the effect size of the necessary condition (Dul, 2016b) and the p-value for the calculated effect size (Dul, van der Laan, & Kuik, 2018). This p-value is calculated by means of a permutation test. This permutation test randomly "resamples the data to create a range of samples (permutations) in which the condition (X) and the outcome (Y) are unrelated" (Breet, Van Rhee, & Dul, 2018). This permutation test ensures that the calculated effect size is not the result of random chance (Dul et al., 2018).

NCA has been already applied in several research disciplines to develop and test theories such as Operations Management (Knol et al. (2018a), van der Valk, Sumo, Dul, and Schroeder (2016), and Servajean-Hilst (2018)), Psychology studies

(Karwowski et al., 2016), Entrepreneurship (Arenius et al., 2017), and Transportation (De Vries, de Koster, Rijsdijk, & Roy, 2017). NCA has not yet been applied in the field of project management. There is, however, a potential for the implementation of NCA in this research discipline. Thus, in this study, certain project management efforts are investigated in terms of front-end activities and project management principles and how intensity and presence of those conditions affect the project performance.

5.2.2 NCA variables explanation

Before presenting the results of NCA, the variables used for this analysis are summarised in this subsection. As explained earlier in Subsection 4.3.1, a multi-item measurement scale is used for measuring the application of the front-end activities and project management principles. After removing the items that have more missing values than the selected threshold (10%), 39 items (15 front-end activities and 24 project management principles) were considered for further analysis. PCA was performed to reduce the number of items which resulted into 12 factors (5 front-end activities and 7 project management principles). See Subsection 4.5.2 and Table 4.7 for the list of the items and factors used for this analysis. The conditions (factors and their underlying items) used for NCA and the explanation for each of the aspects used in the current study are presented in Table 5.2.

Table 5.2: Front-end activities, project management principles, and project performance of engineering projects adopted in this study

Front-end activities and project management principles as condition			Number of items	Number of factors	Scale
X	Front-end activities	The extent to which an effort was put into the application the front-end activities. This was measured using the intensity of the application of specific activity. In other words, how often were these activities applied during the front-end phase of the project.	15	5	1 to 7
	Project management principles	The extent to which certain project management principle was present in practice.	24	7	1 to 5
Y	Project performance	The project performance is measured using the four indicators of within budget, within schedule, meeting specifications, and client satisfaction. The value for project performance is calculated as the mean value of the four indicator rankings.	4	4	1 to 5

5.3 Results

The findings of NCA are presented in this section divided into two subsections. First, in Subsection 5.3.1, project management efforts as necessary conditions for high level of outcome (project performance) are presented. Next, Subsection 5.3.2 dives deeper into the items, constituting those project management efforts, that when absent provide a constraint for achieving high project performance.

5.3.1 Project management efforts as necessary conditions

Using the NCA 3.0.2 package in R (Dul, 2019), necessary front-end conditions for a specific level of project performance were explored. As discussed earlier, NCA finds an empty space in the XY scatter plots suggesting the presence of the necessity condition (van der Valk et al., 2016). Three lines can be drawn in scatter plots provided by NCA: ordinary least squares (OLS) regression, Ceiling Envelopment–Free Disposal Hull (CE-FDH), and Ceiling Regression–Free Disposal Hull (CR-FDH), see Figure 5.1 for better understanding. The two latter ceiling lines are drawn by NCA in order to quantify the degree of necessity (Sorjonen, Wikström Alex, & Melin, 2017). The CE line is used for the discrete necessary conditions where the investigated variables have discrete values, whereas the CR line can be used for further analysis of continuous necessary conditions and where the variables have continuous values such as ratio variables (Dul, 2016b).

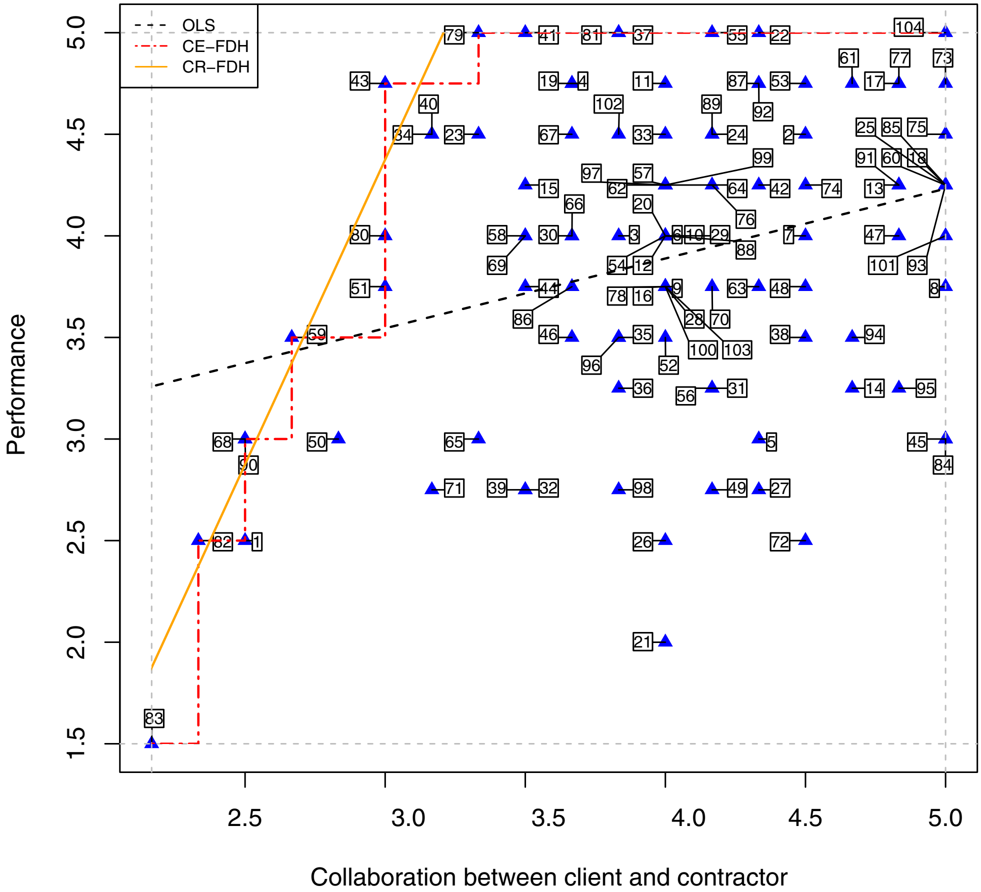

Figure 5.1: NCA plot of the level of collaboration between client and contractor (necessary condition) – project performance

In the scatter plots, the X-axis shows the identified factors of front-end activities and project management principles and the Y-axis presents the project performance score. As an example, the scatter plot for collaboration between client and contractor versus project performance score is presented in Figure 5.1, which reveals a relatively large empty space in the top-left corner. This suggests that, at least in this sample of projects, high levels of project performance cannot be achieved with low levels of collaboration between client and contractor. For completeness, the scatter plot for the other two necessary conditions, top management support and information sharing, versus project performance are shown in Figure 5.2 and Figure 5.3, respectively.

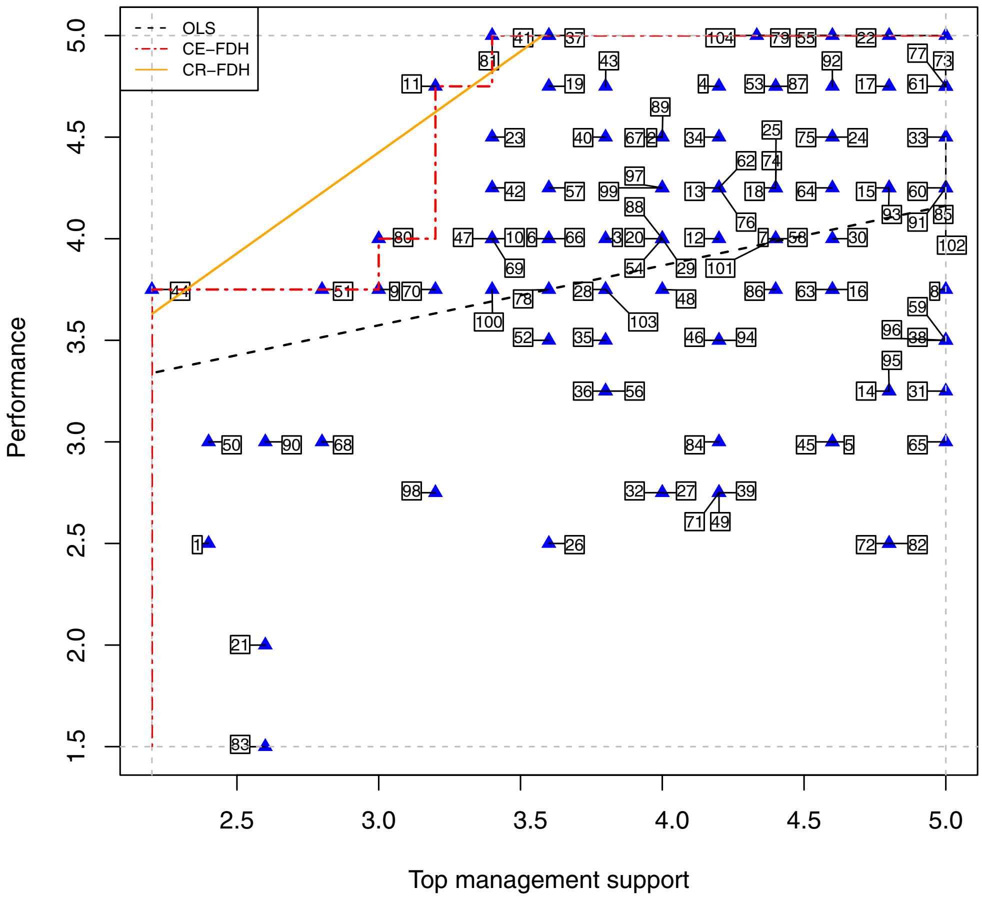

Figure 5.2: NCA plot for top management support – project performance

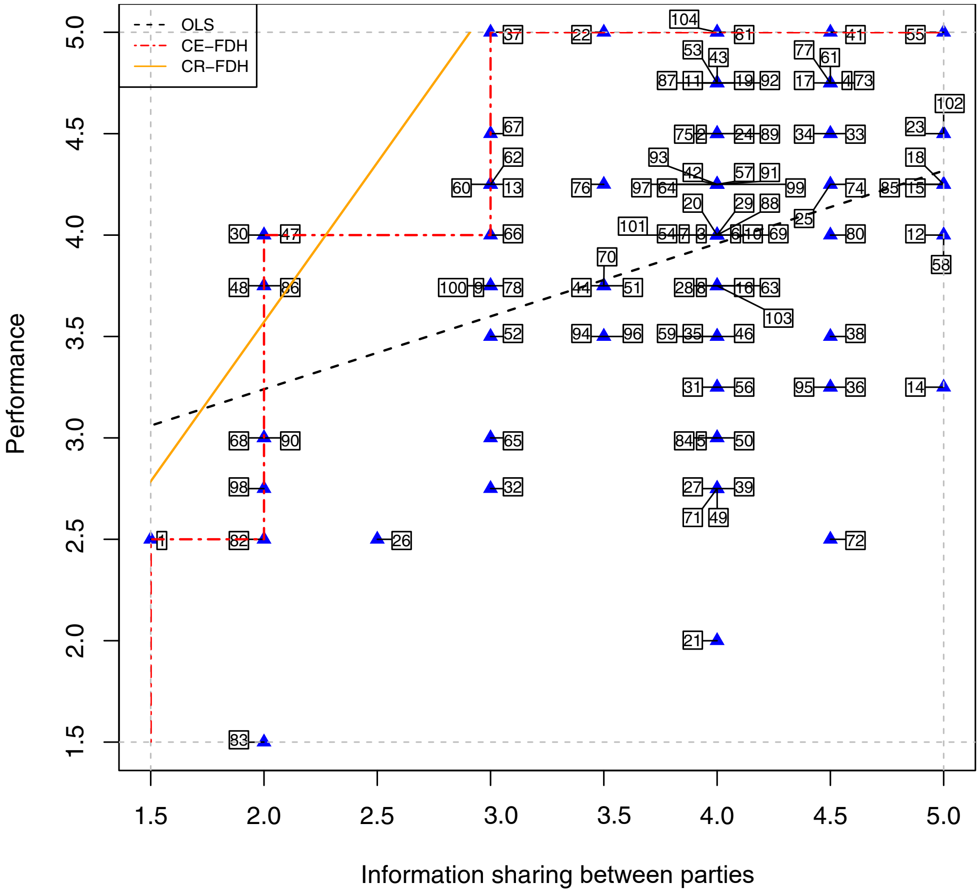

Figure 5.3: NCA plot for information sharing - project performance

The numbers in the scatter plots indicate the case ID of each project. The CR ceiling line was used for identifying the necessary conditions for the main factors since the mean of the variables (calculated factor scores) are continuous. These ceiling lines identify the minimum degree of a given front-end condition to achieve a certain level of project performance.

Following the guidelines of Breet et al. (2018) and Dul et al. (2018), the permutation test was conducted (10000 permutations) to check for the statistical significance (p-value) of the calculated effect size. Out of 12 potential factors (necessary conditions), in the dataset of projects, three factors of project management principles showed a significant effect on the actual project performance at a significance level of 0.05. These factors were "collaboration between client and contractor", "top management support", and "information sharing". More details on the NCA parameters of the 12 identified factors including the ceiling zone, scope, accuracy, and effect size for each of the CR ceiling technique are presented in Table 5.3.

Table 5.3. NCA parameters of 12 identified factors based on CR-FDH method

Aspect	Factor	Ceiling zone	Scope	Accuracy (%)	Mean score	Effect size (d)
Front-end activities	1. Risk management	0.042	21.0	100	3.595	0.002
	2. Embracing and capturing lessons learned	0.042	21.0	100	2.592	0.002
	3. Team building	0.000	21.0	100	3.380	0.000
	4. Setting expectations	0.000	21.0	100	3.288	0.000
	5. Monitor and quality management	0.844	21.0	98.1	4.406	0.040
Project management principles	6. Collaboration between client and contractor	1.628	9.9	9.2	4.010	0.164**
	7. Top management support	0.945	9.8	97.1	4.080	0.096**
	8. Project manager competency	0.437	9.6	100	4.223	0.045
	9. Setting clear goals	0.420	10.5	99	3.728	0.040
	10. Information sharing	1.560	12.2	96	3.792	0.127**
	11. Client involvement	0.187	12.2	100	3.986	0.015
	12. Client competency	0.375	14.0	100	3.871	0.027

Note: ** The p-value of the effect size is significant at the level of 0.05.

These results suggest that the presence of these three conditions is necessary, but there is no guarantee for a certain level of project performance if these conditions are present. At least in the current dataset, a high level of project performance cannot be achieved with low levels of these necessary conditions.

Table 5.4 presents the bottleneck table for the 12 identified factors which is obtained using the CR ceiling line. The intensity value of the application of front-end activities, project management principles, and project performance is presented as the percentage of the lowest and highest observed values in the dataset. This table shows the degree to which the front-end activities and project management principles are necessary for different degrees of project performance. The first column presents the percentage of project performance. The value of 0 in this column corresponds to the performance score of 1 (lowest observed value of the project performance) and the value of 100 associates with the performance score of 5 (highest observed value).

Columns 2 through 13 of Table 5.4 show the extent to which each of the conditions was present in practice. For instance, the minimum observed condition was 1 in both front-end activities and project management principles, which shows "no implementation" (of the applied front-end activity) or "strongly disagree" (with the presence of project management principle). A value of 7 was the highest observed value for the intensity of the front-end activities (represent weekly application) and 5 was the highest value for the project management principles (representing full presence on a 1-5 Likert scale). '-' (NN) in this table indicates the not necessary condition(s) and '100' indicates full presence of the condition(s) (Knol et al., 2018a).

The bottleneck table indicates the order in which the factors were necessary for the achieved project performance. Using this table, it can be concluded that in the current dataset of engineering projects for a low project performance level, none of the conditions identified in this study is necessary (the very first row of the table). Project manager competency is the only necessary condition for having a successful project outcome up to 10% (=level 1 of the five-point Likert scale). After the row of

15%, presence of the front-end conditions become important. In other words, in this set of projects, collaboration between client and contractor and project manager competency are the first front-end conditions which are required for this level of project performance. As the intended level of project performance increased (row 40%=level 3 of the five-point Likert scale), information sharing between the parties involved in the project becomes also necessary.

In order to have a higher project performance score (row 65%=between level 3 and 4 of the five-point Likert scale), a higher degree of the following conditions is required: collaboration between client and contractor (22.4%=level 2), top management support (5.2%=level 1), project manager competency (5.9%= level 1), and information sharing (18.0%=level 2).

The first factor of front-end activities which was required for project performance was monitoring and quality management (row 85%). As project performance increased, risk management and embracing and capturing lessons learned (both for row 95%) were also required.

The last two rows of the bottleneck table suggest that for having a project with the highest performance score (95-100 % = almost level 5 of the five-point Likert scale), at least some degree of the majority of the identified conditions are required. Only two factors, team building and setting expectations, did not show any necessary relation with the project performance. For this advanced level of project performance, more effort should be put into the five following conditions: monitoring and quality management (37.5% corresponding to quarterly application), collaboration between client and contractor (36.8% corresponding to level 3 of the Likert-scale), top management support (49.2% corresponding to level 3 of the Likert-scale), information sharing (40.3% corresponding to level 3 of the five-point Likert scale), and *client involvement* (42.9% corresponding to level 3 of the five-point Likert scale). Although *risk management* and *embracing and capturing lessons learned* showed to be necessary for a fully successful outcome (level 5 of the Likert-scale), the level of their presence is very low (5.6% corresponding to non-application in the front-end phase) indicating that these activities were hardly applied in these projects.

In the dataset, front-end activities related to *team building* and *setting expectations* were not among those necessary conditions, even for high levels of project performance. The total mean scores for the intensity of application of these activities are 3.36 and 3.31, respectively, corresponding to an application rate of annually in the project. These front-end activities are typically applied with lower intensity, compared to other standardised front-end activities such as monitoring and quality management. It can be argued that team building and setting expectations activities create preconditions for the realisation of other activities and project management principles, such as a high-quality collaboration between client and contractor. Although the application of these activities facilitates other project management efforts, they should not be overemphasized. The levels of application of *embracing and capturing lessons learned* is even lower (2.592) which corresponds to an application intensity of once during the front-end phase or annually. This suggests that lessons learned activities are typically considered as one-time activity.

Table 5.4: Bottleneck levels of the factors of the front-end activities and project management principles in % of the total project performance using CR-FDH

Y = project performance (%)	1. Risk management	2. Embracing and capturing lessons learned	3. Team building	4. Setting expectations	5. Monitor and quality management	6. Collaboration between client and contractor **	7. Top management support **	8. Project manager competency	9. Setting clear goals	10. Information sharing **	11. Client involvement	12. Client competency
0	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	0.5	-	-	-	-
10	-	-	-	-	-	-	-	0.9	-	-	-	-
15	-	-	-	-	-	1.8	-	1.4	-	-	-	-
20	-	-	-	-	-	3.8	-	1.8	-	-	-	-
25	-	-	-	-	-	5.9	-	2.3	-	-	-	-
30	-	-	-	-	-	7.9	-	2.7	-	-	-	-
35	-	-	-	-	-	10.0	-	3.2	-	-	-	-
40	-	-	-	-	-	12.1	-	3.6	-	2.1	-	-
45	-	-	-	-	-	14.1	-	4.1	-	5.3	-	-
50	-	-	-	-	-	16.2	-	4.5	-	8.4	-	-
55	-	-	-	-	-	18.2	-	5.0	-	11.6	-	-
60	-	-	-	-	-	20.3	-	5.5	-	14.8	-	-
65	-	-	-	-	-	22.4	5.2	5.9	-	18.0	-	-
70	-	-	-	-	-	24.4	11.5	6.4	-	21.2	-	-
75	-	-	-	-	-	26.5	17.8	6.8	1.4	24.4	-	-
80	-	-	-	-	2.5	28.5	24.1	7.3	7.2	27.5	-	1.7
85	-	-	-	-	11.2	30.6	30.4	7.7	13.1	30.7	-	7.5
90	-	-	-	-	20.0	32.6	36.7	8.2	18.9	33.9	-	13.3
95	1.7	1.7	-	-	28.7	34.7	43.0	8.6	24.7	37.1	12.9	19.2
100	5.6	5.6	-	-	37.5	36.8	49.2	9.1	30.6	40.3	42.9	25.0

Notes:

** The p-value of the effect size is significant at the level of 0.05.

- In the table indicates not necessary (NN) condition for project performance.

The context of a project might affect the intensity of the application of these front-end activities. Thus, in a post-hoc analysis, project characteristics of the cases at the upper left area of the scatter plots (which hinders the existence of a necessity condition) were checked, for all the five factors of front-end activities. These characteristics included the industry sector, project size, project duration, level of front-end complexity, and role of the company in the reference project. No similarities were found across the cases.

The absence of significant necessary links between front-end activities and project performance does not imply that their application can be ignored. The results, however, merely show the importance of particularly some principles in achieving good project performance, mostly focusing on the soft side of project management, over the front-end activities. The absence of these project management principles can prevent reaching a high project performance.

5.3.2 Necessary items of front-end activities and project management principles

This subsection dives a level deeper into investigating the necessary items within the factors of the front-end activities and project management principles for successful project performance. This could provide more in-depth understanding of what those necessary conditions entail. The original data for measuring the items of the front-end activities and project management principles was not continuous but discrete on a scale from 1 to 5 and 1 to 7, respectively. Thus, the CE ceiling line was used for identifying the necessary items for project performance.

The cut-off point for the significant results was set at a p-value of 0.05. In other words, the probability that the calculated effect size could be the result of chance is lower than 5% (Dul et al., 2018). Out of the 39 possible necessary conditions for successful project performance, 11 items (all related to the project management principles) were found to be necessary for successful project performance (around 28% of the total possible relationships). All items with small and moderate effect sizes ($d > 0$) are presented in Table 5.5.

Obviously, the majority of the necessary items belong to the factors which previously showed a significant necessary link with project performance, including ***collaboration between the client and contractor***, ***top management support, and information sharing***. The items in the ***information sharing*** have relatively larger effect sizes compared to items in other factors. The necessary items in this factor include "distribution of information by various parties" and "presence of clear communication channels". A medium effect size was also observed for the following items in the factor of ***collaboration between the client and contractor***: "Shared belief of the team members in performing their roles", "having a sense of belonging to the team", "emphasis of the team member on the joint efforts", and "commitment of the team members to the team tasks". In the factor of ***top management support***, the items which are necessary for achieving project success are: "commitment and support of the project team by top management", "trust towards the project team by top management", "honesty and openness in the interactions with the project team by top management", and "close collaboration between the project manager and top management".

In addition to items in the three necessary factors, previously discussed, "technical skills of the client representative during the front-end development" also showed a significant necessary link with project performance, see Figure 5.4. It suggests that when the client does not have sufficient technical skills regarding the project during front-end phase, very high level of project performance (almost full score on a five-point Likert scale) cannot be achieved. Although, the effect size for this item is low, its presence is required for a very high project outcome which cannot be compensated by other items.

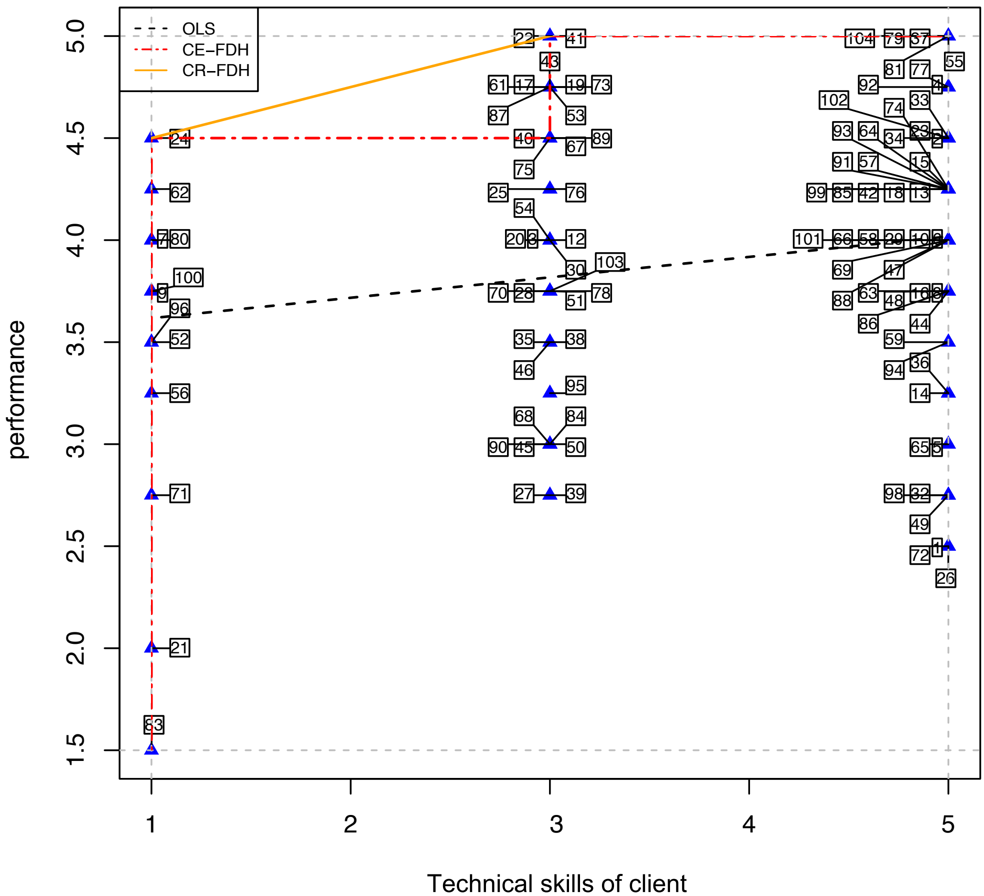

Figure 5.4: NCA plot for technical skill of the client representative during front-end– project performance

Again, no link can be found between the items in the front-end activities and project performance, suggesting that these activities are not among the necessary front-end conditions for project success, in the current dataset. The following top three frequently applied front-end activities in the dataset have the mean score of 4 and more (corresponding to an intensity of quarterly or more often), see Appendix F. 3:

- Track the progress of project performance-A9 (mean score of 5.19, monthly application)
- Report the overall project progress to the client-A7 (mean score of 4.78, between quarterly and monthly application)
- Measure the project performance-A8 (mean score of 4.13, quarterly application)

All these frequently applied activities belong to the factor monitoring and quality management, which might seem to be lagging conditions for project performance. The frequent application of these monitoring activities, however, could lead to the identification of potential deviations in the progress and ultimately provide a timely response. Although these activities are applied frequently in the projects in this dataset, based on the results of NCA, interestingly, none of them is considered to be a necessary condition for the project performance.

Table 5.5. NCA parameters for the items in the identified factors based on CE-FDH method

Factor	Item	Definition	Effect size(d)	Importance of effect size	Ceiling zone	Scope	Accuracy (%)	Mean score
Collaboration between client and contractor	E1 **	Shared belief of the team members in performing their roles and protect the interests of each other	0.119	Moderate	1.250	10.5	100	3.99
	E2 **	Having a sense of belonging to the team	0.119	Moderate	1.250	10.5	100	4.04
	E5 **	Emphasis of the team member on the joint efforts	0.238	Moderate	2.500	10.5	100	4.10
	E6 **	Commitment of the team members to the team tasks	0.214	Moderate	2.250	10.5	100	4.13
Top management support	E20 **	Commitment and support of the project team by top management	0.190	Moderate	2.000	10.5	100	4.23
	E21 **	Trust towards the project team by top management	0.095	Small	1.000	10.5	100	4.04
	E22 **	Honesty and openness in the interactions with the project team by top management	0.119	Moderate	1.250	10.5	100	4.01
	E24 **	Close collaboration between the project manager and top management	0.119	Small	1.250	10.5	100	4.01
Information sharing	E14 **	Timely distribution of information by various parties	0.232	Moderate	3.250	14.0	97	3.69
	E15 **	Presence of the clear communication channels	0.250	Moderate	3.500	14.0	98	3.90
Client competency	E16 **	Technical skills of the client representatives involved in the project during front-end development	0.071	Small	1.000	14.0	100	3.79

Note: ** The p-value of the effect size is significant at the level of 0.05.

5.4 Discussion

In the discussion section, first the findings of the study are presented in Subsection 5.4.1. Next, the theoretical contribution is presented in Subsection 5.4.2 followed by the practical implication in Subsection 5.4.3.

5.4.1 Discussing the findings

This study promotes the understanding of the necessary conditions, in terms of the front-end activities and project management principles, for successful project performance. The reason for focusing on these conditions during the front-end is that what happens during this phase is crucial for the final project outcome (Samset & Volden, 2016).

The study contributes to the understanding of critical factors affecting the performance of engineering projects. The concept of critical project success factors has already been used in project management literature but the current research sheds light on the essence of those critical success factors by using the "necessary" logic. The bottleneck analysis in this study shows that ***collaboration between the client and contractor***, ***top management support***, and ***information sharing*** (all belonging to the project management principles) are necessary for a medium success level of 2.5 (the observed success level in the dataset ranged from 1 to 5 in the five-point Likert scale).

The findings echoed the earlier study of Berssaneti and Carvalho (2015) which suggested that top management support and a competent/dedicated project manager together with organisational maturity in project management could affect the project success in terms of efficiency. Too and Weaver (2014) highlighted the role of project sponsor or top management as a "critical link between the executive and strategic levels" on the journey of creating value by the projects. Project sponsors could create a climate for good project performance by supporting the project team, specifically during the critical instances in the project, such as scope changes (Serrador, Gemino, & Reich, 2018). The earlier study of Zwikael (2008) also provides a set of recommendations for top management support practices positively affecting project success. The study of Zwikael (2008) also proved that these critical top management processes could be tailored to the specific context of the project (type of industry and country).

From the current study, another necessary condition for project success was the quality of collaboration between the members of the project teams, including client and contractor. The results here confirm the findings of Jelodar, Yiu, and Wilkinson (2016) who showed that trust, teamwork (in terms of communication and collaboration) and project team commitment positively affect the relationship quality. This is similar to the findings of Suprapto, Bakker, and Mooi (2015a) who suggested a mediation role of teamwork quality on the relationship between relational attitudes, collaborative practices, and project teams' joint capability. They have operationalised the teamwork quality in the constructs of cohesion, communication, coordination, balanced contribution, aligned effort, mutual trust, and affective trust contributing to project success.

Information sharing is proven to be another necessary front-end condition for project success in the current study. This is in line with Roehrich, Davies, Frederiksen, and Sergeeeva (2019) who found that information exchange amongst the integrated project teams (including the client and contractors) in the context of complex products and systems could lead to performance improvements. As stated by Roehrich et al. (2019), "information is power" and it permits the creation of an environment where there is an equal opportunity for all the parties involved (p.1619). Wu, Liu, Zhao, and Zuo (2017) elucidate the interdependency between communication and information sharing, information exchange and information transmission across project teams. This is also observed in the current study where both collaboration among the client and contractor project teams and information sharing are confirmed to be among the necessary conditions for project success.

Using QCA, Young and Poon (2013) identified the necessity of five success factors in IT projects: top management support, user involvement, project methodologies, high-level planning, and high-quality project staff. The result of their study suggests that "top management support is significantly more important for project success than factors emphasised in traditional practice" (p.953). In contrast, NCA analysis applied by Dul (2016b) on that same data set compared the effect sizes of these five determinants. In Dul's analysis, using the necessary but not sufficient view, high-level planning had the highest effect size among the five determinants of success. This example shows that using a "sufficiency view" instead of "necessity view" might provide different conclusions. To extend the current study, it is proposed to use QCA to investigate the sufficiency of project management activities and principles in specific project contexts.

It was expected that at least some of the front-end activities would be among the necessary conditions for project success. Surprisingly, the results did not support the proposition that activities such as ***risk management*** and ***embracing and capturing lessons learned*** are among the necessary conditions for successful project performance. The study also concluded that these front-end activities are not applied frequently in projects, for which two potential explanations are presented.

First, project governance (selection of the project management processes) and culture of the company can also play a role in the application of these front-end activities. Companies might not see the added value of frequent application of these activities in their projects. Also Olsson (2007) argues that it is difficult to measure the effectiveness of risk management processes. The reason might be the fact risk management activities are not frequent enough to determine their real contribution to project performance (Bosch-Rekveldt, 2011). Carrillo, Ruikar, and Fuller (2013) state that, in many companies, there is a lack of formal and established processes for using lessons learned from the previous projects.

Second, these "not" necessary conditions, in terms of application of activities, might suggest that those activities are preconditions for other conditions such as project management principles. Also, the prior research does not suggest that these activities do not contribute to project success. In the survey, it was asked about the intensity of application of these activities. Still, these activities are applied to some extent, even once during the front-end phase or annually. It should be noted that, necessity and correlation analyses are independent techniques (Karwowski et al., 2016). Hence, it cannot be concluded that if a condition is not necessary for the outcome, there is no relationship between the condition and outcome.

Overall, it is still unclear what activities and procedures constitute the front-end phase (Williams et al., 2019). To large extent, the front-end activities considered in the survey were based on the activities that are well-established in the process industry. As explained in Chapter 4, the findings revealed that, the construction and infrastructure sector lag behind and are less mature in terms of the application of project management efforts. Thus, it is crucial to establish routinized front-end activities and provide a structure for their application in these sectors.

5.4.2 Theoretical contribution

This research enriches the project management research using a novel methodology (NCA) to identify factors in terms of front-end activities and project management principles which are necessary for achieving project success. This study also answers the call by (Joslin & Müller, 2015) suggesting that the project management literature should focus more on the way success factors are applied in practice and not merely on their presence. Hence, the current study contributes to the literature on project performance by introducing a necessity logic approach.

5.4.3 Practical implications

The results of this study could help Project Management Offices (PMOs) to develop a more customized approach in project management. It suggests what activities and/or principles are necessary for achieving a certain level of project performance and what intensity of the activities should be present. These conditions are considered to be minimum boundary requirements for having project success. The bottleneck table can be used as an indicator for the sequence of the critical success factors (Knol, Slomp, Schouteten, & Lauche, 2018b).

Another managerial implication of this study is that the soft side of project management in the early phases in terms of principles plays a crucial role in determining success (or failure). It implies that project managers should first focus on the necessary conditions: collaboration between client and contractor, information sharing, top management support and technical skills of the client. The bottleneck table can be applied as part of the project evaluation and to perform project reviews within the company or across companies in order to compare the project management activities and principles across projects.

5.5 Concluding remark and next step

This study was an attempt to identify the necessary conditions for successful project performance. There has been a vast amount of research in the field of project management concerning what factor, process, condition might increase the chance of project success (Berssaneti & Carvalho, 2015; Demirkesen & Ozorhon, 2017; Serrador et al., 2018). However, most of these studies tested these conditions by applying either a deterministic or a probabilistic relation. In this research, however, a novel approach was used (necessity logic) to explore the criticality of such factors, including intensity and presence level, on the various degrees of project performance.

NCA was performed in order to investigate the extent to which each of these front-end activities and project management principles (conditions) are necessary for the successful project performance (outcome). For selecting these conditions, the data gathered using a survey completed by 104 practitioners was used, as presented in Chapter 4. As presented in Section 4.3, five factors of front-end activities and seven factors of project management principles resulted.

The application of NCA in this research offers new insight into the contribution of front-end activities and principles to project performance. Comparing the rank orders of the conditions resulting from the necessity view shows that collaboration between client and contractor followed by information sharing and top management support are the most important success determinants of any project. The findings also suggest that for different degrees of project performance, various levels of application of front-end activities and project management principles are required.

These results confirm the importance of project management principles and especially soft factors affecting the project performance. The NCA results show that fostering collaboration between two parties (client and contract) is a must for a good project performance. Also, client involvement and client competency were shown to lead to higher project performance.

Not having necessary project management principles, would reduce the project performance, and as a result lower the chance of project success. This effect cannot be compensated by the additional application of front-end activities. The challenge is to structure other relevant front-end activities and project management principles adequately in practice in a fit for purpose manner.

Based on the explanations in the discussion and conclusion sections, some limitations can be perceived. First, the project success indicators used in this research only focused on time, cost, quality, and client satisfaction dimensions, due to unavailability of data for other indicators. In the beginning, it was aimed to consider broader definition of performance including safety, flawless start-up, contractor satisfaction, end user satisfaction. The unavailability of data on these indicators might imply that still the practitioners do assess their projects traditionally. A relevant extension would be to add these missing criteria for assessing the project performance by investigating the projects more in-depth and not only ask the respondents to rank them.

Second, NCA used in this research was performed on the whole dataset (N=104) and not per sector. This has to do with the fact that the small sample size in each sector would not reveal any significant necessary conditions. Future research can replicate the approach followed in this research in a wider range of projects in each sector to identify those necessary conditions for successful project performance in each industry sector.

Another limitation is that the method used in this study for data analysis (NCA) can only anticipate the absence of an outcome, not the presence of it (Dul, 2016b). Put differently, the findings of the NCA only indicate that if these principles are not in place, it leads to project failure. On the other hand, their presence, does not guarantee successful project performance. This is one of the limitations of the method used. The findings of this study can be enhanced by using sufficiency logic where the presence of the outcome is ensured (Vis & Dul, 2016). An example of such methodology using sufficiency logic is QCA which can be applied as a complementary method (Tho, 2018). Thus, the next step of this research is to address this limitation by applying an approach such as fuzzy set QCA in order to identify those sufficient conditions. Combining these two methods can enhance the results in terms of investigating the causal relationships for a particular outcome (Fiss, Sharapov, & Cronqvist, 2013). In addition, it would be helpful to conduct more in-depth analysis to explore the underlying causes for not applying those established front-end activities in practice.

Finally, the research was done on a sample of projects within a set of Dutch companies in three sectors (construction, infrastructure and process industry), which does not allow for generalization to other project contexts. Some of the front-end activities and project management principles are either well-established or not commonly applied in those sectors in the Netherlands (see 4.5.1). Thus, the items and practices used in this analysis are based on the empirical study performed in such context. The research could be extended to identify context-specific practices in other sectors and other countries.

Chapter 6

Seeking configurational explanation for high project performance: A sectoral fuzzy-set analysis

Abstract

Understanding how high-performance projects are managed is of paramount importance. Although a vast amount of research has been done in understanding what factors contribute to project performance, research focusing merely on high performing projects is carried out to a lesser extent. In addition, as explained in the previous chapter necessity and sufficiency logic can be used as complementary approaches to better explain the situation. Hence, this chapter aims to further elaborate on how different configurations of pre-determined project management practices can explain high project performance and compare these patterns across the construction, infrastructure, and the process industry. To this purpose, this chapter takes a set-theoretic approach using the same survey data from Chapter 5. Data was analysed combining regression analysis and fuzzy set qualitative comparison analysis (fsQCA). The results suggest that across the sectors, high-level collaboration together with high-level information sharing could explain the high performance. High performance can be explained differently across the sectors. In the construction sector, such combination is crucial when the level of goal setting is low. In infrastructure projects, alignment on goals among the stakeholders together with high level of collaboration between the team members and smooth information exchange could lead to high performance. In the process industry, the results suggest that playing down the application of expectation management across the team members, such as establishing roles and responsibilities and giving feedback on individual or team performance, could explain projects with high performance. This, however, does not suggest that such activities should be overlooked, rather it implies that such activities should be applied in a more collaborative manner that does not invoke a purely control approach. Such collaboration also is required on the strategic level: high project performance was shown to coincide with top management support.

6.1 Introduction

In Chapter 4, project management efforts in terms of front-end activities and project management principles of 104 engineering projects were compared across three sectors (construction, infrastructure and process industry). In Chapter 5, these project management efforts were linked to performance by investigating which of these efforts (conditions) are necessary for achieving an intended level of performance. Phrased differently, by using NCA, it was explored which of these conditions hinders the achievement of a desired level of performance. In order to provide insights into the causal relationship between project management efforts and performance, in this chapter, fuzzy set qualitative comparative analysis (fsQCA) is employed.

QCA is a promising method and it has three main features: a combination of conditions produces an outcome; several different combinations of conditions may result in the same outcome (equifinality); and a condition may be sufficient but not necessary to generate an outcome (Jordan, Gross, Javernick-Will, & Garvin, 2011). In contrast to conventional quantitative methods, in which each variable is treated independently from others, fsQCA could provide additional insights into the configurations of conditions leading to a presence or absence of the outcome (Awe, Woodside, Nerur, and Prater (2019). Additionally, fsQCA is a useful approach for investigating complementarities as well as substitutes in causal paths (Fiss, 2011).

NCA and QCA both look at causal inferences. The difference between NCA and QCA is that in NCA each condition is investigated independently and adding another condition in the causal explanation cannot compensate its absence (Dul, 2016b). Causal relationships between different sets (conditions and the outcome), however, are core concept in QCA (Schneider & Wagemann, 2012). QCA systematically compares the configurations that have the same outcome but differ in one of the conditions and identify those "*conditions (or configurations) that are necessary (need to be) or sufficient (can be) to generate the desired outcome*" (Verweij, 2015c). Dul (2016a) argues that for determining necessary and sufficient conditions different methods should be applied: NCA for identifying necessary conditions and fsQCA for determining sufficient conditions or configurations. FsQCA is only able to draw up a qualitative *in- kind* necessity statement (presence/absence of the condition for presence/absence of outcome), whereas NCA generates a necessity statement *in degree*: a specific level of the condition is necessary for the intended level of outcome (Dul, 2016a). Following this argument, for the necessary conditions causing the intended project performance, irrespective of project sector, the results of the NCA presented in Chapter 5 suffice.

The main goal of this study, however, is to investigate the patterns of those project management efforts and their combinations in explaining the project performance in a specific sector. More specifically, a so called configurational comparative method was used to perform sectoral analysis on the causal relationships of project management efforts and project performance. In other words, the aim of this chapter is to identify the causal paths for a high level of performance in a specific sector.

Thus, the research questions are formulated as:

Which of the project management efforts, in terms of front-end activities and project management principles, are most strongly contributing to project performance?

Which combinations of such project management efforts produce high project performance in each sector?

FsQCA has already been applied in project management research. An example is the study of Yu, Yoo, Kim, and Kim (2019), who provide causal configurations of success factors for the specific project performance indicator of construction 'integrated project delivery', i.e. schedule, cost, defects and change orders. Using complexity theory, Awe et al. (2019) also conceptualized how different causal conditions (project type, participants, processes, complexity, social capital, project management, and knowledge management effectiveness) could predict the project performance. These studies are performed mostly in a specific industry sector, whereas the current study aims at understanding and comparing those patterns for high performance across the sectors.

The structure of this chapter is as follows. In Section 6.2 the methodology used in this study is explained including multiple regression analysis and fsQCA. Next, the results of the data analysis are presented in Section 6.3. The interpretation of these results, theoretical and practical implications, and the limitations are discussed in Section 6.4. Finally, the conclusion of the chapter is provided in Section 6.5.

6.2 Methodology

Data from the survey study (see Section 4.3 and Section 5.2) was used for this chapter as well. The data analysis for this study consists of two main steps: multiple regression analysis and Qualitative Comparative Analysis (QCA) to explore the results from the regression analysis. First, exploratory multiple regression analysis is explained (Subsection 6.2.1). Next, QCA is introduced (Subsection 6.2.2).

6.2.1 Multiple regression analysis

The reason for conducting multiple regression analysis as the first stage of the analysis was that the number of conditions should be kept at the moderate level in QCA (Schneider & Wagemann, 2010). There is no clear cut prescription in the literature for the optimal number of conditions to be included in QCA (Wagemann, Buche, & Siewert, 2016). Jordan et al. (2011), however, suggest that the number of conditions included in QCA should be limited, otherwise it produces too complex results to be interpreted. There is no clear-cut optimal ratio for conditions-to-cases ratio in QCA, however, there are some indications from earlier QCA studies. For instance, Mellewigt, Hoetker, and Lütkewitte (2018) considered six conditions for 137 cases, Schneider, Schulze-Bentrop, and Paunescu (2010) used six conditions for 76 cases, Yu et al. (2019) considered two to seven conditions (depending on the performance outcome) for analysing 16 projects, and in the study of Verweij

(2015c) five conditions are investigated for 27 projects. Thus, the goal for performing multiple regression in this study was to identify those factors that most strongly relate to project performance (dependent variable) out of the front-end activities and project management principles (independent variables), thereby providing input for the QCA.

Stepwise regression technique (forward and backward) has been applied in earlier studies in project management research for variable selection (Ahadzie, Proverbs, & Sarkodie-Poku, 2014; Ika, Diallo, & Thuillier, 2012). In this technique, the variables are added to the model (in forward method) or removed from it (in backward method) based on the correlation with the outcome variable (Field, 2009). The stepwise regression technique, however, is criticised because the variables might be considered as insignificant in explaining the outcome based on the variables that are already present in the model causing inflated Type I error[1] (Mundry & Nunn, 2009). Hence, in the current study, instead of stepwise regression analysis, the best subset selection method was employed allowing for fitting separate models for each combination of the independent variables and selecting the best subset. In addition to 12 independent variables (five front-end activities and seven project management principles), identified earlier in Subsection 4.5.2, project size and duration were taken as control variables. These control variables were taken because project size and duration could affect the implementation of such project management practices (Bosch-Rekveldt, 2011; Ika et al., 2012). Prior to performing the multiple regression analysis, Little's (1988) missing completely at random (MCAR) test was performed on missing values on these 14 variables. The result of this test was not significant suggesting that there was no systematic pattern regarding the missing values. Thus, regression imputation method was applied to fill in these missing items in the survey responses. With these 14 variables, the best subset selection algorithm was used, as suggested by James, Witten, Hastie, and Tibshirani (2013):

1. Let M_0 denote the null model, which contains no independent variables.
2. For k = 1, 2, …p:
   - Fit all models that contain exactly k independent variables.
   - Pick the best among these models and call it M_k. Here best is defined as having the smallest R^2

The more variables are in the model, the higher the value of R^2 would be (James et al., 2013). Hence, the partial F-test was applied to check whether an increase in R^2 is significant when comparing the nested models. Nested models include models in which one is a subset of the other. If the p-value for the partial F-test is less than the significant level (here 0.05), it can be concluded that the extra factor in the nested model has the coefficient close to zero (Jamshidian, Jennrich, & Liu, 2007). To put it differently, if p-value<0.05 for the F-test the subset model is a better fit compared to the full model.

1. Mundry and Nunn (2009) show in their study that the F-test used for the significance test of the steps in the stepwise analysis is biased because of multiple testing. This could result in inflated Type I error (the probability of incorrectly rejecting a true null hypothesis).

6.2.2 Fuzzy set qualitative comparative analysis (fsQCA)

To advance the investigation of how different combinations of front-end activities and project management principles and their configurations might be linked to a certain level of project performance, Qualitative Comparative Analysis (Ragin, 2008), and more specifically fuzzy set qualitative comparative analysis (fsQCA) was performed (Bakker, Cambré, Korlaar, & Raab, 2011; Fiss, 2011). FsQCA is the most often applied variant of the QCA, among the three variants, in the literature (Roig-Tierno, Gonzalez-Cruz, & Llopis-Martinez, 2017). The high popularity is because fsQCA, different than other QCA variants, allows different degrees of membership in sets ranging across a continuum between 0 (full non-membership) and 1 (full membership) (Schneider & Wagemann, 2010). This degree of membership determines the degree to which a condition is absent or present in a specific case (Schneider & Wagemann, 2012). In order to determine the degree of membership of the cases in each set, the conditions should be calibrated (Ragin, 2008). Further, the configuration of combinations is investigated which caused a specific outcome (Woodside & Zhang, 2012). Generally, the QCA approach is suitable for exploring a minimally sufficient combination of conditions for a specific outcome, combining quantitative and qualitative approaches (Cooper & Glaesser, 2016; Gerrits & Verweij, 2013). QCA is a powerful tool that allows for identifying general patterns from different contexts as well as exploring an in-depth contextualized insight of each case (Bakker et al., 2011).

FsQCA was selected for this study because of its power in identifying the combined effects of causal conditions. Equifinality is one of the core concepts of fsQCA which means that different combinations of conditions can lead to a single outcome (Vis, 2012). FsQCA operationalises the set-theoretic concepts by identifying observed high or low levels of each condition (front-end activities and project management principles) and outcome (project performance) as sets. In moderately large-N (between 50 and 100) studies both regression analysis and fsQCA can be used (Vis, 2012). Regression analysis aims at explaining the variances in the outcome by identifying the most significant predictors (Schneider & Wagemann, 2012). On the other hand, a contextualization approach assumes that projects are unique by nature and are sensitive to their context (Verweij, 2015). FsQCA can enable generalization of the results, while it simultaneously allows for case-specific explanations of the conditions (Kraus, Ribeiro-Soriano, & Schüssler, 2018) and it explores asymmetric patterns across the cases (Wagemann et al., 2016). In this study, the quantitative and qualitative data are linked by using the results from the multiple regression analysis to gain in-depth insights into cases (Gerrits & Verweij, 2013).

Generally, when performing fsQCA, four main steps should be followed: data calibration and constructing the data matrix, truth table formulation, truth table minimization, and interpretation of the results (Verweij, 2015c). Rather than estimating the relative contribution of each condition to the outcome, a set theoretic approach explores the potential combinations of causal conditions (Tóth, Thiesbrummel, Henneberg, & Naudé, 2015). Thus, original data from the survey responses should be rescaled into membership scores ranging from 0 to 1. Additionally, it is crucial that data calibration be related back to the cases, instead of mechanical application (Schneider & Wagemann, 2012). In other words, data calibration in fsQCA is not a "mechanistic" process, in contrast, the case-based knowledge should be maintained (Jordan et al., 2011). In Subsection 6.3.2, the calibration rules used in this study are presented.

After data calibration, in step two, the truth table is constructed in which each row represents one logically possible configuration or path (Verweij et al., 2019). Configurations can be defined as the combinations of the outcomes (Mellewigt et al., 2018).There are 2^k logically possible configurations, where k indicates the number of conditions included in the analysis (Ragin, 2008). In this study, 4 conditions were selected (based on the result of multiple regression analysis) to be included in fsQCA resulting in 16 logically possible configurations. Using the calibrated data both for the conditions and the outcome, each case is assigned to a configuration which best describes it (Ragin, 2008). Step three entails minimization of the configurations in the truth table. In this step, potential configurations are compared to identify those configurations that shared a high level of project performance (outcome). The outcome of this minimization process is a set of "mutually nonexclusive configurations" producing a solution formula (Verweij et al., 2019). For assessing the qualities of the solutions in R outputs, two measurements are considered: consistency of the solution and coverage of the solution (Rihoux & Ragin, 2008). Consistency is the core concept in set-theoretic approaches and can be defined as "the degree to which a given condition is a subset or superset of the outcome" (Schneider & Wagemann, 2012, p. 18). Coverage is another parameter for interpreting the solutions measuring the empirical evidence or importance of a set-theoretic connection (Ragin, 2008, p. 45). Consistency and coverage of set relations are comparable to significance and strength, respectively, of the correlation analysis (Ragin, 2008). In the final step of fsQCA, the results of the minimization table are interpreted.

6.3 Results

The findings from this study are described in four subsections. First, results of multivariate regression analysis are presented in Subsection 6.3.1. Build on the results from this analysis, the selected conditions are calibrated in Subsection 6.3.2 to be further analysed using the fuzzy set QCA approach. The sufficiency of the identified conditions for the intended project performance is presented in Subsection 6.3.3 in which the results of the truth tables are presented. The sectoral analysis of sufficient conditions explaining the high project performance is given in Subsection 6.3.4.

6.3.1 Condition selection

Multiple regression was applied to determine which of the front-end activities and project management principles are most strongly related to project performance. These factors are further selected as the potential conditions to be included in the subsequent QCA. The same categorisation of the front-end activities and project management principles, resulting from the PCA performed in Subsection 4.5.2, was used in this study. The stages followed for multiple regression analysis by James et al. (2013) are followed and as explained in Subsection 6.2.1.

In total 14 models were created using the best subset selection method (see Appendix H. 1), in which the order for adding these factors to each model was based on the results of the applied algorithm. In this table, Model 1 is the best model with only one predictor (information sharing), the best model with two predictors contains (information sharing and project duration), model 3 represents the best model with three predictors (information sharing, project duration, and client competency), and the last model contains all the 14 variables.

Next, pairwise comparison of the resulted models was performed using the partial *F*-test (see Appendix H. 2). The result of the analysis suggests that model 5 with five predictors (setting expectations, collaboration between client and contractor, setting project goals, information sharing, and project duration) is the best amongst the 14 generated models in explaining the project performance. For this model, multiple regression analysis is performed to determine its significance. Table 6.1 shows the results of the analysis on this model with project performance as the dependent variable (F= 5 6.629, p <.001).

Table 6.1: Multiple analysis summary for the front-end activities and project management principles

Variable	Standardised Coefficient	Standard error	Confidence intervals	
			Lower	Upper
(constant)	-	-0.502	1.191	3.182
Setting expectations	-0.124*	0.045	-0.151	0.027
Collaboration between client and contractor	0.181**	0.107	-0.011	0.415
Setting project goals	0.148*	0.096	-0.040	0.342
Information sharing	0.252***	0.090	0.054	0.410
Project duration	-0.222***	0.053	-0.239	-0.028
Explanatory power	R^2 = 0.253, Adj. R^2 = 0.215			

*significant at p < 0.1 **significant at p < 0.05 *** significant at p < 0.01

Based on the results of this exploratory multiple regression analysis, three conditions contribute positively and significantly to the explanation of project performance: information sharing (standardised coefficient 0.252, p <0.01) collaboration between client and contractor (0.181, p <0.05), and setting project goals (0.148, p <0.1). The intensity of application of setting expectations (-0.124, p <0.1) and project duration, as a control variable, (-0.222, p <0.01) have a negative effect on project performance.

FsQCA was performed with these five conditions, however, the resulted configurations could not be meaningfully distinguished which makes the interpretation of the contributing conditions impossible. Whilst acknowledging the interplay between the project duration and the application of project management practices, it was chosen to proceed with these four conditions, in the fsQCA: information sharing, collaboration between client and contractor, setting project goals, and setting expectations. Later, in Subsection 6.3.4, post-hoc tests are performed to check for possible patterns in the resulted configurations regarding the project duration.

6.3.2 Data calibration

Before performing fsQCA, the identified conditions and outcome should be calibrated, in which the raw measurement scores (or as expressed by Dul (2016a) "original data") from the conditions and the outcome are transformed into set membership scores in the intervals between 0 and 1 (Ragin, 2008). Since for assigning these membership scores a thorough knowledge of the cases is required, it was decided to remove those cases with missing data on the items of the selected conditions, which was imputed for regression analysis (see Subsection 6.3.1), leaving a usable sample of 95 completed responses for fsQCA. Further analysis in this chapter refers to this dataset.

Ragin 's (2008) indirect method of calibration was used for this study because it allows for translation of Likert-scale data to fuzzy sets without any loss of information (Emmenegger, Schraff, & Walter, 2014). The indirect method is based on the researcher's knowledge and qualitative interpretation of the cases, in order to categorise them based on their degree of set membership (Ragin, 2008; Thiem, 2014). The four-value fuzzy set was used for this study with the following qualitative categories (Rihoux & Ragin, 2008): (0) "fully out", (0.33) "partly out", (0.66) "partly in", and (1) "fully in". For calibrating the conditions and outcome variables, qualitative assessment of the items per case is required. The three conditions of project management principles (setting project goals, collaboration between client and contractor, and information sharing) were measured using a five-point Likert scale. The condition setting expectations (front-end activity) was measured using a seven-point scale. The factor scores were further calculated by averaging the items that loaded significantly on a factor (see Table 4.7 for the complete list of items creating each factor). Therefore, for assigning each case's degree of set membership an in-depth qualitative assessment of the factors was performed by plotting the histograms of the items as well as factors per target set (Ragin, 2008). This qualitative assessment of the conditions would help in selecting the point of indifference (Schneider & Wagemann, 2012). Additionally, for assigning the membership score for each case, the original measurement scores for each item per condition and project performance were compared relative to other cases. For instance, the "neutral" responses in the Likert scale, reflecting indifferent responses, has some partial membership and are coded as more out than in (Emmenegger et al., 2014).

Table 6.2 presents the calibration rule for the degree of membership per target set of conditions and project performance. In this table, lowercase letters in the third column indicate a 0.00-0.33 membership score and uppercase letters shows 0.66-1.00 membership score. For instance, "goal" indicates a low level of project goals setting and "GOAL" shows a high level of project goal setting.

For two conditions of setting project goals (consisting of three items, see Table 4.7) and collaboration between client and contractor (consisting of six items), consistent calibration rules are used in which projects with a measurement score of lower than 2.6 are coded as fully out. Cases with a measurement score between 2.6 and 3.6 are assigned to the value of 0.33 (partly out), whereas cases with the average value of items between 3.6 and 4.6 are more in than out the set (with a membership score of 0.66). The rest of the cases with a measurement score higher than 4.6 are coded as fully in the set. The information sharing set captures the respondents' opinion with regard to two items: "required information was disseminated in time by various parties" and "clear communication channels were present for information sharing" (see Table 4.7). Looking into the individual responses given to each of these two items, the cases with the average value between 2.3 and 3.3 are assigned the membership score of 0.33 (partly out the set). In contrast, cases with the average value between 3.3 and 4.3 are coded as partly in the set (membership score of 0.66).

The condition setting expectations is made up of two items. Based on the histogram of this condition, the point of indifference is set between the values 3 and 3.5 (corresponding to apply this activity approximately annually). Cases with the original mean score of between 1.70 and 3.20 are considered as partially out of the set (membership score of 0.33) and those cases with the mean score between 3.20 and 4.60 are assigned as the membership score of 0.66 (more in than out the set).

All cases with the mean of performance score below 2.8 (corresponding to neutral statement in the five-point Likert-scale) are coded as fully out of the set and the cases with the mean of performance score higher than 4.4 (corresponding to between agree and strongly agree response) are coded as fully in. For the cases with the performance score between 2.8 and 4.4, the original scores per performance indicator (cost, schedule, quality, and client satisfaction) were used to assign the membership scores.

Table 6.2: Overview of the fsQCA calibration rules for the conditions and project performance

Construct		Ordinal variable range	Fuzzy set membership score
Conditions (front-end activities and project management principles)	Setting project goals (GOAL)	IF 1.00 ≤ goal < 2.60	0.00: Fully out
		IF 2.60 ≤ goal < 3.60	0.33: Partly out
		IF 3.60 ≤ GOAL< 4.60	0.66: Partly in
		IF 4.60 ≤ GOAL ≤ 5.00	1.00: Fully in
	Collaboration between client and contractor (COLL)	IF 1.00 ≤ coll < 2.60	0.00: Fully out
		IF 2.60 ≤ coll < 3.60	0.33: Partly out
		IF 3.60 ≤ COLL < 4.60	0.66: Partly in
		IF 4.60 ≤ COLL ≤ 5.00	1.00: Fully in
	Information sharing (INFO)	IF 1.00 ≤ info < 2.30	0.00: Fully out
		IF 2.30 ≤ info < 3.30	0.33: Partly out
		IF 3.30 ≤ INFO < 4.30	0.66: Partly in
		IF 4.30 ≤ INFO ≤ 5.00	1.00: Fully in
	Setting expectation (EXP)	IF 1.00 ≤ exp < 1.70	0.00: Fully out
		IF 1.70 ≤ exp < 3.20	0.33: Partly out
		IF 3.20 ≤ EXP < 4.60	0.66: Partly in
		IF 4.60 ≤ EXP ≤ 5.00	1.00: Fully in
Outcome	Project performance (PERF)	IF 1.00 ≤ perf < 2.80	0.00: Fully out
		IF 2.80 ≤ perf < 3.70	0.33: Partly out
		IF 3.70 ≤ PERF < 4.40	0.66: Partly in
		IF 4.40 ≤ PERF ≤ 5.00	1.00: Fully in

6.3.3 Analysis of sufficient conditions for high project performance

For analysing the sufficient conditions, the truth table is constructed using QCA package (3.6) for the R environment (Dusa & Thiem, 2019). For refining the truth table two criteria are considered. (1) The frequency threshold for each configuration depends on the sample size. Given the size of the sample (N=95), the frequency threshold of two is set which is higher than the recommended threshold of one case by Schneider and Wagemann (2012) for medium-sized N studies. The frequency threshold of two means that there are at least two empirical cases per configuration. Put it differently, in each row of the truth table, configurations with one or no case are considered as irrelevant and excluded from the table. (2) The threshold consistency (inclusion) of the solution for sufficiency is set at 0.854. The choice for this threshold is based on four criteria (Ragin, 2008; Verweij, 2015c). First, this value is also above the advisable consistency level of 0.75 (Schneider & Wagemann, 2012). Second, there is a large gap in the consistency values of the logically possible configurations above and below this threshold. Third, configurations above this threshold have higher PRI (Proportional Reduction in Inconsistency) indicating that there is a discrepancy in the consistency scores of the configuration for low and high level of outcome (performance). Fourth, a thorough examination of the cases covered by each configuration above and below this threshold is required.

It is also checked whether there are any configurations that can be considered as sufficient for both the outcome and the negation of the outcome. In case there is such configuration, the row should be excluded from the minimization process (Thiem & Dusa, 2012). Three configurations were removed from the truth table since they covered such contradictory cases: exp*COLL*GOAL*INFO; exp*coll*goal*INFO; EXP*coll*goal*INFO. In these three configurations the consistency value is higher than the threshold (0.854), however, the project performance was low. After removing these configurations, the truth table minimization proceeded.

Next, the solutions are generated, allowing to identify the sufficient conditions. Table 6.3 presents the results of fuzzy set analysis for high project performance. Each row in this table represents one path (configuration) of the solution formula leading to high project performance. For each path three measurements are given in Table 6.3: consistency, raw coverage (cov.s), and unique coverage (cov.u). Consistency of a configuration measures the proportion of the projects where both sufficient conditions and the outcome (successful project performance) occur. Raw coverage for sufficiency measures the proportion of the successful performance explained by the configuration, albeit having some overlaps with other configurations (Dusa & Thiem, 2019). Since each project can be covered by more than one path (Schneider et al., 2010), unique coverage indicates the extent to which that certain configuration can uniquely explain the successful project performance.

For assessing the quality of this formula solution (combination of four causal paths in Table 6.3) two measures are considered: Consistency (0.891) and total coverage (0.776) of the solution. Higher consistency values in a solution increase the likelihood of successful project outcome (Yu et al., 2019). Coverage of the solutions indicates the empirical importance (Ragin, 2008) by measuring the proportion of successful project performance that is explained by the solution. A high coverage value indicates that a large portion of projects that have high performance score is explained by the solution. If there are several paths producing the same level of performance, the coverage might be small (Ragin, 2008).

Table 6.3: Analysis of sufficiency combinations of conditions for high project performance, intermediate solution (N=95)

	Minimised configuration	Consistency	Raw coverage (cov.s)	Unique coverage (cov.u)
Path 1	exp*COLL*INFO	0.906	0.495	0.061
Path 2	exp*GOAL*INFO	0.931	0.456	0.028
Path 3	EXP*COLL*info	0.886	0.307	0.022
Path 4	COLL*GOAL*INFO	0.897	0.626	0.000
	Solution	0.891	0.776	

Following the results of NCA presented in Section 5.3, the presence of collaboration between client and contractor (COLL) and information sharing (INFO) are among the single necessary conditions for high level performance. This implies that the absence of these conditions cannot be compensated by other conditions and they should be present in all sufficient configurations. The results of necessary analysis using fsQCA approach, however, did not reveal any necessary conditions for high project performance. As explained by (Dul, 2016a), fsQCA is prone to type 2 error (false negative) in identifying the necessary conditions. This suggests that, following the necessity logic, paths 2 and 3 would not represent the sufficiency configurations as such and they are not further discussed here (see also Subsection 6.4.1).

Since the conditions included in the study resulted from the multiple regression analysis, some directional expectations can be made about how these conditions can contribute to project performance. High levels of collaboration between client and contractor (COLL), high levels of goal setting (GOAL), and high levels of information sharing between parties (INFO) contribute to high level of project performance. Surprisingly, high intensity of application of expectation management, establishing of roles and expectations of the team members, feedback on individual/team performance, negatively contribute to project performance. Such negative contribution to performance can be equivalent to low levels expectation management (exp). The aim of fsQCA presented here, is to explore how different configurations of these conditions could explain a high-level project performance.

Path 1 with the highest unique coverage (0.061) amongst the configurations is the most important explanation for high project performance. This configuration combines high level of collaboration between client and contractor, high levels of information sharing, and low intensity expectation management (exp*COLL*INFO). In this combination, goal setting has no influence on the outcome.

The combination of the following three factors forms path 4 of the intermediate solution: high level of teamworking between the client and contractor, clear project goal formulation, and timely exchange of information between the parties (COLL*GOAL*INFO). Although path 4 was observed in 40 projects, the value of the unique coverage is 0.00 suggesting that it does not provide a unique contribution, compared to path 1, to the project performance.

Next, a fuzzy set qualitative comparative analysis was performed for low levels of performance (absence of high performance), which indicated no consistent patterns.

6.3.4 Comparing sufficient conditions across the sector

Next, a separate sufficiency analysis of high project performance was performed in the three sectors (construction, infrastructure, and process industry). The aim was to identify which combination of factors is most relevant for achieving high project performance per sector. The same procedures, as explained in Subsection 6.3.3, are followed for constructing the truth tables and running the minimization. Table 6.4 presents the configurations of the solution formula per sector that consistently led to the predefined project performance. In this subsection, only the most important configurations with the highest unique coverage in each solution per sector, which are shown in bold, are discussed.

Table 6.4: Intermediate solution, construction sector (N=24)

	Minimised configuration	Consistency	Raw coverage (cov.s)	Unique coverage (cov.u)
Path C1	EXP*INFO	0.821	0.487	0.083
Path C2	coll*GOAL*INFO	0.951	0.427	0.064
Path C3	**COLL*goal*INFO**	**0.903**	**0.596**	**0.106**
	Solution	0.853	0.743	

Note: Consistency threshold of 0.879; Frequency threshold of N= 2

Table 6.5: Intermediate solution, infrastructure sector (N=31)

	Minimised configuration	Consistency	Raw coverage (cov.s)	Unique coverage (cov.u)
Path I1	exp*COLL*INFO	0.869	0.475	0.070
Path I2	**COLL*GOAL*INFO**	**0.875**	**0.790**	**0.208**
	Solution	0.866	0.682	

Note: Consistency threshold of 0.817; Frequency threshold of N= 2

Table 6.6: Intermediate solution, process industry (N=40)

	Minimised configuration	Consistency	Raw coverage (cov.s)	Unique coverage (cov.u)
Path P1	EXP*COLL*info	0.880	0.291	0.106
Path P2	**exp*COLL*INFO**	**0.930**	**0.539**	**0.355**
	Solution	0.923	0.645	

Note: Consistency threshold of 0.869; Frequency threshold of N= 2

Comparing the unique coverages of the most important configuration per sector to those of the configurations for the total dataset (Table 6.3), it can be observed that the unique coverage per sector is much higher. It suggests that the configurations identified per sector provide a more unique explanation of the high performance.

A post-hoc qualitative analysis was performed to investigate whether there is any pattern in the project data covered by a specific configuration. For doing this, project characteristics in each configuration were compared to the total cases per sector. First, project duration, as a control variable which showed a negative contribution to project performance in the multiple regression, of the cases covered by each of these contributions was compared to the total cases in the sector. Next, other project characteristics in each path were compared, i.e. project size, project type, and contract type. No pattern was found regarding these project characteristics in each configuration.

For additional insights, per sector, the difference in the application of eight other project management efforts (that were not included in the fsQCA, based on the results of multiple regression) were also investigated in each solution formula. More specifically, a separate ***t***-test was performed in each sector to compare the mean values of these eight project management efforts between the cases that are explained by the causal path (each bold row in Table 6.4, Table 6.5, and Table 6.6) and those cases that are not explained by the causal path. In the following, the significant results of these tests are presented.

In the construction sector, the most important causal path (COLL*goal*INFO) relies on a high degree of collaboration between team members of client and contractor in combination with a high degree of information dissemination and low degree of goal setting (see Table 6.4). The result of the *t*-test confirms that this configuration (nine cases), has lower than sector average intensity of monitoring and control management activities. This path also shows higher levels of support from top management compared to the sector average.

The infrastructure sector was the only one, in which a high degree of aligned goals is observed in the most important configuration (COLL*GOAL*INFO), see Table 6.5. This path also combines high level of collaboration and high level of information sharing. The *t*-test further confirms that the twelve cases that showed this configuration exhibit also higher levels of top management support.

The most important causal path in the process industry combines again a high level of information exchange together with high level of collaboration between client and contractor teams and a low intensity of team members expectation setting (exp*COLL*INFO), see Table 6.6. None of the paths forming the solution formula for producing high performance in the process industry include clear goal setting. In other words, putting more effort into clear goal setting does not form the sufficient condition for the high project performance in the process industry. This, however, does not suggest that goal setting is not important in the context of the process industry. Rather it indicates that other combinations of the conditions more consistently explain the project performance. Again, the *t*-test shows that the level of top management support in the cases explained by this configuration (fourteen projects) is significantly higher than in other cases.

6.4 Discussion

In this study, a set-theoretic approach was employed to explain how different configurations of the project management efforts can contribute to the performance of engineering projects. The results of this chapter are discussed in three subsections. First, the interpretation of the results is explained in Subsection 6.4.1. Next, theoretical and practical implications of the study are presented in Subsection 6.4.2. Finally, limitations of the study are outlined in Subsection 6.4.3.

6.4.1 Interpretation of the results

Relying on the survey data, explained in Chapter 4, this study proposes that different project management efforts in terms of front-end activities and project management principles can be combined to form configurations for predicting the performance of engineering projects. The four necessary conditions found in Chapter 5 (NCA) should always be present since their absence would guarantee low performance. These conditions are an essential component of any sufficient configurations, despite the fact that they were not found in Chapter 6 (fsQCA). This could be attributed to a type 2 error (false negative). The first important observation from this study is that no single condition is sufficient, independent from other conditions, for the intended level of project performance. The sufficiency analysis presented in this chapter provides empirical evidence on how different combinations of the four selected project management efforts can contribute to project performance.

Path 1 (exp*COLL*INFO) of the intermediate solution (total dataset) is consistent with the directional expectation that high degree of collaboration between project members and timely exchange of information, contribute to high performance. Due to the higher value of unique coverage, this configuration is most relevant, compared to path 4 of the solution.

Comparing these sufficient configurations across the sectors, however, seems to provide more reflective insights into how different configurations of project management efforts combine in each sector for producing successful project performance. First, it can be observed that, consistent with the sufficiency configurations derived for the whole dataset, team collaboration among the team members of client and contractor is the reoccurring condition in the sufficient configurations in all the sectors. In this study, such collaboration was measured by the following indicators: team members sense of belonging to the team, team members supporting each other in performing their tasks, shared belief for protecting each other's interests, team members commitment to team task, putting joint effort into project management activities, and team members motivation. Second, all the configurations leading to high performance across the sectors involve the presence of high degree of transmitting information. Information was operationalised by measuring two indicators: disseminating the required information in a timely manner and the existence of clear communication channels. This result is in line with the study of Awe et al. (2019) finding that social capital in terms of providing people with information and knowledge together with building trust could consistently explain the high project management performance. Additionally, communication in terms of proper information flow can mediate the effect of trust on project performance (Cheung, Yiu, & Lam, 2013). Dow and Taylor (2010, p. 3) distinguish three components of project management communication: communicating project information in a timely manner, producing the right information, and gathering, disseminating and storing project information. The extent to which the information is shared proactively among the parties is determined by the intensity and quality of communication (Chow, Cheung, & Chan, 2012; Das & Teng, 1998). The presence of high-level collaboration together with high level information sharing in all the causal paths might suggest that these two conditions remain together important for explaining the high performance. This confirms the study of Ziek and Anderson (2015), showing that communication should not be considered merely as a hard factor for monitoring the processes for information flow. Rather, it should be regarded as a social interaction among the project participants in which their communicative action could affect the project performance (Sarhadi, Yousefi, & Zamani, 2018).

High levels of goal clarity can only be observed in the sufficiency configuration for high performance in the infrastructure sector. An explanation might be that usually in infrastructure projects many stakeholders are involved who have various opposing interests (Cheung, Ng, Wong, & Suen, 2003) making them crucial for influencing the project outcome (Oppong, Chan, & Dansoh, 2017). It suggests that in infrastructure projects it is of the utmost importance to set clear goals and put extra effort to bring the stakeholders together to make sure that their interests are included.

In construction projects, the absence of goal setting when there is high level of team collaboration and high level of information exchange is associated with high project performance. An explanation for the absence of goal setting for construction projects might be that, as indicated in Subsection 4.5.3, the overall level of project goal setting within the sector was low. When there is unclarity about the goals, in order to produce high project performance, more emphasis should be given to promote high-level collaborative interaction between the client and contractor and high level of information exchange. This confirms the research findings of Larsson et al. (2018) suggesting that project team related factors, specifically motivation can mediate the influence of hard factors, such as goal setting, on project performance. A motivational climate can stimulate collaborations and it can be beneficial when it is also supported by setting clear goals and performance criteria (Caniëls, Chiocchio, & van Loon, 2019). The results of the current study, however, revealed that provide a collaborative environment is more important than prioritising and aligning project goals among the parties in the construction sector.

Setting expectation practices, such as establishing roles and responsibilities among the project team does not seem to be important to explain the project performance, specifically in the infrastructure and construction sector. This condition did not appear in the most relevant causal path. In the process industry, high levels of collaboration and high levels of information exchange produce high performance even with less frequent expectation management. It seems that less emphasis on expressing expectations makes it more likely that projects have higher performance. The prevalence of such practices put an extra burden on project team members. Performing such expectation management more frequent does not contribute to project performance, since it might convey the message that there is too much control within the project team. Overemphasizing these activities and obligations might cause misunderstandings and endanger trust expectations among the project team members (Chow et al., 2012). Thus, a balance should be made between performing these activities and focusing on building trust between the parties.

Interestingly, among the subset of cases explained by the empirically most important configuration per sector, top management support is consistently higher than for other cases. This might imply that top management support facilitates the effective collaboration of project team members from client and contractor and information flow between various parties is smoother. Additionally, no significant difference was found between the application of the other project management efforts, such as intensity of application of lessons learned or team building activities, for the cases explained by the most relevant causal path and other cases. This, however, might imply that those projects in which team members work effectively together from both sides, client and contractor, and information can be communicated easily do not necessarily put extra effort in other activities for achieving high performance. This overemphasises the role of teamwork and communication of information in the achievement of high project performance. Although these observations are based on the post-hoc analysis of the cases in each configuration and not by the fsQCA, still the findings could provide some suggestive insights.

6.4.2 Implications

The study presented in this chapter has both scientific and practical implications. At the scientific level, the study combines two methodologies, NCA (presented in Chapter 5) and fsQCA (presented in this chapter) to enhance the observations for explaining high project performance. Recent studies focused on project performance by applying various methodologies, such as Machine Learning (Locatelli et al., 2017) and multivariate data analysis Fossum et al. (2019). Applying each methodology can provide additional insights by treating the variables and investigating the interrelationships between them differently. This study adopts a set-theoretic approach in explaining the performance of engineering projects. Additionally, the study also systematically compares the conditions (project management efforts) and project performance across three sectors: construction, infrastructure and process industry. Results of the fsQCA suggested that in each sector there is one most important sufficient combination of conditions for explaining the project performance. Two factors appeared in all the causal paths for producing high project performance across the sectors: high level collaboration between team members of client and contractor and high-level information exchange. The other two (preselected) conditions, clear goal setting and roles and expectation management among the teams, either appear in low/high degree or they were absent in the causal configurations.

Specifically, using data from the same survey study, combining the findings of NCA discussed in Chapter 5 with the results of fsQCA presented in this chapter provides a complementary approach in explaining the project performance. Although the sample used for fsQCA is a subset of the sample included in NCA, the results remain valid. The reason is that, if in one case a necessary condition is observed, its absence serves as an obstacle for achieving the intended outcome (Dul, 2016b). In other words, if this necessary condition is not in place, even when considering smaller sample size, high project performance cannot be achieved. Therefore, this study enriches the literature on project performance stating that the interplay between different project management practices that can contribute to high performance.

At the practice level, for practitioners in each sector, the results of the study suggest which configurations of project management efforts can consistently lead to high project performance. In the construction sector, when there is low level of clear goal among the parties, participants from both sides, client and contractor, should put extra effort in promoting high quality collaboration among the team members and make sure that there is a participative environment for fostering information exchange. In infrastructure, even when parties work effectively together and there is a smooth flow of information, goals should be clearly defined and set. In the process industry, high project performance can be reached when team members from the client and contractor side invest in enhancing the quality of collaboration and if there is a smooth information exchange. In such an environment, however, overemphasising the setting of roles and responsibilities and individual feedback on team members contributes negatively to high performance level. The reason might be that the prevalence of those processes induces the control approach. Thus, practitioners should apply these activities cautiously. Support from top management has an interplay with all the configurations for high project performance across the sectors. This suggests that application of those practices can be significantly facilitated with the presence of top management support from both client and contractor side.

6.4.3 Limitations

The current study has two limitations. The first limitation of the study is that the selection of the conditions to be included in fsQCA was based on the results of the multiple regression analysis. Based on this analysis, only four out of 12 potential conditions were included for the sufficiency analysis. The reason was that considering too many conditions, compared to the sample size, in the fsQCA could complicate the interpretation of the configurations. This means that the conditions included in the fsQCA were a subset of the conditions considered in the NCA. Following the necessity logic, however, the absence of the necessary conditions in the sufficient configurations should be further investigated. Future research could include more cases which would allow for considering more conditions to explain project performance.

The second limitation is again with regard to the conditions included in the fsQCA. In this study, only high-level analysis of the factors was possible, whereas in Chapter 5, NCA was also performed on the items (which constitute the factors) to provide in-depth insights. Instead, fsQCA, enabled an investigation of complex interdependencies between the conditions considered (Mellewigt et al., 2018).

6.5 Concluding remark and next step

Using a set-theoretic approach, this study comparatively analysed the management efforts associated with high performance in 95 engineering projects in construction, infrastructure, and process industry. Overall, the findings suggest that not all combinations of project management efforts contribute to project performance in the same way across the sectors. The findings across the whole dataset, as well as across the sectors, suggest that practitioners should invest more time in enhancing the team level collaboration, between client and contractor, and ensuring that the information is smoothly distributed between the parties. Presence of the combination of these two conditions, high-level collaboration together with high level information, is crucial for reaching high performance.

The evidence in the current study provides an indication that, across the sectors, clients and contractors can produce high performance by promoting a collaborative environment. Specifically, in the construction sector, where the goals seem to be less aligned across the parties, this collaboration is the paramount condition. In infrastructure, however, having a formal goal setting process which is aligned with the stakeholders' needs together with the collaborative interactions among the participants can produce high performance. Having more focus on collaboration and communication between the client and contractor combined with less focus on formalised expectation procedures in the process industry can create the high performance. Although performing such formalised expectation setting practices is required, overplaying such practices has an adverse effect on the collaboration between the team members and project performance.

The findings of this chapter and Chapter 5 are relevant since the understanding of the concept of necessary and sufficient conditions could add value in explaining high levels of project performance. Following the necessity logic, it was revealed that the following factors are necessary for the intended level of performance: top management support, collaboration between client and contractor, information sharing among the project parties, and technical skills of the client representatives in the early project phase. Although the results of fsQCA did not reveal any necessary condition, focusing on those necessary conditions (resulted from NCA approach) is important, since they should be an essential component of any sufficient configuration. The NCA was performed on the whole dataset, however, the study presented in this chapter also explains and analyses different configurations for achieving high project performance per sector.

In the next chapter, the analysis of the final part of the survey is presented in which the respondents indicated what can be improved in terms of the applied project management practices. Reflecting on those recommendations gained from the participants and based on the insights extracted from the empirical studies (Chapter 5 and this chapter), a model is developed and evaluated in order to contribute to improving the performance of engineering projects.

Part III

Feeding back to practice

Chapter 7

Building blocks for improving the management of engineering projects

Abstract

In this chapter, the findings of the previous chapters and evaluation of practice are synthetized. As articulated in the introductory chapter, the ultimate goal is to provide an agenda for improving the management of engineering projects. To this aim, this chapter identifies and proposes a set of potential improvement areas in the management of engineering projects. The findings of the previous chapters together with the views of experts are integrated into the Nexcess model. The Nexcess model includes proven practices and suggested practices and twelve core project management efforts. The proven practices are based on the results of the survey study and consist of three sets: necessary conditions, necessary and sufficient conditions, and sufficient configurations. Necessary conditions are shared among projects irrespective of their context, whereas sufficient conditions are specific for a sector. Necessary and sufficient conditions lie at the intersection of these two practices. In the suggested practices, the core emphasis is on providing a collaborative (process industry projects) and integrative (construction and infrastructure projects) environment. The applicability of the model and the accompanying recommendations were evaluated by experts representing two sector groups (construction and infrastructure sector together and process industry). Based on the results of these expert evaluation sessions the Nexcess model is adapted in order to enhance the applicability of the Nexcess model for daily practice.

7.1 Introduction

In part I of this dissertation, perspectives of practitioners on project management practices were identified and compared across three sector groups (construction, infrastructure, and process industry). Next, in part II, insight was gained into the current project management efforts applied in engineering projects, again across different sectors. Necessary condition analysis identified necessary conditions for achieving a high level of project performance. Also, sufficient configurations of project management efforts for achieving high project performance were explored. In this Chapter 7, the findings of the previous chapters are put together, which provides the basis for part III of this dissertation.

The first purpose of this chapter is to evaluate the recommendations given by the respondents on what can be improved in terms of project management practices of engineering projects. Next, an agenda is proposed for improving the performance of engineering projects using all data gathered in this PhD research. More specifically, this chapter focuses on summarising the results of the sub-studies into a practical set of core project management practices called the Nexcess model. By evaluating the current management practices of engineering projects, recommendations are proposed to replicate the practices leading to high project performance or identify those practices, stopping of which would impede the achievement of high project performance. The applicability of the developed model is evaluated by expert judgment.

The research question guiding this chapter is:

What are the building blocks for improving the management of engineering projects?

In contrast to the earlier chapters (Chapter 2 through Chapter 6) where the respondents were asked to reflect on their last completed project, this chapter has a broader view. The aim is to explore what the practitioners would suggest doing to increase the chance of project success in their future projects. Such a more generic view is suitable since the focus of the developed model in this chapter is to highlight those factors which should be in place in any project, irrespective of the project sector next to context-specific factors. For the evaluation of the model and the proposed recommendations, two separate expert evaluation sessions were organised representing two sector groups of the process industry and the construction (including infrastructure) sector.

The structure of this chapter is as follows. Section 7.2 gives a summary of the main findings of the previous sub-studies clustered as proven practices. Section 7.3 discusses the potential improvement areas for managing engineering projects as evidenced by the survey answers and the results of the earlier sub-studies. The results of these sections are synthetized in a model to suggest an agenda for improving the management of engineering projects in Section 7.4. This model is further evaluated by experts (Section 7.5). The discussion and the final model, the outcome of this PhD research, are given in Section 7.6.

7.2 Proven practices

Following the empirical investigation of the project management practices presented in the previous sub-studies (in Chapter 5 and Chapter 6), an inventory of the practices that potentially affect high performance is made. Table 7.1 provides an overview of these main findings in which the core project management activities, as evidenced by practice, are summarised.

Table 7.1: Overview of the core project management efforts affecting the performance (proven practices in this research)

<table>
<tr><th></th><th></th><th>Based on</th><th>Practice</th><th>Clarification of the practice</th></tr>
<tr><td rowspan="4">Necessary practices</td><td rowspan="2"></td><td rowspan="2">Chapter 5</td><td>Top management support</td><td>• Top management show trust towards the project team
• Top management express honesty and openness in the interactions with the project team
• Top management commit to the project and support the project team
• Top management collaborate closely with the project manager
• Top management delegate authority to the project manager for decision making</td></tr>
<tr><td>Technical skills of the client</td><td>• Technical skills of the client representative during the front-end phase</td></tr>
<tr><td rowspan="4">Elements of sufficient configurations (sector-based)</td><td rowspan="2">Chapter 5 and 6</td><td>Collaboration between client and contractor</td><td>• Team members (client and contractor) have a sense of belonging to the team
• Team members share a belief that they perform their roles and protect the interests of each other
• Team members help and support each other in carrying out their tasks
• Project team put their best on joint efforts
• Team members are committed to the team tasks
• Members of the team exhibit motivation to maintain the team</td></tr>
<tr><td>Information sharing</td><td>• Required information is disseminated in time by various parties
• Clear communication channels are present for information sharing</td></tr>
<tr><td></td><td rowspan="2">Chapter 6</td><td>Aligned goal setting</td><td>• Organise a clear project performance measurement system
• Project goals are prioritised and are fully aligned
• Project goals are clearly defined among the stakeholders involved</td></tr>
<tr><td></td><td>Expectation management</td><td>• Establishing of roles and expectations of the team members
• Feedback on individual/team performance</td></tr>
</table>

The core project management practices are categorised into following three sets.

Necessary practices: These practices should be in place, regardless of context or project sector, otherwise the intended project performance cannot be achieved (Chapter 5). Four necessary practices resulting from this research include collaboration between client and contractor, information sharing among the parties, support from top management, and client competency in terms of technical skills.

Each of these practices are individually necessary for high level of performance.

Structuring and aligning project management efforts by all team members including client as well as contractor members is required for a high level of project performance. Specifically, shared belief of team members in protecting each other's interests, having a sense of belonging to the team, emphasis of the team members on the joint efforts, and commitment of the team members to the team tasks appeared necessary.

Additionally, a high level of project performance cannot be achieved unless the respondents spend time and effort into providing clear communication, such as establishing platforms and newsletters, and by ensuring that the required information is distributed timely among the various parties.

It seems to be difficult to achieve a high level of project performance without senior management, from both sides, client and contractor, exhibiting their support. In other words, vertical collaborative processes are equally as important as horizontal collaborative processes (within project team) for high project performance. The findings suggest that this support is required in terms of showing commitment towards the project team and being honest and open in the interactions. Furthermore, showing trust towards the project team and stimulating close collaboration with the project team by top management are also needed, albeit for reaching higher levels of project performance.

Merrow (2011) characterizes "*the owner project management cadre as the glue that binds all of the owner functions together to create an asset*". The findings of the current study revealed that the technical skills and knowledge of the client representative involved during front-end are deemed essential for achieving higher levels of project performance. Such technical knowledge from the client side might strengthen the relationship with the contractor and consultant hired for their technical expertise by facilitating an open environment for discussion on those technical aspects.

Identifying single necessary practices for performance are crucial for both theory and practice (Dul, 2016a). The results of NCA presented in Chapter 5 are based on the whole dataset and not in each sector. The presence of these necessary conditions, however, should always be present for high project performance.

Necessary and sufficient practices: As discussed in Chapter 6, two of the necessary practices are at the intersection of both necessary and configurations for sufficient practices for high levels of project performance across the sectors: collaboration between client and contractor, and information sharing among the parties.

Elements of sufficient configurations: The configuration of these practices should be adapted based on the sector as discussed in Chapter 6. Together with high levels of collaboration between client and contractor and high levels of information sharing among the parties, two other practices comprise the configurations for sufficient conditions for high level of performance: setting aligned project goals and setting expectations. Different levels of each of these two practices are required depending on the sector. None of these practices are individually sufficient for such performance.

Setting aligned project goals include clear definition of project goals, existence of a clear project performance measurement system, and prioritisation and full alignment of project goals among the stakeholders. Such focus on goal setting seems to be sufficient for high levels of project performance in infrastructure projects together with high levels of teamworking and high levels of information sharing between client and contractor. In the construction sector, when such goal alignment cannot be achieved, for instance, when new stakeholders enter during the project, high levels of teamworking and providing more advanced communication channels for facilitating the exchange of information are required.

Setting expectations refers to the establishment of roles and expectations of team members together with the feedback on individual/team performance. In order to achieve a high level of project performance in the process industry, expectation management within the project team is required to be more structured upfront rather than discuss them frequently later throughout the project. This highlights the importance of the formalization of roles and responsibilities in the contract. In projects in the process industry, a high level of performance can be explained by high levels of teamworking, smooth information dissemination and explicit clarification of roles early in the project. This might imply that for managing teams in such projects the focus should be on results to be achieved at the end by the team rather than merely emphasizing the efforts to be spent on the tasks as established by definition of roles and responsibilities.

Summarising the results in a nutshell:

- Necessary practices: Lack of the following practices would result in lower project performance: top management support, technical skills of the client representative in the front-end, collaboration between client and contractor, and information sharing among the parties. It is necessary to focus on the existence as well as the required level of these practices in order to achieve the intended level of performance, irrespective of the project sector.
- Necessary and sufficient practices: High levels of collaboration between team members of client and contractor together with high levels of open information sharing among the parties are both contributing to high performance levels. These two practices are individually necessary for the performance irrespective of sector as well as appear to be constantly present in the sufficient configurations for project performance across the sectors.
- Elements of sufficient configurations: Together with high levels of collaboration between client and contractor and high level of information sharing, these practices are contributing to high performance under specific sector conditions. Higher levels of setting aligned goals among the parties are associated with high project performance in infrastructure projects. Moderate

emphasis on expectation management among team members is associated with high performance in the projects within the process industry.

7.3 What would practitioners do differently in their next project (suggested practices)

This section provides an overview of the potential areas of improvement on the overall project management approach as experienced by practitioners. The survey respondents (see Chapter 4) were also asked to express their recommendations for improving the project management processes in their future projects, based on the experience gained in their reference project. To address these potential improvements, two sets of questions were asked. First, the respondents were given a set of the predetermined activities to determine whether they would put more effort on those activities in their next project. The respondents' answers to this question are presented in Subsection 7.3.1. Second, the reflection of the respondents on the improvement of project management practices was requested which is discussed in Subsection 7.3.2 (for the overall dataset) and Subsection 7.3.3 (per sector group). Finally, the results of these subsections are combined with the empirical evidence gained from Chapter 3 and Chapter 4 to present suggestions for practice.

7.3.1 Effort to be spend on the project management activities in a next project

In the survey (Chapter 4), respondents were asked to determine to what extent the effort they would spend in a next project on specific management aspects would be different. The following processes/activities were selected for the study because of their importance, as revealed in the Q-study (Chapter 3): team building activities, risk management, lessons learned, progress monitoring, quality management, HSE management, stakeholder management, and contract management.

Figure 7.1 presents the extent to which the effort, to be put into specific project management activities (in percentages), would be different according to the respondents in a next project. More specifically, the respondents were asked to indicate whether they would spend more, equal, or less effort on these eight project management activities. The overall comparison of the responses shows that about half of the respondents would focus more on team building (46%) and lessons learned (57%) activities in their next project. This shows that practitioners do understand the importance of these activities, which probably are not applied frequently in their current practice. The respondents' answers for each practice across the sectors are hardly discriminating, thus only the overall results are shown in Figure 7.1.

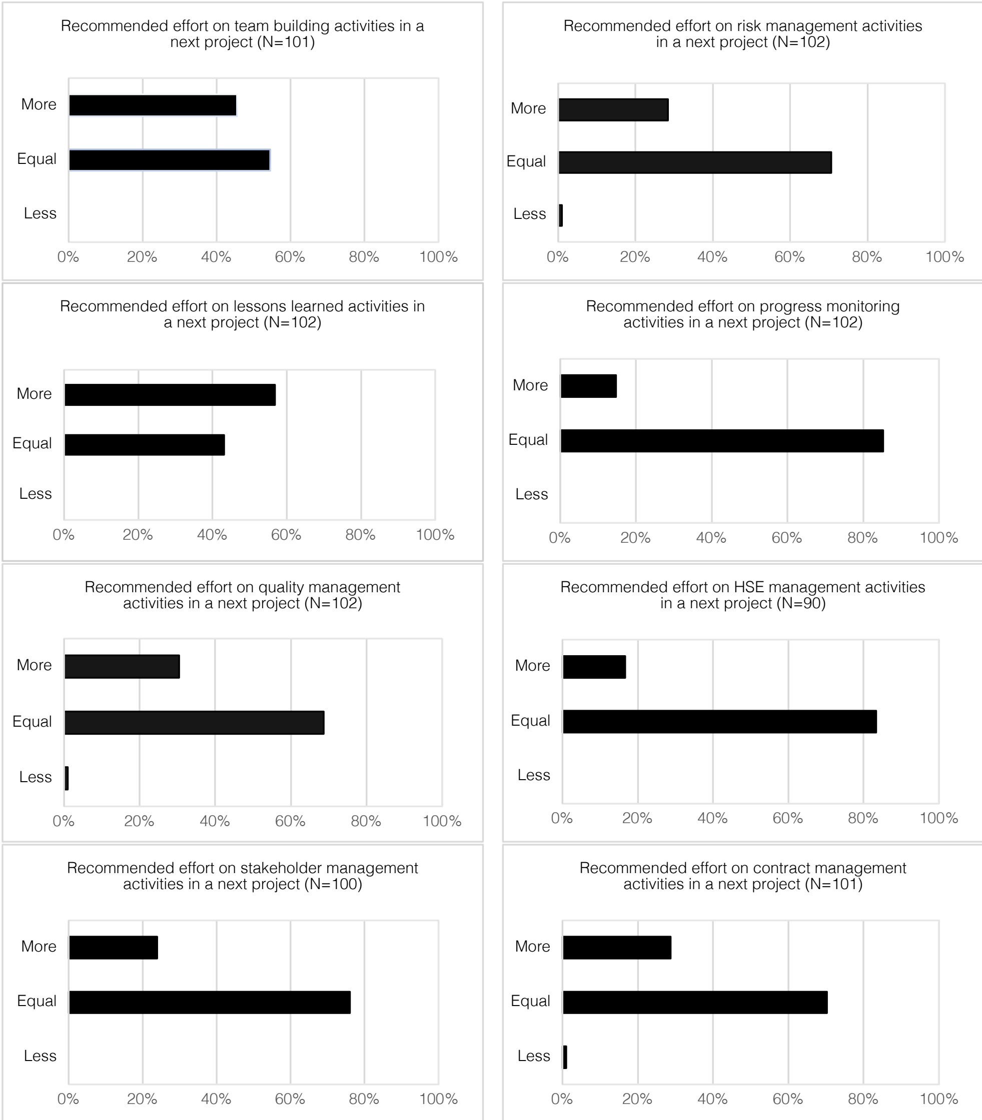

Figure 7.1: The extent to which the effort, to be spent on specific project management activities (%), would be different in a next project

Also, the relationship between the respondents' inclination to emphasise more on these activities in their next project and performance of the (completed) project was investigated. The results indicate a significant negative correlation between the intention of the respondents to put more effort on capturing and disseminating lessons learned and project performance. In other words, those projects of which the respondents believed that lessons learned activities should receive more attention, showed a lower level of performance. Also, the survey results in Chapter 4 indicate that the frequency of lessons learned related activities is relatively low compared to other activities (mean score of 2.59, corresponding to an application rate of once or annually in the project, see Table 4.8). Thus, it is recommended to internalise the lessons learned activities both by capturing, sharing and reusing them effectively with other projects in order to improve the potential project performance. For team building activities no direct significant relationship was found with project performance.

For the other practices including risk management, progress monitoring, quality management, HSE management, and stakeholder management, practitioners believed that no more extra effort is needed. With regard to risk management, it can be observed that in some of those projects where the respondents stated that no extra effort on such activities is required, risk management is not frequently applied (even never or only once during front-end phase). Despite minimal efforts spent on risk management activities, these practitioners are still not willing to commit more effort to risk.

When it comes to risk management, quality management, and contract management only one respondent (not the same respondent) per activity indicated that they would spend less effort on these activities. Therefore, no meaningful conclusions can be drawn on downgrading these activities.

7.3.2 Reflection of the respondents on the general project management practices

Next to the question scoring the predetermined practices (Figure 7.1), an open question was included in the survey to capture the respondents' reflection on general project management practices. The respondents were asked to mention three main activities that they would do differently in a next, similar project. The main aim of this question was to identify potential improvements and recommendations provided by the respondents.

Qualitative content analysis was performed on the gathered data. MAXQDA Software (2018) was used to analyse and categorise the patterns in the data. Again, in this analysis, the practitioners' responses are compared over the total dataset as well as per sector group (construction, infrastructure, and process industry). In total, 15 potential improvement areas were identified and clustered based on their logical relationships. Figure 7.2 provides a visual overview of the frequency of mentioning the improvement areas (size of the circles), overall as well as per sector (R). In total, 93 respondents provided 162 improvement aspects (maximum number of items mentioned by a respondent was three). Answering this question was not mandatory, and thus not all respondents answered this question or provided exactly three items in their answer. In the following, first the dominant improvement areas as expressed by all respondents are presented. Next, the improvement areas per sector group are discussed.

As can be seen from Figure 7.2, for the practitioners in the construction and infrastructure the improvement practices seem to be equally important as the frequency of the mentioned practices are more or less constant. Overall, the top five most frequently mentioned practices by the experts (N=93) include (frequency mentioned):

1. Team building (18)
2. Client involvement (16)
3. Contract management (16)
4. Monitoring and quality management (16)
5. Risk management (15)

Team building activities were mentioned most often as an activity to be improved (18 times out of 93 respondents). The respondents believe that the project team should start very early in the project with the team building both internally and externally. The importance of this was explicated by a respondent by saying that: "*more team building activities and focus on social activities internally as well as with main contractor".* Such team building activities could be done both physically, for instance at the project location, or virtually.

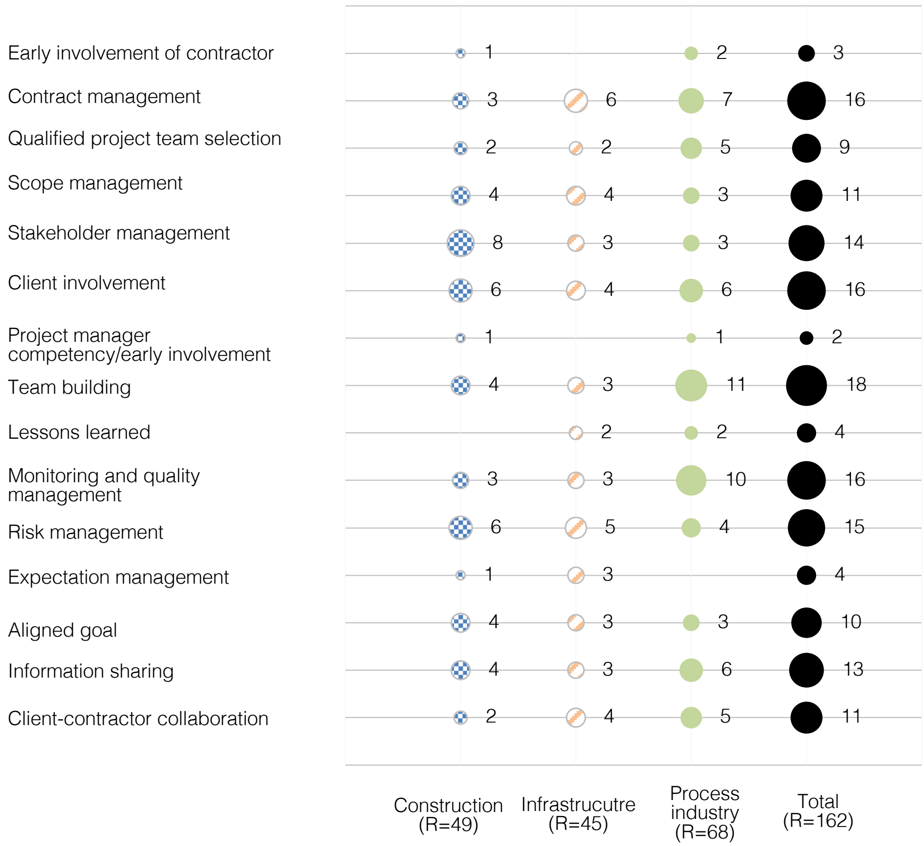

Figure 7.2: An overview of the potential improvement areas based on the frequency of mentions, overall as well as per sector (Total number of items mentioned by 93 respondents, R=162)

Client involvement, contract management, and monitoring and quality management were the second most frequently mentioned processes, for the total dataset (each item was mentioned 16 times by 93 respondents). When mentioning client involvement, the respondents referred to stimulating of formal interaction and integrative communication with the client. Specifically, they recommended more frequent general meetings and face to face interactions with the client to inform them. In the same vein, the respondents acknowledged the importance of informal interaction with the client, client commitment and delegating earlier and more activities to the contractor or consultant. Respondents also highlighted the fact that the client specification should be clearly discussed beforehand and it should be "*frozen early to avoid rework*". Further, throughout the project, demands and specifications should be jointly reviewed by client, contractor, and consultants.

Regarding the improvement required on the contract management aspects, the respondents mentioned that more defined contracts would result in less discussions later in the project. Hence, the importance of establishing a mutual understanding between the client and contractor on the content of the contract was underlined, specifically regarding the technical aspects and at the project start-up. Additionally, roles and responsibilities of the parties on fulfilling project tasks are required to be formalised in the contract.

Respondents highlighted the importance of documentation processes. An illustration of this is a recommendation given by a respondent: *"the way materials are ordered in the front-end and how this is secured should be improved"*. Such written documentation is a prerequisite for monitoring the actual project progress and further can be used as an input for capturing and retrieving lessons learned. The respondents also believed that the quality assurance and quality control processes should be done more effectively.

When addressing the improvement of risk management for their future projects (mentioned 15 times by the respondents) practitioners emphasised the importance of involving those parties who are capable of identifying, assessing, and responding to those risks. The respondents acknowledged that should be done both internally as well as externally by involving contractors early and making them responsible for risk management.

Overall, the least frequently mentioned improvement areas included project manager competency and their early involvement (2), early involvement of contractor (3), lessons learned (4), and expectation management (4). Given the fact that the majority, more than 70%, of the survey respondents were project managers (see Appendix D), it seems logical that they do not doubt about their own competency. Early engagement of the execution party, on its own, is not acknowledged by the respondents as an improvement practice. Instead, they tend to focus on improving the way client and contractor team are brought together in performing project management efforts, for instance by performing uniform team building activities. It can be seen from the practitioners' responses that merely expressing each other's expectations is not sufficient. The challenge is to define and formalise expectations in terms of roles and responsibilities in the contract. Surprisingly, when explicitly asking the respondents regarding lessons learned activities, the majority of them agreed that they would spend more effort into such activities in their next project, see Subsection 7.3.1. From the analysis presented in this subsection, however, it can be interpreted that improving other project management practices gains priority over capturing and retrieving those lessons learned, according to the practitioners. This might imply that practitioners believe that lessons learned practices are well-established (which is not supported by the survey results) or they do not realise the importance of the application of lessons learned practices in improving the performance.

7.3.3 Comparing the respondents' reflection on project management practices across the sector group

Comparing the improvement areas across the sectors (Figure 7.2), in this subsection, the top three improvement areas per sector are presented and compared with each other.

Respondents in the construction sector indicated that more upfront integration between stakeholders is required (8). Stakeholders need to be identified and monitored frequently and in case of any new stakeholder, they should be involved and informed as early as possible. Furthermore, there should be a clear understanding with the end users, as one of the key stakeholders, about how they are communicated with and interacted with throughout the project. Involvement of the client (6 occurrences) was acknowledged by the practitioners as one of the practices to be improved. To provide more professional supervision from the client representatives, they should possess technical capabilities to check whether the requirements for those processes are met. When the client has suitable technical skills, their commitment and engagement create accountability to identify problems and mutually seek the solution with the consultant or the contractor. Improving risk management practices was another frequently mentioned (6) improvement area in the construction sector.

In the infrastructure sector, the practitioners (6 times) indicated that the distribution of roles and responsibilities between the client and contractor should be clearly defined in the contract for improving the management of contracts. In other words, in infrastructure projects, better separation and delegation of tasks between the client and contractor is required, for instance in handling stakeholders and managing their needs. Risk management (5 occurrences) in infrastructure projects can be improved by stimulating a proportional risk and profit-sharing mechanism, according to the respondents. When addressing improving scope management (4), the respondents acknowledged the establishment of clear conformations and escalation procedures upfront. Client involvement, structured and professional project management on their side was also noticed by the respondents as one of the potential aspects to be improved (4). Additionally, an environment should be created where parties, especially contractors, consultants, and asset managers, can openly discuss project goals and concerns with the client. This can be also linked to enhancing collaboration between client and contractor (4 times) as mentioned by the respondents in the infrastructure. Two of the respondents explicitly mentioned that working more on the project location and organising collective housing, for the client and contractor project team, from the start, could contribute positively to this collaboration.

In the process industry, according to the respondents, team building was the most frequently mentioned improvement practice (11 occurrences). By bringing the, internal as well as external, team together in such team building activities teams can move forwards towards better understanding. Furthermore, those activities could also contribute to the team members' satisfaction, if they can share their concerns together. Improving the monitoring and quality management activities was also highlighted by the process industry practitioners (10 times). Progress reporting by tracking the project performance, internally as well as externally by the client, could be improved. A statement from a respondent demonstrates this: "***joint reviews on*** *most of the deliverables*". Internal documentation of project progress could be kept for future project reference, contributing to sharing of lessons learned. Contract management was recognized by the respondents as one of the pivotal practices to be improved (7).

Early involvement of stakeholders, including end users, asset managers, and contractors for grasping their needs and requirements was mostly noticed as a potential improvement area in the construction and infrastructure sector. Such initiation would call for an integrated approach where the client representatives facilitate such processes. In the process industry, the respondents specifically highlighted the role of teamwork, including client and contractor, for aligning the efforts in achieving project goals.

7.3.4 Bringing it together (suggested practices)

A key theme that emerged is the common inclination towards an integrated approach. This seems to be, however, merely wishful thinking since the findings of Chapter 3 (cross-sectoral Q-study) and Chapter 4 (cross-sectoral analysis of the survey study) did not show such integration among the parties. In this section, the respondents' views are synthetized with the findings of the commonly applied practices to present a set of suggested practices.

The prime focus of the proven practices for high project performance, explained in Section 7.2, is on project teams, including both the client and the contractor. This however is not often the case in practice. It is suggested that an integrated and seamless project team could facilitate the joint application of project management efforts. If the client and contractor aim to work more intensively together, such integrative arrangement of teams seems to be crucial. Separate team arrangements and merely limiting the communication to predefined and formalised interactions seem to be a hurdle for sustaining a collaborative environment. A respondent stated that: "*instead of only a monthly meeting between the two teams, seek for a way to really work together in the same building and the same floor!*"

Indeed, there should be clear and formal procedures for the interaction between the client and other involved parties including the contractor and consultant, but attention should also be given to informal and social interactions with the individuals at different levels. Formal and informal interactions are interrelated and equally important in capturing the clients' demands. Although project goals and demands provided by the client should be considered seriously and are important, those requirements should not "*be taken for granted*". Instead, informal interactions with the client would open up discussions on various aspects of project demands.

As evidenced by practice, risk management sessions are often organised internally (see Subsection 4.5.1 and Subsection 7.3.2). It is however suggested to arrange those sessions jointly. For instance, technical risks can be better understood and handled by the discipline engineers or the contractor with in-depth knowledge and expertise. Such joint arrangements of risk management sessions also stimulate creativity which could enhance collaboration.

Joint lessons learned for interim project evaluation and the project close-outs could also foster a collaborative environment. As can be observed from Subsection 4.5.1, organising joint lessons learned sessions is not a common practice. Involving client (and suppliers) in such lessons learned sessions and taking their lessons into account could also enrich capturing and retrieving detailed good practices and mistakes to be avoided in future projects.

Involved project parties could be integrally responsible for monitoring the project performance and quality management practices. This was observed from the respondents' views as presented in Subsection 7.3.2 and 7.3.3. It is crucial that there is a common understanding on what milestones are to be achieved and what success and satisfactory performance really mean for each party.

Early selection of the team is important for organising joint team building. Such joint team building could also facilitate the management of interfaces by bringing the team members from the client and contractor together. This was evidenced by the findings presented in Subsections 7.3.2 and 7.3.3. Moreover, formalised and structured team building sessions generate commonalities for communication and exchange of information among the (integrated) project team.

To summarise, the explanations given in this subsection suggest that the following practices could potentially contribute to improving the performance: seamless and integrated project team, formal and informal interactions with client, joint monitoring and quality management, joint lessons learned, joint teambuilding, and joint risk management. These suggested practices are not commonly applied in projects (Chapter 3 and Chapter 4) or there is some room for improvement in the application of those practices (Section 7.2).

7.4 Suggested agenda for core project management efforts in engineering projects (Nexcess model)

In this section, the results of the previous sections of this chapter are synthesised to reflect the current state of project management practice and to provide an agenda for improvements of such practices. The outcome of this PhD research is summarised in a model as presented in Figure 7.3. The model is called "Nexcess", a combination of the current and "Next Practices" for managing engineering projects. The model consists of two main sections:

I. Proven practices (see Section 7.2)
II. Suggested practices (see Section 7.3)

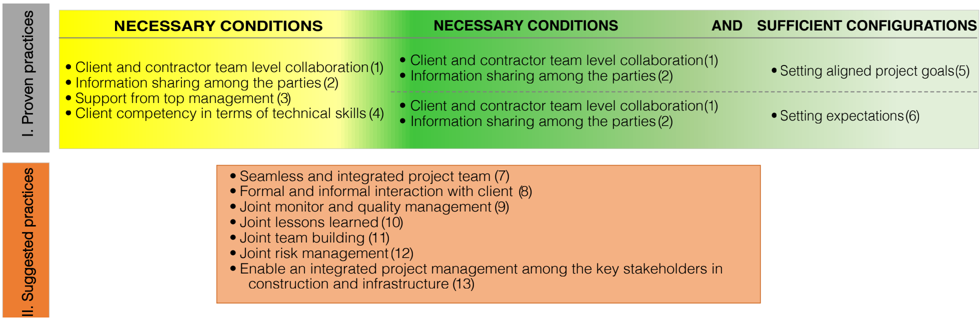

Figure 7.3: Nexcess model of core project management efforts in engineering projects to be validated by the experts

7.4.1 Explanation of the Nexcess model (I. proven practices)

As explained in Section 7.2, proven practices are based on the findings of the empirical studies presented earlier in this research consisting of three main sets (see Figure 7.3): necessary practices (yellow part), necessary and sufficient practices (dark green part), and sufficient configurations (light green part). The latter two practices Table 7.2 presents the associated recommendations regarding the proven practices.

Table 7.2: Statements resulted from the proven practices of the Nexcess model

Recommendations provided based on proven practices (aspect I in Nexcess model)	
No.	**Recommendation**
1.	Align the project management efforts between client and contractor.
2.	Provide clear and explicit communication channels for timely sharing (project) information among the collaborating parties, client and contractor.
3.	Top management from both sides (client and contractor) should support the project team and be committed to the project.
4.	Assign a client representative with sufficient technical skills in the early phase of the project.
5.	Set aligned project goals and agree upon them with the project parties at the project kick-off.
6.	Actively perform expectation management within the project team(s).

7.4.2 Explanation of the Nexcess model (II. suggested practices)

Suggested practices include seamless and integrated project team, formal and informal interaction with client, joint risk management, joint lessons learned, joint team building, joint monitoring and quality management (see Figure 7.3). The focal point of these activities is the fact that project management practices should be shared and applied jointly by the key parties involved in the project, mainly client and contractor(s). Recommendations 7 to 12 presented in Table 7.3 summarise these recommendations.

In terms of sector-specific applicability of the suggested practices, it seems that in the process industry a cooperative culture dominates. In such project culture, teamwork between client and contractor is appreciated with the focus on managing the interfaces (Mok et al., 2015). Infrastructure and construction projects, however, are required to be more integrative which calls for an inclusion of extended parties, such as asset managers and end users. This was also discussed in the findings of the Q-study presented in Chapter 3. Furthermore, the project management approach in the construction and infrastructure sector seems to be shifting between goal seeking and goal oriented, whereas the project management approach in the process industry is inclined towards more goal oriented. In the goal oriented approach, project goals are clearly defined, whereas in goal seeking approach those involved parties are actively searching for goals (Gustavsson & Hallin, 2015). This can also explain the results of Chapter 4, where it was found that in the process industry, more efforts are put into project management activities in the front-end phases. Since in the process industry, those goals are, to a large extent, clear at the early project phases, project management efforts are more directed and guided towards achieving those goals. In order to enable such an integrated approach for achieving project goals in the infrastructure and construction sector, recommendation 13 in Table 7.3 is proposed.

Table 7.3: Statements resulted from the suggested practices of the Nexcess model

Recommendations provided based on suggested practices (aspect II in Nexcess model)	
No.	**Recommendation**
7.	To enhance collaboration, form the project team in an integrated manner, preferably there should be one single integrated team.
8.	Discuss the client's demands throughout the project via formal and informal interactions.
9.	Determine the intensity of application of progress reporting and quality management activities and further perform such activities with the integrated team.
10.	Determine the intensity of application of lessons learned related activities and further perform such activities with the integrated team.
11.	Determine the intensity of application of team building related activities and further perform such activities with the integrated team.
12.	Determine the intensity of application of risk management related activities and further perform such activities with the integrated team.

Sector-specific recommendation for construction / infrastructure	
No.	**Recommendation**
13.	Enable an integrated approach of project management. This means that the key stakeholders including the client, contractor, suppliers, end users, and asset managers should be involved early in the project.

To evaluate these recommendations and to establish their degree of applicability for daily practice, these recommendations are evaluated by experts from the process industry and experts from the construction and infrastructure sector.

7.5 Evaluation of the Nexcess model

In this section, the applicability of the Nexcess model, as evaluated by the two separate expert meetings, is elucidated. Finally, the adjusted Nexcess model is presented, including a roadmap for its use in practice.

7.5.1 Set up of the expert meetings

Two separate expert meetings were organised: one with experts from the process industry and one with experts from the infrastructure and construction sector. Again, construction and infrastructure are treated as one sector group (labelled construction sector, same as in Chapter 4).

The criterion for selection of the experts was to have relevant experience in managing engineering projects. It was aimed to have, in each session, at least one expert from both client and contractor organisations to cover perspectives representing different roles. In total, about 30 experts were invited through our personal networks, of which 9 confirmed their participation in the evaluation sessions: three experts from the process industry, denoted here as P_1, P_2, and P_3, and six experts from the infrastructure and construction sector, indicated here as I_1 to I_6 (see Table 7.4).

Table 7.4: Overview of the experts per session

Sector that the expert is active in	Session	Expert ID	role		
			Client	Contractor	Consultant
Process industry	Session 1	Expert P_1	×		
		Expert P_2		×	
		Expert P_3		×	
Construction and infrastructure sector	Session 2	Expert I_1	×		
		Expert I_2		×	
		Expert I_3			×
		Expert I_4			×
		Expert I_5			×
		Expert I_6	×		×

The expert meetings lasted approximately two hours and were divided into two parts. First, the experts were asked to evaluate each of the 12 provided statements of the Nexcess model. These statements are shared among the process industry sector and construction sector (Table 7.2 and Table 7.3). Based on the evidence gathered in the construction sector, statement 13 was added (see Subsection 7.4.2) for the latter sector. The individual evaluation of the statements is discussed in Subsection 7.5.2. After the individual evaluation, the researcher gave a brief presentation on the findings of the research and the resulting Nexcess model.

In the second half of each meeting, the experts were asked to jointly rank the proven and suggested practices, stated on the cards, based on their relative importance and to discuss their experiences or opinions on the importance of each practice (see Subsection 7.5.3 and Subsection 7.5.4). Finally, to enable application in each sector, the experts were asked to explain how the Nexcess model can help them in their daily practice and also to provide recommendations for the improvement of the model. This is presented in Subsection 7.5.5.

7.5.2 Individual feedback on the statements

In the first half of the meetings, the experts were asked to express whether they agree with the provided statements and whether they had already applied them in their daily practice. The aim of this part was to see whether the experts recognize and perform those presented recommendations in their daily practice. The opinions of the experts on the statements are captured using the following measurement scales: (1) “do not agree, we did not try it yet”, (2) “do not agree, we have tried it already”, (3) “agree, we apply it already”, (4) “agree, we will try it soon”.

The experts’ responses per validation session for the proven practices are given in Figure 7.4. From this figure, it can be observed that the experts in the process industry (session 1) all agreed on all statements, and that they already have applied them in their projects. Indeed, the experts were chosen to participate because of their relevant work experience, but that was also the case for the experts in the construction sector.

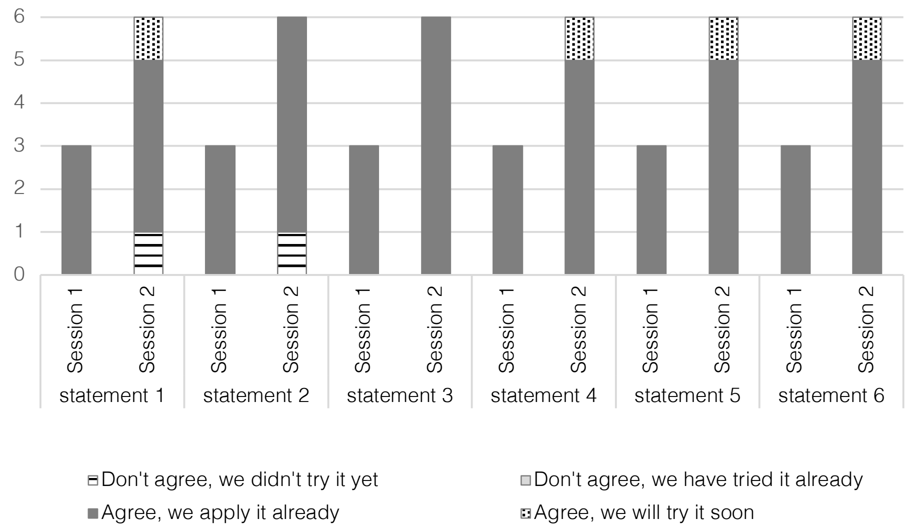

Figure 7.4: Responses on the statements related to proven practices presented in the validation sessions

The experts from the construction sector generally agreed with the proven practices, except for one expert for statement 1 and another expert for statement 2. Not all proven practices seem to be practiced.

The responses of the experts on statements 7 to 13 are presented in Figure 7.5. Again, the experts from the process industry seem to apply all practices already. Statement 7 reached the least consensus among the experts in the construction and infrastructure sector, with only one expert agreeing on it, applying it already in practice. Only three out of six experts agreed on the statement 9 and 10. Two out of six experts did not agree on statement 13; it seems challenging to involve all key stakeholders early in the project for enabling an integrated project management approach.

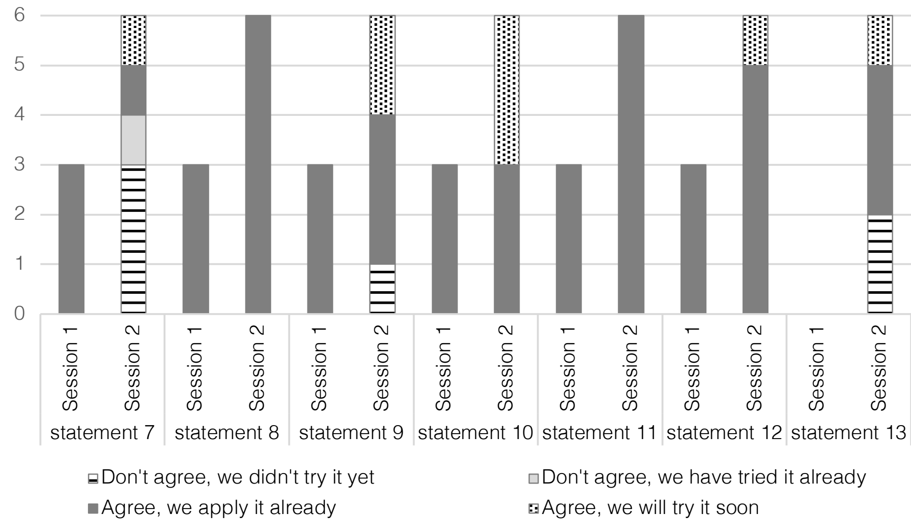

Figure 7.5: Responses on the statements related to suggested practices presented in the validation sessions

Comparing Figure 7.4 and Figure 7.5, overall, the process industry seems to know all with unanimous “agree, we apply it already” answers. The experts in the construction sector are aligned with respect to the proven practices, but seem to have different opinions regarding the application of some suggested practices. An in-depth explanation of the individual responses per statement is provided in Appendix I.

7.5.3 The experts’ opinions on the proven practices

In the second half of the expert evaluation, the experts were asked to jointly rank and discuss the perceived importance of the specified proven and suggested practices as presented in the Nexcess model. The aim was to investigate the extent to which these practices are recognized by the experts per sector and further compare their discussions around these practices across the sector groups. These discussions provide a more holistic expert view of each sector, compared to their individual feedback explained in Subsection 7.5.2. The current subsection provides a brief overview of their discussions.

Table 7.5 presents the experts’ ranking on the proven practices (process industry on the left and construction industry on the right). The first two most important factors of the proven practices (collaboration between client and contractor and setting aligned goals) were equally important across the sectors. Without having those two factors, early in the project, it seems that parties cannot find their ways through the project. The experts in both sectors shared the opinion that the technical competency of the client is the least important practice, compared to other proven practices. In the following the main reflection of the experts on these proven practices per sector is presented.

Table 7.5: Experts' ranking on the proven practices

Process industry		Construction sector	
Ranking number	Experts' ranking on the proven practices	Ranking number	Experts' ranking on the proven practices
1	Collaboration between client and contractor	1	Collaboration between client and contractor
2	Setting aligned goals	2	Setting aligned goals
3	Information sharing among the parties	3	Setting expectations
4	Support from top management	4	Information sharing among the parties
5	Setting expectations	5	Support from top management
6	Technical competency of the client	6	Technical competency of the client

Process industry

For the experts in the process industry the following three practices should be in place in a project irrespective of the context: collaboration between client and contractor, aligned goals, and information sharing among the project parties. Although these factors are interlinked, one cannot automatically lead to another. Providing a working environment and designing a proper behavioural environment between the client and contractor team members are prerequisites for starting a project. In other words, without a real working environment everything gets stuck. For setting aligned goals, it is important that short-term as well as long-term goals are made visible in such a way that it is understandable and tangible for everyone in the project. Investing in enhancing the collaboration would help in creating trust among the parties which, in turn, can create an open and transparent environment. In such an environment, where there is a "*joint team spirit*" people can talk about aligned goals. Information is needed to check the progress against the goals. For sharing information among the parties, two conditions should be met for achieving project goals:

1. Data should have a sufficient quality. It is important that such data can be transformed into information which can be further shared among the parties.
2. There is one set of data. In practice, however, there are some situations where two (or even several sets) of data exist: internal versus external data. This implies that there is no clarity on what the real data is.

On a higher level, making sure that these three factors (collaboration between client and contractor, aligned goals, and information sharing) work properly together calls for creating "one" reality of the project. Albeit that this coherent reality might be changed due to various circumstances resulting from organisational (either client or contractor) and personal influences. Such an environment can only be created based on trust, respect at all levels, and transparency in sharing information. Otherwise, if there are different sets of data, this automatically creates different project realities which could jeopardize project goals.

Subsequently, the experts in the process industry expressed that the importance of the remainder of the proven practices (support from top management, setting expectations, and technical competency of the client) depends on the project context including the regional, cultural background, state of project, and contractual setting.

Construction sector

The experts in the construction sector expressed that investing in a real collaboration would take some effort from client and contractor and it is not influenced by the project context such as the contract type. In order to help the client shaping his requirements along the project journey, it is crucial to facilitate collaboration, irrespective of chosen contracting strategy. The fact that in the infrastructure sector, usually, a project should start with a tender, might provide a challenge to focus on a real collaboration at the very beginning. But the focus should be on laying the foundation for a good collaboration, according to the experts.

In order to set up a successful collaboration, setting aligned goals, setting expectations, and open information sharing is required. These practices form an iterative loop. Specifically, the role of open information exchange and not having hidden agendas (internal versus external information) were highlighted. The openness in the communication can be built upon trust. There were two opposing views with regard to trust: trust should be gradually fed and be built throughout the project versus the idea that "***trust is a choice***" (expert I_5) and it should be present among the parties from the beginning of the project.

Least important: technical competencies of the client

For the experts in both sector groups, technical competencies of the client had the least importance among the proven practices. The experts indicated that abundance of technical skills in the project would create an environment with an excess of information, in which the overall picture might get easily lost. Specifically, in infrastructure projects due to their multifaceted characteristics, the client should have an inclusive view of all relevant aspects of the project. The experts defined "technical skills" in different ways:

1. Technical skills can be defined as those aspects related to the technical specifications of the project, usually offered by a consultant and a contractor.
2. Operational skills and understanding of the future operational procedures can also be part of technical skills.
3. Contract management skills of the client could also be seen as the technical skills. The recent stream in the Dutch infrastructure sector relies on the creativity of the market for the actual design and construction (Rijkswaterstaat, 2008; Verweij, 2015a) .This has forced the client to act merely as a party who manages the contracts. The idea of this approach is that the market plays a dominant role in performing the infrastructure projects. The contractor should find a partner to deal with all the technical issues and the client manages those contracts by only checking the requirements and ticking the box. This, however, has brought a challenge to projects which negatively affects the project performance.

The lack of client knowledge about what they and the end users really want, provides a barrier in conveying their actual demands to the contractor. It is not necessary that the client has "all" required technical skills because the lack of such skills can be compensated, for example by setting aligned goals. The client, however, needs to be competent to some extent to collaborate effectively with their consultant and contractor(s). As illustrated by one of the experts *"the client should have enough technical skills to ask the right questions even to his consultant, but he does not have to come up with the answers himself!" (Expert I_6)*

7.5.4 The experts' opinion on the suggested practices

Subsequently, the experts in each session were asked to jointly rank and discuss the perceived importance of the suggested practices as presented in the Nexcess model (Table 7.6). For the process industry, an integrated team is a top priority, whereas in the construction sector it is the least important practice compared to other suggested practices. Although organising an integrated project team would not be a predominant focus in construction projects, enabling an integrated approach of project management among the key stakeholders could contribute positively to the performance. Further explanation of the findings presented in Table 7.6 is given next.

Table 7.6: Experts' ranking on the suggested practices

Process industry		**Construction sector**	
Ranking number	Experts' ranking on the suggested practices	Ranking number	Experts' ranking on the suggested practices
1	Seamless and integrated project team	1	Formal and informal interaction with client
	Joint team building	2	Enabling integrated approach of project management among the key stakeholders
2	Formal and informal interaction with client	3	Joint monitoring and quality management
3	Joint monitoring and quality management	4	Joint risk management
	Joint risk management	5	Joint team building
	Joint lessons learned	6	Joint lessons learned
		7	Seamless and integrated project team

<u>Process industry</u>

A seamless team could contribute to joint team building, according to the experts in the process industry. Having an integrated project team would create a common accountability for the team members (both from client and contractor). It is almost impossible to take out all the doublings (coming from each organisation) in the project team because the interests and goals of the organisations differ. These differences, however, should be managed enabling having aligned drivers and ultimately aligned goals. In other words, an integrated project team would help in creating one reality for the project (see earlier discussion on the proven practices). It is, however, important that the team members (from client and contractor) leave each other the required space where they can serve the interest of their own company.

Formal and informal client interactions could also, to some extent, entail the joint progress reporting and quality management, according to the experts in the process industry. Usually, the content of interaction with the client is about their requirements, how to achieve them, increasing the technical items, and the quality specifications. Experts recognized the integrated quality management as an activity which is performed frequently in their projects because it could help in understanding what the client really wants to achieve at the end.

Joint risk management and joint lessons learned both can be equally important and interlinked. Often the risks in the risk register already happened in practice. Thus, risk management could avoid the same mistake to happen again. Creating a unified and integrated system for having joint risk management and share those lessons would require an extra effort from both sides.

Construction sector

For the experts in the construction sector, formal and informal interaction with the client was the top priority. These interactions are required to understand what the client really needs, especially when considering important success criteria such as end user satisfaction and adding value to the society. These interactions could also happen even without having an integrated project team. Experts considered the "informal" aspect of the interaction vital: "***the most problems are being solved in the informal conversations and not in the formal conversations"*** (expert I_6). Furthermore, in construction projects many stakeholders are involved at different levels affecting the formation of demands. For high-level stakeholders, it might be easy to understand their interests. Understanding the interests of other key stakeholders, however, might be challenging. It is crucial for the contractor to understand which stakeholder(s) can support him throughout the project.

Performing "joint" activities such as joint monitoring and quality control and joint team building in the early stages of the project could help to provide a balance in the project. In order to facilitate those joint activities, the corresponding role for each task should be mirrored at each organisation. Performing the reporting jointly with each other can be a very nice form of shared team building. In other words, joint team building can be the result of joint reporting sessions. Although a project should be started and finished with sharing lessons learned with each other, it is not a common practice.

7.5.5 Adjusting the Nexcess model

At the end of the expert evaluation sessions, the experts were asked to discuss their views on how the core project management practices presented in the Nexcess model can be applied in order to improve the project performance. Furthermore, they were requested to provide recommendations on the use of the model in daily practice.

As can be observed from the explanations in Subsections 7.5.2 and 7.5.3, the difference in the opinion of the experts between the sector groups of the process industry and construction sector, lies mainly on the applicability of the suggested practices. For the practitioners in the process industry, an integrated project team is a prerequisite for joint activities. This, however, is not current practice in the construction and infrastructure sector.

For the experts in the process industry, the so called "suggested practices" of the Nexcess model are already the "common practices". Although these suggested practices are acknowledged by the practitioners in this industry, their applicability depends on the project environment. There might be some barriers for the application of the presented suggested practices. For instance, the political or commercial environment of the project would create preconditions for the applicability of the suggested practices. These boundary conditions could also hinder the application of necessary practices (such as collaboration) which could negatively affect the project performance. Thus, having discussions during the project kick-off those boundary conditions and reach a consensus on the understanding of those conditions is crucial for project success.

An example of such boundary conditions given by the experts was the common management trend or culture within each sector. Despite the previous trend, in which the technical skills of the client could be easily sourced from the market, in the current practice within the process industry it is more common to have technical staff at both sides to enable deep collaboration. Developments are also seen in contracting strategies. Recently, the practice is gradually starting to shift towards more collaborative procurement and contracting strategies, compared to traditional lump sum and lowest price contracts. The mindset of people working in such projects, however, still has to change. The experts also mentioned the influence of industry-specific or national culture on the application of the Nexcess model as a boundary condition. This, however, was not in the context of this study and could be addressed in future research.

Experts in the construction sector acknowledged the fact that those "suggested practices", having a predominant focus on performing the project activities jointly, are not really common in the construction and infrastructure projects. A "joint" way of doing the project tasks seems to be challenging in this sector. Although those recommendations regarding the suggested practices might be very obvious and it was hard to disagree, it was interesting for the experts to realise that those practices are not yet "commonly" applied in practice. Based on the expert sessions, three explanations were formulated:

1. Existence of the conservative culture within the construction sector might hamper joint application of project activities. Additionally, politics and the opinion of people at the administrative levels, which might be outside the project, could also affect the application of suggested practices. Thus, one should not only consider the role of "top management" but also "top stakeholders".

2. On the personal and team level, the shared leadership capabilities by the team members might facilitate or hamper the application of those practices. An

example is the lack of trust in the construction sector, which might hinder parties to “join” their forces for the project. Therefore, the personal experience and leadership of the manager who stands up to the external and political forces might be a game changer.

3. In the construction sector, tendering procedures might also hold the parties back from joining their efforts. The pre-tender situation would lay the foundation for the further alignment of interests. If there is too much emphasis on the monetary aspects in this stage, it would be likely that the potential deficits later in the project impede obtaining the project goals. The client has a crucial role in alleviating the pressure and fixing the deficits. This, however, might only be possible when the client is a government whose aim is to provide value for the citizens and not only focuses on delivering the project within budget.

The experts stated that the suggested practices in the current form of the Nexcess model seem to be more concrete than the proven practices. For improving the applicability of the model, it was suggested that the proven practices should be presented in a more practical way. More specifically, the exact definition of some of the terms used in the proven practices, such as collaboration and expectations, should be clarified to avoid different interpretations by individuals. The experts suggested that, when starting a project, team members at both sides, client and contractor, could express what each of those practices mean to them. This can ensure that they are on the same page with regard to the meaning of those practices. As stated before, in order to make those practices happen on a certain level, the role of personal development of people in leadership should be made more visible.

To sum up, the feedback from the experts at the end of the sessions on the applicability of the Nexcess model is categorised in two main themes:

- **Content related:** Suggested practices are defined in a more concrete and practical way compared to the proven practices. Thus, for better understanding of the core management practices presented in the model, the exact definition of the terms used in the model should be presented. More specifically, a complementary definition for the proven practices should be accompanied, for instance, the definition of collaboration.

- **Practical application of Nexcess model:** In order to enhance the applicability of the Nexcess model in daily practice, the experts suggested that the model can be discussed between the parties during the project kick-off. This would enable the understanding of the importance of those core project management practices for achieving optimal project performance. Additionally, the involved parties could take time in reaching consensus on the concrete definition of the practices and the extent to which these practices could be applied in a specific project, given these boundary conditions. Furthermore, it is crucial for the parties to understand and discuss openly the added value of applying such practices.

It should be noted that the limited number of experts (three in the process industry and six in the construction sector) representing each sector might not be enough to generalize the evaluation of the model. The main aim of the evaluation presented in this chapter, however, was to check whether the experts acknowledge the proposed core project management practices and whether the terms used can properly convey the message.

7.6 Final model

The two main recommendations, content related and practical application of the model, given by the experts in Subsection 7.5.5 are employed for presenting the final model in this concluding section. First, the highlights of the evaluation of the Nexcess model are presented and compared with literature. This results into the formulation of the final model addressing the recommendation given related to the content of the model in Subsection 7.6.1. Next, as the outcome of this research, a roadmap for using this model in practice is presented in Subsection 7.6.

7.6.1 Formulating the final Nexcess model

All proven practices, derived from the survey findings on the common activities performed, were to a large extent acknowledged by the experts as a base for the project management practices. Technical skills of the client representative during the front-end (recommendation 6) is a necessary condition for high project performance. Less depth, however, is required for the technical knowledge of the client compared to that of the consultant or contractor. Compared with the process industry, in the infrastructure and construction sector the client relies mostly on the creativity and technical knowledge of the market rather than possessing such knowledge internally (Rijkswaterstaat, 2008). For defining actual demands, however, the client of such projects should acquire a broader range of technical knowledge, including operational skills. This has to do with the fact that usually the client should further deal with the operation of the project. Thus, it is crucial for the client to have required operational skills to avoid potential problems during the operation phase and ultimately meet the end users' requirements.

Regarding the suggested practices, there was a clear difference of opinion between the experts across the two sector groups on the applicability of recommendation 7. Compared to the experts of the construction and infrastructure sector, the experts of the process industry put more emphasis on creating an integrated environment facilitating a real collaboration between the client and contractor. Integrated project team and joint team building are prerequisites for joint risk management and joint lessons learned; otherwise, sharing those risks and lessons could create liability issues. For creating the integrated team, parties should show trust towards each other and the willingness to back each other up, if it is really needed. Such an integrated team can work in harmony towards success. On the other hand, for the experts in the construction sector, having an integrated team is not a prerequisite for working on other "joint" activities. Organising such an integrated team in the construction sector is very challenging due to different interests of various stakeholders. This integration is ideal when it is facilitated by the contract, more specifically integrated project delivery models such as alliance or Design and Construct. This difference was also observed in the findings of Chapter 3 (Q-study). The results from the survey study, however, revealed that, even in the process industry, only 9 out of 43 cases did have a single integrated team. This implies that there is a difference between the practitioners' perception of team integration and what actually happens in practice.

Although experts in the construction sector explicitly indicated that it would be challenging to organise a seamless project team, an exceptional showcase like the Sluiskiltunnel project indicates that such an arrangement is possible (Hertogh, Bakker, de Man, & Scholten, 2015). According to the experts, integration of project management activities in terms of reporting and quality management, lessons learned, team building, and risk management (recommendations 9 to 12) can be possible without enforcing an integrated team. Joint application of these activities among the client and contractor, however, was also not supported by the survey data (Chapter 4). The study of Demirkesen and Ozorhon (2017) distinguished six attributes of integration management in construction and infrastructure projects: development of project charter, knowledge integration, process integration, staff integration, supply chain integration, and integration of changes. They showed that such an integration management, in all six attributes, has a positive influence on project performance. This implies that the key to the application of joint tasks and activities might be an integrated team.

Although enabling an integrated project management approach (recommendation 13) was acknowledged by the experts in the construction sector, they do not agree that an integrated project team adds value to the project without considering its contextual enablers. The contextual enablers include politics surrounding the project, contractual arrangements, and leadership capabilities of the project team members. The political dimension of the project entails a broad range of aspects which is out of the scope of this research. The latter two boundary conditions as the potential barriers (or enablers) are discussed in the following.

The influence of tender and contractual arrangements on the application of the suggested practices was observed mostly by the experts of the construction and infrastructure sector. The contracting strategy might be seen as a boundary condition, or sometimes an obstacle for organising an integrated approach. In more collaborative contractual arrangements, such an integrated approach can be stimulated by sharing Key Performance Indicators (KPIs), penalties, and bonuses which are aligned with the interests of the organisations. Although contractual arrangements can be considered as a boundary condition enabling the integration, they can merely act as a facilitator for open cooperation (Martinsuo & Ahola, 2010). Experts, however, admitted that irrespective of the type of contract, team members should invest in openly expressing their goals, expectations and be transparent in sharing information (recommendations 1 to 4). Beyond this, the team members should be able to act as unified entity. Expert I_1 demonstrates this by stating that parties should "*join their problems, join their risks, join their chances, and join their fears"*. This kind of relational attitudes and teamworking leads to high project performance, the contract type by itself cannot affect the nature of the collaboration between the team members (Suprapto et al., 2016).

It seems that in the construction sector the requirements for the integrated approach among the main involved parties, client and contractor, are set outside the project. More specifically, current practice in this sector focuses mostly on the top-down approach ignoring the bottom-up approach in facilitating joint application of the project activities. Although the influence of the politics and the administrative level cannot be disregarded, from a project perspective the people within the project have a crucial role in setting the scene for an actual integration approach. At the team level, shared leadership of the team members can affect the team processes (such as coordination, joint efforts, commitment, and shared learning) as well as team status or affective processes (such as motivation and trust) (Han, Lee, Beyerlein, & Kolb, 2018; Scott-Young, Georgy, & Grisinger, 2019). Shared leadership as an emergent team property highlights the role of the distributed leadership among the team members, instead of focusing merely on the individual person or role (for instance project manager, project director, or top management) (Carson, Tesluk, & Marrone, 2007; Kozlowski, Mak, & Chao, 2016). Experts expressed that failure occurs as soon as people start blaming each other and create a fear-based environment. Instead, intra team trust can safeguard agreements which are not specified formally in the contract (Lu, Yuan, & Wu, 2017). Bottom- up feeding of mutual trust across the team members can foster integration contributing to collaboration, which in turn positively affects the performance.

Formal and informal interaction with the client team (recommendation 8) was recognized by the experts to play a pivotal role in grasping the client demands. Specifically, informal interaction can open up the discussion on specific aspects and alignment on the actual interpretation of client demands. Such a spontaneously interaction could further contribute to solving potential problems. Formal and informal interaction can be intensified by blending the project team members from client and contractor together (Kokkonen & Vaagaasar, 2018; Matinheikki, Aaltonen, & Walker, 2019) and promoting an integrated approach.

Given the above explanations, the final model remains unchanged to a large extent. However, the concrete definition of the terms used for the proven practices should be given. Thus, some adjustments are made in the model to avoid different interpretations. First, the term "collaboration between client and contractor" is replaced by the "client and contractor team level collaboration". Second, for clarification of the proven practices, a complementary definition of each of the practices is presented in the final model (Table 7.7), which serves as the implementation guide for these practices. This is presented in the next subsection.

7.6.2 How to use the Nexcess model

Overall, the experts in both sessions acknowledged the value of the Nexcess model, however, they provided some feedback in order to enhance the applicability of the model in daily practice (see Subsection 7.5.5). Hence, the applicability of the model is enhanced by adding a roadmap for the application of core project management practices. The roadmap for the application of the Nexcess model is presented in Table 7.7 guiding practitioners on how to use the model.

The roadmap consists of two steps:

> ***Step 1:*** As a point of departure, the focus should be given to the ***proven practices*** and the underlying items for each factor by ensuring that they are realised in the project. These practices should be discussed among the participants to guarantee that they are implemented in the project.
>
> ***Step 2:*** In this step, the extent to which ***suggested practices*** can be stimulated by or integrated with each other can be discussed. For instance, given the project boundaries, performing joint risk management can lead to sharing lessons learned. In other words, sharing risk management sessions sharing can also incorporate lessons learned. As observed from practice, sharing lessons learned among the parties might bring value to the project but it is undermined in the current practice. Since various individuals go through different failures and successful practices, blending their experiences from both sides can enrich the added value of lessons learned sessions. Another example is to increase the possibility of informal interactions with the client team for ensuring that the actual demands of the client are recognized. This can be facilitated, for example by organising a joint project team and providing a co-located shared working area for the project team of client, contractor, and consultant.

Regarding the application of the ***suggested practices*** the participants would first discuss the boundary conditions, including political influence and contractual arrangements shaping their project. This could stimulate decisions made by the parties on how to operationalise these practices within the given boundary conditions. For instance, the parties can agree upon the intensity of the joint quality and progress screening activities and what such activities should entail within the given contractual setting.

Finally, potential point of disagreements between the parties concerning the exact and concrete definition of the proven and suggested practices can be discussed during preliminary sessions. An illustration of this is to consent on the exact definition of the required technical skills of the client representative during the front-end phase.

When to use the model: The roadmap can be discussed between the main project parties, including client, contractor and consultant, during the project kick-off and at stage gates.

Table 7.7: Roadmap for the application of core project management practices to be discussed between parties

Steps		Core project management practices	Implementation guide
Step 1: Establish the consensus on the definition of the proven practices and agree on the actions to be undertaken	Proven practices	Practice 1: boost team level collaboration between client and contractor	1. Client and contractor team level collaboration 1.1 Sense of belonging to the team 1.2 Sharing a belief that they perform their roles and protect the interests of each other 1.3 Helping and supporting each other in carrying out their tasks 1.4 Putting best on joint efforts 1.5 Commitment to the team tasks 1.6 Motivation to maintain the team
		Practice 2: leverage open information sharing	2. Open information sharing 2.1 In-time distribution of the required information by the parties 2.2 Presence of clear communication channels
		Practice 3: Enhance top management support from both sides, client and contractor	3. Top management support 3.1 Showing trust towards project team 3.2 Showing honesty and openness in the interactions 3.3 Commitment to the project and supporting the project team 3.4 Closely collaborate with the project management 3.5 Delegation of authority to project manager
		Practice 4: Assign client representative with the right technical skills	4. Technical skills of the client representative during front-end
		Practice 5: Ensure that aligned goals are set	5. Aligned goal setting 5.1 Organise a clear project performance measurement system 5.2 Prioritised of aligned project goals 5.3 Clearly definition of goals among the stakeholders involved
		Practice 6: Establish expectations among the team members	6. Expectation management 6.1 Establishing of roles and expectations of the team members 6.2 Feedback on individual/team performance
Step 2: Investigate the requirements for applying the suggested practices	Suggested practices *	Practice 7: Organise a single integrated team	7. Provide the requirements for organising a single integrated project team
		Practice 8: Formal and informal interaction with client	8. Agree on the intensity of formal interactions and enable the possibilities for informal interactions with client
		Practice 9: Joint monitoring and quality management	9. Agree on the intensity joint monitoring and quality management
		Practice 10: Joint lessons learned	10. Agree on the intensity of joint lessons learned activities
		Practice 11: Joint team building	11. Agree on the intensity of joint team building activities
		Practice 12: Joint risk management	12. Agree on the intensity of joint risk management activities
		Practice 13 (construction and infrastructure): Enable an integrated project management among the key stakeholders	13. Identify the key stakeholders and establish an integrated project management among them

* Discuss what project boundaries affect the implementation of the suggested practices in terms of political influence and contractual arrangements

Chapter 8

Closing

Abstract

Projects play a crucial role in contributing to our society and economy. Therefore, evaluation of their management and which practices yield better performance is crucial. With this chapter, this dissertation is concluded. In this closing chapter, the general discussion is presented including the research validity and the limitations of the research. Sub-questions are answered by drawing on the findings of the earlier chapters in this dissertation. Having answered these sub-questions enables answering the main research question. Further, the relevance of the findings for practice is presented followed by the theoretical contribution and recommendations for future research.

8.1 Discussion

In this discussion section, first the validity of the research design is explained in Subsection 8.1.1. Next, the limitations of the research are discussed in Subsection 8.1.2.

8.1.1 Validity of the research

In order to check the quality of the research design in social science research, four assessments are applied: reliability, internal validity, external validity, and construct validity (Yin, 2014). Reliability refers to the extent to which the results are consistent and it determines the precision of the measurement procedures followed (Saunders et al., 2016). Validity of the research, in the broad sense, can be defined as whether the research measures what it was intended to measure (Cooper & Schindler, 2014). In this subsection, reliability and validity of the current research are addressed. Reliability is a necessary, but not sufficient, condition for validity (Saunders et al., 2016). So, if a research design is not reliable, it cannot be valid. Hence, first the concept of the reliability of the current research design is discussed.

Reliability assesses the reproducibility and consistency of the results, if it is performed again under the same or very similar conditions (Neuman, 2002). In the Q-methodology, replicability and reliability of the results have been criticised in several studies (Cross, 2005; Mettler & Wulf, 2019; Van Exel & De Graaf, 2005). However, the replicability of the Q-sorts is of less concern (Van Exel & De Graaf, 2005), since it examines the collective viewpoints of the practitioners on the potential factors leading to good project performance which are influential in a specific industry sector.

In the survey study and qualitative study presented in Section 7.5, reliability, in terms of reproducibility, is about whether an alternative researcher can interpret the same information (Saunders et al., 2016). Therefore, all data collection procedures followed for conducting these survey and expert evaluation meetings were documented and stored in a drive (survey data files, transcripts of expert meetings, and subsequent data analysis files and codes). Such standardised research approach can ensure the repeatability of the results (Saunders et al., 2016). Cronbach's alpha, as an index of internal consistency, was calculated to ensure that the items in a test measure the same concept or construct (Tavakol & Dennick, 2011).

Internal validity refers to the extent to which the findings actually represent the reality of what was designed to measure (Saunders et al., 2016) and whether the measurement model is able to establish a causal relationship (Yin, 2014). Since the internal validity is applicable for explanatory and causal studies, it was not relevant for the Q-sorting (Chapter 2 and Chapter 3). The survey was developed based on the literature review and expert evaluation of the framework performed in Chapter 2. In addition, to increase the internal validity of the survey, the questionnaire was pretested with practitioners to ensure that the appropriate terminology was used in the questions to collect the intended data. In the survey study, the applied standard statistical procedures were followed to unravel statistically significant differences among the sectors in Chapter 4, and necessary (whole dataset, Chapter 5) and sufficient conditions (per sector, Chapter 6) for project performance. The final model was developed based on the observations made from practice and further evaluated with the experts to enhance the internal validity of the research.

External validity addresses the extent to which the results of the research can be generalised to other contexts and groups (Saunders et al., 2016). The Q-studies presented in this research involved 14 companies in the construction sector (including infrastructure) and only one company in the process industry. This suggests that the generalization is only possible to a limited extent. In the survey study, the exact number of involved companies is not known since not all the participants indicated the name of their companies. However, based on data provided by the participants at least eight companies from the construction and six companies from the process industry were involved. In total, 212 practitioners participated in this research, 86 from the process industry and 126 from the construction sector, providing a broad range of cases in these two sectors. External validity of the conclusions was enhanced by evaluating the findings with experts from both sectors.

Construct validity indicates whether the right measures have been used for the constructs being studied (Yin, 2014). Several strategies were followed to strengthen the construct validity. In the Q-study, the respondents were asked to explain their answers for the rankings on the extreme positions. In order to enhance the construct validity in the survey study, as suggested by Podsakoff, MacKenzie, Lee, and Podsakoff (2003), the anonymity of the participants and their data were ensured when inviting them to participate in the survey. For better understanding, simple questions were formulated and different constructs were separated purposefully in the survey. Several control measures were used for questions regarding independent variables (front-end activities and project management principles) and performance outcomes.

Mixed methods research is an emerging approach (Cameron, Sankaran, & Scales, 2015) which was followed in the current research by combining qualitative and quantitative approaches in research methods, analysis procedures and data interpretation (Tashakkori & Teddlie, 1998). Triangulation can be applied to decrease the bias, enhance the validity and provide multiple perspectives on the same phenomenon (Joslin & Müller, 2016a). In the current research, triangulation was used in terms of data collection (from different sources including companies and participants with different roles in projects) and employing multiple (both qualitative and quantitative) methods. Methodological triangulation, more specifically between-method triangulation (Teddlie & Tashakkori, 2009), included expert evaluation and Q-methodology for exploring the practice (Chapter 2 and Chapter 3), followed by the survey study and quantitative analysis to describe practice (Chapter 4, Chapter 5, and Chapter 6). The final results of the study, summarised in the Nexcess model, were evaluated qualitatively by the experts in Chapter 7.

8.1.2 Research limitations

As in every empirical study, some research limitations can be identified. The current study provides new insights on the causal relationships between the applied project management practices, specifically during front-end development, and performance in two major sector groups: process industry and construction sector.

The final Nexcess model presented in this research suggests that project team integration in the early phases and joint application of the project management activities could positively contribute to the performance. Such “actual” integration, however, is applied to a lesser extent in practice, compared to the ***proven practices***. Hence, the potential effect of these ***suggested practices*** could not be empirically examined in this research.

Another limitation of the research was that data from a single case was provided by one project participant (mainly the project manager). Surveying one single respondent could introduce bias (Bowman & Ambrosini, 1997) as it might not provide a complete overview of some factors, such as the team level collaboration at the sides of both client and contractor and a performance indicator such as client satisfaction. Although the role of project manager cannot be neglected, they cannot represent the whole team in perceiving and assessing those subjective concepts. Therefore, future research can address this limitation by including respondents involved in a single project representing various roles.

The sample sizes both in the Q-study and survey study were large enough to interpret the causal relationships between the project management practices and project performance. However, given the relatively small sample sizes, the results should be extended with caution. In the Q-study (Chapter 3), the perception of the practitioners was explored and compared regarding the factors contributing most to the performance across the three datasets in two sector groups, process industry and construction industry. In this study, sector was considered as the main contextual factor. Looking at it from a different perspective, each dataset might also represent a specific organisational role (consultant, client, and contractor) in a project. Subsequently, this organisational role could be also considered as a contextual factor. The current data did not allow such analysis. Thus, more datasets are required representing each role in both sector groups to enable comparisons across these contexts.

In Chapter 5 and Chapter 6, in which the causal relationship between those project management practices and performance were analysed, project performance has been delineated based on only four indicators: time, cost, quality, and client satisfaction. Although the survey included some questions for measuring other aspects of project performance, unavailability of data for these indicators did not allow to include them in the analysis. Such lack of knowledge on these broader indicators of project performance does suggest that practitioners still measure the performance of their projects in a “traditional” way. The broader indicators include no accidents (safety), flawless operation/start-up, contractor satisfaction, team satisfaction, end user satisfaction, preparing for the future, business success, and sustainability considerations. The prevalence of the “traditional” view of performance still was observed in practice. Future research can measure the “non-traditional” indicators by evaluating the projects more in-depth.

Another limitation was the lack of a clear-cut distinction between construction (including urban development and real estate) and infrastructure as two separate sectors. The main reason was that the network contacted for gathering data for both the Q-study and the survey study consists of companies working in both sectors. Although it was aimed to collect enough data from each of these sectors, it was difficult to find respondents working specifically in one of these sectors. Thus, it was not possible to make such distinction when analysing data in Chapter 3 and subsequently Chapter 7. Future research could address these two sectors separately, because the nature of their projects seems to be different in terms of the stakeholders involved or the contract types used.

8.2 Conclusions

The main objective of the research was to contribute to the improvement of management of engineering projects, by investigating practice. The research presented a comparison of the practice across two main sector groups of process industry and construction (including infrastructure). In order to answer the main research question, the findings of each sub-study are explained by answering the related sub-question in Subsection 8.2.1. Subsequently, the answer to the main research question is given in Subsection 8.2.2.

8.2.1 Answers to the research sub-questions

RQ1: What are practitioners’ views on obtaining good project performance?

In order to answer this question, an extensive literature review of peer reviewed papers, published from 2000 onwards, was performed in Chapter 2. This literature review together with the expert evaluation of the factors resulted in a framework summarising 33 factors contributing to project performance presented in Table 2.1. Subsequently, a Q-sorting was applied to explore the diversity of the practitioners’ perspectives on those factors in three different sectors: urban development, real estate, and infrastructure. This framework was used to identify the practitioners’ views regarding the importance of application of these factors in their projects.

In total, 34 practitioners, from consultant companies, participated in this sub-study (16 from real estate, 9 from urban development, and 9 from infrastructure) which resulted in the identification of four distinctive perspectives: “seeking the best match”, “being adaptive and open”, “keeping the team focused”, and “preparing for opportunities”. In the first perspective, the factors associated with the procurement were emphasised, such as ***selection of contracting strategy and tender process*** and ***proper selection of project execution resources.*** The practitioners within the second perspective valued information sharing and being adaptive the most. Perspective three noted that having a focused project team is more important than other factors. Specifically, they highlighted the importance of ***integrated project team*** and ***active involvement of client***. In the view of perspective four, identifying opportunities, emphasizing simultaneously on ***opportunity management*** and ***monitoring and control*** activities, contributes most to project success

Overall, these identified perspectives highlight the importance of soft factors, especially competences of the people who actually perform the project and how they interact with each other. However, the traditional view of managing projects by closely monitoring them still exists. Another observation was that no direct link can be found between the identified perspectives and the sector (real estate, infrastructure, and urban development) where the respondents worked in.

RQ2: How do the perceptions of the practitioners on obtaining good project performance differ across construction sector and process industry?

In the next study presented in Chapter 3, the practitioners' perspectives regarding the focal aspects of project management practices were compared by considering the sector as a contextual factor. Two sector groups were considered in this study: process industry and construction sector. This qualitative study was performed by using Q-sorting in which three datasets were collected and analysed separately: dataset 1 (construction-consultant), dataset 2 (construction-client), and dataset 3 (process industry-contractor). The dataset for the construction sector (dataset 1) was the same dataset as presented in Chapter 2. In total, 108 practitioners were involved in this study (65 from construction sector and 43 from process industry).

For each dataset, four distinctive perspectives were revealed. Further, the answer to this sub-question was given by identifying the similarities and differences across the identified perspectives. Some differences were observed across the sector groups. A major difference was observed across the sectors regarding the definition and importance of integration for achieving good project performance. In the process industry, more attention is given to the broader definition of integration involving the key parties and end users, compared to the construction industry. The lack of integration, even in the narrow sense within the project team including client and contractor, leads to the fragmentation in the construction industry, which is also evidenced in the earlier studies. The practitioners in the construction industry emphasised the importance of procurement implying that they believe that the contractors should take the majority of the responsibilities for performing the project tasks. Such behaviour, focusing on the procurement, adopted by the practitioners can also be served as a contributing factor to the existence of fragmentation in that sector. Another difference was the dominant focus on ***health and safety considerations*** which was observed among the practitioners in the process industry. Such importance can be linked to presence of "safety first" culture within this sector. Specifically, the importance of integration among the parties in establishing a safety culture is a lesson which can be learned by the construction sector.

Regarding the similarities on the perspectives across the datasets, six shared themes were recognized: client emphasis, traditional approach, team focus, end user focus, procurement focus, and opportunity focus. Regardless of the type of project or sector, the importance of client involvement and professional knowledge in defining the project requirements and boundaries were observed. Collaboration between project parties was acknowledged as the most important contributing factor to project performance overall. Although the dominant focus of the two sector groups was on the traditional approach, such as control and setting of the project, the focus on soft factors including project team management and interactions between people was also observed. Moreover, ***adaptive project management*** does not yet predominantly exist in the current opinions of project management practitioners in both sector groups. Based on the answers given by the practitioners, barriers for applying adaptive project management include contractual arrangements and regulatory frameworks.

Although different aspects can be considered for the project context, in this study, sector was regarded as the main contributing contextual factor. Thus, data was not stratified per se for other contextual factors such as organisational role which can be a potential extension to this study.

RQ3: Which front-end activities and project management principles are typically applied in engineering projects?

The answer to this question was given by investigating practice using a survey study of 104 engineering projects in three different sectors (26 from construction, 35 from infrastructure, and 43 from process industry). The survey questions were based on the framework already used in Chapter 2 and Chapter 3. Due to the different nature of these factors, they were divided into two main aspects of applied front-end activities (factors which can be measured by their intensity of application) and project management principles (factors which can be measured more qualitatively and not per se their intensity of application). However, not all the 33 factors could be operationalised and included in the analysis throughout this research. Some factors were removed from the framework due to their abstract level of definition and contribution to project performance (such as adaptive project management, project planning, and awareness of project nature). Some other factors were removed because of their high percentage of missing values in the received answers. This resulted into 25 factors as presented in Table 4.1. Subsequently, multi-item measurement scales (suggesting that each factor can be measured by more than one item) were used for operationalising each of these factors. In total, for measuring the front-end activities and project management principles, 31 and 38 items were used, respectively.

Analysing "missing values" provides insights into what front-end activities and project management principles are not commonly applied in current practice, overall as well as per sector. Overall, some front-end activities are not acknowledged by practice, such as ***environmental impact assessment, checking deliverables against***

the business case, training programs tailoring to the project requirements, and performance assessment with the aim of continuous improvement. Some front-end activities are the so-called Value Improving Practices (VIPs) which are well-known in the process industry including ***design to capacity,*** and ***technology selection.*** The results of the survey showed that these activities were not applied during the front-end phase of engineering projects, even not in the process industry where they originated from. Moreover, in terms of project management principles, ***use of an integrated contract, considering the technical skills, and project management skills of the contractor*** were not applied to a large extent in practice. These items are corresponding to the following factors: selection of contracting strategy and tender process, contract management, and proper selection of project execution resources. The lack of recognition of the latter two items (***considering the technical skills, and project management skills of the contractor)*** by the respondents suggest that contractors are not typically involved during the front-end phase. These "not commonly applied practices", specifically related to the lack of contractor involvement during the front-end phase, draw an implication for practice: client (and consultants working on behalf of the client) should be more prudent to define a proper contracting strategy, early during the project and not postpone it to the later stages. This also requires that parties, including the contractor are involved early in the front-end.

Analysing the survey data, it was concluded that a number of front-end activities and project management principles seem to be well-established in a specific sector. As an example, ***constructability review*** and ***value engineering***, are less recognized by the respondents in the construction and infrastructure sectors. Such practices are better known in the process industry. Terminology used for certain activities could vary across sectors. Legal and regulatory frameworks supporting the project procurement is more evident in the construction and infrastructure, compared to the process industry. The reason might be that construction and infrastructure projects are more often publicly owned which makes it crucial to define such legal framework. More specific project management knowledge is required for each sector. In addition, comparing the "not commonly applied practices" across the sector groups suggests that process industry does slightly more of some of these practices. For instance, ***process conformance (quality audit with regard to service conformance)***, ***self-assessment of project team members, joint lessons learned with client and contractor,*** and ***HSE management*** are better known and applied to a larger extent in the process industry compared to the construction industry. Identifying these practices provides a learning opportunity for the practitioners in the construction industry who are seeking to broaden their knowledge on various aspects of project management. These learning opportunities are further discussed in the general reflection on this PhD research (see Subsection 8.3.1).

For further analysis presented in this research, the "not commonly applied practices", across the sectors, were removed. This resulted into inclusion of 39 items (15 front-end activities and 24 project management principles). Next, the items were reduced into more manageable factors resulting into five front-end activities (risk management, monitoring and quality management, embracing and capturing lessons learned, team building, and setting expectations) and seven project management principles (collaboration between client and contractor, project manager competency, setting project goals, top management support, client competency, information sharing, and client involvement). These factors provide an input for the next analyses.

RQ4: What differences and similarities do appear in the intensity of application of front-end activities and level of project management principles across construction, infrastructure and process sectors?

By adopting qualitative and multivariate data analysis on the survey data, it was concluded that construction projects put considerably less effort into aligning project goals among the key stakeholders during the front- end. Mostly contractors, as one of the key stakeholders, are not involved that early in typical construction projects. Contractors, with their profound technical and project management skills and experience can provide a valuable insight into defining those project goals. This alignment of the goals is crucial since it gives direction throughout the project journey. Additionally, team building activities are applied to a lesser extent in the construction sector, compared to the infrastructure and process industry. The results of the survey study suggested that projects, in all the sectors, do not incorporate an integrated approach in terms of having an integrated project team with client and contractor or using an integrated contract. These findings, partly, confirmed the findings of Chapter 3, regarding the lack of integration in construction projects. In the process industry, the results of the survey showed that the subjective opinion of the practitioners are different from what commonly happened in reality. In other words, practitioners intend to work in an integrative manner, however, this is not applied to a large extent in practice. This shows that the mindset of people is changing towards a more integrated approach, but more enforcement is required to actually make it happen.

Overall, the cross-sectoral analysis presented in Chapter 4 suggests that the process industry, to some extent, seems to be more mature in terms of application of front-end activities and project management principles, compared to infrastructure and construction sectors.

RQ5: Which combinations of intensity of application of front-end activities and level of project management principles are necessary for achieving good project performance?

In Chapter 5, a necessity logic was adopted to answer this sub-question using the same survey data as in Chapter 4. In Chapter 4, the analysis focused on the extent to which front-end activities and project management principles are applied in practice by making a cross-sectoral analysis without linking to the performance. Chapter 5 aimed at identifying necessary but not sufficient conditions for successful project performance. Project performance was operationalised using four indicators: within budget, within schedule, within specifications, and client satisfaction.

Considering the whole dataset, findings of NCA showed that there are four (out of 12 identified factors earlier in Chapter 4) necessary conditions for a high level of performance: ***collaboration between the client and contractor***, ***top management support***, ***information sharing***, and ***technical competencies of the client representative in front-end.*** Not having these necessary conditions would reduce the project performance, and as a result lower the chance of project success. The absence of those necessary conditions cannot be compensated by the additional application of other front-end activities or project management principles.

Looking at the results, it can be observed that none of the front-end activities were among the necessary conditions for project performance. Hence, the results did not support the proposition that front-end activities such as ***risk management*** and ***embracing and capturing lessons learned*** are among the necessary conditions for successful project performance. What is more important, is the soft side of project management in the early phases such as collaboration between the project teams and level of information sharing which were shown to play a crucial role in determining success (or failure). Moreover, the presented approach in Chapter 5 can be applied as part of the evaluation of projects. If an organisation would opt for achieving an intended level of performance, determining those necessary conditions is crucial.

RQ6: Which combinations of such project management efforts produce high project performance in each sector?

The findings of the previous study in Chapter 5 were further enhanced by using sufficiency logic in Chapter 6, in which the presence of the performance (outcome) is ensured. The methodology used for answering this sub-question (QCA) produces promising results only when the number of conditions considered is limited. Therefore, using multiple regression analysis, first it was explored which of those project management efforts most strongly contribute to project performance. Based on this analysis, it was concluded that a combination of four conditions best explains the performance. These four conditions were selected for further analysis: ***setting expectations, collaboration between client and contractor, information sharing, and setting aligned goals.***

The first observation from this study was that no single condition is sufficient, independent from other conditions, for the intended level of project performance. Chapter 6 showed that different combinations of those four selected conditions can contribute to project performance. Unlike Chapter 5, the sufficiency analysis was performed on the total dataset as well as per sector. The reason was that the definition of a sector-dependent condition seems to be aligned with the sufficiency logic: a condition which is more likely to be sufficient for an intended project performance in a specific context.

Another observation was that in line with the sufficiency configurations derived for the whole dataset, teamwork collaboration among the team members (client and contractor) is also the reoccurring condition in the sufficient configurations in all the sectors. Moreover, all configurations leading to high project performance across the sectors include a high degree of information transfer among the parties.

Looking more specifically into the configurations in each sector, it can be observed that high levels of goal clarity result in high performance in the infrastructure projects. This suggests that in the infrastructure sector, the main focus first should be put on setting aligned project goals and bringing the stakeholders together, making sure that their interests are included in the defined project goals. In the construction sector, high level of team collaboration and high level of information sharing when there is an absence of goal setting are associated with high project performance. This is in line with the findings of Chapter 4 suggesting that the overall level of goal setting is low in the construction sector. Thus, the conclusion was that, in the construction sector, more attention should be paid to prioritise and align the project goals among the parties. In the process industry, high levels of collaboration and high levels of information exchange, even with low levels of expectation management, can produce high performance.

RQ7: What are the building blocks for improving the management of engineering projects?

In Chapter 7, the results of the previous sub studies were summarised. Based on the results of Chapter 5 and Chapter 6, a set of ***proven practices*** was identified. Necessary practices (from Chapter 5) include collaboration between client and contractor, information sharing among the parties, support from top management, and client competency in terms of technical skills. Sufficient configurations of practices (from Chapter 6) comprise the following practices: collaboration between client and contractor, information sharing among the parties, setting aligned project goals, and setting expectations. For each sector, specific configuration of these practices can contribute to high level of performance. The detailed list of underlying items for each of these practices considered in this research is presented in Table 7.1.

From Section 7.3, a set of improvement areas was identified, which were given by the respondents in the survey study. In their next projects, respondents would focus more on the following practices: team building, client involvement, contract management, monitoring and quality management, and risk management. The respondents emphasise the fact that more "joint" application of those activities in terms of team building, monitoring and quality management, and risk management is required. These results together with the findings in Chapter 3 and Chapter 4 formed the basis for ***suggested practices***. Further in Chapter 7, the Nexcess model is presented, as the core project management practices in the engineering projects, consisting of ***proven practices and suggested practices***.

Following the observations made in Chapter 3, fragmentation and lack of an integrated approach was observed, specifically, in the perception of practitioners in the construction sector. Thus, in the Nexcess model recommendation 13 was added for this sector enabling integrated project management among the key stakeholders.

Eventually, the Nexcess model was evaluated separately by the experts from the process industry and construction sector. Overall, the experts largely agreed on the application of the *proven practices*. It was perceived, according to the experts, that such an integrated approach, presented by the *suggested practices*, can be merely enabled (or hampered) by the factors outside the project (such as politics and contractual arrangements) or inside the project (such as individual leadership of project team members).

Finally, a roadmap was presented for the application of the core project management practices which can be discussed between the main project parties, including client, contractor and consultant, during the project kick-off. Potential boundary conditions (or barriers) should be discussed among these parties for enabling the application of *suggested practices* in a given project.

8.2.2 Answer to the main research question

Having answered the sub-questions, the answer to the main research question can be given:

What practices and applied methods can be extracted from completed projects in different project contexts with the aim of improving the performance of future projects?

The overarching aim of this research was to contribute to improving the performance of engineering projects in two main sectors: construction (including infrastructure) and process industry. Based on a mixed methods approach, both general and sector-specific practices leading to performance were identified by evaluating projects in these two sectors. The overall conclusions of the research split in the main findings from each sub-study are presented in Table 8.1. The empirical evidence showed that *client and contractor team level collaboration* and *information sharing among the parties* serve as two important practices which could ultimately determine the performance of such projects. Moreover, application of suggested practices, irrespective of the project boundary conditions, can be improved if the people at team level provide a proper basis for them.

Table 8.1: Core project management efforts, main findings based on the sub-studies

	The findings based on			Resulted practices
I. Proven practices	Chapter 5	Necessary practices		*1. Client and contractor team level collaboration* *2. Information sharing among the parties* 3. Support from top management 4. Technical skills of client representative in the front-end phase
	Chapeter 5 and 6		Elements of sufficient Configurations-per sector	*1. Client and contractor team level collaboration* *2. Information sharing among the parties*
	Chapter 6			5. Setting expectations 6. Setting aligned project goals
II. Suggested practices	Chapter 3 Chapter 4 Chapter 7			7. Seamless and integrated project team 8. Formal and informal interactions with client 9. Joint monitoring and quality management 10. Joint lessons learned 11. Joint teambuilding 12. Joint risk management 13. Enabling an integrated project management among the key stakeholders within the construction and infrastructure sector

8.3 Practical recommendations

In this section, recommendations of the current PhD research for practice are discussed. General reflections on the research are given in Subsection 8.3.1. Next, the practical relevance of the research is presented in Subsection 8.3.2.

8.3.1 General reflections

In this subsection, some general reflections are presented based on the overall research performed, which is not per se related to the formulated research sub-questions.

The research started with a framework consisting of 33 factors contributing to project performance. After collecting and analysing data from practice, 13 practices contributing to performance of engineering projects are summarised in the final model. The reason for the exclusion of factors was, partly, that the majority of these removed factors were not acknowledged in practice. This provides some food for thought for practitioners: they could be made aware of what practices normally take priority and what practices are usually discarded across the sectors. Examples of such 'neglected' practices include requirements for an integral approach or integrated contract, incorporating innovation by actively looking for new technology, and training provisions tailored to project requirements. In the following these 'neglected' practices are reflected upon:

- Using an integrated contract is among the main drivers for the development of an integrated approach and bringing different stakeholders together. One of the benefits of such an integrated approach is that it can stimulate the implementation of innovation in projects. In the modern world, companies are obliged to incorporate innovation within their projects in order to improve the performance of their projects, leverage the competitive advantage of their organisations, and win the market. As explained earlier in Chapter 4, innovation encompasses two major aspects: product (use of new materials and technologies) and process (applying new methods and processes) (Davies et al., 2014). Regarding innovation, our findings have confirmed that use of new technologies (in terms of product innovation) is not acknowledged in practice suggesting that, at least in the current dataset of engineering projects, the established technologies are more commonly applied. In addition, stimulating new ideas and processes calls for an integral approach in which all key actors (including consultants, contractors, end users, and maintenance actors) are involved early in the project and incentivised to come up with innovative solutions. Leveraging such knowledge diversity requires that new collaborative forms of (integrated) contracts are applied fostering the inclusion of professional expertise.

As discussed in Subsection 3.5.2, innovation usually is initiated and further promoted by the client. Thus, clients play a crucial role in promoting the innovation. Given the fact that about half of the respondents (53%) in our survey study were from client organisations, they are encouraged to focus (more) on incorporating innovation. More specifically, the clients should set up support for innovation and make it explicit when formulating their demands during the front-end phase. On the other side, consultants and contractors (market) have the proper knowledge for pragmatic application of innovative technologies. Thus, incorporating innovation requires mutual support from both sides (client as well as other parties including consultants and contractors), which can be facilitated via early engagement. Though the evidence seems to be anecdotal, a collaborative environment where the parties are encouraged to create innovative solutions could ultimately contribute to project performance.

- Regarding training, the findings of the Q-study as well as the survey study confirmed that it is mostly undermined by the practitioners. Each project requires specific technical and project management knowledge and skills. Lack of the tailored competencies required for the project within the team or not having up-to-date knowledge would ultimately diminish the ability of the organisation to deliver successful projects. Training can serve as a means to disseminate the experiences of senior practitioners across the organisation and ultimately improve the organisational performance (Bakker & de Kleijn, 2018). An explanation for the perceived low importance could be that the organisation does not properly understand the relevance of such training for their organisation leading to the improved performance. Training cannot be applied merely at the project level, rather it needs some enforcement at the organisation level. In addition, project management is not always considered as a discipline which makes it difficult at the organisation to invest in it. This has an important implication for the current practice: make the added value of the training visible at the organisation level. This explicit formulation of the benefits of training could also help in highlighting the importance of training and how it can contribute to project and organisational performance. An example can be observed in the Shell Project Academy, where training was enforced at the strategic level and it resulted into the improvement of the project performance at the organisation level (Bakker & de Kleijn, 2018, p. 5).

- In contrast to the view beyond the iron triangle of project performance in academic research, practice still predominantly assesses the performance based on time, cost, and quality. At the beginning of this research, it was opted to include a broader definition of performance beyond these traditional indicators. When asking the participants of the survey study regarding performance criteria such as safety, contractor satisfaction, team satisfaction, and preparing for the future, respondents seem to less recognize them in their daily practice (Chapter 5). Perhaps practitioners are aware of the existence of these non-traditional performance indicators, however, once assessing their own project the traditional measures gain priority. This does not suggest that those projects are not successful in terms of delivering satisfactory outcome on the strategic and long-term aspects. Rather it implies that compared to traditional performance criteria, the importance of these broaden criteria fades away. Thus, the potential solution can be that measuring these broader aspects of performance (including contractor and team satisfaction, flawless operation/start up, preparing for the future, and end user satisfaction) should be explicitly incorporated when formulating project goals.

- Some contradictions were observed between what is perceived as the opinion of the practitioners (Q-study presented in Chapter 2 and Chapter 3) and what is commonly happening in daily practice (survey study presented in Chapter 4). For instance, respondents in the Q-study highlighted the importance of an integrated approach and integrated project team as a driver of project performance. The results of the survey, however, showed that such an integrated approach may exist only as wishful thinking of the practitioners. Although the study identified the team level collaboration between client and contractor and smooth information exchange as the main drivers of project performance, as evidenced by the survey results, an integrated project team does not actually exist in practice. Even in the process industry, where the practitioners perceived the existence of an integrated project team of client and contractor as a positive contributing factor to performance, such an integrated team composition does not actually materialise in practice (see Subsection 4.5.3).

- The results of the survey showed that fragmentation does exist in both sector groups. This fragmentation includes lack of involvement of contractors and future users, as the key stakeholders, early enough during the front-end phase. The results of the study suggest that it is not possible to achieve high levels of project performance without a proper collaboration of the client and contractor at the team level and information exchange among them. Therefore, a takeaway here for practitioners is that facilitating the integration of these key stakeholders is crucial for determining the level of project performance. It is suggested that practitioners should be working harmoniously with each other by aligning the project management activities such as organising joint risk management sessions, joint quality reviews and screening the progress, joint team building sessions, and joint lessons learned events.

- Contract type was perceived as a barrier for having such an integrated project team. It seems that practitioners, specifically in the construction sector, "hide behind" the procurement processes rather than focusing on their individual roles for enhancing collaboration through creating an integrated project setting. Alternatively, the attention should be directed to the improvements of the behaviour of the people at the project level.

8.3.2 Practical relevance

The present study provides practical implications for boosting project performance of engineering projects by structuring the project management practices in two ways. First, the cross-sectoral analysis of the applied methods provides a knowledge base for comparing the project management practice and what can be learned across the sectors. The findings suggest that the process industry seems to be ahead in the application of project management practices, compared to the construction sector. Thus, more structure is required for the applied standards and project management practices within the construction sector. These project management practices have been already well set up in the process industry.

Second, to improve project performance, the proposed roadmap can be used by the practitioners. Although proven practices seem not to be new recommendations, it shows that practitioners should yet address these practices with more care. Failing to fulfil those necessary conditions would prepare the project for low performance levels. Additionally, practitioners in each sector should pay attention to those sufficient conditions identified in each sector, if they aim at achieving high levels of project performance. The current research has an important implication for the client organisation in terms of possessing the required technical skills during the front-end phase. This is crucial, since the findings suggest that if the client representative does not have the proper skills regarding the technical aspects of the project, a high-level outcome cannot be achieved. Although NCA was performed across the sectors, and not per sector, this necessary condition might be more relevant for the construction (including infrastructure) sector. The reason is that in the process industry usually the client has their own technical team during the front-end development. Therefore, an implication for the construction sector is to assign the representatives with sufficient technical skill about the project, already during the early project phases. This might also facilitate the formulation of client needs and requirements in terms of project goals.

The empirical results of the survey suggest that core project management activities such as risk management and lessons learned are mostly performed separately by the project teams. Thus, suggested practices of the Nexcess model imply that project managers should enable joint formalization of those project management processes and determine the intensity of such processes. This requires that team members work together as a single team and everyone has a joint understanding of what processes should be followed for each of these activities. Clearly, the focus here is on the integrative and joint activities between key project parties including client, contractor, consultants, and end users. Looking back at other project evaluation studies (Section 1.2), the current study echoes the stance of the earlier findings in holding the importance of the collaboration between the main parties involved. It shows that current practice is still lagging behind such integration practices. Creating a seamless team and formalization of these joint processes would create a collaborative environment in which it is clear for everyone what to pursue.

Given the above explanation, improving the performance using the proposed model is twofold:

1. It encourages practitioners to check for those practices which absence hinders the achievement of high level of performance.

2. The roadmap offers a space for interaction in which practitioners can understand the extent to which they can contribute positively to the performance by promoting an integrated approach.

Leveraging the results of this PhD research, two general implications are presented to organisations intending to improve the performance of their projects and ultimately their organisations by embracing an integrated approach.

- **Incorporate a collaborative approach in contracts as an agreement for fostering integration:**

The influence of the contractual arrangements (such as contract type used in the front-end) was not considered directly in the relationship between the proven practices and the performance, for instance as a mediator. However, in-depth analysis of the cases showed no pattern which supports the influence of contractual arrangements on the application of necessary conditions (Chapter 5) across the whole sample and sufficient conditions (Chapter 6) in each sector group. Those proven practices should be in place without considering the sector or contract as project contextual factors. As an example, it was discussed in one of the evaluation sessions that, for creating a collaborative setting *“contract has only a relative value”.*

Contractual arrangements were mentioned, however, in both evaluation sessions as one of the potential barriers hindering an integrated approach. The extent to which each of these practices can be exercised is determined by the contracts and agreements made between the parties. It was discussed in the evaluation sessions that integration can be enabled by the contract settings, more specifically integrated contacts. An integrated contract was, however, only applied in less than one quarter of the total cases studied in the survey (see Subsection 4.5.1). More collaborative contractual arrangements such as early contractor involvement, integrated project delivery, and alliance models are recommended as a strategy for successful integration practices.

- **Bottom-up approach as a stimulus for adopting an integrated approach:**

With regard to the application of the proven practices, personal experience of people is very important. The behaviour of the people at the operational level can be a catalyst for adopting an open and collaboration environment. In such an open environment, irrespective of project context, transparency and not having shadow planning is crucial.

The application of the suggested practices and creating an integrated team spirit brings up the need for more bottom-up approach within the team itself. As discussed in the evaluation of the suggested practices of the Nexcess model (Subsection 7.5.4) and the discussion presented in 3.5.1, it can be observed that the suggested practices are more commonly applied in the process industry, compared to the construction sector. Even in the process industry, an integrated approach is not applied to a large extent and it is just a desire. It seems that project participants rely too much on the outside forces as a powerful hurdle for not stimulating the integration among the parties. People at the operational level with their motivation, however, can provide a joint environment by exhibiting this in their acts. Put it differently, application of suggested practices can be triggered by an integration of a top-down and bottom-up approach. Achieving project success seems to be unsustainable unless project team members from both sides invest in organising a joint project setting early in the project.

8.4 Scientific recommendations

Next to the relevance of the research findings for practice, scientific recommendations of the study are given in this section. This includes scientific contribution (Subsection 8.4.1) and potential recommendations for further research (Subsection 8.4.2).

8.4.1 Scientific contribution

The current study identifies a number of scientific results by addressing the current practice of project management and how those applied practices are interlinked with high levels of performance. The goal here was to contribute to the advancement of theory and methods used in the project management research. More specifically, the findings of this research provide contributions to project evaluation research by systematically assessing the management practices applied in engineering projects.

The research followed contingency theory suggesting that projects within different contexts required "best fitted practice" (Ramalingam et al., 2014; Sauser et al., 2009). Thus, the study aims at understanding the relationship between project management practices and project performance considering the industry sector as the contextual factor. Despite this dependency on the context (industry sector), in this research it is claimed that still some lessons can be learned across the sectors.

The point of departure for this research was a new framework consisting of 33 success factors from literature that was used in the Q-study. In order to operationalise these factors a limited number of these factors (25), divided into front-end activities and project management principles, were used in the survey study. The reason for such a division was that the research aimed at identifying what activities are performed and how often. This was the first contribution of the research, since earlier studies mainly assess those activities binary and not by measuring their intensity. Measuring the intensity of the applied activities provided a better view on how they are handled in practice.

Next, the survey results revealed that not all these front-end activities and project management principles were applied. This implies that there is a gap between what is suggested in the literature and what practices are commonly applied in engineering projects. Specifically, it was observed that such gap between scientific recommendation and applied practices does exist in construction projects. Moreover, the difference was also recognised between what respondents intend or prefer to do (Q-study) and what it is exercised in projects (survey study). Studying merely the respondents' opinion might not reflect what commonly happens in practice. Therefore, in social science, it is crucial to combine different methodologies and paradigm approaches as each of them focuses on specific aspects of the concept under study.

Joslin and Müller (2016a) argue that project management research is typically performed within a single-paradigm approach. In reality, however, practitioners who actually perform the projects hold a multiple ontological perspective simultaneously. Narrow application of theoretical lenses by using a single-paradigm approach or single methodology would result in investigating a narrow, predictable or less interesting phenomenon. Müller and Söderlund (2015), in the editorial of IJPM reflecting on the 2013 IRNOP conference, urged scholars in the project management research to employ more innovative approaches and methodologies.

In this study, NCA was employed in Chapter 5 to identify necessary front-end activities or project management principles required for high project performance. Using fsQCA in Chapter 6 a sectoral analysis was made on those patterns of project management practices which are sufficient conditions for high performance. These two methodologies are complementary (Tho, 2018; Vis & Dul, 2016) and relevant for studying high-performance projects. Hence, the current study adds value to the project evaluation research by embracing and combining multiple methodologies in understanding project performance.

The focus of the research was on high-performing engineering projects to explain how they are managed in practice and what can be learned from these practices to be used in next projects. Relying on the earlier research and based on the findings of the current study, the Nexcess model is developed in Chapter 7. Specifically, the focus of this model is to integrate and direct the project management practices by various parties involved, including client, contractor, and consultant.

8.4.2 Future avenues for research

One of the methodological limitations of the presented Q-study in Chapter 3 was the size of the dataset and the absence of data per organisational role. More data is required representing all sectors and organisational roles. This might give a broader overview on the practitioners' opinions across their organisational roles.

The survey also sought to explore how frequently front-end activities are applied in engineering projects. Such analysis can extend to the execution phase to find how the application of those activities might evolve during the execution and how the intensity of application of the execution activities might influence the project performance.

The scope of research was narrowed to engineering projects within the construction, infrastructure, and the process industry. Construction and infrastructure were considered as one overarching industry sector in the analysis performed in Chapter 3 and Chapter 7. Although these two sectors share some characteristics, as observed from the findings from Chapter 4 and Chapter 6, also differences can be seen regarding their project management practices. A more-in-depth analysis of differences and the underlying reason for such differences can be addressed in future research.

Yet another proposed avenue for future research is to explore the effect of project boundaries (political influence, contractual arrangements) on the application of suggested practices, either qualitatively or quantitatively. Understanding the mechanism behind these project boundaries or barriers seems to be more relevant in the construction sector, albeit also important in the process industry.

The majority of the projects studied in this research were performed in the Netherlands. Therefore, those proven and suggested practices might not be applied to the same extent in projects in other countries. As observed from the expert evaluation of the Nexcess model, practitioners with international experience already acknowledged the role of culture as another contextual factor affecting the application of those practices. Hence, future research is needed to investigate how culture can affect the application of proven and suggested practices.

Finally, the current study calls for the application and combination of methodologies from the neighbouring disciplines to enrich project management research. The added value of creating and adopting different philosophical orientations to practice rather than adopting a single philosophy has been already addressed by Konstantinou and Müller (2016). They suggest that the application of various philosophical perspectives can provide opportunities to generate a variety of options and alternatives to be used in a context-dependent practice. Such a suggestion can be extended for employing non-conventional research methods in project management research.

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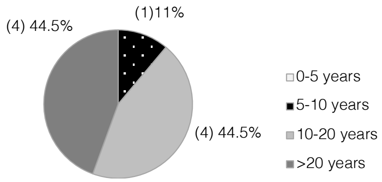
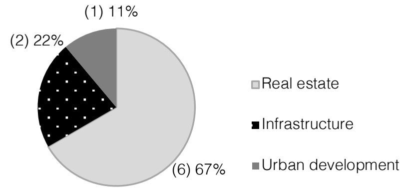
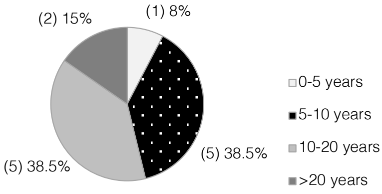
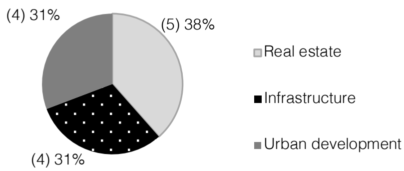
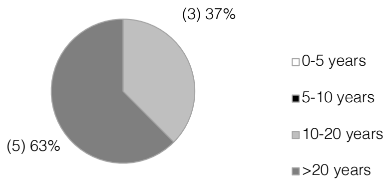
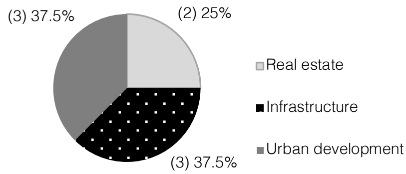
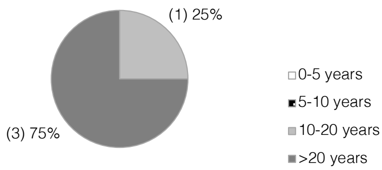
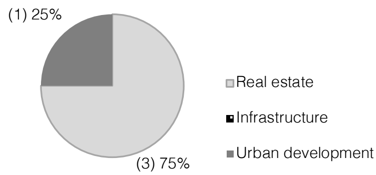
Appendix A. Results of Q-study in dataset 1 (Chapter 2)

Appendix A. 1: Demography of the respondents per perspective (in dataset 1)

Perspective	Work experience per perspective	Role per perspective
Perspective N1 (Seeking the best match)		
Perspective N2 (Being adaptive and open)		
Perspective N3 (Keeping the team focused)		
Perspective N4 (Preparing for opportunities)		

Appendix A. 2: Success criteria framework used for this study

Category of Success Criteria		
Stakeholder Satisfaction	**Iron Triangle**	**Beyond Iron Triangle**
End user satisfaction	Within schedule	Safety
Client satisfaction	Within budget	Long term impact
Team satisfaction		
Contractor satisfaction	Quality	Flawless utilization
External stakeholder satisfaction		

Appendix A. 3: Factor Loadings for four-factor solution in dataset 1

Respondent ID	Factor 1	Factor 2	Factor 3	Factor 4	
N01	0.206	0.134	0.589 *	0.303	
N02	0.538 *	0.062	0.236	0.350	
N03	0.188	0.343	0.583 *	−0.167	
N04	0.089	0.601 *	0.178	−0.083	
N05	0.334	0.305	0.717 *	−0.070	
N06	0.178	0.489 *	0.068	0.279	
N07	0.3804	0.706 *	0.081	0.299	
N08	0.759 *	0.058	0.111	0.006	
N09	0.310	0.525 *	−0.542 *	0.123	confounder
N10	0.599 *	0.222	0.418	−0.011	
N11	0.284	0.478 *	0.066	−0.061	
N12	0.230	0.127	0.322 *	0.457 *	confounder
N13	0.168	0.430 *	0.535 *	0.419	confounder
N14	0.1521	0.691 *	−0.075	0.500	
N15	0.716 *	0.120	0.030	0.174	
N16	0.605 *	0.370	0.028	0.181	
N17	0.046	0.009	0.241	0.721 *	
N18	−0.196	0.797 *	0.186	0.139	
N19	0.740 *	0.304	0.141	−0.237	
N20	0.021	0.112	−0.213	0.722 *	
N21	0.261	0.654 *	0.386	−0.106	
N22	0.226	0.309	0.486 *	0.129	
N23	0.452 *	0.368 *	0.338	0.110	confounder
N24	−0.239	0.497 *	0.311	0.441 *	confounder
N25	0.238	0.186	−0.414 *	0.121	
N26	0.097	0.190	0.702 *	0.015	
N27	0.006	0.010	0.092	−0.540 *	
N28	0.375	−0.068	0.586 *	0.062	
N29	0.409 *	0.441 *	0.408	0.101	confounder
N30	0.418 *	0.399 *	0.359	−0.056	confounder
N31	0.283	0.425 *	0.146	0.014	
N32	0.564 *	0.556 *	0.259	−0.072	confounder
N33	0.112	0.722 *	−0.019	0.068	
N34	0.344	0.670 *	0.112	0.072	

* indicates the defining sort. For the confounders loading on multiple perspectives, the dark grey cells display the factors which eventually the respondent load on.

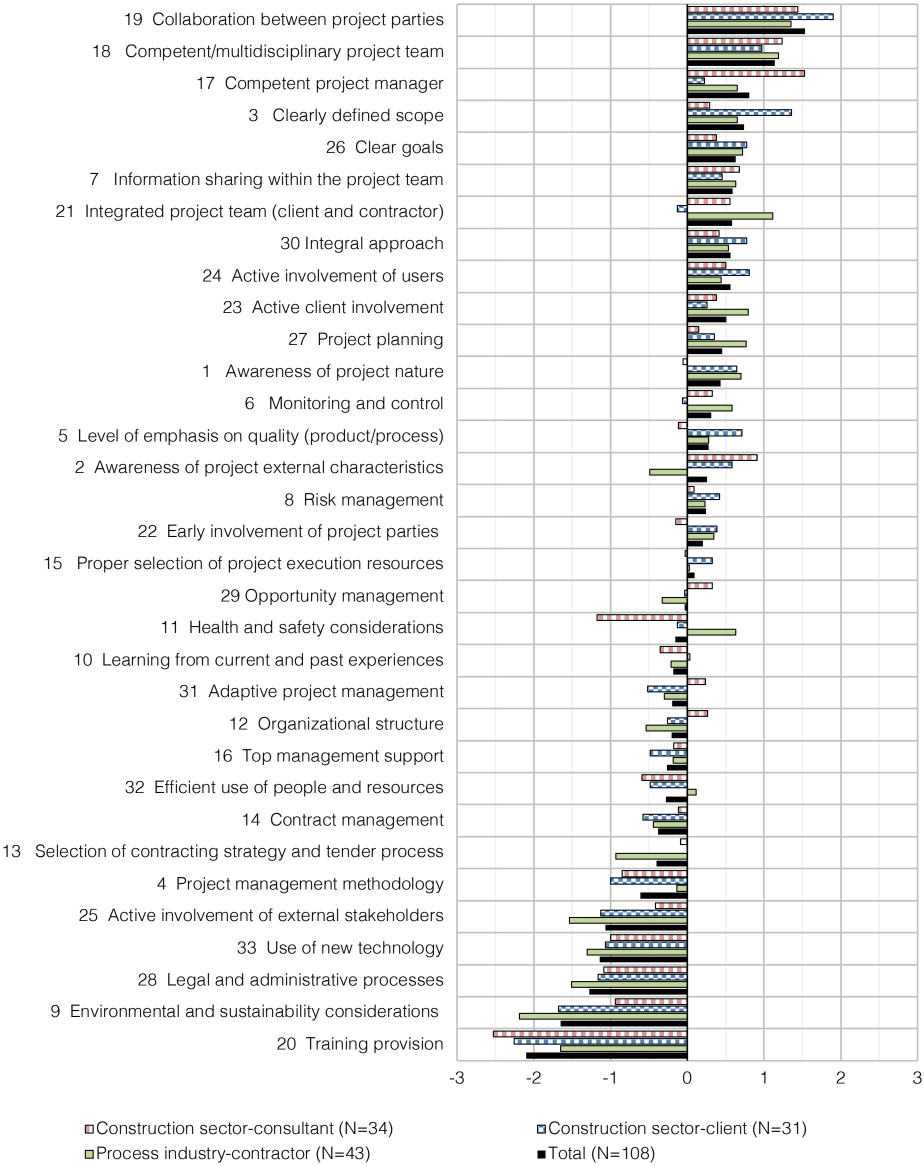
Appendix A. 4: Z-scores and corresponding position of success factors in the Q-set per perspective in dataset 1

No.	Statement (Success Factor)	N1. Seeking the best match		N2. Being adaptive and open		N3. Keeping the integrated team focused		N4. Preparing for opportunities	
		Z-score	Pos.	Z-score	Pos.	Z-score	Pos.	Z-score	Pos.
1	Awareness of project nature	0.28	0	−0.96	−1*	0.34	1	0.96	1
2	Awareness of project external factors	0.29	0	1.33	2	0.64	1	1.85	3
3	Clearly defined scope	0.26	0	0.22	0	1.12	2	1.13	2
4	Project management methodology	−0.55	−1	−1,40	−2	−0.24	0	−1.16	−2
5	Level of emphasis on quality (product/process)	−0.41	−1	−0.45	−1	−0.05	0	0.32	0
6	Monitoring and control	−0.07	0	−0.34	−1	0.92	1	1.53	2
7	Information sharing within the project team	0.20	0	1.48	3*	0.21	0	0.61	1
8	Risk management	−0.06	0	−0.08	0	0.55	1	−0.08	0
9	Environmental and sustainability considerations	−2.10	−3*	−0.28	0*	−1.39	−3*	1.57	2*
10	Learning from current and past experiences	−0.69	−1	−0.17	0	−0.34	0	−1.00	−1
11	Health and safety considerations	−1.53	−2	−0.89	−1	−1.13	−2	0.36	1*
12	Organisational structure	0.79	1	0.18	0	−0.45	−1	0.12	0
13	Selection of contracting strategy and tender process	1.26	2*	−0.59	−1	−1.32	−2	−0.60	−1
14	Contract management	0.54	1	−1.17	−2*	0.67	1	−0.20	0
15	Proper selection of project execution resources	1.18	2*	0.05	0	−1.22	−2*	0.36	1
16	Top management support	0.35	1	0.00	0	−0.22	0	−0.12	0
17	Competent project manager	1.83	3	1.50	3	1.41	2	−0.12	0*
18	Competent/multidisciplinary project team	1.07	2	1.45	2	0.82	1	−0.01	0*
19	Collaboration between project parties	2.19	3	1.26	1	1.81	3	0.49	1*
20	Training provision	−2.53	−3	−2.47	−3	−2.67	−3	−1.36	−2*
21	Integrated project team (client and contractor)	−0.38	−1	0.82	1*	1.41	2*	0.04	0
22	Early involvement of project parties	−0.77	−1	0.67	1*	−0.58	−1	−0.76	−1
23	Active client involvement	0.34	1	−0.40	−1	1.97	3*	−0.37	−1
24	Active involvement of users	0.47	1	0.31	1	−0.09	0	1.01	1
25	Active involvement of external stakeholders	−0.86	−2	−0.11	0	−0.36	−1	−0.37	−1
26	Clear goals	0.63	1	0.30	0	0.16	0	0.48	1
27	Project planning	0.13	0	0.35	1	0.62	1	−1.76	−3*
28	Legal and administrative processes	−1.11	−2	−1.71	−3	0.14	0*	−1.49	−2
29	Opportunity management	−0.29	0	0.94	1*	−0.52	−1	2.08	3*
30	Integrated approach	0.62	1	0.69	1	−0.52	−1	−1.05	−1
31	Adaptive project management	−0.35	−1	1.44	2*	−0.11	0	−1.60	−3*
32	Efficient use of people and resources	−0.25	0	−0.66	−1	−0,62	−1	−0.73	−1
33	Use of new technology	−0.48	−1	−1.32	−2	−0.95	−1	−0.12	0

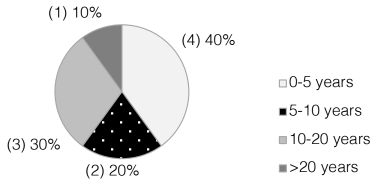
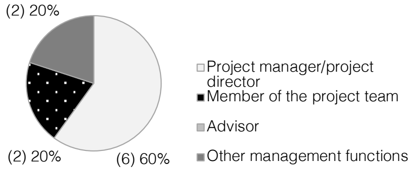
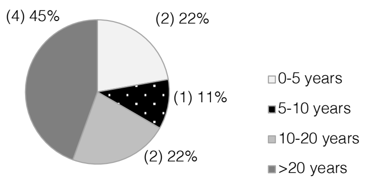
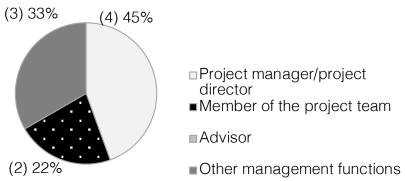
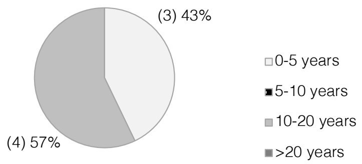
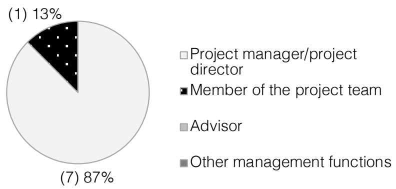
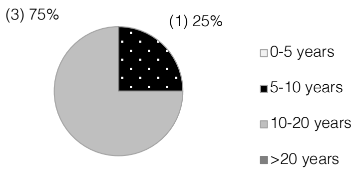
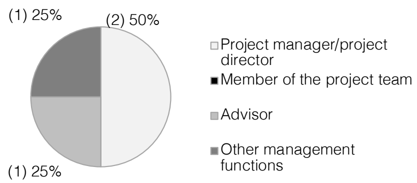
Note: All the grey cells in this table represent the distinguishing statements per perspective at $p < 0.05$, the statements with * are success factors which are distinguishing at $p < 0.01$.

Appendix B. Results of Q-study in datasets 2 and 3 (Chapter 3)

Appendix B. 1: Overall rank of success factors across the three datasets



Appendix B. 2: Demography of the respondents per perspective (in dataset 2)

Perspective	Work experience per perspective	Role per perspective
Perspective P1 (Client defined project)		
Perspective P2 (Steering by procedures)		
Perspective P3 (Collaborating with user and team orientation*)		
Perspective P4 (Innovating in project and procurement)		

* One respondent in Perspective P3 did not provide information regarding the working experience.

Appendix B. 3: Factor Loadings for four-factor solution in dataset 2

Respondent ID	Factor 1	Factor 2	Factor 3	Factor 4	
P01	0.324	0.136	-0.016	0.621 *	
P02	-0.324	0.376	0.318	0.618 *	
P03	0.313	-0.113	0.603 *	0.197	
P04	0.690 *	0.363	0.297	0.071	
P05	0.826 *	0.162	0.156	-0.231	
P06	0.165	0.334	0.748 *	0.094	
P07	0.070	0.742 *	0.167	0.265	
P08	0.126	0.418	0.563 *	0.032	
P09	0.292	0.640 *	0.253	0.124	
P10	-0.005	0.421 *	0.338	0.068	
P11	0.607 *	0.273	0.270	0.467	
P12	0.113	0.1207	0.272	0.729 *	
P13	0.362	-0.057	0.600 *	0.006	
P14	0.457	0.667 *	0.175	-0.018	
P15	0.803 *	0.104	0.139	-0.183	
P16	-0.008	0.814 *	-0.088	-0.174	
P17	0.206	0.739 *	-0.030	0.302	
P18	-0.059	0.336	0.354 *	0.184	Confounder
P19	0.722 *	-0.036	0.124	0.344	
P20	0.481	0.557 *	-0.211	0.124	
P21	0.503 *	0.022	0.342	0.183	
P22	0.574 *	0.353	0.344	0.122	
P23	0.324	0.494	0.564 *	-0.003	Confounder
P24	0.653 *	0.197	0.095	-0.034	
P25	0.681 *	-0.038	0.239	0.155	
P26	0.181	0.362	0.460 *	-0.224	Confounder
P27	0.563 *	0.467	0.173	0.045	
P28	0.057	0.543 *	0.376	0.124	
P29	0.328	0.213	0.434	-0.524 *	Confounder
P30	0.325	0.094	0.727 *	0.209	
P31	0.153	0.596 *	0.406	-0.089	

* indicates the defining sort. For the confounders loading on multiple perspectives, the dark grey cells display the factors which eventually the respondent load on.

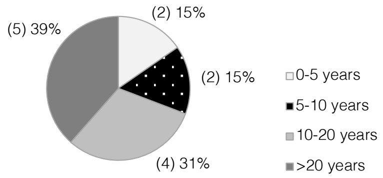
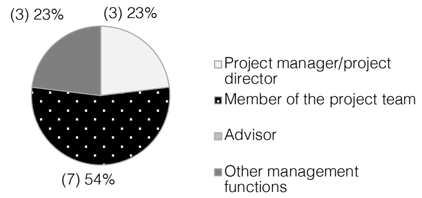
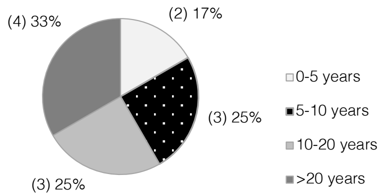
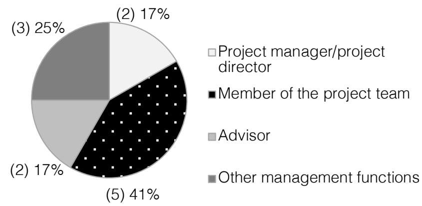
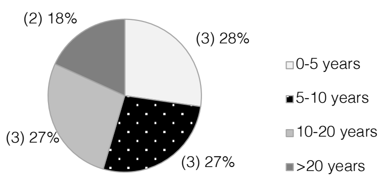
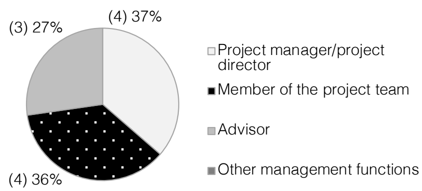
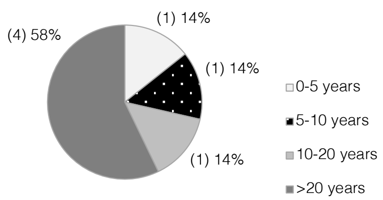
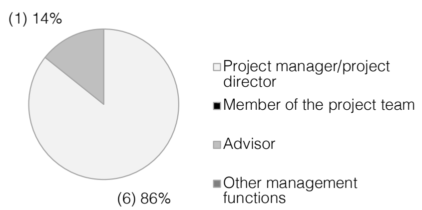
Appendix B. 4: Z-scores and corresponding position of success factors in the Q-set per perspective in dataset 2

No.	Statement (Success Factor)	P1. Defining the project by client		P2. Steering by procedures		P3. Collaborating with user and team orientation		P4. Innovating in project and procurement	
		Z-score	Pos.	Z-score	Pos.	Z-score	Pos.	Z-score	Pos.
1	Awareness of project nature	0.33	0	0.62	1	0.84	1	0.49	0
2	Awareness of project external Perspectives	0.37	1	0.02	0	1.02	2	0.37	0
3	Clearly defined scope	2.17	3*	0.70	1	0.48	1	1.60	2
4	Project management methodology	-0.73	-1	-0.95	-1	-1.00	-2	-0.86	-1
5	Level of emphasis on quality (product/ process)	0.36	0	1.86	3*	-0.36	0*	0.62	1
6	Monitoring and control	-0.12	0	0.56	1	-0.62	-1	0.73	1
7	Information sharing within the project team	0.45	1	0.55	0	-0.03	0	0.86	1
8	Risk management	-0.42	-1	1.54	2*	0.35	1*	-0.38	-1
9	Environmental and sustainability considerations	-1.92	-3	-0.99	-2	-1.96	-3	-1.23	-1
10	Learning from current and past experiences	0.37	1	-0.47	-1	-0.03	0	0.24	0
11	Health and safety considerations	-1.53	-2*	1.18	2	-0.32	-1*	1.12	1
12	Organisational structure	0.39	1*	-0.25	0	-0.46	-1	-0.85	-1
13	Selection of contracting strategy and tender process	-0.42	-1	-0.50	-1	0.29	1*	1.34	2*
14	Contract management	-0.52	-1	-0.46	-1	-0.88	-1	0.36	1*
15	Proper selection of project execution resources	-0.95	-1*	0.33	0*	0.88	1	1.34	3
16	Top management support	0.11	0	-0.38	0	-0.73	-1	-0.72	0
17	Competent project manager	0.25	0	-0.16	0	0.95	1*	-0.24	0
18	Competent/multidisciplinary project team	1.07	2	0.76	1	1.74	3*	-0.35	-1*
19	Collaboration between project parties	2.28	3	2.17	3	1.43	2*	-0.37	0*
20	Training provision	-1.27	-2	-2.47	-3	-2.30	-3	-1.95	-2
21	Integrated project team (client and contractor)	-0.31	0	0.64	1*	-0.66	-2	-1.12	-3
22	Early involvement of project parties	0.09	0	0.63	1	-0.08	0	0.72	1
23	Active client involvement	0.95	2*	-0.58	-1	0.16	0	0.00	0
24	Active involvement of users	0.49	1	-0.78	-1*	2.10	3*	1.34	2
25	Active involvement of external stakeholders	-1.40	-2	-1.30	-2	-0.18	0*	-2.09	-3
26	Clear goals	1.58	2*	-0.13	0	0.20	0	0.99	1
27	Project planning	0.53	1	0.87	1	0.12	0	-0.49	-1
28	Legal and administrative processes	-0.41	-1	-1.35	-3	-1.46	-2	-0.85	-1
29	Opportunity management	-0.02	0	-0.39	0	0.46	1	0.50	0
30	Integrated approach	0.53	1	0.99	2	1.47	2	-0.99	-2*
31	Adaptive project management	-0.48	-1	-1.07	-2	0.14	0*	-1.10	-2
32	Efficient use of people and resources	0.07	0	-0.78	-1	-0.59	-1	-0.48	0
33	Use of new technology	-1.91	-3*	-0.40	0	-0.98	-1	1.47	3*

Note: All the grey cells in this table represent the distinguishing statements per perspective at $p < 0.05$, the statements with * are success factors which are distinguishing at $p < 0.01$.

Appendix B

Appendix B. 5: Demography of the respondents per perspective (in dataset 3)

<table>
<tr><th>Perspective</th><th>Work experience per perspective</th><th>Role per perspective</th></tr>
<tr><td>Perspective R1
(Keeping the client close)</td><td></td><td></td></tr>
<tr><td>Perspective R2
(Co-creating with end users)</td><td></td><td></td></tr>
<tr><td>Perspective R3
(Managing by conventional wisdom)</td><td></td><td></td></tr>
<tr><td>Perspective R4
(Bringing the team together with integrated approach)</td><td></td><td></td></tr>
</table>

Appendix B. 6: Factor Loadings for four-factor solution in dataset 3

Respondent ID	Factor 1	Factor 2	Factor 3	Factor 4	
R101	0.238	0.2343	0.221	0.540 *	
R102	0.2191	0.0158	0.653 *	0.3315	
R103	0.2627	0.2655	-0.0083	0.664 *	
R104	0.3386	0.1193	0.479 *	0.4647	Confounder
R105	0.368	0.668 *	0.2553	0.1929	
R106	0.3329	0.2791	0.599 *	-0.1229	
R107	0.2322	0.835 *	0.0606	-0.022	
R108	0.1625	0.3561	0.2531	0.579 *	
R109	0.0691	0.545 *	0.1123	-0.0045	
R10	0.522 *	-0.3606	-0.0269	0.1851	
R11	0.2962	0.498 *	0.1794	0.4114	Confounder
R12	0.4975	0.3943	0.594 *	0.2012	Confounder
R13	0.718 *	0.0349	0.0132	0.0323	
R14	0.3916	0.1045	-0.0701	0.801 *	
R15	0.476 *	0.3572	0.1739	0.1987	
R16	0.3796	0.609 *	0.0598	0.2393	
R17	0.3493	0.2827	0.450 *	0.0403	Confounder
R18	0.572 *	0.5101	0.411	0.0447	Confounder
R19	0.0446	-0.0577	0.736 *	0.0868	
R120	0.486*	0.3676	0.2346	0.3412	Confounder
R121	0.775 *	0.1536	0.2498	-0.0876	
R122	0.479 *	-0.0623	0.4739	0.0699	Confounder
R123	0.639 *	0.4184	0.1259	0.2341	
R124	-0.098	0.796 *	0.0566	0.1996	
R125	0.0053	-0.068	0.681 *	0.2368	
R126	0.675 *	0.3557	0.2173	0.2231	
R127	0.097	0.611 *	0.1461	0.1886	
R128	-0.1924	0.2477	0.785 *	0.2827	
R129	0.743 *	0.0526	0.0433	-0.0196	
R130	0.540 *	0.2721	0.0316	0.461	
R131	0.2632	0.4656	0.601 *	0.0589	
R132	0.501	0.2104	0.539 *	-0.0346	Confounder
R133	0.1537	0.3797	0.622 *	0.0505	
R134	-0.2079	-0.0247	0.3588	0.535 *	
R135	-0.1194	0.0155	0.1762	0.604 *	
R136	0.2835	0.492 *	0.3651	0.3879	Confounder
R137	0.2533	0.572 *	0.0545	0.0289	
R138	0.739 *	0.2617	0.142	0.1614	
R139	0.4629	0.507 *	0.3622	0.1741	Confounder
R140	0.216	0.792 *	0.0228	0.1293	
R141	-0.0986	0.685 *	0.0469	0.2893	
R142	0.532 *	0.2485	0.4463	0.1788	Confounder
R143	-0.015	0.5213	0.129	0.550 *	

* indicates the defining sort. For the confounders loading on multiple perspectives, the dark grey cells display the factors which eventually the respondent load on.

Appendix B

Appendix B. 7: Z-scores and corresponding position of success factors in the Q-set per perspective in dataset 3

No.	Statement (Success Factor)	R1. Keeping the client close		R2. Co-creating with end users		R3. Managing by conventional wisdom		R4. Bringing the team together with integrated approach	
		Z-score	Pos.	Z-score	Pos.	Z-score	Pos.	Z-score	Pos.
1	Awareness of project nature	0.80	1	0.32	1	1.09	2	0.36	1
2	Awareness of project external Perspectives	-0.69	-1	-0.66	-1	-0.13	0	0.04	0
3	Clearly defined scope	1.33	2	1.44	2	0.51	1*	-1.66	-2*
4	Project management methodology	-0.72	-1	0.26	0	-0.03	0	-0.16	0
5	Level of emphasis on quality (product/process)	-0.27	0	0.10	0	0.71	1	0.25	0
6	Monitoring and control	-0.16	0	-0.04	0	1.96	3*	0.20	0
7	Information sharing within the project team	0.75	1	0.42	1	0.45	1	0.38	1
8	Risk management	0.38	0	-0.55	-1*	0.10	0	1.00	1*
9	Environmental and sustainability considerations	-1.69	-3	-1.87	-3	-2.44	-3	-2.31	-3
10	Learning from current and past experiences	-0.62	-1*	0.00	0	0.17	0	0.15	0
11	Health and safety considerations	1.20	2	-0.09	-1*	1.28	2	-0.85	-1
12	Organisational structure	-1.11	-2	0.38	1*	-0.57	-1	-1.01	-2
13	Selection of contracting strategy and tender process	0.52	1*	-1.82	-2	-0.45	-1*	-2.00	-3
14	Contract management	-0.10	0	-1.35	-2*	0.09	0	-0.31	-1
15	Proper selection of project execution resources	0.32	0	-0.07	0	-0.27	-1	-0.14	0
16	Top management support	-0.92	-1	0.99	1*	-0.68	-1	-0.08	0
17	Competent project manager	0.18	0*	0.90	1	0.76	1	0.85	1
18	Competent/multidisciplinary project team	0.53	1	0.62	1	1.84	3	1.34	2
19	Collaboration between project parties	1.61	3	1.85	3	0.19	0*	1.04	1
20	Training provision	-2.17	-3	-0.27	-1	-1.90	-3	-0.87	-1
21	Integrated project team (client and contractor)	1.46	2	1.52	3	-0.12	0*	1.17	2
22	Early involvement of project parties	1.03	1	-0.04	0*	-0.71	-2*	1.43	3
23	Active client involvement	1.69	3*	0.04	0	0.70	1	0.22	0
24	Active involvement of users	0.42	0	1.43	2*	-0.60	-1*	0.31	1
25	Active involvement of external stakeholders	-1.09	-2	-1.82	-3	-1.62	-2	-1.00	-1
26	Clear goals	0.47	1	0.93	1	0.31	0	1.05	2
27	Project planning	0.35	0	1.05	2	0.94	2	0.16	0
28	Legal and administrative processes	-1.68	-2	-1.65	-2	-0.68	-1	-1.06	-2
29	Opportunity management	-0.71	-1	-0.80	-1	-0.16	0*	0.96	1*
30	Integrated approach	0.75	1 *	-0.04	0	-0.22	-1	1.88	3*
31	Adaptive project management	-0.97	-1*	-0.18	-1	0.51	1*	-0.23	-1
32	Efficient use of people and resources	-0.40	0	0.14	0	0.76	1*	-0.17	-1
33	Use of new technology	-0.49	-1	-1.12	-1	-1.82	-2*	-0.93	-1

Note: All the grey cells in this table represent the distinguishing statements per perspective at $p < 0.05$, the statements with * are success factors which are distinguishing at $p < 0.01$.

Appendix B. 8: Perspectives with single focus on specific success factor

	No.	Success factor	Z-score	Pos.
		Dataset 2. Construction sector (clients)		
Focus on quality		P2. Steering by procedures		
	5	Level of emphasis on quality (product/process)	1.86	3*
Focus on innovation		**Dataset 2. Construction sector (clients)**		
		P4. Innovating in project and procurement		
	33	Use of new technology	1.47	3*
Focus on being open and adaptive		**Dataset 1. Construction sector (consultants)**		
		N2. Being adaptive and open		
	7	Information sharing within the project team	1.48	3*
	31	Adaptive project management	1.44	2*

Appendix C. Survey questions (Chapter 4)

Welcome to this survey enabling data collection for learning from ex-post evaluations

Purpose
This survey is being conducted by the Infrastructure Design and Management Section of Delft University of Technology . The result of this survey will contribute to the research on capturing the experiences gained in the management of **infrastructure and construction projects.** The overarching aim of this survey is to get insight into the profession of project management to further identify the potential opportunities for improvement in various project management areas in all phases of projects with a particular focus on the early project phases (called front end development phase in this survey).

Value for your company
The results of this study can be used by practitioners in order to evaluate their projects. We might also use the result of this survey for cross-industry knowledge sharing. In addition, this research can provide some directions and recommendations for future projects contributing to improved project performance.

Instruction for this survey
Please consider your last completed project while answering the survey. At the start of the survey, a question is asked whether you were involved only during the front end development phase (including scope development, plans for area development) or whether you were involved also during the execution phase. After answering this question you are directed to the questions that fit your situation.

If you were only involved in the front end development phase:
In this case, the survey is structured in seven sections:

Section 1. Project characteristics
Section 2. People and organization
Section 3. Front end development
Section 4. Control and management
Section 5. Project (front end development) results
Section 6. Company profile
Section 7. Personal profile

If you were involved both the front end development phase and execution:
In this case, the survey has an additional section about *Execution and operation.*

The full survey will take about an hour to complete. You can choose to interrupt the survey by simply closing the internet page. To continue, please reopen the link in the e-mail (using the same computer and same browser since cookies are used to restore the link to your data). While filling in the survey, you can use the "next" and "previous" buttons of this application to navigate to previous answers (lower corner left). Please do not use your web browser to navigate between the different pages. Data is stored as soon as you progress to the next page.

Confidentiality of data
No company name, nor any respondent's name will explicitly be asked for. All results will be analyzed anonymously and future publications regarding this research will never make any project data, company or person traceable.

Thank you in advance for your kind cooperation in this research.

Hans Bakker, Marian Bosch-Rekveldt, Marcel Hertogh, Maedeh Molaei
Infrastructure Design and Management Department

If you have any questions about this survey, please email Maedeh.molaei@tudelft.nl.

TU Delft Delft University of Technology

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Project characteristics:

1. For the project to be considered in this research:
   In what **industry sector** was this project performed?
   - Construction (real estate, etc)
   - Construction (urban / area development, etc)
   - Infrastructure (transportation e.g, rail, highway)
   - Energy
   - Food and pharma
   - Petrochemical
   - Other, please specify:

2. What was the total duration of the reference project (in months)?

3. In which country was the project located?

4. What was the size of the project under consideration in Million Euro (MEuro)?
   - less than 1 MEuro
   - Between 1 and 10 MEuro
   - Between 10 and 100 MEuro
   - Between 100 and 1000 MEuro
   - More than 1000 MEuro

5. What was the main physical deliverable of the project (e.g. Tunnel, Highway, Hydrocracker, Design specification, Office building, Report, ...)?

6. How could the type of this project best be characterised?
   - Greenfield construction project (a project that lacks constraints imposed by prior work)
   - Brownfield construction project (extension or redevelopment of the existing structure / facility / asset where there are already existing connections to the project site)
   - Maintenance project (e.g, of a plant)
   - Product development
   - Consultancy project
   - R&D project
   - Other please specify:

7. In what sector is your **project** executed?
   - Public
   - Private
   - Public and private
   - Do not know

8. How could the **urgency** of this project for your organization best be characterised?
   - High
   - Medium
   - Low
   - Do not know

People and organisation

9. What was **your company's** role in this project?

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- ○ Project owner/client
- ○ Managing contractor
- ○ (Engineering) Contractor
- ○ Subcontractor
- ○ Consultant
- ○ External project manager (on behalf of the owner / client)
- ○ External project manager (on behalf of the contractor)
- ○ Other, please specify: ______

10. What was your **own** role in this project?

- ○ Project manager
- ○ Project controls manager
- ○ Technical manager
- ○ Stakeholder manager
- ○ Contract manager
- ○ Project team member (like a (project) engineer, specialist, etc.)
- ○ Business representative (like a line manager, principal, project steering committee member, etc.)
- ○ Other, please specify: ______

11. What project phase were you personally involved in?

	Yes	No	Not applicable
Front-end development (initiation and concept development, ends with final investment decision)	○	○	○

12. Next to your company, which **other** parties were involved in the project (please note that multiple answers possible)?

- ☐ Joint venture partner(s)
- ☐ Consortium partner(s)
- ☐ Project developer
- ☐ Project owner/client
- ☐ Project end user
- ☐ Managing contractor
- ☐ (Engineering) Contractor(s)
- ☐ Subcontractor(s)
- ☐ Politics (local or national)
- ☐ Supplier(s)
- ☐ Other stakeholders, please specify: ______

13. How was the team consisting of **contractor(s) and project owner (client)** organised?

- ○ Client managed team (contractor not yet involved)
- ○ Integrated team at contractors' level, separate client's team
- ○ Single integrated team of contractor(s) and client
- ○ Multiple co-existing teams from contractor(s) and client
- ○ Other composition, please specify, ______

14. Before the project activities started, my company had, over the years, developed a relationship build on trust with:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	○	○	○	○	○
2	○	○	○	○	○
3	○	○	○	○	○
4	○	○	○	○	○
5	○	○	○	○	○
6	○	○	○	○	○
7	○	○	○	○	○
8	○	○	○	○	○
9	○	○	○	○	○
10	○	○	○	○	○
11	○	○	○	○	○

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15. The parties involved in the project had experience in the country where the project was executed:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	○	○	○	○	○
2	○	○	○	○	○
3	○	○	○	○	○
4	○	○	○	○	○
5	○	○	○	○	○
6	○	○	○	○	○
7	○	○	○	○	○
8	○	○	○	○	○
9	○	○	○	○	○
10	○	○	○	○	○
11	○	○	○	○	○

16. How many people were (approximately) involved in the project, in total, over all participating companies, during **front end development phase** (in headcounts)?

	Less than 10	Between 10-100	Between 100-1000	More than 1000	Not applicable	Do not know
People involved in the **front end development (prior to final investment decision)**	○	○	○	○	○	○

17. What was the total number of work sites, different nationalities and languages during the **front-end development phase** of this project?

	1	2	3	4	4 or more	Do not know
Number of work sites (locations/offices) including contractor locations during **front end development phase**	○	○	○	○	○	○
Number of different nationalities involved in the project during **front end development phase**	○	○	○	○	○	○
Number of different languages (written and spoken) used in the project team for work or work related communication during **front end development phase**	○	○	○	○	○	○

18. For collaboration, relational attitudes from **client and contractor at senior/company level** are important.

In my view, senior management and business representatives:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Not applicable	Do not know
were committed to this project and supported the project team	○	○	○	○	○	○	○
Exhibited trust towards project the team	○	○	○	○	○	○	○
Expressed honesty and openness in the interactions with the project team	○	○	○	○	○	○	○
Delegated authority to the project manager for decision making	○	○	○	○	○	○	○
Collaborated closely with the project manager	○	○	○	○	○	○	○

19. For collaboration, team work quality at **team level** (members of the owner team & contractor team) is important.

Please review how you experienced the following statements in your project:

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree	Not applicable	Do not know
Team members shared a belief that they will perform their roles and protect the interests of each other	○	○	○	○	○	○	○
Team members had a sense of belonging to the team	○	○	○	○	○	○	○
Team members helped and supported each other in carrying out their tasks	○	○	○	○	○	○	○
Members of team exhibited motivation to maintain the team	○	○	○	○	○	○	○
Project team put their best on joint efforts	○	○	○	○	○	○	○
Team members were committed to the team tasks	○	○	○	○	○	○	○

20. Please review the following statements with regard to the "**project manager**" of this project:

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	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Not applicable	Do not know
The foreseen complexity of this project was taken into account when selecting the project manager for this project	○	○	○	○	○	○	○
The project manager had sufficient technical skills for managing this project	○	○	○	○	○	○	○
The project manager exhibited leadership and managerial competencies	○	○	○	○	○	○	○
The project manager was committed to the project	○	○	○	○	○	○	○
The project manager was involved early in the front end development phase	○	○	○	○	○	○	○

21. Did the project manager change during the front end phase?

- No Continue with question 103.
- Yes Continue with question 102.

22. To what extent to you agree with the following statement:

The project was positively impacted by changing the project manager / leader during the project.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree
- Not applicable
- Do not know

Front end development

Please note that front end development is defined as the project phases including design and planning phase which results in a final investment decision (FID).

23. Project goals have to be met while honoring the project constraints of cost, time and scope. Why a project is undertaken is related to the business goals and justified in the business case of a project. What was the **business justification** for the client / sponsor / owner / principal to undertake this project (please note that multiple answers possible)?

- To obtain growth (profit)
- For operational necessity
- To comply to legislation
- To build a long term relationship with the customer
- To gather knowledge and/or experience in the field
- To get introduced in a new market
- For the benefit of the general public
- To increase efficiency or effectiveness
- To reduce environmental impact
- To increase sustainability
- Other, please specify:
- Do not know

24. Has a business case been drafted?

- Yes
- Not yet, follows later Continue with question 108.
- No Continue with question 108.
- Don't know Continue with question 108.

25. Which of the following stakeholders have been involved in developing the **business case** (more than one answer possible):

- Local/regional government
- National government
- Joint Venture (or business) partner(s)
- Project/Finance/Business developer
- Line management of PM
- Project manager and his organisation
- Contractor(s)

- Supplier(s)
- Future users/inhabitants
- NGOs
- Other, please specify:

26. To what extent have the following stakeholders been involved in the development of the **business case**?

	Informed	Consulted	Participated
1	○	○	○
2	○	○	○
3	○	○	○
4	○	○	○
5	○	○	○
6	○	○	○
7	○	○	○
8	○	○	○
9	○	○	○
10	○	○	○
11	○	○	○

27. What was the outcome of the business case review?

- No business case review was performed
- The business case was clearly accepted
- The business case, although marginally positive/negative, was accepted
- The business case was negative but still accepted
- The business case had to be adjusted after discussion
- The business case was rejected

28. Which parties participated in the **front end development phase** of the project?

- Local/regional government
- National government
- Joint Venture (or business) partner(s)
- Project/Finance/Business developer
- Line management of PM
- Project manager and his organisation
- Contractor(s)
- Supplier(s)
- Future users/inhabitants
- NGOs
- Other parties, please specify:

29. Amongst the parties that took part in the **front end development** phase:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Not applicable
Project goals were clearly defined	○	○	○	○	○	○
Project goals were prioritised and were fully aligned	○	○	○	○	○	○
A clear project performance measurement system existed	○	○	○	○	○	○

30. What activities did you perform at the start of the project?

- Opportunity framing/Project kick-off
- Feasibility study
- Initial risk management
- Initial stakeholder assessment
- Option selection
- Environmental impact assessment
- Basis of Design
- Other, please specify:
- None of the above

31. Which of the following management processes were applied during the front end development phase of the project (early project phase)?

- Safety management

- ☐ Cost management
- ☐ Time management
- ☐ Scope management
- ☐ Human resource management
- ☐ Quality management
- ☐ Risk management
- ☐ Communication management
- ☐ Procurement management
- ☐ Integration management
- ☐ Stakeholder management
- ☐ Other processes, like: ______
- ☐ None of these processes

32. Please prioritise those management processes that were used in **front end development** phase of the project:

	First priority	Second priority	Third priority	Fourth priority	Fifth priority
1	○	○	○	○	○
2	○	○	○	○	○
3	○	○	○	○	○
4	○	○	○	○	○
5	○	○	○	○	○
6	○	○	○	○	○
7	○	○	○	○	○
8	○	○	○	○	○
9	○	○	○	○	○
10	○	○	○	○	○
11	○	○	○	○	○
12	○	○	○	○	○
13	○	○	○	○	○

33. In my view, the project was driven by the following criteria (value drivers):

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Not applicable
Within budget	○	○	○	○	○	○
Within schedule	○	○	○	○	○	○
Meeting specifications	○	○	○	○	○	○
No accidents	○	○	○	○	○	○
Client satisfaction	○	○	○	○	○	○
Contractor satisfaction	○	○	○	○	○	○
Team satisfaction	○	○	○	○	○	○
End user satisfaction	○	○	○	○	○	○
Flawless start of utilisation/operation	○	○	○	○	○	○
Sustainability considerations	○	○	○	○	○	○
Business success	○	○	○	○	○	○
Preparing for the future	○	○	○	○	○	○

34. One way to look at the complexity of the project is to distinguish technical, organizational and external complexity.

At what level would you rate these complexity categories and their influence on the **front end development** phase on a scale from 1 (very low) to 5 (very high):

	1 (very low)	2 (low)	3 (moderate)	4 (high)	5 (very high)	Not applicable	Do not know
Technical complexity (related to goals, scope, tasks, innovation, and technical risk)	○	○	○	○	○	○	○
Organizational complexity (related to resources, project team, interfaces, trust, and organizational risk)	○	○	○	○	○	○	○
External complexity (related to stakeholders, location, market conditions, political influence, and environmental risk)	○	○	○	○	○	○	○

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35. We consider the **Final Investment Decision (FID)** as the final milestone in "front end development". At this point, the decision is taken whether or not to proceed to the execution phase.

At FID, not all scope might be known. What percentage of the scope **was identified at FID** and to what extent was this changed compared to the initial scope at Business Case approval?

	0%	1-20%	21-40%	41-60%	61-80%	81-99%	100%	Do not know
Percentage of the scope known at **FID**.	○	○	○	○	○	○	○	○
Percentage of budget modification due to scope changes since **Business Case approval**.	○	○	○	○	○	○	○	○

36. Were the following activities with regard to start-up/operation initiated?

	Front end development	Not applicable
Involvement of operators/future users	○	○
Development of operating procedures	○	○
Emergency response training	○	○
Subsystem acceptance	○	○
Involvement of asset manager	○	○

Control and management

37. Does your company use a structured stage-gated approach throughout the project lifecycle?

- ○ Yes
- ○ No
- ○ Do not know

38. What project management standard was used in the project? Please select the most dominant standard.

- ○ No standard was used
- ○ APM
- ○ IPMA / ICB
- ○ PMI/PM-BoK
- ○ Prince2
- ○ ISO21500
- ○ Company specific
- ○ Other, please specify: ______

39. Which of the following statements best describes the project management methodologies applied in this project?

- ○ A comprehensive and standardized project management methodology was applied.
- ○ When necessary, the missing aspects of the project management methodology were supplemented by the project manager.
- ○ Only relevant aspects of the project management methodology were applied by the project manager.
- ○ Other, please explain your answer: ______

40. Literature indicates a number of best practices and value improving practices (VIPs) to be applied on top of the standard practices. We have selected the ones most relevant for project management.

Please answer how often you performed the following activities in **front end development phase** of this project:

	Front end development
Technology selection	○ None ○ Only once ○ Weekly

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(A systematic process to select the best technology options that meet the business objectives and improve competitive advantage)	Every two weeks Monthly Quarterly Annually Not applicable Do not know
Constructability review (Analyzing the design to ensure that the facilities can be built in a manner that minimises construction cost while maintaining standards of safety, quality and schedule reduce costs/time)	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know
Design-to-capacity (Evaluating the maximum capacity of each major piece of equipment, action is taken to reduce unnecessary excess capacity that is identified)	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know
Value engineering (A disciplined method used during design aimed at eliminating or modifying items that do not add value to meeting business needs)	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know
Goal-setting and alignment (Identifying the goals and opportunities for the project and aligning these with the parties involved)	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know
Operations implementation planning (Up front planning to improve the probability of achieving a flawless start of operation by involving future users)	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know

41. Looking at different control and management processes in more detail, what practices did you apply regarding **team building** in front end development of this project and how often?

	Front end development
Joint social events (like drinks, bbq, sports, etc)	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know
	None Only once

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Work related **informal** joint activities (like lunch and learn, lectures, etc)	Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know
Work related **formal** joint activities (like joint team meetings, workshops, etc)	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know
Feedback on individual/team performance	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know
Training programs (required skills for the project, communication skills, and team development)	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know
Establishing of roles and expectations of the team members	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know
Joint problem solving/trouble shooting sessions for developing and evaluating action plans by the team members	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know

42. What practices did you apply regarding **risk management** in front end development phase of this project and how often?

	Front end development
Development of risk register including mitigation plan	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know
	None

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Prioritization of risks based on the risk assessment matrix	Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know
Updating the risk register (including mitigation plan)	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know
Specific attention for opportunities in order to seize them	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know
Joint risk management sessions with client, contractor(s), and other main stakeholders	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know

43. What practices did you apply regarding **lessons learned** in front end development phase of this project and how often?

Check for applicable lessons from previous projects	
Thorough documentation of the project for future reference	
Capture lessons learned from this project	

Organise joint lessons learned sessions with both client and contractor(s)	
Distribute lessons learned from this project to other projects	
Check deliverables against the business case	

44. With regard to **progress monitoring**, what practices did you apply in front end development of this project and how often?

	Front end development
Track the progress of project performance	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know
Report the overall project progress to the client	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know
Incorporate the result of the performance assessment for continous improvement	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know

45. Looking at processes which you followed for **quality management**, what practices did you apply in front end development phase of the project and how often?

	Front end development
Measure the project performance	None Only once Weekly Every two weeks Monthly Quarterly

	Annually Not applicable Do not know
Quality audit with regard to **design conformance** (meeting the specifications of the product)	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know
Quality audit with regard to **service conformance** (process conformance)	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know
Self-assessment of project team members	None Only once Weekly Every two weeks Monthly Quarterly Annually Not applicable Do not know

46. What practices did you apply for **health, safety and environment (HSE) management** in front end development phase of the project?

Report of health and safety records

Environmental assessment

47. What **other** management activities have you performed in the project, next to the application of the standard project management processes, the value improving and best practices?

48. For your project, please indicate the availability of the following resources & skills:

Technical skills of the client / owner representatives involved in the project

Project management skills of the client /owner representatives involved in the project

Technical skills of the contractor representatives involved in the project

Project management skills of the contractor representatives involved in the project

Skilled workers

Materials and equipment

49. Please review the following statements regarding the financial situation in this project:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Not applicable	Do not know
Adequate budget was available from the financiers	○	○	○	○	○	○	○
Financial resources were available in time during front end development phase	○	○	○	○	○	○	○

50. In your assurance process, to what extent do you check the completion of the deliverables in terms of:

	Not at all	Little	Substantially	Completely	Not applicable
1	○	○	○	○	○
2	○	○	○	○	○
3	○	○	○	○	○
4	○	○	○	○	○
5	○	○	○	○	○
6	○	○	○	○	○
7	○	○	○	○	○
8	○	○	○	○	○
9	○	○	○	○	○
10	○	○	○	○	○
11	○	○	○	○	○
12	○	○	○	○	○

51. Did you have to do rework in front end development due to either design flaws or failing quality?

	None	Very few	Some	Substantial
Cost of rework due to **design flaws**	○	○	○	○
Cost of rework due to **failing quality**	○	○	○	○

52. What was the main contract in the front end phase of the project?

53. The following statements address the aspects related to some of the management and control processes, including quality management, contracting (or tendering if the contracting has not yet started) and information sharing.

Please indicate for each statement the answer that applies best to your project:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Not applicable	Do not know
Quality management							
Formal quality management systems and procedures were developed for the project team before the execution phase							
Contractor(s) and supplier(s) have been supported by a structured training process with regard to the established quality management systems							
Quality audit procedures have been established covering the **design conformance** (meeting specifications of the product)							
Quality audit procedures have been established covering the **service conformance** (service compliance)							
A high-quality project brief including the output specifications will be used for the tendering process							
Contracting (Tendering)							
Technical capability of the (sub)contractor(s) will be taken into account in selecting the (sub)contractor(s)							
Project management capability of the (sub)contractor(s) will be taken into account in selecting the (sub)contractor(s)							
Financial capability of the (sub)contractor(s) will be taken into account in selecting the (sub)contractor(s)							
Risks will be shared and allocated proportionally among the parties, allowing the capable party to bear them							
Cooperation with (sub)contractors will be supported by the main contract							
Contract documentation will be comprehensive							
Responsibilities of the parties will be clearly defined in the contract							
Information sharing between project parties							
Required information was disseminated in time by various parties							
Clear communication channels were present for information sharing							

54. The effort we will spend in a **next project** on the following processes/activites will probably be:

	Less	Equal	More	Not applicable
Team building activities				
Risk management processes				
Lessons learned processes				
Progress monitoring				
Quality management				
HSE management				
Stakeholder management				
Contract management				

55. Reflecting upon the general project management approach: what are your main three activities that you would do differently in a next similar project?

Activity 1:

Activity 2:

Activity 3:

56. Looking at client / owner involvement during the project, what is your view on the following statements?

15

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Not applicable	Do not know
Client / owner representatives involved regularly in the front end development phase and in defining project goals and specifications							
The frequency and intensity of the interactions with client / owner representatives were sufficient							
Client / owner representatives had sufficient technical and managerial skills							

57. Was the external benchmarking carried out for comparing the outcome of this project with that of similar projects within the industry at final investment decision (FID)? If yes, please indicate what the result was:

- No industry benchmarking was performed Continue with question 139.
- The project scored above industry average
- The project scored equal to industry average
- The project scored below industry average
- Do not know / Not applicable Continue with question 139.

58. Looking more specifically at the external benchmarking carried out for this project, please explain the most positive and negative finding.

Most positive finding:

Most negative finding:

Project (front end development) result

59. Please reflect on the targets set at the start of the project. In my view, the project was successful in terms of:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Not applicable
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						

60. Please indicate for each proposition the answer that applies best to this project:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Not applicable	Do not know
The client was satisfied with the project results							
There was uncertainty in the technical methods to be applied							
The project suffered from lack of political support in the country where it was located							
Social situation was unstable where the project was located							
The project had to deal with volatile economic environment (such as exchange rates, raw material pricing, oil prices, unit labor costs, etc).							
The project faced problems with climatic conditions and ecological environment where the project was located							
The project site location was in a remote area							

16

For this project, there was pressure from the business department in my company to deliver **cheaper**	○	○	○	○	○	○	○
For this project, there was pressure from the business department in my company to deliver **faster**	○	○	○	○	○	○	○
The project was to be run in a highly competitive market	○	○	○	○	○	○	○
There was clear understanding of project complexity throughout the project	○	○	○	○	○	○	○
There was lack of legal/regulatory framework to support the project procurement	○	○	○	○	○	○	○

Company profile

61. What is the organisation structure of the company you are working in?
- ○ Project-based organization
- ○ Functional organisation
- ○ Matrix organisation
- ○ Other, please specify:

62. What is the dominant sector your company is active in?
- ○ Public (government)
- ○ Private
- ○ Public Private Partnership
- ○ Other, please specify:

63. To what extent the project manager is responsible for:

	Not at all	Joint responsibility
Human resources	○	○
Selection of project management methodologies	○	○

Personal profile

64. What is your educational background?
- ☐ Business
- ☐ Engineering
- ☐ Science
- ☐ Other, please specify:

65. What is your highest level of education?
- ○ Secondary vocational education ("MBO"-like in the Netherlands)
- ○ Bachelor
- ○ Master
- ○ PhD
- ○ Other, please specify

66. How many years of working experience do you have?
- ○ Less than 5 years
- ○ Between 5 and 10 years
- ○ Between 10 and 15 years
- ○ Between 15 and 20 years
- ○ Between 20 and 25 years
- ○ Between 25 and 30 years
- ○ More than 30 years

67. How many years of experience do you have as a **project manager**?
- ○ No experience
- ○ Less than 5 years
- ○ Between 5 and 10 years
- ○ Between 10 and 15 years

- ○ Between 15 and 20 years
- ○ Between 20 and 25 years
- ○ More than 25 years

68. Are you a certified project manager?
- ☐ No
- ☐ No, but I did follow at least one course
- ☐ Yes, IPMA level D
- ☐ Yes, IPMA level C
- ☐ Yes, IPMA level B
- ☐ Yes, IPMA level A
- ☐ Yes, PMI - PMP
- ☐ Yes, PRINCE2 Foundation
- ☐ Yes, PRINCE2 Practitioner
- ☐ Yes, APM qualifications, please specify
- ☐ Yes, other, please specify

69. May we contact you for a subsequent in-depth interview, if required? If yes, please provide your email adress:

You have reached the end of this survey.

Thank you very much for your effort and kind cooperation!

Appendix D. Survey demographics (Chapter 4)

Characteristic	Count	%	Characteristic	Count	%
Industry sector of the project			***Educational background***		
Construction	26	25.0	Business	15	12.4
Infrastructure	35	33.7	Engineering	88	72.7
Process	43	41.3	Science	18	14.9
Total	104	100	Total (more than one answer possible)	121	
Project sector			***Level of education***		
Public	49	47.1	Secondary vocational education	4	3.8
Private	40	38.5	Bachelor	39	37.5
Public and private	14	13.5	Master	56	54
Total	103	99.1	PhD	5	4.8
Missing	1	0.9	Total	104	100
Role of the company in the project			***Work experience***		
Owner / client	55	52.9	Less than 5 years	2	1.9
Contractor	25	24.0	Between 5 and 10 years	8	7.7
Sub-contractor	3	2.9	Between 10 and 15 years	24	23.1
Consultant	21	20.2	Between 15 and 20 years	24	23.1
Total	104	100	Between 20 and 25 years	29	27.9
			Between 25 and 30 years	13	12.5
			More than 30 years	4	3.8
Role of the respondent in the project			Total	104	100
Project manager	75	72.1			
Project controls manager	2	1.9			
Technical manager	10	9.6	***Work experience as a project manager***		
Stakeholder manager	2	1.9	No experience	2	1.9
Contract manager	4	3.9	Less than 5 years	8	7.7
Project team member	5	4.8	Between 5 and 10 years	24	23.1
Business representative	2	1.9	Between 10 and 15 years	24	23.1
			Between 15 and 20 years	29	27.9
Other (including project director and consultant)	4	3.9	Between 20 and 25 years	13	12.5
			More than 25 years	4	3.8
Total	104	100	Total	104	100

Appendix E. Items with missing values in the survey (Chapter 4)

Appendix E. 1: Frequency and percentage of missing data ("not applicable" and "do not know" options for the aspect front-end activities

No.	Front-end activities	Construction (N= 26)						Infrastructure (N=35)						Process (N=43)						Total (N=104)	
		Frequency of "not applicable" responses	Percentage of "not applicable" responses	Frequency of "do not know" responses	Percentage of "do not know" responses	Total missing values	Percentage of missing values	Frequency of "not applicable" responses	Percentage of "not applicable" responses	Frequency of "do not know" responses	Percentage of "do not know" responses	Total missing values	Percentage of missing values	Frequency of "not applicable" responses	Percentage of "not applicable" responses	Frequency of "do not know" responses	Percentage of "do not know" responses	Total missing values	Percentage of missing values	Total missing values	Total percentage of missing data across sectors
1	Technology selection	3	11.5	2	7.7	5	19.2	10	31.4	4	11.4	14	40.0	2	0	1	4.4	3	7.0	22	21.2
2	Constructability review	1	3.8	1	3.8	2	7.7	4	11.4	5	17.1	9	25.7	0	0	0	0	0	0.0	11	10.6
3	Design-to-capacity	2	7.7	4	15.4	6	23.1	11	31.4	6	17.1	17	48.6	6	13.3	2	4.4	8	18.6	31	29.8
4	Value engineering	4	15.4	1	3.8	5	19.2	9	28.6	2	5.7	11	31.4	1	2.2	2	4.4	3	7.0	19	18.3
5	Operations implementation planning	3	11.5	4	15.4	7	26.9	7	20	4	11.4	11	31.4	2	4.4	1	2.2	3	7.0	21	20.2
6	Training programs	3	11.5	0	11.5	3	11.5	10	28.6	0	0	10	28.6	5	11.1	2	4.4	7	16.3	20	19.2
7	Organise joint lessons learned sessions with both client and contractor(s)	2	7.7	2	7.7	4	15.4	7	20	2	8.6	9	25.7	2	6.7	1	2.2	3	7.0	16	15.4
8	Disseminate lessons learned from this project to other projects	1	3.8	2	7.7	3	11.5	1	2.9	4	14.3	5	14.3	3	8.9	3	6.7	6	14.0	14	13.5
9	Check deliverables against the business case	3	11.5	3	11.5	6	23.1	6	17.1	4	11.4	10	28.6	2	4.4	3	8.9	5	11.6	21	20.2
10	Incorporate the result of the performance assessment for continuous improvement	1	3.8	3	11.5	4	15.4	4	11.4	3	5.7	7	20.0	2	6.7	5	13.3	7	16.3	18	17.3
11	Quality audit with regard to service conformance	4	15.4	4	15.4	8	30.8	7	22.9	2	5.7	9	25.7	1	2.2	1	2.2	2	4.7	19	18.3
12	Self-assessment of project team members	3	11.5	3	11.5	6	23.1	6	20	7	17.1	13	37.1	1	4.4	1	4.4	2	4.7	21	20.2
13	HSE management	3	11.5	0	0	3	11.5	8	25.7	5	14.3	13	37.1	3	6.7	0	0	3	7.0	19	18.3
14	Environmental impact assessment	2	7.7	1	3.8	3	11.5	8	25.7	7	20	15	42.9	4	11.1	0	0	4	9.3	22	21.2

The grey cells show the percent values higher than 10%

Appendix E. 2: Frequency and percentage of missing data (“not applicable” and “do not know” options for the aspect project management principles)

No.	Project management principles	Construction (N= 26)						Infrastructure (N=35)						Process (N=43)						Total (N=104)	
		Frequency of “not applicable” responses	Percentage of “not applicable” responses	Frequency of “do not know” responses	Percentage of “do not know” responses	Total missing values	Percentage of missing values	Frequency of “not applicable” responses	Percentage of “not applicable” responses	Frequency of “do not know” responses	Percentage of “do not know” responses	Total missing values	Percentage of missing values	Frequency of “not applicable” responses	Percentage of “not applicable” responses	Frequency of “do not know” responses	Percentage of “do not know” responses	Total missing values	Percentage of missing values	Total missing values	Total percentage of missing data across sectors
1	Using of high-quality project brief including the output specifications for the tendering processes	3	11.5	3	11.5	6	23.1	2	8.6	4	11.4	6	17.1	5	8.9	5	11.1	10	23.3	22	21.2
2	Proportional risk sharing among the parties	3	11.5	2	7.7	5	19.2	0	2.9	4	11.4	4	11.4	6	11.1	1	4.4	7	16.3	16	15.4
3	The contract supports the cooperation with (sub)contractors	3	11.5	2	7.7	5	19.2	0	0	4	11.4	4	11.4	7	13.3	1	4.4	8	18.6	17	16.3
4	Comprehensive contract documentation	2	7.7	2	7.7	4	15.4	0	0	4	11.4	4	11.4	2	2.2	1	4.4	3	7.0	11	10.6
5	Considering the technical capability of the (sub)contractor(s) in the selection procedures	2	7.7	2	7.7	4	15.4	0	2.9	4	11.4	4	11.4	4	6.7	1	4.4	5	11.6	13	12.5
6	Considering the project management capability of the (sub)contractor(s) in the selection procedures	2	7.7	3	11.5	5	19.2	0	0	5	14.3	5	14.3	4	6.7	1	4.4	5	11.6	15	14.4
7	Considering the financial capability of the (sub)contractor(s) in the selection procedures	2	7.7	2	7.7	4	15.4	1	5.7	4	11.4	5	14.3	5	8.9	4	11.1	9	20.9	18	17.3
8	Technical skills of the contractor	9	34.6	1	3.8	10	38.5	10	31.4	1	2.9	11	31.4	7	13.3	1	2.2	8	18.6	29	27.9
9	Project management skills of the contractor	11	42.3	2	7.7	13	50.0	11	34.3	0	0	11	31.4	9	20	1	2.2	10	23.3	34	32.7
10	Early involvement of the user in the front-end development	2	7.7	2	7.7	4	15.4	2	5.7	1	2.9	3	8.6	4	8.9	0	0	4	9.3	11	10.6
11	Use of an integrated contract	0	0	13	50	13	50.0	0	0	14	40	14	40.0	0	0	1	2.2	1	2.3	28	26.9
12	Percentage of the scope known at FID	0	0	4	15.4	4	15.4	0	0	11	31.4	11	31.4	0	0	2	4.4	2	4.7	17	16.3
13	Legal/regulatory framework to support the project procurement	0	0	2	3.8	2	7.7	1	2.9	1	2.9	2	5.7	6	13.3	2	4.4	8	18.6	12	11.5

The grey cells show the percent values higher than 10%

Appendix F. Factor loadings and descriptive statistics of items in the questionnaire (Chapter 4)

Appendix F. 1: Assessment of factor loadings for front-end activities using oblique rotation

Factor					
	1. Risk management	2. Embracing and capturing lessons learned	3. Team building	4. Setting expectations	5. Monitoring and quality management
Cronbach Alpha	0.89	0.76	0.73	0.68	0.76
A2	0.90				
A1	0.88				
A3	0.86				
A6		0.80			
A4		0.74			
A5		0.73			
A14			0.89		
A12			0.73		
A13			0.68		
A11				0.82	
A15				0.69	
A8					0.79
A7					0.78
A9					0.66
A10					0.57

Appendix F. 2: Assessment of factor loadings for project management principles using oblique rotation

Factor	6. Collaboration between client and contractor	7. Top management support	8. Project manager competency	9. Setting project goals	10. Information sharing	11. Client involvement	12. Client competency
Cronbach alpha	0.92	0.87	0.84	0.72	0.80	0.70	0.74
E2	0.83						
E3	0.80						
E1	0.80						
E6	0.79						
E5	0.79						
E4	0.76						
E21		-0.86					
E22		-0.83					
E20		-0.69					
E24		-0.67					
E23		-0.66					
E7			-0.86				
E9			-0.83				
E8			-0.81				
E10			-0.73				
E11				0.79			
E13				0.76			
E12				0.75			
E14					-0.87		
E15					-0.82		
E18						0.76	
E19						0.75	
E16							0.88
E17							0.86

Appendix F. 3: Descriptive statistics of items of front-end activities and project management principles

	Item ID	Item definition	Mean	Standard deviation
Front-end activities	A2	Development of risk register including mitigation plan	3.55	1.68
	A1	Prioritisation of risks based on the risk assessment matrix	3.48	1.80
	A3	Updating the risk register (including mitigation plan)	3.77	1.72
	A6	Thorough documentation of the project for future reference	2.71	1.60
	A4	Check for applicable lessons from previous projects	2.55	1.42
	A5	Capture lessons learned from this project	2.47	1.35
	A14	Joint social events	2.84	1.49
	A12	Work related informal joint activities	3.27	2.18
	A13	Joint problem solving/trouble shooting sessions for developing and evaluating action plans by the team members	4.02	2.02
	A11	Establishing of roles and expectations of the team members	2.88	1.57
	A15	Feedback on individual/team performance	3.69	1.86
	A8	Measure the project performance	4.13	1.86
	A7	Report the overall project progress to the client	4.78	1.29
	A9	Track the progress of project performance	5.19	1.64
	A10	Quality audit with regard to design conformance (meeting the specifications of the product)	3.47	1.67
Project management principles	E2	Team members (client & contractor) had a sense of belonging to the team	4.04	0.79
	E3	Team members helped and supported each other in carrying out their tasks	3.91	0.86
	E1	Team members shared a belief that they will perform their roles and protect the interests of each other	3.99	0.83
	E6	Team members were committed to the team tasks	4.13	0.75
	E5	Project team put their best on joint efforts	4.10	0.73
	E4	Members of team exhibited motivation to maintain the team	3.90	0.80
	E21	Senior management exhibited trust towards project the team	4.04	0.90
	E22	Senior management expressed honesty and openness in the interactions with the project team	4.01	0.90
	E20	Senior management were committed to this project and supported the project team	4.23	0.75
	E24	Senior management collaborated closely with the project manager	4.01	0.87
	E23	Senior management delegated authority to the project manager for decision making	4.09	0.86
	E7	The project manager exhibited leadership and managerial competencies	4.13	0.85
	E9	The foreseen complexity of this project was takin into account when selecting the project manager for this project	4.13	0.89
	E8	The project manager had sufficient technical skills for managing this project	4.11	0.84
	E10	The project manager was committed to the project	4.53	0.64
	E11	Project goals were clearly defined	4.18	0.73
	E13	A clear project performance measurement system existed	3.21	1.08
	E12	Project goals were prioritised and were fully aligned	3.79	0.82
	E14	Required information was disseminated in time by various parties	3.69	0.90
	E15	Clear communication channels were present for information sharing	3.90	0.89
	E18	Client/owner representatives involved regularly in the front-end development phase and in defining project goals and specifications	4.27	0.81
	E19	The frequency and intensity of the interactions with client/owner representatives were sufficient	3.99	0.83
	E16	Sufficient technical skills were available from the client/owner representatives involved in the project	3.79	1.39
	E17	Project management skills were available from the client/owner representatives involved in the project	3.97	1.41

Appendix G. Survey results of cross-sectoral comparison of front-end activites and project management principles (Chapter 4)

Appendix G. 1: The results of Kruskal-Wallis test for factors considering industry sectors

Test factor	Mean Rank			Kruskal-Wallis H	df	Asymp. Sig.
	Construction	Infrastructure	Process			
Risk management	42.73	56.49	55.16	3.736	2	0.154
Embracing and capturing lessons learned	47.33	59.77	47.09	4.225	2	0.121
Team building	41.81	59.59	53.20	5.255	2	0.072*
Setting expectations	50.52	58.49	48.83	2.165	2	0.339
Monitoring and quality management	54.92	46.34	56.05	2.234	2	0.327
Collaboration between client and contractor	46.13	50.29	58.15	2.898	2	0.235
Top management support	44.77	47.84	60.97	5.984	2	0.050*
Project manager competency	50.04	47.53	58.03	2.634	2	0.268
Setting project goals	37.04	51.66	57.95	8.588	2	0.014*
Information sharing	54.44	52.88	47.43	1.242	2	0.537
Client involvement	50.62	46.17	58.79	3.735	2	0.155
Client competency	46.98	49.56	54.68	1.346	2	0.510

* The output of Kruskal-Wallis test is significant at the level of p-value= 0.10

Appendix G. 2:The results Kruskal-Wallis test for the items of front-end activities considering industry sector

Test item	Mean Rank			Kruskal-Wallis H	df	Asymp. Sig.
	Construction	Infrastructure	Process			
A2	45.87	52.86	55.08	1.650	2	0.438
A1	42.04	57.33	54.90	4.497	2	0.106
A3	42.54	56.04	55.64	4.071	2	0.131
A6	44.00	53.38	45.16	2.237	2	0.327
A4	40.25	60.02	46.16	8.212	2	0.016*
A5	47.08	51.14	47.51	0.403	2	0.817
A14	43.31	56.91	53.29	3.431	2	0.180
A12	36.33	58.23	48.99	9.017	2	0.011*
A13	44.73	51.50	49.55	0.857	2	0.651
A11	50.83	57.47	43.65	4.522	2	0.104
A15	44.02	52.32	49.39	1.226	2	0.542
A8	56.77	43.03	53.69	4.052	2	0.132
A7	51.23	43.62	58.05	6.068	2	0.048*
A9	48.42	47.75	55.33	1.649	2	0.439
A10	52.58	49.75	47.43	0.539	2	0.764

* The output of Kruskal-Wallis test is significant at the level of p-value= 0.10

Appendix G

Appendix G. 3: The results Kruskal-Wallis test for the items of project management principles considering industry sector

Test item	Mean rank			Kruskal-Wallis H	df	Asymp. Sig.
	Construction	Infrastructure	Process			
E2	47.23	51.31	56.65	2.008	2	0.366
E3	47.38	49.10	58.36	3.219	2	0.200
E1	49.46	51.56	53.84	0.424	2	0.809
E6	48.35	50.37	56.74	1.886	2	0.389
E5	44.58	49.04	60.10	6.013	2	0.049*
E4	44.72	52.43	55.88	2.744	2	0.254
E21	46.50	48.50	59.38	4.419	2	0.110
E22	45.88	47.24	57.10	3.538	2	0.170
E20	42.77	50.37	60.12	6.747	2	0.034*
E24	48.42	48.30	57.30	2.663	2	0.264
E23	25.00	35.00	43.00	4.669	2	0.101
E7	50.63	44.53	57.68	4.417	2	0.110
E9	40.69	49.77	55.79	4.792	2	0.091*
E8	50.46	49.01	56.57	1.607	2	0.448
E10	54.17	47.71	54.23	1.469	2	0.480
E11	41.92	52.80	54.06	3.725	2	0.155
E13	37.68	46.57	54.51	6.382	2	0.041*
E12	38.23	49.77	55.74	6.675	2	0.036*
E14	52.83	53.65	44.42	3.181	2	0.204
E15	52.80	51.84	49.25	0.324	2	0.850
E18	49.37	46.25	57.07	3.219	2	0.200
E19	51.23	47.09	57.67	2.913	2	0.233
E16	51.80	45.45	52.56	1.537	2	0.464
E17	42.02	53.04	52.38	3.430	2	0.180

* The output of Kruskal-Wallis test is significant at the level of p-value= 0.10

Appendix H. Multiple regression analysis and QCA results (Chapter 6)

Appendix H. 1: Models resulted by using best subset selection algorithm

Model number	Independent variables included
Model 1	Information sharing
Model 2	Model 1 + Project duration
Model 3	Model 2 + Client competency
Model 4	Model 3 + Collaboration between client & contractor
Model 5	Model 2 + Collaboration between client & contractor + Setting project goals + Setting expectations
Model 6	Model 4 + Monitoring and quality management
Model 7	Model 6 + Client competency
Model 8	Model 7 + Team building
Model 9	Model 8 + Project size
Model 10	Model 9 + Top management support
Model 11	Model 10 + Client involvement
Model 12	Model 11 + Risk management
Model 13	Model 12 + Embracing and capturing lessons
Model 14	Model 13 + Project manager competency

Appendix H. 2: Results of pairwise comparison (partial *F*-test) of the models resulted from the best subset selection

Pairwise comparison	Models	Residual sum of squares	p-value
Model 1 – Model 2	Model 1	48.727	0.011**
	Model 2	45.684	
Model 2 – Model 3	Model 2	45.684	0.053
	Model 3	43.685	
Model 3 – Model 4	Model 2	43.685	0.092
	Model 4	42.446	
Model 3 – Model 5	Model 3	43.685	0.184
	Model 5	42.200	
Model 2 – Model 5	Model 2	45.684	0.049**
	Model 5	42.200	
Model 5 – Model 6	Model 5	42.200	0.212
	Model 6	41.523	
Model 5 – Model 7	Model 5	42.200	0.188
	Model 7	40.753	
Model 5 – Model 8	Model 5	42.200	0.316
	Model 8	40.666	
Model 5 – Model 9	Model 5	42.200	0.397
	Model 9	40.431	

Appendix I. Individual experts' assessment of the statements resulted from the Nexcess model (Chapter 7)

In this appendix, a summary of the individual reflection of the experts on the proposed recommendations are presented.

Statement 1: Align the project management efforts between client and contractor.

The respondents acknowledged that the increasing complexity of projects calls for very close collaboration as well as binding contracts facilitating such collaborative arrangements. An oversight of what this collaboration entails should be captured in the execution strategy before starting with project execution. Aligning project efforts could also stimulate the discussions on project goals and interest between the parties which helps better understanding of each other's behaviour in the project. Expert I_4 disagrees with the given statement by explaining that this alignment could be only possible at "*the management or organisational level*". An explanation of this is that the collaboration between the contractor and client should be organised top-down, with legally binding contracts and by top management. The experts, however, mentioned that project management "effort" can be interpreted differently and more explanation on the exact definition of such efforts are required.

Statement 2: Provide clear and explicit communication channels for timely sharing (project) information among the collaborating parties, client and contractor.

Sharing and exchanging proper information would enhance and speed up the decision-making process by avoiding making bad decisions based on incomplete information. Information on various aspects such as safety, project progress, technical content, and manpower needs to be shared between project parties, both top-down and bottom-up, to ensure proper execution of the work. One of the challenges in practice, however, is that information is tampered with by parties to create a base for claims later in the project. In other words, opportunistic behaviour of the parties and lack of trust might jeopardize open information sharing. Another difficulty with open information sharing is the lack of willingness of the parties to act proactively in exchanging the information. To elaborate this, expert I_2 mentioned that "*some people in the team do not want to share (not real) confidential information".*

Statement 3: Top management from both sides (client and contractor) should support the project team and be committed to the project.

According to the experts, top management and their commitment would facilitate the development of governance for the project which should be embedded throughout the organisation. The executives from client and contractor should demonstrate their commitment to the values and the project teams by having regular meetings. This could enhance communication and mutual understanding on the values between the parties. In the same vein, the role of top management is crucial to prevent and solve the conflicts between the parties.

Statement 4: Assign the client representative with sufficient technical skills in the early phase of the project.

It is essential that the client representative(s) have the technical skills and capabilities including project planning, design, and specifications. It would help in blending the technical teams together by facilitating the knowledge exchange process with the other team. Furthermore, if the client does not have such technical skills, the contractor should be involved during the early stages of the new business development for assigning the project focal points. In the infrastructure sector, however, the views are slightly different from that of process industry when asked about this statement (the detailed explanation on this statement provided by the experts and not their views as can be seen from Figure 7.4). Expert I_5 shared this experience: "***contractor needs to be able to discuss technical issues and ideas with the client. (…). Rijkswtatersaat (as the main client of the Dutch infrastructure projects) has underestimated this for a long period".***

Statement 5: Set aligned project goals and agree upon them with the project parties at the project kick-off.

Although alignment of the project goals is vital, the challenge is to set the goals reflecting the real drivers of the project stakeholders and the individual drivers of the parties involved. These goals and interests of the parties, however, are not easy to align. The parties pursue different goals and values, for instance, *"client wants to limit the spending of money, contractor will go for profit",* as expressed by expert I_1. Regular alignment sessions are also required to avoid derailments from the joint path to success (goals). A good example of such alignment sessions is the discussion on the "conditions of satisfaction" at the project kick-off and later monitor this on a monthly basis throughout the project, as mentioned by expert I_3. In practice, this alignment is often set late during the project execution which could negatively affect the project performance.

Statement 6: Actively perform expectation management within the project team(s).

Not actively performing expectation management would increase the risk of disengagement. Expectation management could facilitate the alignment of the team members by inviting them to work on the same goals and continue the journey together. It can also contribute to bringing the project goals together, as noted by expert I_1: "***since the project goals are not always the same, expectation management should be constantly followed***". In order to make those expectations clear, they should be translated into simple, understandable, and measurable terms for the project team.

Statement 7: To enhance collaboration, form the project team in an integrated manner, preferably there should be one single integrated team.

This statement was least agreed by the experts in the construction and infrastructure sector. The explanations given by the experts in these sectors show that they had difficulty applying it in the (current) practice. Instead, replicating similar functions at both sides (client and contractor) and assigning the tasks to them would be more efficient, according to the experts. Expert I_6 clarified it by this statement: "*mirroring the organisations is a more practical solution"*. Creating such an integrated project team seems to be challenging in practice and requires a strong mandate and obligations from both sides. Although organising an integrated project team might be valuable, it is not necessarily preferred in all project circumstances. According to the experts in this sector, organising such an integrated project team can be only optimal with the new forms of contractual and collaborative arrangements such as "bouwteam" and alliance.

Surprisingly, all the experts in the process industry did acknowledge the integration of project teams in their projects. Thus, it seems to be a more common practice in the process industry compared to the construction sector. Such an integration facilitates the existence of short communication lines between all members of the project team and it could speed up the decision-making processes. An integrated project team is a blend of team members from both client and contractor without any difference between them. Expert P_2 illustrated this by stating that: "*fully integrated teams only see difference in the paycheck coming from different directions!*". One of the obstacles of forming a seamless project team is the contractual arrangements and non-alignment of the commercial goals, as experienced by the experts.

Statement 8: Discuss the client's demands throughout the project via formal and informal interactions.

Experts in both sessions expressed that formal as well as informal communication with the client could enable timely decision making and grasping the actual demands of the client. Although the client has a prominent role in defining the project demands, in many cases they not have a precise view of what they exactly need to reach their goals. Furthermore, those demands for the contractor might not be as clear as they are for the client leading to misinterpretation of demands. One practice, mentioned by ***expert I_5,*** which could help in increasing the clarity of demands is "verification" and "validation" through a formal and informal setting in early stages of the project. Expert P_2 summed this up by stating that: ***"better to "pre-cook" conversations about demands. It avoids surprises and unwanted ramifications. Translations (interpretations) of demands is more important".*** Specifically, the experts highlighted the importance of informal interactions and putting extra effort to get information to answer the following questions: why client demands it and how it can be achieved. Additionally, the client being consistent in their high-level demands is crucial, otherwise changing them along the way would confuse the stakeholders.

Statement 9: Determine the intensity of application of progress reporting and quality management activities and further perform such activities with the integrated team.

Transparency and open communication in performing progress reporting and quality management activities is crucial, according to the experts. A practical example of such an integrated progress screening session was given by expert P_2: "*digital Obeya rooms help to set the course of action effectively together".* Obeya rooms originate from the lean approach and provide an environment for storing and sharing all the necessary information across the disciplines (Aasland & Blankenburg, 2012). Project characteristics, such as complexity and speed of the project, determine the intensity of progress reporting and quality management activities. Usually the client "dictates" the form and intensity of such practices and the contractor performs the bare minimum to satisfy the client. This, however, can be improved by performing integrated progress reporting as well as joint testing and quality results.

Statement 10: Determine the intensity of application of lessons learned related activities and further perform such activities with the integrated team.

Lessons learned activities usually have a very low intensity in practice and it is only applied at the end of a project phase, according to the experts. Even when it is applied, it is often applied internally and not jointly. Sharing lessons among the client and contractor, however, requires more effort from both sides. To do so, the mindset of practitioners with regard to lessons learned needs to be changed in such a way that the parties could openly express those lessons and experiences during the project. To illustrate this, expert P_2 mentioned that: *"consider even "pre-mortem" sessions to translate (the) actions of earlier lessons learned. Avoid that lessons learned are seen as liability/risk".* Additionally, those lessons learned should also be captured and transferred at different levels, bottom-up as well as top-down.

Statement 11: Determine the intensity of application of team building related activities and further perform such activities with the integrated team.

Joint team building activities in the form of joined leisure activities, formal team building workshops, external team coaching, and improve the team results at different stages throughout the project can be seen as a means to celebrate success. The real definition of joint team building, however, can be much broader and it entails joint efforts on the project tasks. As explained by the experts, the intensity of application of team building activities varies depending on the duration of the project (more important for long-term projects), newness of the team members with each other, and the real challenge at hand (more complex projects call for more team building activities).

Statement 12: Determine the intensity of application of risk management related activities and further perform such activities with the integrated team.

Risk management activities could be done internally as well as externally. Usually external risk management sessions (or joint sessions with both client and contractor) are applied less frequently compared to those which are organised internally. In the opinion of some practitioners, however, risk management should not be applied separately by the parties. As noted by expert P_2*"avoid tendency that risk management is seen as an internal activity to protect own interest. It should be a joint attempt with joint (assigned) mitigation measures*". Thus, risk management requires that parties are working closely with each other. In addition, it can be seen as an iterative activity which should involve all levels including the strategic level.

Linking statement 12 to statement 9, if risk management can be viewed as an important part of reporting, performing joint reporting automatically would lead to joint risk management.

It seems that, however, "joint" risk management is a more common practice in the process industry compared to the construction projects. The reason lies probably in the contractual issues regarding the tendering in the construction and infrastructure sectors. As a result, contractor might not have access to all those risks before the contract award for preparing his tender offer. Another reason given as a barrier for performing joint risk management is the lack of consistency on the level of details on the risks.

Statement 13 (only asked from the experts in the construction): Enable an integrated approach of project management. This means that the key stakeholders including the client, contractor, suppliers, end users, and asset managers should be involved early in the project.

Having all these key stakeholders get on board early during the project kick-off seems to be challenging. One barrier for such an integrated approach was given by expert I_6: "*Not all the stakeholders are interested and are willing to be involved early in the project. And sometimes their interests might be changed throughout the project".* According to the experts, suppliers and end users are often involved later in the project during the execution. Even, at the client side the operator and asset managers are not always fully assigned early in the project. Another challenge is that the interaction between all these "key stakeholders" is not always direct. For instance, as noted by expert I_5 *"end users and asset managers do not often interact with the contractor. This interaction is usually via the client"*.

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Maedeh Molaei,
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About the author

Maedeh Molaei was born in 1988 in Tehran, Iran. She studied Civil Engineering at the Iran University of Science and Technology. In 2013, she moved to the Netherlands to continue her Master in Construction Management and Engineering at Delft University of Technology. As part of her graduation, she performed a research at DSM where the application of lean and agile principles was explored during the front-end phase of a chemical plant. After her master studies, she worked as a consulting engineer in Iran and later as a market researcher in The Netherlands.

In February 2016, Maedeh started her PhD research in the Integral Design and Management section at the Faculty of Civil Engineering and Geosciences, TU Delft. During her PhD studies, she guided several students during their internship and master thesis research. She was also involved as a teacher assistant in the minor Project Management: from Nano to mega, since beginning of her PhD. Furthermore, she was also part of a team supporting the development of an MOOC in edX called Project Management of Engineering Projects: Preparing for Success.

She presented the results of her research at several national and international academic conferences. Her research interests include project success and performance, project evaluation, sustainability in project management, integrated project management, and (innovative) contracts.

Currently, Maedeh is working as a post-doctoral researcher in the Public Commissioning group at the Faculty of Architecture and the Built environment at the same university where she pursues her passion for research in managing projects.

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Scientific Contributions

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Successful delivery of projects is the ultimate goal of many organisations. What is observed in practice, however, is that projects do not usually follow what is recommended in literature. Moreover, the dynamic nature of projects calls for continuous adjustments regarding the required project management practices contributing to performance. Therefore, this research aims at evaluating the current practice of managing engineering projects and investigating potential learning points across two main industry sectors: construction (including infrastructure) and process industry. The main output of this research is a model called “Nexcess model” that could help in improving project performance by providing practical recommendations. The model offers a space for interaction in which practitioners can understand the extent to which they can contribute positively to the performance by promoting an integrated approach.