Flexibility in project management
Towards improving project performance

Jalali Sohi, Afshin

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FLEXIBILITY IN PROJECT MANAGEMENT

TOWARDS IMPROVING PROJECT PERFORMANCE

Afshin Jalali Sohi

Stellingen behorende bij het proefschrift

Flexibility in project management: towards improving project performance

Door Afshin Jalali Sohi

Dit proefschrift

1. Flexibiliteit gaat over durven vertrouwen (*hoofdstukken 6 en 8 van dit proefschrift*).
2. Flexibiliteit vereist structuur (*dit proefschrift*).
3. De bijklank van het woord 'Agile' staat succesvolle toepassing in de bouwsector in de weg (*hoofdstuk 3 van dit proefschrift*).
4. Hoewel professionals zeggen dat ze de voorkeur geven aan het omarmen van verandering, weerspiegelt hun praktijk dit niet (*hoofdstukken 6, 7 en 8 van dit proefschrift*).

Overige

5. Flexibiliteit gaat niet om het toenemen van de lusten, maar om het verdelen van de lasten (*Marco Eykelenboom, 2015*)
6. Het pakken van kansen vereist het onderkennen van complexiteit.
7. Een projectmanager zou vertraging moeten verwelkomen om waarde te vermeerderen.
8. Zoek niet naar hypes in projectmanagement, maar zoek naar een 'fit-for-purpose' benadering van projectmanagement.
9. Het agile principe 'werkende software boven projectdocumentatie' compliceert het leren van projecten.
10. Het onderzoeken van flexibiliteit vereist een flexibele aanpak, ondanks het vooraf stellen van enkele randvoorwaarden.

Deze stellingen worden opponeerbaar en verdedigbaar geacht en zijn als zodanig goedgekeurd door de promotor Prof. dr. ir M.J.C.M. Hertogh en copromotor Dr.ir. M.G.C. Bosch-Rekveldt.

Propositions accompanying the dissertation

Flexibility in project management: towards improving project performance

By Afshin Jalali Sohi

Own dissertation

1. Flexibility is about dare to trust *(chapters 6 and 8 of this dissertation)*.
2. Flexibility needs structure *(this dissertation)*.
3. In the construction industry the connotation of the word 'Agile' hinders its potential *(chapter 3 of this dissertation)*.
4. Although practitioners ideally 'embrace change', this is not reflected in their practice *(chapters 6, 7 and 8 of this dissertation)*.

Other

5. Flexibility is not about increasing the gain but cutting the pain *(Marco Eykelenboom, 2015)*.
6. Embracing opportunities requires embracing complexity.
7. A project manager should welcome delay as a means to increase value.
8. Don't search for what is *hot* and what is *not,* instead search for fit-for-purpose project management.
9. Working software over comprehensive documentation as one of the Agile values complicates project learning.
10. Investigating flexibility requires flexible approach, however, some boundary conditions should be set up-front.

These propositions are regarded as opposable and defendable, and have been approved as such by the promotor Prof. dr. ir M.J.C.M. Hertogh and copromotor Dr.ir. M.G.C. Bosch-Rekveldt.

Flexibility in project management

Towards improving project performance

Afshin Jalali Sohi

Flexibility in project management

Towards improving project performance

Proefschrift

ter verkrijging van de graad van doctor
aan de Technische Universiteit Delft,
op gezag van de Rector Magnificus prof. dr. ir. T.H.J.J van der Hagen;
voorzitter van het College voor Promoties,
in het openbaar te verdedigen op
maandag 19 november 2018 om 15:00 uur

door

Afshin JALALI SOHI
Master of Science in Construction Project Management,
University of Tehran, Iran geboren te Teheran, Iran

Dit proefschrift is goedgekeurd door de promotor:

Prof. dr. ir M.J.C.M. Hertogh
Copromotor: Dr.ir. M.G.C. Bosch-Rekveldt

Samenstelling promotiecommissie bestaat uit:

Rector Magnificus.	Voorzitter
Prof. dr. ir M.J.C.M. Hertogh	Delft University of Technology
Dr.ir. M.G.C. Bosch-Rekveldt	Delft University of Technology

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Prof. dr. M. Radujkovic	University of Zagreb, Croatia
Prof. dr.ir. L. Boelens	Gent University, Belgium
Prof.dr.ir. J.W.F. Wamelink	Delft University of Technology
Prof.dr. H.L.M. Bakker	Delft University of Technology
Dr. J.L. Heintz	Delft University of Technology

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Summary

It has been a few decades since project management was born and it is evolving in different directions since then. Despite the fact that project management has developed during these decades, it is still claimed to be immature to deal with challenges of today's projects. This is reflected by a considerable rate of failed projects. Increasingly it is argued that nowadays a pure project management approach (the conventional project management approach) is no longer effective. The inadequacy of current project management methods and practices and the growing complexity of nowadays projects form a potential cause of project failure. Complexity of projects is mainly caused by the ever-changing environment and related dynamics. Complexity can influence projects both negatively in the form of threats and positively in the form of opportunities.

Most of the current project management methods seem to underestimate the influence of the dynamic environment. A new approach is needed which recognises the complexities of a project and provides tools to cope with these; an approach that is aimed at increasing flexibility. Project management ideally consists of a combination of control and flexibility. Control means that parameters should be specified and stuck to and flexibility means that necessary changes should be accepted. Literature suggests that complex projects need adaptions in their management to overcome internal deadlocks and external changes, in order to manage threats and opportunities.

After exploring literature and current practices the following problem statement was formulated:

Current project management approaches seem to underestimate the influence of complexity of projects.

Based on the problem statement the objective of this research project is:

To investigate the effect of project management flexibility and project complexity on project performance, resulting in a framework for enabling flexibility in project management.

The research objective is translated to this main research question:

How could flexibility in project management improve project performance in complex infrastructure projects in their early phases?

This dissertation comprises five main blocks: the introduction to the research (Chapter 1), reviewing the evidence of flexibility in literature and practice (Chapters 2, 3 and 4), exploring the idea of flexibility in terms of flexibility enablers (Chapters 5, 6 and 7), investigating flexible project management and its effect on project performance (Chapter 8) and providing conclusions and recommendations including the developed framework for making project management flexible (Chapter 9).

After formulating the research objective and main research question, an in-depth literature study formed the basis of the research (Chapter 2). Project complexity, project management, flexibility in project management, project performance and early project phases were studied in this chapter. The literature claims that project management is aimed at increasing the probability of successful delivery of projects. However, it had been reflected by scholars that project management shows deficiencies in managing nowadays complex projects. The awareness of dynamism and its effect on projects empowers the assumption that project management needs to evolve in a direction which deals with the consequences of such dynamics. Literature suggests so-called dynamic management to deal with highly complex projects. This management approach requires a balance between control and interaction strategies; hence it requires flexibility. It is also stated in the literature that early project phases or the so-called front-end development phase (FED) has an important role in the success of projects. Understanding the importance of the FED phase and given the evolvement of project management in the direction of flexibility, the literature review supports the formulated research hypotheses: 1) flexible project management in early project phases has a positive effect on project performance, and 2) project complexity has a negative effect on current project performance.

Two streams in project management can be recognised: the Waterfall (conventional) approach and Agile project management. The latter is known for its flexibility to embrace change. Chapter 3 compares these two management approaches by means of case-study research. In total 20 interviews were performed with interviewees having key roles in three projects which were managed using the Waterfall approach and in three projects which were managed using Scrum as a tool of Agile project management. The research shows that different management methods applied in practice influenced project performance differently. For example, the time performance of projects managed in an Agile way was better than the performance of projects managed following the Waterfall approach, which practitioners claimed to be the result of the application of Agile. Iterative proves and short intervals enhanced achieving the strict deadlines. Also, projects managed in an Agile way were successful regarding the client satisfaction which was not the case for the Waterfall managed projects. These observations highlight the positive consequences of a more Agile approach compared to a conventional Waterfall managed project. This research reveals that although Agile and its tool Scrum are new to the construction industry for infrastructure projects, it seems to work considerably well. It revealed that Agile had some achievement for the construction industry, like meeting very strict deadlines. However, by comparing the practice of Scrum to what theory says about it, major differences were found. Full adaptation of Scrum cannot be in place because the characteristics and requirements of projects in this industry (construction) differ from the industry where Agile originates from (ICT) such as duration of the project, tendering and amount of physical material required for the project. Prototyping of bits and pieces of software is a different story than prototyping a bridge.

After understanding how Agile and its tool Scrum have been applied in practice at construction projects, and how this application contributes to project performance in Chapter 3, Chapter 4 explores the relationship between Agile and project complexity. Does the implementation of Agile lead to better management of project complexity? A quantitative research was performed to test this relationship. Given that lean management also has features that add flexibility to management, the relationship between lean and Agile management and project complexity was studied. By doing

correlation analysis on gathered data from 67 completed surveys, eight significant positive correlations were found among the clusters of Lean and Agile elements and complexity elements as shown in Table. From the existing correlations, it was concluded that the implicit usage of lean and Agile elements can help to cope with project complexity. As an example, planning related elements of Lean and Agile have a positive effect on managing a project's technical complexity. This also applies to Lean and Agile individual elements which showed significant correlations with any clusters of project complexity.

Table 1: Correlation matrix between complexity and Lean & Agile

	Complexity 1 (technical complexity)	Complexity 2 (uncertainty)	Complexity 3 (organisational complexity)	Complexity 4 (stakeholder)	Complexity 5 (external complexity)
Lean & Agile 1 (structure & integration)	0.443**	0.205	0.594**	0.175	0.521**
Lean & Agile 2 (coordination)	0.079	0.092	0.173	0.157	0.261*
Lean & Agile 3 (planning)	0.249*	0.278*	0.325**	-0.093	0.112
Lean & Agile 4 (resource allocation)	0.147	0.195	0.196	-0.080	0.180
Lean & Agile 5 (communication)	0.226	0.120	0.431**	-0.173	0.198

**. Correlation is significant at the 0.01 level
*. Correlation is significant at the 0.05 level

Chapters 2, 3 and 4 provide insight into the concept of flexibility in project management and its evidence in practice. After understanding the positive effect of a flexible project management approach, it is time to investigate all enablers of flexibility (Chapter 5). Flexibility and adaptability were introduced in literature as two terms which both aim at increasing the flexibility of project management. Although they have the same goal, the application of the term 'adaptability' is more common in natural resource management or as one of the dynamic capabilities in organisational studies. Hence for this research it was concluded to stick to the term 'flexibility'. For the purpose of this research, flexibility is defined as the ability and readiness to deal with dynamics in the project. Next to defining flexibility, the enablers of flexibility need to be identified. An in-depth literature study, followed by interviews with 14 practitioners resulted in a list of 26 flexibility enablers. Those identified enablers were grouped into suggested areas of flexibility from literature: what, how, who, when and where. The flexibility of 'what' is about the ability to change the project goal and scope. The flexibility of 'how' is about the ability to change the implementation process. The flexibility of 'who' is about the ability to apply changes in the team who carries out the project. The flexibility of 'when' is about the ability to change the project schedule without influencing the final deadlines. The flexibility of 'where' is about the ability to change the location where the task is performed. Each of these areas comprises a number of flexibility enablers.

After understanding what enablers contribute to flexibility of project management, the next step is to identify practitioner's perspectives regarding flexible project management (Chapter 6). This was done by means of a Q-study with 43 respondents. Q-methodology allows a researcher to explore the subjectivity on the studied subject by giving importance to statements in a Q-sorting exercise. The statements to be sorted were the 26 flexibility enablers from Chapter 5. For this study, two organisation types were included: client and consultancy organisations. Three similar perspectives were revealed per organisation type, implying that these client and consultancy organisations have similar mind-sets regarding flexible project management. The three perspectives are: 'trust', 'scope flexibility by contractual flexibility' and 'proactive management'. The perspective of 'trust' finds trust, short feedback loops, as two of the most important enablers of project management flexibility. The perspective of 'scope flexibility by contractual flexibility' finds broad task definition, functional realisation-based contract as two high-ranked flexibility enablers. The perspective of 'proactive management' ranked seizing opportunities and coping with threats and possible alternative as two important enablers of flexibility. Recognition of different perspectives helps practitioners to understand what perspectives exist among them.

Next, the flexibility of current practice was explored in Chapter 7. This chapter aimed to investigate whether the project management of infrastructure projects in the construction industry currently is flexible or not. To do so, the list of flexibility enablers (Chapter 5) was given to practitioners. They rated their last finished project based on their selected top 5 and bottom 5 flexibility enablers. The resulting top 5 and bottom 5 flexibility enablers are presented in Table.

Table 2: Top 5 and bottom 5 flexibility enablers from practitioners' point of view

Top 5 flexibility enablers	Embracing change Trust Seizing opportunities and coping with threats Broad task definition Possible alternatives
Bottom 5 flexibility enablers	Flexible desks Standardised process and design Late locking Consensus among team members Contingency planning

The qualitative data analysis revealed that the application of flexibility enablers in practice ranges from 'not applied' to 'have been applied'. Large differences were seen, even within organisations. The research showed that the current practice of project management has some degree of flexibility, albeit very implicit. To make full advantage of flexibility, flexibility has to become explicit. In our view and based on prior research, conscious application of flexibility could add value to project management processes and ultimately to the project performance.

Chapter 8 includes the evaluation of the assumed relationships between project management flexibility and project performance, the effect of project complexity on project performance and the mediating role of flexible project management on dealing with complex projects. Using structural equation modeling (SEM-PLS (partial least squares)), statistical analysis was performed on data gathered from 111 surveys. SEM-PLS was chosen because it fitted the research as the topic is not well-developed and PLS-SEM is appropriate for small sample sizes. Six hypotheses were tested; five hypotheses regarding the effect of the flexibility areas (what, how, who, when and where) on project performance and one hypothesis regarding the effect of project complexity on project performance. In order to reduce the complexity of the research model, the flexibility enablers in the 'how' category were split into two clusters labeled as 'how-attitude' and 'how-organisation', see Table. The flexibility enablers of 'how-attitude' and 'how-organisation' were shown to have a significant positive effect on project performance: the higher the flexibility of 'how', the better the project performance. Project complexity as a control variable was shown to have a significant effect on project performance but in opposite direction: the less complex the project, the better the project performance. The control effect of project complexity in the model means that the flexibility of 'how' has a significant positive effect on project performance, even if the project is complex.

Table 3: Flexibility enablers in the How categories

How	**How-attitude**	**Open attitude**	Interactive decision making
			Close involvement of stakeholders
		Wide approach	Open information exchange among different groups
			possible alternatives
		Proactive attitude	Contingency planning
			Seizing opportunities and coping with threats
	How-organisation	**Facilitate planning**	Visualised project planning and progress
			Continuous learning
		Outer organisation	Self-steering of the complete project team
			Shared interface management
			Trust among involved parties
		Inner organisation	Management support
			Network structure rather than hierarchical structure

The mediating role of flexible project management on the relationship between project complexity and project performance was also studied. The results showed that the 'how-organisation' flexibility enablers mediate the negative effect of project complexity on project performance.

Throughout this PhD research, several research sub-questions were answered in different chapters. The achieved results come together in the so-called flexible project management framework (Figure). The framework includes four steps in an iterative way.

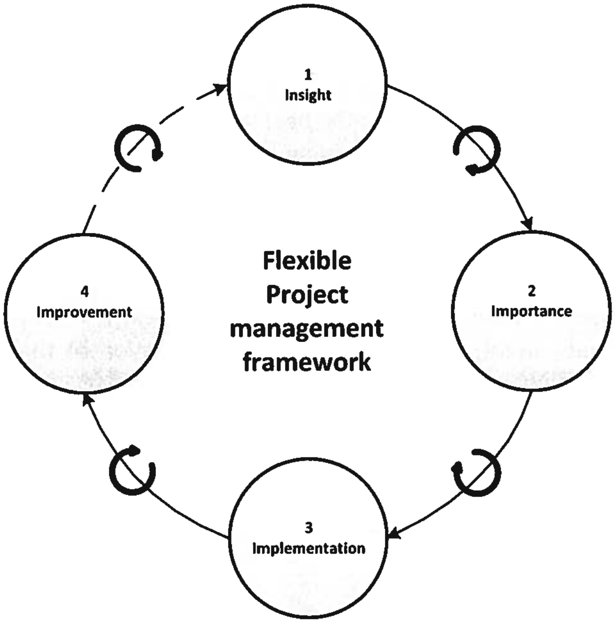


Figure 1: Flexible project management framework

- Step 1: Insight

As the name suggests, the goal of this step is the awareness of project complexity and applied project management approaches in practice. Project complexity is important to be understood and investigated, to be managed well. Selection of the right project management approach based on the type and degree of project complexity is a means to project success. Next, there should be awareness of what has been applied as the project management approach. Regardless of what is applied as the project management approach, it is also important to be aware of its position in the spectrum from pure Waterfall to pure Agile. In this step, practitioners make a clear picture of their status regarding applied project management and the complexity of the project at hand.

- Step 2: Importance

This step is about investigating the practitioners' perspectives regarding flexible project management. While the first step in the framework was about awareness of the applied project management approach in practice, the second step is about awareness of the practitioners' mind-sets. Based on what practitioners find important to enable flexibility in project management, three distinct perspectives were derived. Each perspective gives higher priority to certain flexibility enablers. It was revealed that the perspectives of practitioners who work in client organisations were the same as the perspectives of those who work at engineering consultancy organisations. In this step of the framework, it is suggested to understand which of these perspectives exist in the project team. Different perspectives might exist at the same time in any project team. The goal is to make it explicit which perspectives exist and to discuss what is important for the project. This can be done in the form of a workshop at the beginning of the project. After knowing which perspectives exist among the team members, the project team should investigate which perspective contributes most to the project they want to perform. There might be a specific perspective which fits the best to the project context. The project team can put the emphasis on the application of high-ranked enablers from that specific perspective.

- Step 3: Implementation

This step is about enabling flexibility in project management. Statistical analysis showed that 23 enablers of flexibility contribute positively to five areas of flexibility (what, how, who, when and where). This means that the application of these 23 enablers in practice, enables flexibility in project management.

As an example, to enable flexibility in terms of defining project scope the scope should be defined into broad tasks rather than specified work packages. Another example: by having short feedback loops during the project the degree of flexibility increases in terms of shorter communication lines, a better understanding of the project and integration of the project team.

- Step 4: Improvement

In this step, two approaches can be taken. The first is to improve the project performance regardless of the complexity of the project at hand. Statistical analysis proved that if 'how' flexibility enablers were applied in practice, the performance of project management improved significantly. The second approach is to deal with project complexity by applying flexible elements in project management: specifically the 'how-organisation' flexibility enablers.

The managerial implications of the research cover a few areas including the application of Agile project management in the construction industry, making project management flexible, improving project performance and dealing with project complexity:

- This research gives some insight how the application of Agile can be improved by putting the emphasis on the observed benefits such as structure of work, team spirit, interchange of knowledge, rework reduction and mitigate the observed challenges like multitasking and intensity of scrum meetings.
- Recognition of different practitioners' perspectives ('trust', 'scope flexibility by contractual flexibility' and 'proactive management') about making project management flexible in order to give priority to the flexibility enablers of a certain perspective which fits the best to the project context. Understanding of existing perspectives among practitioners, working as a team in a project, also helps to create alignment.
- Making project management flexible by applying (a selection of) the flexibility enablers identified in this research. In general, making project management flexible can be done by enabling the flexibility in terms of the scope of project (what), in terms of project processes (how), project team (who), project scheduling (when) and the location the project team is organised (where).

- Focusing on 'open attitude', 'wide approach' and 'proactive attitude' to increase flexibility in terms of 'how-attitude' flexibility (see Table 1) in order to improve project performance.
- Focusing on 'facilitate planning', 'outer organisation' and 'inner organisation' to increase flexibility in terms of 'how-organisation' flexibility (see Table 1) in order to manage project complexity.

As a limitation of the research, it is noted that the research was performed in The Netherlands: all data in different stages of the research was collected from Dutch organisations. It is recommended to further explore the subject of flexibility in other countries to see whether the research results are influenced by culture. Future research is also suggested in the areas of the application of Agile. This research showed that Agile project management has potential to be used in the construction industry, however, it needs to be tailored to fit the context of the industry. Further research can investigate the adjustment of Agile project management for the construction industry. Regarding flexible project management, further research can investigate the applicability of the proposed flexible project management framework in practice.

Samenvatting

Sinds het ontstaan van projectmanagement, enkele tientallen jaren geleden, heeft de discipline zich in verschillende opzichten ontwikkeld. Desondanks wordt er betoogd dat de discipline verre van volwassen is en zeker niet geschikt om de uitdagingen van hedendaagse projecten aan te gaan. Dit uit zich bijvoorbeeld in het grote aantal mislukte projecten. In toenemende mate wordt betoogd dat conventionele projectmanagement-benaderingen niet langer toereikend zijn. Naast conventionele methoden is de groeiende complexiteit van hedendaagse projecten een mogelijke oorzaak voor het falen van deze projecten. De complexiteit is een gevolg van de steeds veranderende omgeving waarin projecten worden uitgevoerd. Op twee manieren beïnvloedt complexiteit projectmanagement: enerzijds negatief in de zin van bedreigingen, anderzijds positief in de zin van kansen en mogelijkheden.

Huidige projectmanagementmethoden lijken met name de invloed van de veranderende omgeving te onderschatten. Daarom is een nieuwe benadering nodig die wel oog heeft voor de complexiteit van een project en handreikingen biedt hoe om te kunnen gaan met complexiteit; een benadering die is gericht op toenemende flexibiliteit. Projectmanagement is idealiter een combinatie van enerzijds 'controle' – het definiëren van een plan en dat uitvoeren – en anderzijds flexibiliteit – het accepteren van noodzakelijke aanpassingen. In de bestaande literatuur bestaat de notie dat aanpassingen in het managen van complexe projecten nodig zijn om "deadlocks" te voorkomen of te boven te komen, om zo mogelijke bedreigingen en kansen te managen.

Na een verkenning van de literatuur en huidige praktijken is de volgende propositie geformuleerd:
Huidige projectmanagement-benaderingen lijken de invloed van de complexiteit van projecten te onderschatten.

Gebaseerd op deze propositie heeft dit onderzoek tot doel het onderzoeken van **het effect van projectmanagementflexibiliteit en projectcomplexiteit op projectprestatie om te komen tot een raamwerk dat flexibiliteit in projectmanagement mogelijk maakt.**

Deze doelstelling is vertaald naar de volgende onderzoeksvraag:

Hoe kan flexibiliteit in projectmanagement de projectprestatie van complexe infrastructurele projecten in hun vroege fasen bevorderen?

Deze dissertatie bestaat uit vijf delen en is als volgt opgebouwd: in hoofdstuk 1 wordt het onderzoek geïntroduceerd (deel 1). In deel 2 wordt verslag gedaan van een literatuurverkenning en een eerste empirisch onderzoek naar flexibiliteit (hoofdstuk 2, 3 en 4). Hoofdstuk 5, 6 en 7 vormen het 3e deel van dit proefschrift waarin het idee van flexibiliteit als zijnde factoren die flexibiliteit mogelijk maken (zogenaamde *enablers*) wordt verkend. In deel 4 van dit proefschrift wordt het kwantitatieve onderzoek naar het effect van flexibel projectmanagement op projectresultaten gepresenteerd. Deel 5 (hoofdstuk 9) presenteert de eindconclusies en aanbevelingen, leidend tot een raamwerk voor flexibel projectmanagement als belangrijkste resultaat van dit promotieonderzoek.

Dit onderzoek is gebaseerd op een uitvoerige literatuurstudie, gepresenteerd in hoofdstuk 2. De centrale begrippen van dit onderzoek, te weten projectcomplexiteit, projectmanagement, flexibiliteit in projectmanagement, projectprestatie en vroege projectfasen worden in dit hoofdstuk behandeld. In de bestudeerde literatuur wordt gesteld dat projectmanagement tot doel heeft om de kans op het met succes afronden van projecten te vergroten. Wetenschappers wijzen er echter op dat projectmanagement tekortkomingen kent in het managen van huidige complexe projecten. De onderkenning van het effect van omgevingsdynamiek op projecten staaft de aanname dat het veld van projectmanagement zich zal moeten ontwikkelen in een richting die zich hiervan rekenschap geeft. Dynamisch management wordt in de literatuur voorgesteld als principe om met hoog-complexe projecten om te gaan. Deze benadering gaat uit van een balans tussen controle- en interactiestrategieën en vraagt om flexibiliteit. Voorts wordt er in de literatuur gesteld dat dat de vroege projectfasen, ook wel *front-end development* (FED) fase genoemd, bepalend zijn voor het succes van projecten. De onderkenning van het belang van de FED fase en de ontwikkeling van projectmanagement gericht op flexibiliteit hebben geleid tot de volgende hypothesen van dit promotieonderzoek: 1) flexibel projectmanagement in de vroege projectfasen heeft een positief effect op projectprestaties; en 2) de complexiteit van een project heeft een negatief effect op projectprestaties.

In de literatuur worden twee stromingen van projectmanagement-benaderingen onderscheiden: de 'Waterfall' (conventionele) benadering en de 'Agile' benadering. De laatste staat bekend om haar flexibiliteit. In hoofdstuk 3 worden deze twee benaderingen met elkaar vergeleken door middel van casestudieonderzoek. In deze casestudie werden zes projecten met elkaar vergeleken: in drie projecten werd de conventionele projectmanagement-benadering gehanteerd en in drie projecten werd Scrum als instrument voor Agile projectmanagement gehanteerd. In totaal werden 20 respondenten geïnterviewd die elk een sleutelrol vervulden in deze projecten. De resultaten van deze casestudie wijzen op verschillende effecten. De tijdsprestatie van de projecten die werden beheerst volgens de Agile benadering was bijvoorbeeld beter, wat volgens de respondenten een direct gevolg was van het hanteren van deze benadering. De iteratieve bewijzen en kortdurende intervallen bevorderden het behalen van de strikt gestelde deadlines. Bovendien waren de Agile gemanagede projecten succesvoller ten aanzien van klanttevredenheid dan de projecten die de conventionele benadering hanteerden. Het onderzoek laat zien dat ondanks dat Agile en het instrument Scrum betrekkelijk nieuw zijn als beheersingsinstrument in infrastructurele projecten en in de toeleverende industrie, deze relatief goed kunnen werken. Echter, het onderzoek laat ook zien dat er belangrijke verschillen zijn in de theorie en de uitvoeringspraktijk ten aanzien van Scrum. Volledige invoering van scrum is niet aan de orde, omdat er verschillen zijn tussen de industrie waar de Agile benadering vandaan komt (ICT) en de hier onderzochte bouwsector. Denk aan specifieke kenmerken zoals bijvoorbeeld de duur van de projecten, aanbestedingseisen, of de hoeveelheid fysiek materiaal dat besteld moet worden in bouwprojecten. Het maken van een software prototype is andere koek dan het maken van een prototype van een brug.

Nadat in hoofdstuk 3 inzichtelijk is gemaakt hoe de Agile methode en het Scrum instrument in de praktijk van infrastructurele bouwprojecten wordt toegepast en hoe deze toepassing bijdraagt aan de projectprestaties, wordt in hoofdstuk 4 op kwantitatieve wijze de relatie tussen de Agile benadering en projectcomplexiteit verkend. Centraal staat in dat hoofdstuk de vraag of implementatie van een Agile benadering leidt tot een betere beheersing van projectcomplexiteit. Gegeven het feit dat Lean management ook kenmerken heeft die bijdragen aan flexibiliteit, is de relatie tussen Lean en Agile management en complexiteit bestudeerd. Om de relatie tussen de twee variabelen te testen, is een kwantitatief onderzoek uitgevoerd. Een correlatieanalyse met 67 ingevulde vragenlijsten leverde acht significante positieve correlaties tussen de clusters Lean & Agile en complexiteit (zie tabel 1). Op basis hiervan mag geconcludeerd worden dat het impliciet gebruik van Lean en Agile elementen kan helpen in het omgaan met complexiteit. Een voorbeeld hiervan is het positieve effect van Lean en Agile planning om om te gaan met de technische complexiteit van een project. Een aantal individuele Lean en Agile elementen laten een significante correlatie zien met elk cluster van projectcomplexiteit.

Tabel 4: Correlatiematrix tussen complexiteit en Lean & Agile

	Complexiteit 1 (technische complexiteit)	**Complexiteit 2 (onzekerheid)**	**Complexiteit 3 (organisatiel complexiteit)**	**Complexiteit 4 (stakeholder)**	**Complexiteit 5 (externe complexiteit)**
Lean & Agile 1 (structuur & integratie)	0.443**	0.205	0.594**	0.175	0.521**
Lean & Agile 2 (coördinatie)	0.079	0.092	0.173	0.157	0.261*
Lean & Agile 3 (planning)	0.249*	0.278*	0.325**	-0.093	0.112
Lean & Agile 4 (middelen allocatie)	0.147	0.195	0.196	-0.080	0.180
Lean & Agile 5 (communicatie)	0.226	0.120	0.431**	-0.173	0.198

**. Correlatie is significant op niveau 0.01
*. Correlatie is significant op niveau 0.05

Nadat in de hoofdstukken 2, 3 en 4 het concept flexibiliteit is onderzocht en inzichtelijk is gemaakt dat een flexibele projectmanagement-benadering een positief effect kan sorteren, wordt in hoofdstuk 5 verslag gedaan van het onderzoek naar de factoren die flexibiliteit mogelijk maken (hierna genoemd *enablers*). In de literatuur hebben de concepten flexibiliteit en aanpassingsvermogen (*adaptability*) beide tot doel de flexibiliteit van projectmanagement te vergroten. Ondanks dat het doel hetzelfde is, wordt de term *adaptability* met name gebruikt in het veld van *Natural Resource Management* en in de organisatiewetenschappen als *dynamic capability*. In dit onderzoek is ervoor gekozen om flexibiliteit te hanteren en te definiëren als het vermogen en de bereidwilligheid om om te gaan met dynamiek. Naast het definiëren van flexibiliteit is het van belang de *enablers* te identificeren. Op basis van een uitvoerige literatuurstudie en interviews met 14 respondenten uit de praktijk is een lijst van 26 flexibiliteits-*enablers* opgesteld. Op basis van de bestudeerde literatuur zijn deze gegroepeerd naar de dimensies flexibiliteit van 'wat', 'hoe', 'wie', 'waar' en 'wanneer'. Deze dimensies van flexibiliteit hebben betrekking op het vermogen om aan te passen ten aanzien van projectdoelen- en reikwijdte (wat), implementatie (hoe), personele bezetting (wie), uitvoeringslocatie (waar) en planning zonder de uiteindelijke deadlines te veranderen (wanneer). Elk van deze dimensies bestaat uit een aantal flexibiliteits-*enablers.*

Na theoretische begripsvorming ten aanzien van de bijdrage van *enablers* aan de flexibiliteit van projectmanagement, bespreekt hoofdstuk 6 de perspectieven van projectmanagement professionals aangaande deze enablers. Om deze perspectieven te identificeren is Q-methodologie gehanteerd. Het voordeel van deze onderzoeksmethode is dat het plaats biedt aan subjectiviteit in de onderzoekspopulatie. In totaal werden aan 43 respondenten, 26 stellingen voorgelegd. Deze stellingen waren gebaseerd op de 26 geïdentificeerde *enablers* uit het voorgaande hoofdstuk en de respondenten werd gevraagd deze stellingen te rangschikken. Twee organisatietypes werden voor dit onderzoek geselecteerd: klant- en consultancy-organisaties. Uit het onderzoek kwamen drie vergelijkbare perspectieven naar voren, wat impliceert dat deze twee typen organisaties eenzelfde soort mind-set hebben ten aanzien van flexibel projectmanagement. De drie perspectieven betreffen 'vertrouwen', 'reikwijdte van flexibiliteit op basis van contractuele flexibiliteit' en 'proactief management'. Het perspectief 'vertrouwen' kent vertrouwen en korte feedback loops als twee belangrijkste *enablers*; in het tweede perspectief zijn brede taakopvatting en functionele *realisation-based* contracten de twee belangrijkste *enablers.* Het perspectief 'proactive management' kent het aangrijpen van kansen en het omgaan met bedreigingen en mogelijke alternatieven als de twee belangrijkste *enablers.* Het onderkennen van een variëteit aan perspectieven door projectmanagement professionals helpt bij het begrijpen ervan.

Vervolgens presenteert hoofdstuk 7 het onderzoek naar de flexibiliteit van de huidige praktijk. Het doel was om inzichtelijk te maken in hoeverre het projectmanagement van infrastructurele projecten in de bouwsector op dit moment flexibel is. De lijst met *flexibiliteits-enablers,* behandeld in Hoofdstuk 5, is voorgelegd aan projectmanagementprofessionals. Respondenten hebben voor hun laatste afgeronde project de *enablers* beoordeeld. Tabel 2 geeft een overzicht van de daaruit volgende top 5 meest toegepaste en minst toegepaste 5 *enablers.*

Tabel 5: Top 5 en bottom 5 flexibiliteits-enablers vanuit de praktijk

Top 5 flexibiliteits-enablers	Open houding t.o.v. verandering Vertrouwen Proactief t.o.v. kansen en bedreigingen Globale Scope Meerdere scenario's
Bottom 5 flexibiliteits-enablers	Flexibele werkplekken Standaardisatie van proces en ontwerp Late vaststelling van het ontwerp Consensus team leden Plan B. achter de hand

De analyse van de vergaarde data laat zien dat de toepassing van de *enablers* in de praktijk varieert van 'niet toegepast' tot 'toegepast'. Resultaten laten zien dat er grote verschillen bestaan zowel tussen als binnen de onderzochte organisaties. Er bestaat een zeker niveau van flexibiliteit, echter impliciet van aard. Om volledig te kunnen profiteren van flexibiliteit is het noodzakelijk om het expliciet te maken. Bewust inzetten van flexibiliteit kan een waardevolle bijdrage opleveren voor het proces van projectmanagement om uiteindelijk de prestaties van het project te verbeteren.

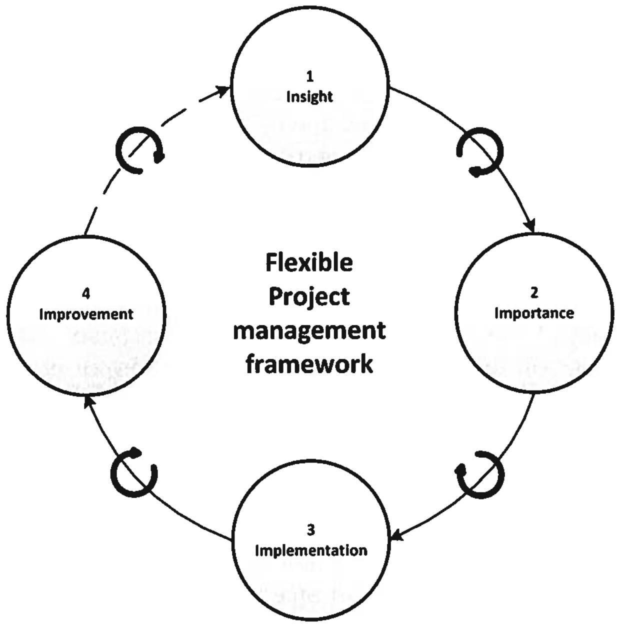
In hoofdstuk 8 wordt verslag gedaan van de evaluatie van de veronderstelde relaties tussen projectmanagement flexibiliteit en projectprestaties, het effect van projectcomplexiteit op projectprestatie en de mediërende rol van flexibel projectmanagement op het omgaan met complexiteit. Op basis van 'Etructural Equation Modeling' (SEM-PLS (Partial Least Squares)) is statistische analyse uitgevoerd op data verkregen vanuit 111 vragenlijsten. SEM-PLS is gekozen omdat het past bij dit onderzoek, waar het onderzoeksonderwerp nog niet geheel ontwikkeld is en de onderzoekstechniek uitgevoerd kan worden met relatief kleine samples. Zes hypotheses zijn getest; vijf hebben betrekking op het effect van de flexibiliteit dimensies (wat, hoe, wie, wanneer, waar) op projectprestaties, en één hypothese heeft betrekking op het effect van projectcomplexiteit op projectprestaties. Om de complexiteit van het onderzoekmodel te reduceren zijn de flexibiliteits-enablers in de dimensie 'hoe' opgesplitst in twee clusters en gelabeld als 'hoe-houding' en 'hoe-organisatie' (zie Tabel 3). Deze twee clusters hebben een significant positief effect op projectprestaties: hoe hoger de flexibiliteit van 'hoe', des te beter de projectprestaties. Als controle-variabele heeft projectcomplexiteit een significant effect op projectprestaties in omgekeerde richting: hoe minder complex het project, des te beter de projectprestaties. Het controle-effect van projectcomplexiteit in het model betekent dat de flexibiliteit van 'hoe' een significant positief effect heeft op projectprestatie, zelfs al is het project complex.

Table 6: Flexibiliteits-enablers in categorie van 'hoe'

Hoe	**Hoe-houding**	**Open houding**	Interactive besluitvorming
			Vaste betrokkenheid van stakeholders
		Brede blik	Open informatie voor alle partijen
			Meerdere scenario's
		Proactieve houding	Plan B. achter de hand
			Proactief t.o.v. kansen en bedreigingen
	Hoe-organisatie	**Planning faciliteren**	Visualisatie van projectplanning en voortgang
			Continu leren
		Onderlinge relaties	Zelfsturend team
			Interface management door alle teamleden
			Vertrouwen tussen alle partijen
		Interne organisatie	Management ondersteuning
			Network structuur i.p.v. hiërarchische structuur

De mediërende rol van flexibel projectmanagement op de relatie tussen projectcomplexiteit en projectprestatie was ook onderdeel van deze studie. De resultaten van het onderzoek laten zien dat de 'hoe-organisatie' flexibiliteits-*enablers* mediëren in het negatieve effect van projectcomplexiteit op projectprestatie.

De uitkomsten van het promotie-onderzoek leiden tot het ontwerp van een raamwerk voor flexibel projectmanagement in hoofdstuk 9 (Figuur 1). Het raamwerk bestaat uit vier iteratieve stappen.



Figuur 2: Flexibel projectmanagement raamwerk

Stap 1: Inzicht (Insight)

Zoals de naam al suggereert is het doel van deze eerste stap het bewust zijn van complexiteit en de toepassing van projectmanagement-benaderingen. Het is van belang de complexiteit te onderzoeken en te onderkennen, om deze te kunnen beheersen. De keuze voor een juiste projectmanagement-benadering, gebaseerd op het type en de mate van complexiteit, is een middel om tot succesvolle projecten te komen. Vervolgens is bewustwording van de wijze van toepassing van belang. Ongeacht welke benadering wordt gekozen, is het van belang bewust te zijn waar men staat in het spectrum van Waterfall naar Agile. In deze eerste stap bepalen projectprofessionals waar ze staan qua methodiek en wat de complexiteit is van het voorliggende project.

Stap 2: Belang (Importance)

De tweede stap in het model betreft het onderzoeken welke perspectieven betrokkenen hebben ten aanzien van flexibel projectmanagement. Het gaat er in deze stap dus om welke mind-sets aanwezig zijn. Zoals dit onderzoek heeft aangetoond zijn er drie perspectieven te onderscheiden met elk een eigen rangschikking van de belangrijkste *enablers* voor flexibiliteit. Het kan zijn dat in het team van betrokkenen meerdere perspectieven tegelijkertijd worden gearticuleerd. Het is van belang hierover overeenstemming te verkrijgen. Aan het begin van een project kunnen daartoe workshops worden georganiseerd. Nadat in de workshops in kaart is gebracht welke perspectieven worden aangehangen, zullen de betrokkenen moeten onderzoeken en vaststellen welk perspectief het beste past en in de uitvoeringspraktijk de nadruk leggen op de daarbij behorende *enablers*.

Stap 3. Implementatie (Implementation)

Deze stap draait om het daadwerkelijk mogelijk maken van flexibiliteit in een project. Het uitgevoerde statistische onderzoek toont aan dat 23 *enablers* bijdragen aan flexibiliteit over vijf dimensies van flexibiliteit. Dat betekent dat het toepassen van deze 23 *enablers,* flexibiliteit mogelijk maakt.

Ter illustratie: om flexibiliteit mogelijk te maken in termen van het definiëren van de projectscope, wordt aangeraden de scope te definiëren als breed geformuleerde taken in plaats van specifieke werkpakketten. Een ander voorbeeld is dat korte feedback loops gedurende het project de mate van flexibiliteit bevorderen, omdat door korte communicatielijnen er een beter begrip komt van het project en een betere integratie binnen en met het projectteam.

Stap 4. Verbetering (improvement)

Voor deze stap kunnen twee benaderingen gekozen worden. De eerste is het verbeteren van de prestatie ongeacht de mate van complexiteit. Statistische analyse heeft aangetoond dat *enablers* op de dimensie 'hoe'-flexibiliteit de prestaties van projectmanagement significant positief beïnvloeden. De tweede benadering betreft het omgaan met complexiteit door gebruik te maken van flexibele elementen in projectmanagement, met name de 'hoe-organisatie'-*enablers.*

De uitkomsten van het uitgevoerde onderzoek impliceren dat de toepassing van Agile projectmanagement-benaderingen in de bouwsector projectmanagement flexibeler maken, en als gevolg daarvan de prestaties verbeteren en er beter omgegaan kan worden met de complexiteit van projecten:

- Het onderzoek biedt inzicht in hoe de toepassing Agile verbeterd kan worden door de nadruk te leggen op de voordelen zoals de structuur van het werk, teamspirit, uitwisseling van kennis, "rework reduction" en het mitigeren van uitdagingen zoals multitasking en de intensiteit van Scrumbijeenkomsten.
- Het herkennen van bestaande perspectieven ten aanzien van flexibilisering van projectmanagement die worden gearticuleerd door de betrokkenen. Het herkennen en erkennen van deze verschillende perspectieven is de basis voor het bespreekbaar maken hiervan en op basis van die uitkomsten in gezamenlijkheid te komen tot prioritering van *enablers* die het beste passen bij de context van het project.
- Projectmanagement kan flexibeler gemaakt worden door het toepassen (van een selectie) van de *enablers* uit dit onderzoek. In het algemeen kan een hogere mate van flexibiliteit bereikt worden door de flexibiliteit te vergroten ten aanzien van de dimensies wat, hoe, wie, wanneer en waar: de reikwijdte van het project ('wat'), projectprocessen ('hoe'), het projectteam ('wie'), planning ('wanneer') en de locatie ('waar').

- Het benadrukken van het belang van een 'open attitude', 'brede benadering' en 'proactieve houding om flexibiliteit in termen van 'hoe-attitude' flexibiliteit te verhogen (zie tabel 1), om zodoende projectprestaties verbeteren.
- Het benadrukken van het belang van 'planning faciliteren', 'onderlinge relaties en 'interne organisatie' om flexibiliteit in termen van 'hoe-organisatie' flexibiliteit te verhogen om zodoende projectcomplexiteit te beheersen.

Het uitgevoerde onderzoek kent enkele beperkingen. Het onderzoek is uitgevoerd in Nederland, onder Nederlandse bedrijven. Het verdient de aanbeveling om onderzoek naar organisaties buiten Nederland te verrichten om vast te kunnen stellen of en in hoeverre cultuur van invloed is. Verder is nader onderzoek naar toepassing van Agile aan te bevelen. Het uitgevoerde onderzoek laat zien dat Agile projectmanagement de potentie heeft om toegepast te kunnen worden in de bouwsector, maar deze benadering moet verder uitgewerkt worden om geschikt te worden voor de context van deze sector. Ten aanzien van flexibel projectmanagement is het aan te bevelen om de toepassing van het gepresenteerde raamwerk nader te onderzoeken.

Table of Contents

List of figures

List of tables

Chapter 1: INTRODUCTION

Abstract

It has been a few decades since project management was born and it has been evolved in different directions since then. Despite the fact that project management has developed during these decades, it is still claimed to be immature to deal with challenges of today's projects. For instance, for today's projects value plays a significant role, beyond focusing on meeting the iron triangle constraints cost, time and quality. Also, the growth of project management ties together with increased project complexity. Inadequacy of current project management methodologies and growing complexity of nowadays projects form a high potential cause of project failure. Failure not only in terms of cost overruns or time delays but also in dissatisfaction and not obtaining projects' goals, among others. Complexity and uncertainty of projects are mainly because of the ever-changing environment and dynamism which conventional project management methodologies seem not capable of coping with. The focus of conventional project management is mainly on the achievement of predefined goals, mostly composed of criteria such as time, budget and quality. However, such preplanning becomes less appropriate due to complexity and uncertainty of many projects. In this PhD research, it is chosen to explore project complexity as one of the concepts that affect the performance of projects and flexibility in project management as an approach to deal with complexity.

This first chapter provides an introductory literature review on project complexity and flexibility as a new paradigm in project management (Section 1.1 and 1.2). Next, voices from the field are presented in Section 1.3, followed by a gap analysis in Section 1.4. Next, the research objective and research questions are provided. Research methodology is elaborated in Section 1.5. Scientific and social relevance are discussed in Section 1.6. The chapter ends by presenting the thesis outline in Section 1.7.

1.1 MANAGING PROJECT COMPLEXITY

Reports indicate that construction projects struggle with time delays and cost overruns which will affect their performance (Flyvbjerg, 2011, 2014; Flyvbjerg, Holm and Buhl, 2002). The attention of construction practitioners and researchers has been drawn to investigate the reasons of projects' poor performance (Mansfield, Ugwu and Doran, 1994; Meng, 2012). Not only cost overruns and delays, but satisfaction is also important when it comes to project success (Oppong, Chan and Dansoh, 2017; R Ireland, 1992; Verweij, 2015). Searching for the reasons of poor performance, some scholars shed light on 'the way that projects are being managed' as an important fact which could affect project performance and the successful delivery of the project (Chan, Scott and Chan, 2004; Gil and Tether, 2011; Hubbard, 1990; Olsson, 2006). Also Hertogh and Westerveld (2010) stated that the performance of megaprojects is influenced by their management. In a study in 2014, Davis claims that project management is immature as a research field, although project management processes must be in place for a project to be successful (Davis, 2014). Sanjuan and Froese (2013) claim weak project management practices are commonplace in practice, especially in project owner organisations. They recognise two contributing factors to poor project management practices: 1) unawareness of project organisations about best practices compared to their own practices, and 2) unawareness of the value offered by different project management practices.

Talking about project success, literature highlights the importance of early project phases or so-called front-end development phase on project results (Gibson Jr, Wang, Cho and Pappas, 2006; Samset and Volden, 2016). Also project value delivery is dependent on a good project value definition in the front-end phase (Bosch-Rekveldt, 2011).

Apart from the importance of project management in general, differentiation in size, uniqueness and complexity of projects put emphasis on the necessity of a tailored management method. Project complexity is claimed as one of the causes of cost overruns and consequently poor performance (Bosch-Rekveldt, 2011; Kaming, Olomolaiye, Holt and Harris, 1997). Studies show that the causes of poor performance can be divided into two main categories: external and internal (Meng, 2012). The causes which are beyond the control of project teams are labelled as external causes like weather conditions and market changes. The causes which are generated by the involved actors such as the client or the contractor are categorised as internal causes (Assaf and Al-Hejji, 2006). It can be argued that both external and internal causes are related to project dynamics. Nowadays, a pure project management approach (the traditional project management approach) is no longer effective (Hertogh and Westerveld, 2010; Koppenjan, Veeneman, van der Voort, ten Heuvelhof and Leijten, 2011). On top of that, most of the current project management approaches still seem to underestimate the influence of the dynamic environment (Priemus and van Wee, 2013). Fernandes, Ward and Araújo (2015) believe that realising effective project management still is a challenge although project management has developed and spread significantly in science in the past six decades.

1.2 FLEXIBILITY: A NEW PARADIGM SHIFT IN PROJECT MANAGEMENT

Projects are influenced by their complexities in two ways: positively and negatively. The effect of complexity will be positive in terms of defining new opportunities and negative in terms of threats. Therefore, management of project complexity can focus on maximising the opportunities and minimising the threats (Vidal, Marle and Bocquet, 2011) to add value. While many fundamental sources of uncertainty are not addressed well by conventional project management, a complementary management approach is required (Atkinson, Crawford and Ward, 2006). For example by combining the conventional project management with other approaches in order to compensate the pitfalls of the each other (Koppenjan et al., 2011). Geraldi (2008) discusses that each project has a degree of chaos which needs to be recognised and structured to deal with it. Koppenjan et al. (2011) stated that project management needs a combination of control and flexibility. Control implies the parameters should be fixed and stuck to, while flexibility implies accepting the required changes. Although it is hard to find the right balance between control and flexibility, the practice requires it. It is often the case that practice tends more toward either control or flexibility. In order to compensate the pitfalls and weaknesses of the dominant approach, it should be complemented with the other approach.

Consequently, a conventional project management approach which is characterized as a control-oriented approach should be complemented by flexibility and adaptivity. In order to cope with complexity and uncertainty, literature suggests increasing the flexibility of project management (Koppenjan et al., 2011). An approach which puts the emphasis on achieving flexibility is called as 'prepare-and-commit' approach. Based on literature, the realisation of a 'prepare-and-commit' approach can be done by: defining the project's scope into required functions rather than detailed technical specifications, having broad task definition, establishing close cooperation among the involved stakeholders, recognising that change is unavoidable during the project which not only causes threats but can also lead to opportunities, replacing hierarchy by more self-steered project team, establishing a more open attitude for information exchange and lastly, managing the interfaces in a shared approach as a responsibility of all stakeholders involved rather than a task of a single project manager.

Similar to flexibility, adaptability in project management is a term emphasising the adaptation of project management to the (changing) context of projects. Giezen (2012) defines adaptability as the ability of adaptation to changes. Priemus and van Wee (2013) argue that adaptability is needed. They argue that complex projects require adaptations in their management in order to deal with threats and opportunities to overcome the internal deadlocks and external changes.

Giezen (2012) stated that the solution put forward for managing complexity is to keep projects simple. The uncertainty in projects will be reduced by diminishing the project's complexity. This way it becomes easier to better predict the project and consequently better manage the project. However, reducing a project's complexity has also some disadvantages like ignorance of the project's strategic potential.

Perminova, Gustafsson and Wikström (2008) stated that reflective learning and sense-making is required in order to increase flexibility. Reflective learning can be done by standardisation or repetitiveness of procedures. Standardisation helps to react to possible changes by providing flexibility in choosing among a number of alternative actions. However, it is not possible to reduce all the uncertainty by standardisation. While uncertainty can be decreased to some degree, some uncertainty is wished for to grab opportunities. Evolution is tied with opportunities and the elimination of all uncertainties hinders the evolution of the project. Similarly, Collyer and Warren (2009) identified one of the management approaches in dynamic environments as 'environment manipulation: making dynamic static'. This can be done by fixing objective and design, refusing change requests, reducing or delaying adoption of new technologies or techniques and extending the life of existing systems. The approach of making dynamic static also has disadvantages like lost opportunity and productivity through delayed implementation of new approaches. On top, it is not always possible to reduce complexity or making dynamic static since we do live in a dynamic environment.

A number of strategies are mentioned by Atkinson et al. (2006) for reducing uncertainty by recognising the fact that mostly project contexts are characterized by high levels of uncertainty. In such conditions, management flexibility and tolerance of vagueness are required to be able to manage the project's uncertainty. They indicate that dealing with uncertainty can be done by means of replacing ambiguity by vagueness while vagueness is about having a less tangible and more generic management process. The project requires a degree of tolerance to vagueness. They argued that uncertainty can also be caused by the incompleteness of information and unevenly distributed information. Trust is the easiest way to overcome this problem. Thus, the project requires a fine balance between control and trust, with trust underlying the control.

This brief literature scan suggests that in order to manage the project's complexity and dynamics an ideal project management approach should take the following into account:

- Redundancy in terms of keeping alternatives open and making a decision at the last responsible moment (Priemus and van Wee, 2013)
- Achieving reflecting learning by standardisation of process and design to the degree that fits the project's context (Giezen, 2012; Perminova et al., 2008).
- Being open to change by understanding that change is unavoidable, coping with threats and seizing opportunities (resilience) (Priemus and van Wee, 2013)
- Defining the project's scope into required functions (Koppenjan et al., 2011)
- Establishing stakeholders' close collaboration (Koppenjan et al., 2011)
- Self-steering of the complete project team (Koppenjan et al., 2011)
- Having an open attitude for information exchange (Koppenjan et al., 2011)
- Building trust among the parties involved in the project (Atkinson et al., 2006)

The aforementioned characteristics point out some features of flexibility in project management. However, the question what makes project management flexible, was left unanswered in the literature. In other words, whether these characteristics are the only ones which contribute to flexibility in project management and can be used in managing project complexity.

What can be concluded from the studied literature in this section is that flexibility is required in project management.

1.3 TRIGGERS FROM PRACTICE

In this section, some motives for the research from practice are explained. First, exploratory interviews performed with practitioners are discussed. Secondly, the observed triggers from practice are elaborated.

1.3.1 VOICES FROM THE FIELD

Five exploratory interviews were conducted to investigate if any kind of flexible management is recognised as a potential measure to improve project performance.

The interviewees were five well-experienced project managers from five big companies in (construction) industry in The Netherlands. These interviewees were chosen because of their years of experience in large complex projects. An overview of the interviewees is provided in Table 1-1.

Table 1-1: Interviewees overview

Respondents	Company type	Role/ position	Experience (years)		Educational background
			Total	Current position	
1	High-tech	Manager Programme Office Corporate Change Programme	23	4	Mechanical engineering
2	Consultancy	Project manager	15	5	Construction management and engineering
3	Client	Project director	30	4	Civil engineering
4	Client	Principal project engineer	18	2	Industrial engineering and management science
5	Academy for Public Construction and Infrastructural Projects	Manager (knowledge & development)	23	4	Civil engineering

The interview protocol is added in Appendix A. For this chapter, only the relevant part of the results is discussed. Interviews were held in 2014.

A number of researches claimed that poor project performance is common (Flyvbjerg et al., 2002; Kaming et al., 1997; Mansfield et al., 1994). To investigate whether it is the case in practice the interviewees were asked about how they measure project performance and if their projects were successful. It revealed that cost, time, and quality were always included for measuring performance. Apart from the iron triangle, in some projects customer value, added value to society and/or impact on the environment were considered for evaluating the project's success. Dedication of team members to the project, changes in team and teamwork were the other soft aspects for evaluation of success, all related to teamwork quality.

After realising what the measure of project performance was, the reasons of poor performance from practitioners' point of view were asked for. Interviewees pointed to a few outstanding reasons for poor performance: neglecting the influences of stakeholders and other people around the project, too much control to be within budget and time, project complexity, project environment (both neglecting and listening too much to environmental influences), misalignments at the beginning of the project, poor preparation, political and social needs and effects.

Next, the interviewees were asked about the project management approaches applied in their projects, as there would be a possible link between project management approach and project performance. They were asked if they found the applied project management method in their project appropriate or not. *"As projects follow a fuzzy process then there should be a fitting methodology to this characteristic"* was given as an answer by one of the respondents, indicating that project requirements should be taken into account for choosing the right management approach or tools.

Asking about the issues regarding project management revealed a few areas of attention: the people side of the project, technical and environmental aspects of the project, value drivers of the project, legal and contractual issues. Also stakeholder management, team management, constant change of project scope, legal arrangement (emphasis on contract), too much focus on time and money as value drivers of the project were examples of those areas of attention.

Next, the interview included questions about project complexity and Agile project management as a flexible project management methodology. It became apparent that Agile project management was not (well) known amongst the interviewees. The only interviewee who knew about Agile project management mentioned that dynamic management is needed. He believed that Agile could not be fitted to the execution of projects outside the IT world. One of the interviewees mentioned that complexity is not widely known in practice. Although practitioners often use the word 'complex' to describe their projects, the indicators of complexity are unknown to them. It was observed during the interviews that complexity was implicitly mentioned while answering the other questions. The interviewees did not use the word 'complexity' to describe their story about their projects.

To conclude the results of these exploratory interviews, several points are drawn. Although measuring project success is subjective, still time and money were the most common measures of project success. The addressed issues by practitioners regarding project management were partly related to managing project complexity. Comparing some of those issues with the core values and principal of Agile project management as a flexible project management approach supports the idea of searching for Agile outside IT.

Even if the results of using such methodology were not obvious to everyone, it seems worthwhile to investigate.

1.3.2 ADDITIONAL TRIGGERS

Not only exploratory interviews, but also some observations from practice and research streams inspired the research on flexible project management for infrastructure construction projects. The additional triggers are observations from three sources: the interest of the industry to apply Agile approaches, the interest of project management institutions and communities like IPMA and Neerlands Diep on flexible approaches and discussions within the research group (Infrastructure Design & Management (IDM)).

At the beginning of this research, A Dutch company in the construction industry showed interest in collaborative research. Their main interest was in the application of an Agile approach in construction projects. Previously the company observed satisfactory results of applying Agile project management in their IT projects. Such satisfaction motivated the other departments like the infrastructure department to apply an Agile approach. Therefore, the company used a few projects as pilot projects to be managed in an Agile way. However, the transition to Agile, the application of Agile in none IT projects and its contribution to project performance needed to be researched and understood.

Dedication of research to introduce Agile (wendbaarheid in Dutch) by a Dutch institution (Neerlands diep, 2014) in research in infrastructure projects was another example which expresses the interest of industry for Agile (flexible) approaches in project management in the infrastructure sector. Offering workshops and certified courses in the theme of Agile by project management associations like IPMA, highlights the fact that such management approach is becoming widespread.

The third trigger comes from the discussion in the research group (IDM) in which this PhD research was performed. The discussions on project complexity (as one of the research directions of our research group) lead to recognition of project management flexibility as a key to success. There were some insights in literature, but not the answer to our questions regarding flexibility: what is flexibility in project management?, How to achieve it?, What can be learned from IT projects which have used Agile? etc.

In the next section, the results of exploratory interviews are linked to the results of the exploratory literature study to investigate the existing gap.

1.4 GAP ANALYSIS

Project management is aimed at supporting practitioners to increase the probability of the successful delivery of their projects in a way stakeholders appreciate and include both hard factors and soft factors of project management, as discussed in project excellence model of Westerveld (2003). It is developed in the 1950s and is maturing day after day but still has deficiencies which arise as consequences of environmental changes and developments. Scientists' and practitioners' attention is drawn to study and understand project complexity in order to be able to manage it. Conventional project management seems no longer effective in meeting project promises. Adaptability and flexibility are two characteristics that can enrich project management.

According to the project complexity framework of Hertogh and Westerveld (2010) it could be hypothesised that flexibility in project management is required as the key for applying dynamic management methods in complex projects, in order to result in performance satisfaction. In complexity theories, strategies are not seen simply as responses to environmental changes or to another agent, but as *"adaptive moves"* that affect both the initiator of the action and all others influenced by them (Teisman, van Buuren and Gerrits, 2009).

Project management is evolving in different directions in sake of improving project performance; better understanding of projects' context and characteristics and projects' requirements. The improvements might be in the form of new management approaches like Agile project management.

Although project management has a crucial role in the whole project lifecycle, its role in early project phases has been stressed out in literature (Artto, Ahola and Vartiainen, 2016; Gibson Jr et al., 2006; Morgan, 1987; Tzortzopoulos, Cooper, Chan and Kagioglou, 2006) specially when it comes to the influence of the early project phases on the project performance (PMI, 2013).

This PhD research focuses on the need for flexibility as a consequence of dynamism and project management methodologies as a way to deal with complexity in early project phases. Both are hypothesised to influence project performance. After exploring literature and current practices the following problem statement was formulated:

Current project management approaches seem not able to deal with current dynamism and related complexities in infrastructure projects.

Bringing the results of the literature study (Kreiner, 1995; Olsson, 2006; Sager, 1990; Turner, 2004), the exploratory interviews and the needs from practice together, it can be concluded that project management methodologies significantly influence project performance. 'Too much control', 'too less client involvement', 'emphasis on cost and time rather than value', 'too much focus on threats and less on opportunities' are examples of misfit that seem to confirm the need for adoption of a new element in project management: flexibility.

This new development of need for flexibility in project management can be seen as a movement from 'upfront planning' to 'flexible planning'. To what extent need the project be open for change of functionalities and requirements, and adding new? How much estimations at the very beginning of the project are accurate and to what extent does everything continue on the early predictions? To what extent project managers should be kept to the early assumptions? How much control is required to stay within the boundaries of those early assumptions? The answers to all these questions can be summarized into the idea of 'flexibility in project management' which shapes the direction of this PhD research project (see the conceptual model in Figure 1-1).

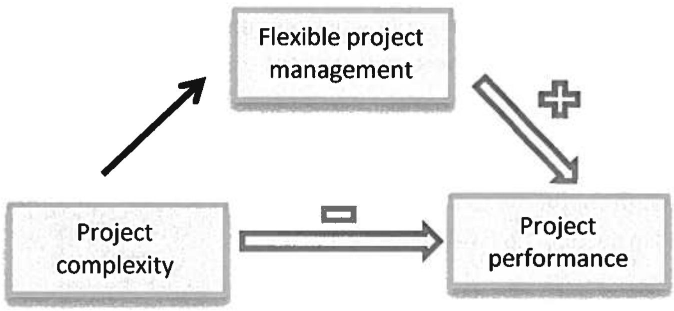


Figure 1-1: Conceptual research model

The literature emphasized the required flexibility in project management (Geraldi, 2008; Kreiner, 1995; Olsson, 2006; Osipova and Eriksson, 2013) to improve the project performance. Also, the literature supports the negative effect of project complexity on project performance (Bosch-Rekveldt, 2011; Reilly, 2000; Shenhar, Dvir, Lechler and Poli, 2002; Smith and Irwin, 2006). On the other hand, sometimes the complexity needs to be increased to reach more added value, as is the case by adding extra functionalities (Hertogh, 2014). Taking the effects of flexibility and project complexity on project performance into account, the base conceptual model of the research is a fit between flexible project management methodology and the project complexity and how these two influence project performance (Figure 1-1). The initial hypotheses behind this model are:

(1) Flexible project management has a positive effect on project performance in early project phases.

(2) Project complexity has a negative effect on project performance.

(3) Flexible project management can mediate the effect of project complexity on project performance.

The objective of this research project is: to investigate the effect of project management flexibility and project complexity on project performance in early project phases of infrastructure projects, resulting in a framework to make project management flexible.

1.5 Research Questions

The research objective is translated to this main research question: **how could flexibility in project management improve project performance in complex infrastructure projects in their early phases?**

The main research question is broken down into 6 sub-questions. Answering these sub-questions leads to the answer to the main research question:

1. What is the evidence of project management flexibility in literature and practice?
2. What are project management flexibility enablers?
3. What are practitioner's perspectives regarding flexible project management?

4. How flexible is the current practice of project management?
5. How does flexible project management contribute to project performance?
6. How does flexible project management contribute to the effect of project complexity on project performance?

Each chapter of this dissertation provides an answer to one of these sub-questions as it is explained in Section 1.6 (see Figure 1-3).

1.6 METHODS APPLIED IN THIS RESEARCH

This research aims to deliver a framework which application can improve the conventional project management approach to become a more flexible, in order to positively influence project performance. This section briefly elaborates on the research methods that are applied in this PhD research.

Söderlund (2004) distinguished two main theoretical directions in project management: one with intellectual roots in engineering science and applied mathematics and the other one with intellectual roots in social sciences. It can be said that project management is part of social sciences in which theory is build based on empirical data (Timmermans and Tavory, 2012). However, empirical data is not the only source for building any theory in project management (Söderlund, 2004).

Each research needs a research design which includes a philosophical view, strategies of inquiry and specific methods (Creswell, 2009). Each of these parameters is explained briefly.

The practice of research is widely influenced by philosophical worldviews (Creswell, 2009). The choice of philosophical view helps in selecting the right research method in the later stages of the research. The worldviews are also called paradigms (epistemologies and ontologies) (Crotty, 1998). Creswell (2009) distinguishes four different philosophical worldviews: post-positivism, constructivism, advocacy/participatory and pragmatism. Based on defined characteristics for each philosophical worldview (Creswell, 2009; Tashakkori and Teddlie, 1998), this PhD research fits into the post-positivism paradigm. Post-positivist research believes that there are logical, reasonably stable relationships among social phenomena which might be known imperfectly (Tashakkori and Teddlie, 1998). Although the prediction accuracy of such relationships can never be 100%, it improves over time. Post-positivism holds a deterministic philosophy where causes probably determine effects or outcomes (Creswell, 2009). In this PhD research based on the formulated research objective, the main focus of the study is to test the relationships between different predictors and outcome variables. According to Tashakkori and Teddlie (1998) post-positivism research is mainly quantitative and deductive which is the case in testing the relationships in this PhD research (see Chapter 8). However, before testing the aforementioned relationships, the phenomena (the predictors and outcome variables) need to be studied and understood well. This part of the research is more qualitative and fits into inductive research which is explained further in Chapter 5.

Next, the strategies of inquiry need to be chosen, also called research methodology (Mertens, 1998). Note that literature suggests choosing the research strategy before choosing the research methodology (Blaikie, 2009). In fact, they go hand in hand. The four research strategies based on Blaikie (2009) are: inductive, deductive, retroductive and abductive. Given the characteristics of this PhD project, the research fits into both inductive and deductive research strategies. Deductive research tests out the developed theories and hypotheses through empirical observation, while in an inductive research, the researcher aims to develop hypotheses and theories based on empirical observations of the real world (Lancaster, 2005). Although post-positivism research is preliminarily seen as deductive research (Tashakkori and Teddlie, 1998), there might be a switch between deductive and inductive research at different stages of the research. This is what Wallace (1971) already introduced as 'The Wheel of Science' (see Figure 1-2). Also in this PhD research a combination of inductive and deductive strategies is applied.

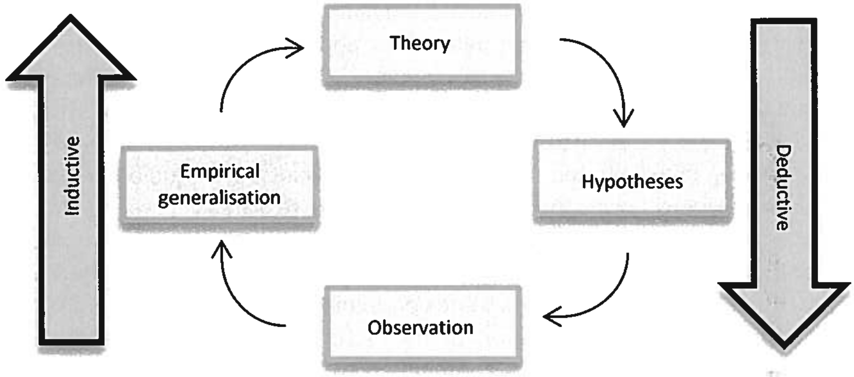


Figure 1-2: Wheel of science (Wallace, 1971)

Lancaster (2005) identified three different types of research in management based on the research objective or primary focus of the research, including 'theory building research', 'theory testing research', and 'problem centred/practical research', with some overlap between them (Lancaster, 2005). The first two types correspond to Wallace's Wheel of Science, e.g. correspond to inductive and deductive research. The third type, as Lancaster implies, unlike the first two is not aimed at theories building or testing, but aimed at investigating an existing problem or question in practice in the context of an organisation or specific management approach by resolving the problem and therefore make recommendations for an action plan. The focus of this third stream is on exploring solutions to real-life management problems rather a knowledge building or academic purposes (Lancaster, 2005).

In this PhD research, the part of the research which is dedicated to <u>understanding</u> the current situation and knowledge gaps (not only in theory but also in practice), is following a deductive research strategy. It is deductive because the starting point is the theory stated in the literature. After making a clear image of the literature and the current practice, the research strategy will switch into a more inductive character. Inductive because by analysing the observed situation and existing literature, the research contributes to theory by concluding the status of flexible project management in theory and practice. The same loop will be repeated to establish the conceptual model and test it (see Figure 1-2). By starting from in-depth literature review and exploring the practice, research hypotheses are reformulated (deductive). Testing the hypotheses will contribute to literature (inductive). So in total we round two loops.

In general three types of research methods (strategy of inquiry) can be distinguished, based on data type: qualitative, quantitative and mixed method research. Qualitative research is aimed at investigating the meaning individuals or groups ascribe to a social or human problem, whereas quantitative research is aimed at testing theories by testing the relationship between dependent and independent variables (Creswell, 2009). Qualitative research can be performed by conducting a qualitative small-scale study. This may imply an ethnography study, in which the culture of a population is studied, a grounded theory study, in which a general theory is derived from studying the different views of participants, a case study, in which a specific case is studied, a phenomenological study, which studies the experiences of participants with a particular phenomenon, or a narrative study, in which the lives of the participants are studied (Creswell, 2009). Qualitative data which forms the input of a qualitative research is presented in the form of descriptive statements about observations made from phenomena or data which is classified by type (Lancaster, 2005). Quantitative research can be performed by means of a survey research, in order to assess trends or opinions within a population by examining a sample population, or an experimental research, used for examining the effect of a treatment. Mixed method research combines both qualitative and quantitative research. It can do so by means of three different research strategies: sequential, concurrent, and transformative. The sequential strategy is used when one research (qualitative or quantitative) is used to further elaborate on the results of the other research (qualitative or quantitative). The concurrent strategy is employed when the results are merged and complement each other. The transformative strategy uses a theoretical lens to set constraints for both qualitative and quantitative research (Creswell, 2009).

To answer the sub-questions in this research, different research methodologies are applied, see the overview in Figure 1-3. Hence from the point of view of research methodology this research applies mixed methods.

After the topic of the research has been chosen and the research strategy is defined, it is time to choose research methods and approaches for the data collecting phase of this research. There are different methods for collecting data, such as survey, case study and experiment (Creswell, 2009). Each formulated research sub-question requires a specific research method for data gathering.

To answer the main research question, a few research steps following the Wheel of Science were defined (see Figure 1-3).

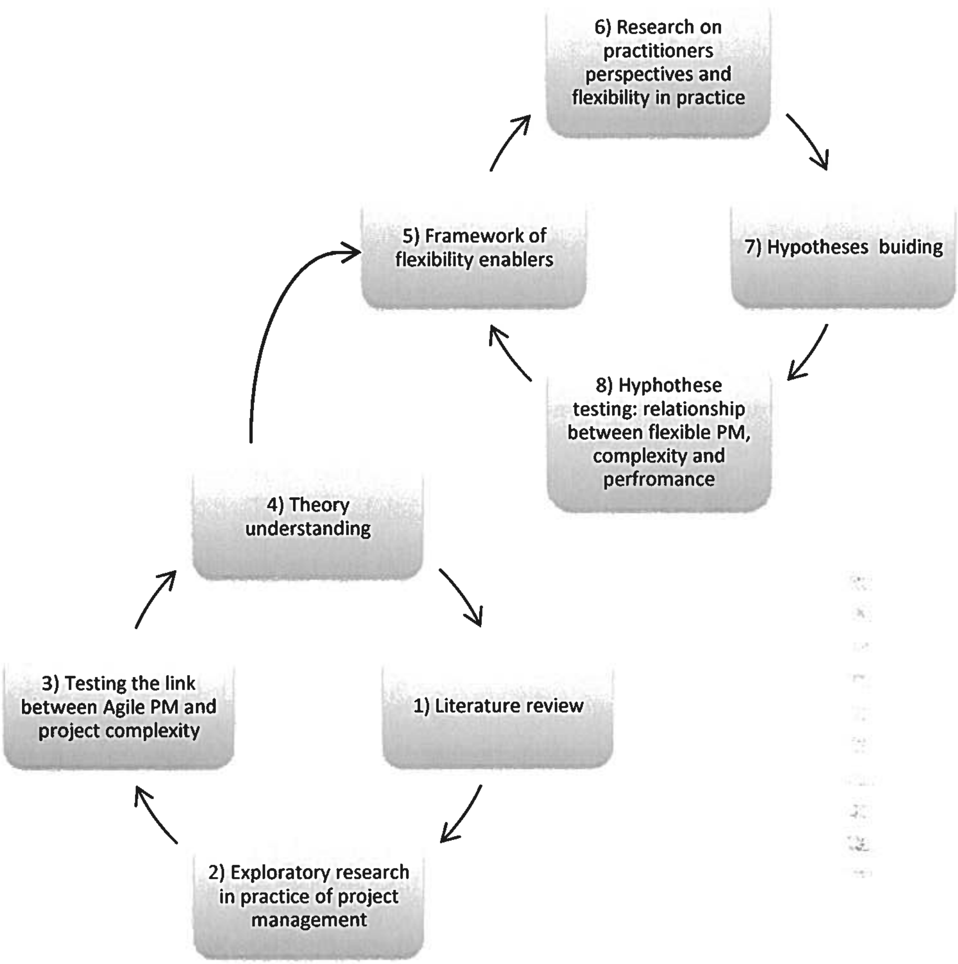


Figure 1-3: Research design

The steps are briefly explained:

- Step 1: The starting point of this research is literature review (Chapter 2). It covers the review of project complexity, project management history, its development and changes during past decades, the required balance between control and flexibility. It follows by looking for new paradigms in project management, elaborating on the idea of flexibility and adaptability in project management. These new paradigms are mostly based on nowadays projects' characteristics including complexity.
- Step 2: After the literature review, a case study is carried out to understand the current situation about the usage of the project management methods (Chapter 3). To make a clear image of what we are looking for, the multiple exploratory case

study is most appropriate (Yin, 2014). This phase of the research is qualitative research.

- Step 3: Next, to understand the link between project complexity and current flexible management approaches, a survey study is conducted which forms a quantitative research (Chapter 4).
- Step 4: Based on steps 1 to 3 the answer to the first research sub-question is provided (Chapters 2 to 4). These steps help to understand the theory and practice of project management in order to develop the flexibility framework.
- Step 5: The next phase of research covers an in-depth literature review on flexible project management in Chapter 5 (second research sub-question).
- Step 6: Next, by use of a mixed-method approach (Q-methodology) practitioners' perspectives on project management flexibility are explored in Chapter 6 (third research sub-question). To answer the fourth research sub-question about flexibility of project management in practice, a quantitative research is carried out (Chapter 7). The data required for this step is gathered through a semi-structured survey.
- Step 7: In this step, the hypotheses from chapter 1 are reformulated into several smaller ones to be tested quantitatively. Chapter 8 presents the hypotheses.
- Step 8: The reformulated hypotheses are tested in this step of the research. By testing the hypotheses, sub-questions 5 and 6 are answered in Chapter 8.

1.7 SOCIAL AND SCIENTIFIC RELEVANCE

The number of ongoing construction projects all over the world is considerable. Especially large size projects, like mega projects including infrastructure, water and energy, mining, information technology and many other types of projects (Flyvbjerg, 2014). Dobbs, Pohl, Lin, Mischke, Garemo, Hexter, Matzinger, Palter and Nanavatty (2013) claim that global infrastructure investment needed in 2013 till 2030 is around 57 trillion dollars. All those projects are being built to fulfil the needs of people. Flyvbjerg (2014) noted that mega projects impact millions of people in different ways. Lin, Zeng, Ma, Zeng and Tam (2017) stated that (mega) projects are responsible for providing fundamental social production for modern societies in terms of economic development in daily life. They call megaprojects backbones of the modern society. But the question here is whether the impact on society is always positive. There are reports on projects' failure that threaten such impact on the society (Davis, 2014; Flyvbjerg et al., 2002) especially in money terms as addressed by Flyvbjerg (2011). Dobbs et al. (2013) stated that poor performance of infrastructure projects cause major economic and social challenges across the world. The projects' impact on society was also highlighted by Samset and Volden (2016). They noted that the benefit of these projects to society should be studied in expansive societal perspectives to secure the value for money and contribution to the desired developments.

All mentioned references above address the growth in construction of projects worldwide to add value to society. However, the reports on projects poor performance and failure questioned the added value and the impact to the society. Considering such impact, the importance of the project management role in delivering projects' value to society is more recognisable.

Literature indicates that project management as a research field is still immature (Davis, 2014) although high numbers of researches are being done in the field. Also it is proved that if project management is implemented correctly, it adds value to practice (Munns and Bjeirmi, 1996; Shi, 2011). However, the performance of projects is not satisfying due to different reasons (Flyvbjerg, 2011; Flyvbjerg et al., 2002). Hence it should be understood in which direction project management needs to be further developed or improved.

Some researchers have looked into the areas in which project management is growing as a research field (Cicmil, Williams, Thomas and Hodgson, 2006; Söderlund, 2004; Svejvig and Andersen, 2014). Söderlund (2004) distinguishes seven schools of thought in project management: optimization school, factor school, contingency school, behaviour school, governance school, relationship school and decision school. Flexibility, complexity and adaptability are among the keywords which define the contingency school. There are researches going on in the field of project management which focus on any of these keywords or a combination of them. Definition, identification and management of project complexity is a topic which was introduced decades ago and has been still continuing as a research field (Baccarini, 1996; Bakhshi, Ireland and Gorod, 2016; Bosch-Rekveldt, 2011; Browning, 2014; Christoph and Konrad, 2014; Dao, Kermanshachi, Shane and Anderson, 2016; Delei, Qinghua, Lan, Jianxun and Guangdong; Dunović, Radujković and Škreb, 2014; Hertogh and Westerveld, 2010; Kermanshachi, Dao, Shane and Anderson, 2016b; Padalkar and Gopinath, 2016). Managerial flexibility and adaptability is the other topic in the contingency school which is addressed by scholars in search for new paradigms in project management (Geraldi, 2008; Kreiner, 1995; Olsson, 2006; Osipova and Eriksson, 2013; Walker and Shen, 2002; Wirkus, 2016; Wysocki, 2007; Yadav, 2016).

Although project management flexibility has been introduced in literature, no extensive research was performed translating flexibility into managerial practices. Also its effect on project complexity and whether it contributes to project performance was not elaborated in literature when this PhD research was started. Hence it is assumed that theoretically this research moves towards building knowledge in a theme that has not been researched enough yet: flexible project management.

The ultimate goal of the research is to improve project performance which delivers the business value for the society. It was mentioned that the investment in infrastructure projects is huge. Delivering value to society for such huge investments is expected by society. Therefore in this PhD research, the idea is to investigate how flexible project management can improve project performance. And consequently, improved project performance will impact society in a positive way in future.

1.8 Thesis outline

As can be also seen in figure 1.3, Chapter 2 includes a background literature study. In search of flexibility in project management, Chapter 3 presents an exploratory research to understand the current practice in project management. Chapter 4 explores the link between Lean & Agile project management and project complexity. The enablers of project management flexibility are covered in Chapter 5. Chapter 6 is looking at the practitioners' perspectives regarding flexible project management. How flexible the current practice is, is reported in Chapter 7. Chapter 8 illustrates the effect of flexible project management on project performance and its mediating role. Conclusions and recommendations, including the flexibility framework, are provided in Chapter 9.

Chapter 2: LITERATURE REVIEW

Abstract

Nowadays projects are often labelled by their complexity. The importance of understanding project complexity is acknowledged in several ways, including its importance for the selection of a proper project organisation, determining the coordination and control requirements and the management of risks. Once the importance of understanding project complexity is recognised, much effort was given to find the causes and root causes of complexity, define it and identify its elements. Project complexity is also often addressed as the cause of project failure since it affects the project objectives. Once project complexity is understood, it would be possible to choose an appropriate project management approach based on the complexity of the project at hand.

This chapter presents an in-depth literature review as the basis for the current research. The following themes are addressed: project complexity, project management and its new evolvements; flexibility and adaptability in project management, project performance and early project phases (front-end development).

The chapter ends by bringing the subjects together to make a clearer picture of what is explored in subsequent chapters.

The purpose of the literature study is to form a solid ground for performing the research.

The scope of the literature study for this research is narrowed down to the three main building blocks of the research conceptual model (see Figure 1-1): project complexity, project management with focus on project management flexibility and project performance. Moreover, as the research focuses on early project phases, these phases should be studied and understood.

In order to perform the literature review, a number of keywords were searched in different databases. The targeted databases were: Google Scholar, Scopus and Science Direct. The keywords were: project complexity, flexibility, adaptability, project performance and project management. Depending on the importance of each keyword in the research, some were explored thoroughly in the literature and some were studied to be understood enough for the purpose of the research. Flexibility and adaptability in project management were the two keywords that had to be studied thoroughly since they are the primary focus of the research. Project complexity and project performance were the variables in the research conceptual model to test the effect of project management flexibility. Therefore, project complexity and project performance were explored in the literature to the extent which provides enough ground for the research.

Before getting into the literature review on the abovementioned key words, the first step is to define what a project is in the context of this research.

2.1 WHAT IS A PROJECT?

PMI (2013) defines a project as *"a temporary endeavour undertaken to create a unique product, service, or result"*. PRINCE2 also provides a definition for a project: *"a temporary organisation that is created for the purpose of delivering one or more business products according to an agreed Business Case"* (OGC, 2009). The handbook of project-based management defines a project as *"a temporary organisation to which resources are assigned to do work to deliver beneficial change"* (Turner, 2014a). From these definitions it can be concluded that a project 1) is temporary, 2) has one or multiple goals and 3) needs resources.

Although it seems easy to distinguish a project from a program, sometimes the terms are used interchangeably. According to PMBoK, a programme is defined as *"a group of related projects, subprograms and programme activities managed in a coordinated way to obtain benefits not available from managing them individually" (PMI, 2013).* The management of individual projects is different than the management of a programme (PMI, 2013). The focus of programme management is on the project interdependencies and determination of an optimal approach for managing them.

Considering the differences between a project and a programme as well as differences in the management of an individual project and a programme, it is important to specify where the focus of the research is. This research focuses on the project level, as the starting point of the research is related to the observed difficulties in management of complex projects (Bosch-Rekveldt, Jongkind, Mooi, Bakker and Verbraeck, 2011; Hertogh and Westerveld, 2010; Van Marrewijk, Clegg, Pitsis and Veenswijk, 2008; Williams, 1999). All the provided definitions of a project given above have the same line of reasoning and highlight similar characteristics. Given those similarities, this research adopts Turner's definition of a project (Turner, 2014a).

2.2 PROJECT COMPLEXITY

From available literature it is obvious that an understanding of complexity not only developed since 2 or 3 decades (Simon, 1962). However, considerably more attention is given to the subject in past decade in multidisciplinary research on project complexity (Bakhshi et al., 2016; Christoph and Konrad, 2014; Floricel, Michela and Piperca, 2016; Qazi, Quigley, Dickson and Kirytopoulos, 2016; Vidal et al., 2011). Aritua, Smith and Bower (2009) believe that mastering of project complexity is not a new challenge, but an old challenge which is recognised more recently and understood as a factor that has influence on project performance and the required project management.

Why does project complexity need to be understood? One of the reasons that construction projects suffer from cost overruns and delays could be assigned to the complexity of construction projects. Mainly large construction projects have to deal with high complexity. It is also stated in the literature that projects over time have become more complex (Baccarini, 1996; Harvett, 2013; Hillson and Simon, 2007; Philbin, 2008; Williams, 1999). Ourdev, Xie and AbouRizk (2008) state that construction projects are embedded in an environment which is characterised by dynamics and complexities, involving many unpredictable parts and including a considerable level of uncertainty. Van Marrewijk et al. (2008) believe the large infrastructure projects are characterised as complex, uncertain, sensitive to political conditions and known for the involvement of a large number of stakeholders. Complexity of large projects can be found in (Reilly, 2000): increasing standards of design, predefined quality requirements, better definition as well as awareness of environmental concerns, more sensitivity to both urban design and aesthetic issues, awareness regarding the fulfilment of the public's needs and the importance of public involvement. Floricel et al. (2016) noted that complexity as a major source of uncertainty and risks would affect project costs and performance if not addressed well from the planning phase of the project.

Understanding the importance of studying project complexity, much effort has been given into defining complex systems and project complexity and grouping complexity elements and dimensions (Baccarini, 1996; Bakhshi et al., 2016; Bosch-Rekveldt, 2011; Hertogh and Westerveld, 2010; Reilly, 2000; Shenhar et al., 2002; Shenhar, Dvir and Shulman, 1995), or looking for reasons of complexity (Gray and Hughes, 2001).

Baccarini (1996) as one of the pioneers who studied the subject of project complexity in the construction industry, defined project complexity as 'consisting of many varied interrelated parts and can be operationalized in terms of differentiation and interdependency'.

Are complexity and uncertainty the same? Complexity and uncertainty are two concepts that from very first studies have been discussed either being part of each other or distinct subjects. Scholars like Jones and Deckro (1993), Turner and Cochrane (1993) and Bosch-Rekveldt et al. (2011) considered uncertainty in the projects as one of the complexity's elements while others (Baccarini, 1996) believe complexity and uncertainty are two different concepts.

Apart from defining project complexity, recognition of types of complexity is covered in the literature. Maylor (2010) believes that complexity includes five main elements: mission, stakeholder, organisation, team and delivery. He believes any of these five elements can be translated into issues which also makes management complex and can be used as metrics to assess project complexity. Cooke-Davies, Cicmil, Crawford and Richardson (2007) identified some recurring properties of complex systems as emergence, indeterminacy, nonlinearity, interrelatedness and dynamics. Maylor, Vidgen and Carver (2008) recognise different elements of complexity: individual and interacting structural elements, the dynamic effects as result of changes in individual elements, moreover, the interaction which also causes dynamic effects. This dynamic effect is also reflected in the complexity model of Hertogh and Westerveld (2010) (Figure 2-1). Two types of complexity recognised by them are detailed and dynamic complexity. According to them, detail complexity can be quantified and measured. Therefore it can be predicted and required preparation can be planned if necessary. Detail complexity includes the components and the interrelations in the product-, stakeholder-, and activity sub-system whereas dynamic complexity includes the uncertainties in the decision-making and changeable cause-and-effect relations. They proposed different management styles, dependent on the specific complexity in a project.

Identification of complexity elements has been given attention among scholars (Bakhshi et al., 2016; Bosch-Rekveldt, 2011; Geraldi, Maylor and Williams, 2011; Kian Manesh Rad, Sun and Bosché, 2017). Bosch-Rekveldt (2011) developed the TOE (Technical, Organisational, and External) framework consisting of 47 complexity elements to assess the complexity of engineering projects. Bakhshi et al. (2016) extracted a list of 152 complexity elements by systematic literature review.

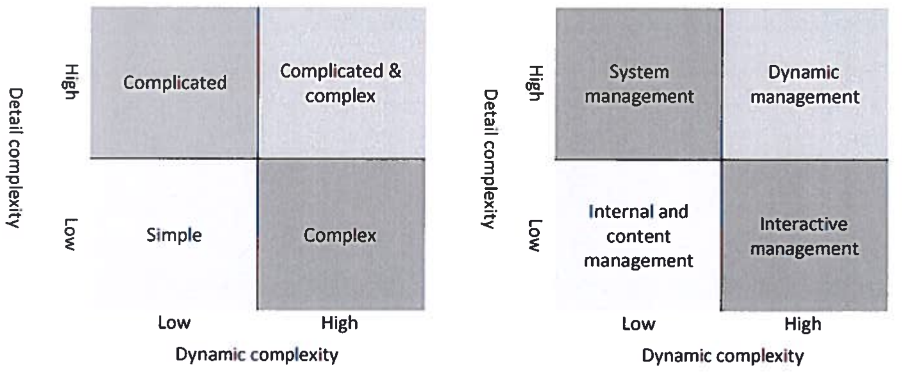


Figure 2-1: Complexity vs. management approaches (Hertogh and Westerveld, 2010)

To manage project complexity, there should be a fit between project management and the type of complexity. Hertogh and Westerveld (2010) proposed four different management approaches based on the level of detail and dynamic complexity: internal and content focus management, interactive management, systems management and dynamic management. They observed in their research that the internal and content focused approach was most often used to manage projects, even when the project does not fit in this quartile based on its complexity. For these projects, applying the internal and content approach could lead to problems and in the end to unsatisfying project performance. Rather, the management approach should fit the complexity of the project at hand. For projects with high detail and dynamic complexity, dynamic management should be applied. Dynamic management combines control, with strategies of decomposition (time, end product and organisation) and management processes (schedule, costs, quality and risks) and interaction with strategies of alignment, redefinition of the problem and change of scope, as well as variation, selection and evaluation of strategies.

To summarize the literature on project complexity: in this section it was discussed that project complexity and how to manage it was in the core focus of several scholars. Effort was made to define it, to further identify what different types of complexity are and what the elements of complexity are for each complexity type. Next to this recognition of project complexity, the importance of selecting the appropriate project management approach to fit the project complexity of the project at hand was discussed. Given the importance of project complexity in influencing project performance, in this PhD research it was chosen to investigate whether flexibility of project management could help managing project complexity. Let's explore project management to understand why this was chosen.

2.3 DEVELOPMENTS IN PROJECT MANAGEMENT

What we know as project management these days, also known as conventional project management, was evolved in the 1950s in the defence and aerospace sectors. The conditions in which project management was born is characterized as little flexible and less complex (Morris, 1997). It was assumed that project management is rational and normative, in which the causal relationships are predictable based on the reality. In such conditions using for example a Work Breakdown Structure to manage the project's scope should be the main concern (Williams, 2005). Conventional project management puts the emphasis on extensive front-end planning to achieve the predetermined triple constraints of budget, time and quality. The result of such extensive front-end analysis forms a 'blueprint-type scope description' including a list of work packages (Koppenjan et al., 2011). The work packages, also called tasks should be performed and delivered during the execution phase based on a plan which is set and frozen in the planning phase. Any deviation from such frozen and control-oriented plan is undesirable. PMBOK as one of the most known project management guidelines gives a more elaborated description of conventional project management (Koskela and Howell, 2002). According to the PMBOK guide, a project generally consists of two processes: the project management processes and product-oriented processes. The first one ensures a sufficient flow throughout different project's phases while the later ensures the end result of the project based on the agreed specification. The focus of the PMBOK guide is mostly on the project management processes (PMI, 2013).

By definition, project management is the deliberate application of certain knowledge, techniques, tools and skills in order to make a unique product or service (Kenny, 2003). Like other fields of management such as operation management, finance or IT (Information Technology), project management has also developed into a subject discipline (Mir and Pinnington, 2014). The availability of different processes, tools and techniques gives the project manager the opportunity to choose a specific set to manage the project. The selection of right project management processes can be based on the project specification, however, Kenny (2003) indicates that traditionally project management does not take the project type or specifications into account for choosing the right management approach. Differentiation in projects' size, uniqueness and complexity potentially emphasises the necessity of a tailored management method.

Maylor and Blackmon (2005) identified three stages in the historical development of project management methods:

- Pre-1950s: in this period there was no accepted process as project management approach.
- 1950s: the time that project management was developed as a discipline for management of mega-projects in the USA. The newborn project management was based on numerical methods.
- 1990s: the third stage in project management development starts with the recognition of differentiation between project types and methods by evolvement of strategy-based contingent approach.

While conventional project management has been dominated by the hard paradigms to manage projects (Aritua et al., 2009), there is a need to investigate new approached and theories. Literature emphasised that such new theories in terms of new ontologies and epistemologies should recognise the concepts such as reality of complexity and project management practice (Winter, Smith, Morris and Cicmil, 2006). This new approach values the soft paradigms of project management which were neglected in conventional project management.

In 2014, Davis claims that project management is immature as a research field, although project management processes are required for successful delivery of projects (Davis, 2014). Project management is a growing subject as a knowledge field by different professional associations and institutions and has been developed in form of standards, methodologies, tools and techniques all aiming at failure reduction. The development of strategies in project management requires considerable investments to ensure project success which is reflected in progressive upgrades of project management methodologies and tools such as PMBoK and PRINCE2 (Davis, 2014). This, however, is not reflected in research results showing the failure rates (24% of projects failing and 44% being challenged in 2009) in terms of delivery time, budget, required features and functions (The Standish Group, 2009). The research in 2016 reported failure of 19% of projects and

52% of projects being challenged (The Standish Group, 2016). PMI (2017) reported waste of 97 million dollars for every one billion dollars invested due to poor project performance, so 9,7%. In the same annual survey report PMI compared the organisations which are under-performers (organisations with 60% or fewer projects being completed on time and on budget, meeting original goals and business intent and having low benefit realisation maturity) versus champion organisations (organisations with 80% or more of the projects being on time and on budget, meeting original goals and business intent and having high benefits realisation maturity. The results show that even in champion organisations, which have performed relatively well, there is room for improvement. In underperformed organisations the performance averages are far from satisfying (see Table 2-1).

Table 2-1: Project performance averages of champions versus underperformers (PMI, 2017)

	Champions	Under-performers
Average percentage of projects completed on time	88%	24%
Average percentage of projects completed within budget	90%	25%
Average percentage of projects that meet original goals/business intent	92%	33%
Average percentage of projects experiencing scope creep	28%	68%
Average percentage of projects deemed failure	6%	24%
Average percentage of budget lost when a project fails	14%	46%

In the development of project management approaches Pryke and Smyth (2006) observed different conceptual approaches: traditional project management approach, functional management approach, information processing approach and relationship approach. They believe that each approach makes its own contribution to the project while they are complementary.

The awareness of the changing and dynamic project environment is growing since the beginning of 1990s which is the third stage in project management developments (Bosch-Rekveldt, 2011). It is recognised that complex and changing context of a project as a response to the changing and dynamic environment makes predictions less reliable. Consequently, prediction and a change-avoidant mindset should be replaced by change-acceptance mindset in order to incorporate changes in the project (Priemus and van Wee, 2013). The switch from a change-avoidant (control-oriented) approach to change-acceptance is reflected in a broader approach in management as called 'prepare and commit' approach by Koppenjan et al. (2011). Their new approach acknowledges the uncertainty and complexity of infrastructure projects by recognising that scope changes are inevitable because of the uncertainties and complexities. The 'prepare-and-commit' approach aims at managing both uncertainty and complexity in an effective way (Atkinson et al., 2006).

Literature argues that project management should evolve and mature in the direction of a 'prepare-and-commit' approach as the complementary approach to conventional project management (Geraldi, 2008; Geraldi, Turner, Maylor, Söderholm, Hobday and Brady, 2008; Koppenjan et al., 2011; Perminova et al., 2008). Geraldi (2008) states that projects require both mechanic (order) and organic (chaos) paradigms: order being reflected by conventional project management while chaos acknowledges the complexity and uncertainty of projects. Combining both approaches means that a certain degree of flexibility is needed or in other words a balance is to be found between controlling complexity and uncertainty and maintaining flexible in order to cope with complexity and uncertainty (Geraldi, 2008; Koppenjan et al., 2011).

Cooke-Davies, Cicmil, Crawford and Richardson (2008) argue that a paradigm shift is required away from conventional project management, to enable the management of nowadays modern practice challenges. Conventional project management is known as a rational and linear approach (Williams, 2005) which makes it be ineffective in the management of project complexity in the project lifecycle (Harvett, 2013).

Smith and Irwin (2006) were one of those who questioned the ability of traditional project management approaches to effectively deal with complexity which is not rational and linear. The need for a move towards an 'uncertainty management paradigm' was highlighted in the literature (Harvett, 2013). Increasingly it is argued that nowadays a pure project management approach (the traditional project management approach mentioned above) is no longer effective (Koppenjan et al., 2011). Hertogh and Westerveld (2010) believe there should be a balance between control (traditional project management) and interaction.

To summarize the developments in project management: given the disappointing project performance rates, the need for a change seems evident. Project management needs to change from a conventional approach towards an approach that could be better capable of dealing with complex and changing environments. The next section elaborates on balancing control and flexibility, as a suggested paradigm shift in project management.

2.4 BALANCING CONTROL AND FLEXIBILITY

Whatever the definition of 'project' is, the ultimate goal of a project is to create value for the stakeholders, although what is meant by 'value' would be different for the various stakeholders involved in the project (Achterkamp and Vos, 2008). As the project life cycle progresses through its different stages, existing uncertainties and risks are generally reduced, but new uncertainties and risks may come up. Risks and uncertainties play an important role in project management (Hillson and Simon, 2012). Too much emphasis on efficiency criteria (cost and schedule) may lead to unsuccessful delivery of the project in terms of project's value:

"Too often project managers (and those above them) focus on the usual constraints of time and cost. There are times when value does not seem to matter at all-its schedule, schedule, schedule, as if value will take care of itself. Then there are those that focus on the scope and detailed requirements but not the end goal of value. The assumption gets made that delivering on scope, schedule, and cost means delivering value." (Highsmith, Jim, 2010)

Excessive control can impose unnecessary bureaucracy in project management processes which hampers achieving project objectives (Buuren, Buijs and Teisman, 2010;

Rijke, van Herk, Zevenbergen, Ashley, Hertogh and ten Heuvelhof, 2014). The relationship between programme managers and project managers can be hindered by too much bureaucratic control resulting in rigidness and less focus on value-adding activities (Lycett, Rassau and Danson, 2004). Platje and Seidel (1993) state that bureaucracy and control fall in a loop which invokes inflexibility and de-motivation.

Cobb (2011) mentioned a number of suspects to blame in case a project fails to deliver the desired business value:

- The inadequacy of the requirements' specification set by users
- Insufficient requirements' definition
- Misunderstanding of the requirements by the team
- Required changes in the business case

The root cause of the aforementioned suspects may lay in the way projects have typically been managed. This was also highlighted by Hertogh and Westerveld (2010) in choosing the right management approach based on project complexity, see Figure 2-1. An inappropriate project management approach may satisfy neither the management of cost and schedule nor the achievement of the desired business value (Cobb, 2011).

Summarizing the above, it is concluded that the required project management approach for today's projects in an uncertain environment should provide the right balance between flexibility and responsiveness to be able to adapt to required changes (Cobb, 2011; Geraldi, 2008; Hertogh and Westerveld, 2010; Koppenjan et al., 2011). The next step is to understand what then is meant by flexibility in project management.

2.5 FLEXIBILITY IN PROJECT MANAGEMENT

Before exploring flexibility in project management, there are a few points to highlight. One of the projects' characteristics is the uniqueness of each project and based on this, each project faces unknown unknowns during its lifecycle. During the project life-cycle, these unknowns are transformed into knowns. Therefore project plans including the project scope, time and cost should be revised accordingly. This phenomenon (updating the plans while unknowns turn to knowns during the project) is called progressive elaboration. Progressive elaboration indicates that as a project progresses, the uncertainty decreases by the identification of more detailed information about the project (Dloi, 2014). Changes are an unavoidable part of any project. It is not possible to prevent changes. Lycett et al. (2004) state that there is a direct relationship between the amount of required changes and the contract period meaning that more changes will be anticipated when the contract period is longer. The challenge for project managers is to keep their projects focused while ensuring their organisation's needs in an uncertain business environment (Olsson, 2006).

Mentioning these facts brings the attention to the need for adding flexibility to project management. Kreiner (1995) mentions that flexibility is required to deal with changes and uncertainties in the changing business environment. Sager (1990) found several examples of flexibility in order to prepare the management to deal with uncertainty and its effect on the project in urban planning. Also Kreiner (1995) believes that the uncertainty challenges the stability of traditional project management. Flexibility can also be seen as a response to environmental uncertainty (Olsson, 2006). Hertogh (2014) discussed the fact that project managers should be open for opportunities, not only at the start, but also during the course of the project. This so-called opportunity framing is supposed to be a recurring, iterative process, aiming at maximum value creation. However, usually project managers stick to their scope, whereby missing possible enrichment of their projects.

Turner (2004) states that *"the project manager should be empowered with flexibility to deal with unforeseen circumstances as they see best, and with the owner giving guidance as to how they think the project should be best achieved"*. Flexibility can be seen as a way of postponing irreversible decisions until more information is available to make reversible decisions (Olsson, 2006). Priemus and van Wee (2013) believe the best way to deal with complexity is to adapt redundancy, resilience, alternatives and options, starting in the early project phases. The solution is to adopt different types of adaptation:

- Redundancy: keeping all possible alternatives open and postponing the decisions to the latest possible moment.
- Resilience: embracing changes by recognising that change is inevitable, seizing opportunities and coping with threats.
- Reflective learning: standardising the process and design to an extent that fits with the project's context resulting in reflective learning.

Based on Giezen (2012) it is concluded that adaptation is required in the planning and decision-making of complex mega-projects to handle the possible deadlocks and bottlenecks in the process and unexpected changes in the context.

In this section a brief explanation of what is meant by flexibility was given. It was discussed that increased project complexity, environmental dynamics, uncertainty and risks are all sources of changes in projects. Changes should be managed in order not to affect projects negatively, moreover, these changes may include opportunities to improve the project. The key to manage changes or better say dealing with dynamics is flexibility. Hence the base definition of project management flexibility is: *the ability to deal with project dynamics*. The idea of flexibility was introduced briefly here in this section however, it is elaborated in detail in chapter 5 of this thesis. Now first adaptability in project management is discussed.

2.6 Adaptability in project management

There is a term which can be considered as a synonym of flexibility: adaptability. This term also appeared in project management literature (Godinho and Branco, 2012; Ourdev et al., 2008; Stoica and Brouse, 2013; Walker and Shen, 2002). The question here is if flexibility and adaptability are the same in project management. To clarify further steps, this section focuses on a general understanding of adaptability.

The term 'adaptive management' first appeared in the natural resources management sciences in the mid-1970s. The idea behind adaptive management is borrowed heavily from adaptive control process theory, which investigates how to construct decision-making or control devices, capable of learning from experience (McLain and Lee, 1996).

The uncertainty in managers' knowledge of a system is acknowledged in adaptive management. Based on such uncertainty, adaptive management believes that instead of a single best policy, a set of alternatives should be dynamically tracked. This way, the information is gained about the effects of different courses of action from implementation of different alternatives (Linkov, Satterstrom, Kiker, Batchelor, Bridges and Ferguson, 2006). Scientifically, an adaptive management approach is based on operations research and management science (OR/MS) which help decision makers in the decision process by use of the scientific method and mathematical in an environment known by its complexity, shifting conditions, and uncertainty (McLain and Lee, 1996). Svejvig and Andersen (2014) by exploring literature in a research about rethinking project management versus classical project management pointed to adaptive project management as one of the rethinking project management views. It can be said that adaptive management embeds informational feedback loops into the management process for environmental decision makers to enhance their learning from experience (McLain and Lee, 1996).

Aritua et al. (2009) consider adaptability as one of the six characteristics of a complex system and state that based on the adaptability concept, in an open system, new information flows in, circulates in the processes and feedback loops, influences the system and flows out as an adaptation to external environment. Such an open system responses to change continuously by being open to the new information from the environment.

Biedenback and Müller (2012) look at adaptability as a capability which has an impact on project and portfolio performance in the pharmaceutical and biotechnology industry. Based on their research, adaptive capability is defined as the ability of an organisation to identify and capitalize on emerging market opportunities. Basically they agree that dynamic capabilities are utilised by organisations to gain competitive advantage (Biedenbach and Müller, 2012). They also noted that adaptive capability is one of the primary contributors to the performance outcome. Wang and Ahmad (2007) named adaptive capability as one of the dynamic capabilities in organisational studies (Wang and Ahmed, 2007).

Adaptive capacity is a crucial way to deal with environmental changes, risks and uncertainties. Giezen (2012) defines adaptive capacity as the ability to adapt the respond to contextual changes. Adaptive capacity enables a system reconfigures as a response to change without significant declines in main functions (Folke, Hahn, Olsson and Norberg, 2005). Giezen (2012) argues that the adaptive capacity in the planning and decision-making process plays an important role in the long-term sustainability of a mega-project.

This section provided a brief introduction to adaptability in management. Adaptability, as the name suggests, is about making decisions based on insights from the environment while this knowledge is gained progressively. Chapter 5 of this thesis provides more details about adaptability.

In this chapter, so far it was discussed that project management needs evolution by adding flexibility (or adaptability) to it, to improve project performance. Hence it should be understood whether added flexibility to project management could have any effect on project performance. Before that, however, project performance and its measures need to be defined. Therefore the next section elaborates on project performance.

2.7 PROJECT PERFORMANCE

Peter Drucker, the industrial revolutionary, stated: *"You cannot manage something you cannot control and you cannot control something you cannot measure"* (Smith and Mobley, 2008). In projects with many stakeholders, one actor cannot control the process. No one is in charge. Interaction is needed in a way to align interests and find suitable strategies (Hertogh and Westerveld, 2010).

Evaluation of projects is usually described by terms like 'assessing project performance' and 'meeting success criteria'. Performance measurement can be defined as using quantitative or qualitative measures to provide insight about the performance of individuals, activities, systems, groups and organisations in order to track the progress toward the achievement of objectives (Crawford, 2014). As it can be understood from this definition, the purpose of performance measurement is to check the progress regarding the achievement of objectives. In the same line of reasoning, Lim and Mohamed (1999) defined project performance measurement as the achievement of some pre-determined project goals.

Success criteria are the measures for measuring project performance (Crawford, 2014). They provide the measures to assess the success or failure of a project. Factors composing the success criteria are mostly referred to as the key performance indicators or KPIs (Toor and Ogunlana, 2010). For years, financial measures had been the only criteria to assess the performance. Furthermore, the so-called iron triangle, being within time, within budget and according to set quality measures were the commonly used criteria for performance assessment (Atkinson, 1999; Jha, 2011). Recognition of dynamic project environment, other success criteria with attention to contextual elements were introduced (Koops, 2017). Since the 1980s, clients or customers specific needs or expectations, the external context, strategic alignment and other similar factors are taken into account as performance criteria. Crawford (2014) named the Balanced ScoreCard approach as one of the answers to this trend but she also indicates although the time and budget performance are not the only factors to measure the project success, they are still important components of performance measurement. The five most commonly used criteria to measure project performance as mentioned by Freeman and Beale (1992) are: technical performance, efficiency of execution, managerial and organisational implications, personal growth and manufacturer's ability and business performance.

According to Lim and Mohamed (1999) success can be seen from two points of view: macro-level success and micro-level success. The earlier ensures that if the project achieved its desired objectives by answering the question 'does the original concept tick?'. The macro viewpoint is usually judged by the end users and project beneficiaries. The latter is the concern of the parties such as consultants and contractors who are responsible for the realisation of the project. Moreover, micro success contributes to the so-called iron triangle assessing if the project is on time, within budget, and specifications are met. Unlike micro success which concerns about short-term gains, macro success ensures the required functions or long-term gains of the project. Consequently, Toor and Ogunlana (2008) claim that different parties involved in the project or benefit from it might have a different opinion about the project success. For example, a successful project from the viewpoint of project's client might be considered as unsuccessful from the viewpoint of a contractor.

What Lim and Mohamed (1999) identified as micro- and macro-success is reflected by Shenhar et al. (2001) as the achievements of short- and long-term project strategic objectives. By linking project success with competitive advantage, they proposed a framework to assess project success including the following criteria:

- Efficiency criteria in terms of meeting schedule and budget constraints;
- Impact on customers criteria by ensuring that the end products meet customer requirements;
- Business success criteria by ensuring that the expected commercial value and market share is obtained;
- Preparing for the future in terms of new technological and operational infrastructure and market opportunities.

Their proposed framework is dependent on time and technological uncertainties (Shenhar, Dvir, Levy and Maltz, 2001).

The concept of success can be seen from two different angles: project success and project management success. While both aspects need attention to be ensured that they are in place, they require different considerations. According to Radujković and Sjekavica (2017a) project management success is a significant contributor to project success. Therefore attention needs to be paid to project management success factors (Radujković and Sjekavica, 2017b) to ensure that project management would be successful which leads to project success.

Table 2-2: Differences between project management success and project success (Radujković and Sjekavica, 2017a)

Project management success	Project success
Focus: short-term and specific organisational goals	Focus: long-term goals and project owner's organisational needs
Successful project delivery-ready for use	Successful business case-benefit for project owner
Internal focus on the way the project is managed	Focus on the project's effects on the organisation, i. e. on the community being the owner of the project
Evaluation through traditional performance criteria, e.g. time, cost and quality	Evaluation through all-comprising criteria and final outcome of the project-benefit during service life of the project
Efficiency is an internal and short-term dimension during preparation and implementation of the project	Efficiency and effectiveness, internal and external, long-term and short-term dimensions, during all phases and especially through the service life of the project
Three dimensions: time, cost, quality and short-term perspective	Fourth dimension: project benefits and long-term perspective

Although in most of the studies success criteria are named very general to all projects, project success can also be considered as project specific (Davis, 2014). Bakker et al. (2010) looked at the success from owners' and contractor's point of view (Bakker, Arkesteijn, Bosch-Rekveldt and Mooi, 2010). Their study shows that there is not much difference between the criteria for project success seen from the perspective of contractors or owners while in case of success factors (the enablers for success) significant different perspectives were reported.

Although project management literature has tried to define and identify measures to evaluate project success, research shows that projects still are challenged in meeting their desired objectives (Mir and Pinnington, 2014). This emphasises the point that next to developments in introducing contextual success criteria for measuring projects' success, project management itself also needs to develop to deliver successful projects.

Given the importance of the early project phase for projects to be successful (Artto, Lehtonen and Saranen, 2001; Bosch-Rekveldt, 2011), the next section briefly discusses the early project phases.

2.8 EARLY PROJECT PHASES (FRONT-END DEVELOPMENT)

Earlier in Chapter 1 (Section 1.4) it was mentioned that the focus of this research is on early project phases. In this section it is discussed what is meant by early project phases by giving a short introduction to the project lifecycle.

In order to achieve projects goals and objectives, projects should go through a specific process characterized by the project lifecycle (Morris, 1983). Project phases are typically completed sequentially, but can overlap in some project situations. Splitting the project lifecycle into phases allows it to be segmented into logical subdivisions in order to simplify its management, planning, and control. Project's size, complexity, and potential impact are the factors to consider for phasing of the project and the required degree of control in each phase(PMI, 2001).

There are different categorizations of project phases by different scholars, in general (Cantarelli, Molin, van Wee and Flyvbjerg, 2012; Halawa, Abdelalim and Elrashed, 2013; PMI, 2013; Turner, 2014b; Yescombe, 2014), for specific project type (Abdul-Kadir and Price, 1995; Ahadzie, Proverbs and Sarkodie-Poku, 2014) or from financial point of view (Halawa et al., 2013). Table 2-3 summarizes and compares the project phases as suggested by different scholars.

Yescombe (2014) divided the project lifecycle into the development, construction and operation phases. During the development phase the project objective is formulated, the contracting strategy is chosen, one or more constructing parties are selected and the contracts are signed, and come into effect, the financial sources are in place and available. The end of the development phase is known as 'Financial Close'. The development phase might be more complex than anticipated and can easily take several years. Other scholars use terms like concept and design, planning and detail design. The construction phase as the name suggests, is the period in which the project is financed and constructed. The end of construction phase is known as 'Project Completion'. The phase in which the project starts operating and hence produces cash flow is called operation phase.

Table 2-3: Project phases by different sources

Source	Project phases							
	Front-end				Execution			
Abdul-Kadir and Price (1995)		Conceptual	Detailed engineering		Procurement	Construction		Start-up
Turner (2014b)		Proposal and initiation	Design and appraisal		Execution and control		Finalization and close out	
Yescombe (2014)		Development	Construction					Operation
Halawa et al. (2013)	Pre-investment	Conception and design			Construction and commissioning			
Halawa et al. (2013)	Pre-construction				Construction		Post-construction	
Cantarelli et al. (2012)	Pre-construction				Construction			
Ahadzie et al. (2014)		Conception	Planning	Design	Tendering	Construction		Operational
PMI (2013)		Initiation	Planning		Execution		Closure	
		Monitor and controlling						

It can be seen in Table 2-3 that some scholars include the operation phase in the project lifecycle while others don't. Such differences in the naming of project phases are related to the purpose of phasing of the project.

As Table 2-3 shows, each phase has several definitions and characteristics. The early project phase is defined by Kolltveit and Grønhaug (2004) as: *"the process and activities to follow which leads to the decision to undertake feasibility studies and to execute the project"*. They subdivided the early project phase into two phases: innovative and planning sub-phase. In the innovative sub-phase the project owner, experts such as the architects, and the decision making local government are the key stakeholders. This sub-phase continuous until the project proposal has been defined. The main tasks in this part of the early phase are feasibility study, value analysis, formation of the project goals etc. The planning sub-phase starts when the project proposal is completed, and strategic choices have to be made. Important tasks in this sub-phase are to develop project and contract strategies, establish procedures for strategic risk management, benchmarking, planning, estimating etc. this phase lasts until a decision is taken to execute the project. The key stakeholders in this sub-phase are project's owner, architects, contractors and sub-contractors (Kolltveit and Grønhaug, 2004).

The early project phase is generally called front-end development phase. Front-end development (FED) refers specifically to the phase in which the necessary information to approach a project is developed (Gibson Jr et al., 2006). Its main goal is to create the best possible picture of the project, so the owner can objectively make an investment decision. The outcomes of FED are the projects needs and constraints, such as objectives, planning, risks, etc. (Bosch-Rekveldt, 2011). According to Table 2-3, the project life cycle can be divided into two main phases: the front-end phase and execution phase. The FED phase covers the timespan from the beginning of the project till the moment the execution phase starts.

Numerous researches highlight the importance of project management in the FED phase of projects (Artto et al., 2001; Bosch-Rekveldt, 2011; Morgan, 1987; Samset and Volden, 2016). Some others elaborate on the added value of FED on projects (Artto et al., 2016; Matinheikki, Artto, Peltokorpi and Rajala, 2016; Nobelius and Trygg, 2002). Abdul-Kadir and Price (1995) believe that the conceptual phase (early project phase) is of strategic importance in the project environment. Understanding this phase is a prerequisite for improving productivity on site. To obtain the advantages of good project management, selection of proper project management approach as well as selection of an appropriate project manager and project organisation should be based on the level of risk and complexity of the project (Morgan, 1987). The importance of FED on project success in long-term is increasingly recognised (Merrow, 2011; Morris, 2013; Samset and Volden, 2016).

According to PMI 55% of the required processes for developing a project are in the first two phases, initiation and planning, making them the most complex phases of any project (PMI, 2013). Morgan (1987) believes that FED also has a relationship with project complexity and proper project management can overcome the possible problems. Inadequate project management, more difficult management problems than anticipated, unclear objectives and poor definition of requirements, poor initial assessment, poor control of change, late change and inadequate information flow are examples of problems related to project management in the FED (Morgan, 1987).

It can be concluded that early project phases (FED) are important in achieving the value of the project. Taking the importance of the FED phase into account, in this PhD research the focus is given to this phase of the projects.

Giving the introduction of project management and its flexibility in previous sections and the importance of FED phase in this section, the idea is to research the flexibility of project management in the FED phase of infrastructure construction projects. This idea is also supported by the literature. Nobelius and Trygg (2002) stated that flexibility is required in the FED phase of projects to overcome the problems. For the purpose of this PhD research, the FED phase is the timespan from the moment the idea of the project is formed till the construction work starts.

In the next section the findings of this chapter are summarized.

2.9 Summarizing the literature study

Project management is aimed at supporting practitioners to increase the probability of successful delivery of projects. Project management knowledge is developed decades ago and is maturing day after day but still, it has its deficiencies and gaps which arise as consequences of environment changes and developments. Increasing project complexity is drawing scientists' and practitioner's attention in order to be able to cope with it. Also it was argued that conventional project management is no longer effective in meeting project promises. As it was pointed earlier in this chapter, Maylor (2010) believes that a 'lack of common or appropriate project management methods' and a 'lack of flexibility for the project manager to respond to changes' are common issues that have a relation with complexity. According to the project complexity framework of Hertogh and Westerveld (2010) dynamic management is proposed for projects with high dynamic and detail complexity. They state that dynamic management is characterized by balancing control and interaction. Such a balance between control and interaction is in line with the idea of flexibility in project management. Hence it could be hypothesised that flexibility in project management is required as the key for applying dynamic management methods in complex projects, in order to achieve performance satisfaction. In complexity theories, strategies are not seen simply as responses to a changing environment or to another agent, but as 'adaptive moves' that affect both the initiator of the action and all others influenced by them (Teisman et al., 2009).

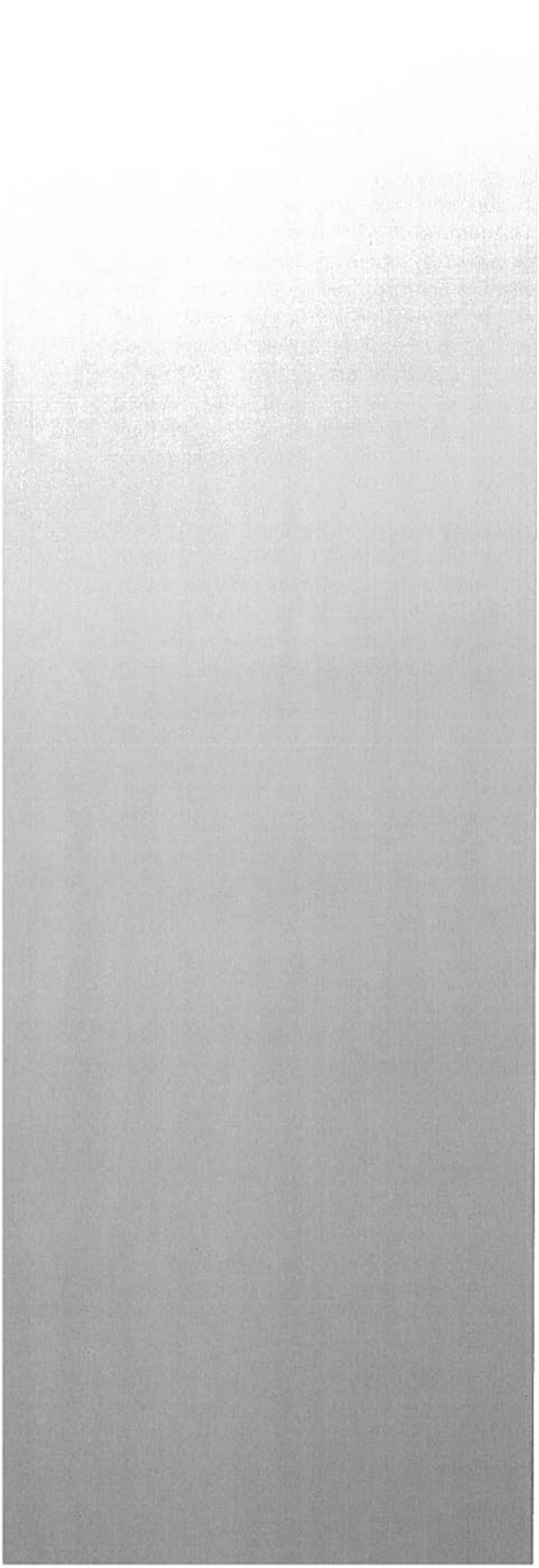
Adaptability and flexibility are two characteristics that can enrich project management in this way. Fulfilment of the flexibility gaps of conventional project management needs exploration to investigate how it is possible to add flexibility to project management. Whilst there are numerous research papers that shed light on the flexibility and adaptability in project management as an important fact for nowadays projects, there is hardly any operationalization of flexibility. Therefore flexibility needs further exploration.

It was also discussed that the early project phase, or the so-called front-end development (FED) phase, has an important role in the success of projects. For the purpose of this research, the early project phase is defined as the timespan between the beginning of the project (when the idea of the project is formed) till the beginning of the execution phase. Combining the importance of the FED phase and the evolution of project management in the direction of flexibility, the literature review supports the initial hypotheses in Chapter 1: 1) flexible project management has a positive effect on project performance in early project phases and 2) project complexity has a negative effect on project performance.

As flexibility is highlighted in literature as a response to project complexity (which includes changes in the environment), it will be investigated if flexibility mediates the effect of complexity on project performance, e.g. if, by applying flexibility the negative effect of complexity on project performance could be reduced, or maybe can be turned around in a positive effect.

Next step

After this literature study, Chapter 3 provides a view on current practice by means of case study research. That chapter focusses on the applicability of Agile project management and its tool Scrum, which are known to be enriched by flexibility, on the management of infrastructure construction projects. Next, Chapter 4 explores if Agile project management and Lean construction have any relationship with project complexity. This current literature chapter did not include a detailed review on Agile project management, Scrum and Lean construction, since these are provided in Chapter 3 and 4 respectively.



Chapter 3: Scrum in practice in infrastructure construction projects

Abstract

Project management is a growing subject in which two main streams are known: waterfall management approach and Agile project management (APM). Literature study showed that flexibility in project management can result in better project performance. Although there is not much literature investigating the essence of flexibility in project management, there is evidence that some project management methodologies and tools are characterized by flexibility. Among them, Agile project management and its tool Scrum are most famous. Knowing that, the applicability of such a flexible project management approach in the context of infrastructure construction projects is under question.

In this chapter we compare waterfall approach and Scrum in theory and practice, to investigate whether Scrum is applicable for the infrastructure construction projects. Agile is an umbrella name for the methodology while Scrum defines processes for managing the project. Scrum is the most known tool of Agile in practice. Hence, for studying the practice of Agile, it was chosen to study the practice of Scrum. Qualitative research was performed by means of conducting 20 interviews in six cases. The findings suggest that the application of Scrum contributes to project success, although its application was not fully aligned with theory. Ideally, Scrum should be tailored to fulfil the requirements of the specific project, which requires additional research.

Preliminary results of this chapter were presented at EURAM 2016 annual conference in Paris (Jalali Sohi, Hertogh and Bosch-Rekveldt, 2016).

3.1 INTRODUCTION

There are many well-established guidelines which put efforts in describing project management methods and tools and several have become widely-known in the field (OGC, 2009; P2M, 2008; PMI, 2013). The developments in project management lead to a range of management methodologies. In general two main streams can be recognised for project management; the waterfall approach, which is often recalled as conventional or waterfall project management, and the other one: Agile project management. Different scholars addressed the shortcomings of existing project management methodologies. Some shed light on the weaknesses of conventional project management because of increased complexity and uncertainty of projects (Maylor, 2010; Turner and Cochrane, 1993; Whitty and Maylor, 2009; Williams, 2005) which conventional project management is not capable of dealing with (Baccarini, 1996; Geraldi, 2008; Hobday, 1998; Williams, 1999). Therefore a high need for a new approach is recognised in the literature (Aritua et al., 2009). Koskela and Howell (2002) even go a step further and claim that "*waterfall project management is simply counterproductive; it creates self-inflicted problems that seriously undermine performance*" (Koskela and Howell, 2002).

Artto and Wikström (2005) also recognise the inadequacy of conventional project management not only in practice but also as the research field by stating that the research in project management area is based on "*a too rigid and narrow closed system view*". The conventional project management as a system approach is focused more on planning and control (Bosch-Rekveldt, 2011). The inadequacy of conventional project management might be caused by this much focus on planning and control (Atkinson et al., 2006) or the emphasis on achieving predefined goals (Aritua et al., 2009), with the most focus on triple constraints of time, budget and performance goals (Koppenjan et al., 2011) with the assumption that project's goal can be predefined at the beginning and stay unchanged during the project processes (Atkinson et al., 2006). However, the complexity and uncertainty of projects make the predetermined projects planning less appropriate (Hertogh and Westerveld, 2010; Williams, 2005). Therefore, instead of following a fully predetermined plan which focuses on triple constraints, projects should aim at real performance (Perminova et al., 2008). This viewpoint requires a new approach which recognises the complexity and uncertainty of projects and provides sufficient tools to deal with such complexity and uncertainty, or in other words, an approach that replaces the rigidness of conventional project management by flexibility (Atkinson et al., 2006; Koppenjan et al., 2011).

As mentioned earlier the second stream in project management is the stream of Agile project management. The Agile approach was developed in the software industry in 2001 but it became widespread in many other industries (Dingsøyr, Nerur, Balijepally and Moe, 2012) including the construction industry (Johansson, 2012; Owen, Koskela, Henrich and Codinhoto, 2006). Agile project management is an umbrella name for project management methodologies which intend to increase the relevance, quality, flexibility, and business value of software solutions. It has been developed during the past two decades. The intention of Agile methodologies as adaptive approaches was to address the challenges that software development projects had faced such as budget overruns, time delays, low-quality end products, and unsatisfied users (Cooke, 2012).

Since Agile project management (and Scrum as a tool of Agile) is new in the civil sector in infrastructure projects and only very few firms are applying it at this stage, there is a need to investigate how it works in practice for such projects and if it improves project performance. Therefore the objective of this research is to critically look at the application of Scrum in comparison to waterfall approaches in the front-end development (FED) phases of infrastructure construction projects.

The outline of this chapter is as follows. Next section presents the literature review including the review of the history of project management with a focus on conventional project management methods on one hand, and Agile and its tool Scrum on the other hand. Next, the research methodology is discussed, together with the followed Scrum processes in the case studies. Cross-case analysis is presented in Section 'Results and analysis', followed by a discussion about the application of Scrum in practice. Next, the managerial implication of this research together with the scientific contribution is discussed. This chapter ends with the conclusions and recommendations.

3.2 LITERATURE REVIEW

Project management is the disciplined application of certain knowledge, techniques, tools and skills to create a unique product or service (Kenny, 2003). Project management has gone through three main stages since it was born: the period before the 1950s in which there was no generally accepted project management method and it was mainly a tailor-made practice. The second stage starting in 1950s, is the stage in which project management was developed as a standard approach (Maylor, 2010). The new-born project management was initiated from best practices (Wysocki and McGary, 2003). This standard approach is reflected by bodies of knowledge and project management handbooks like the PMBoK developed by the Project Management Institute (PMI, 2013), PRINCE2 developed by office of government commerce in UK (OGC, 2009) or the IPMA Competence Baseline established by the International Project Management Association (Caupin et al., 2006). The third stage, from 1990 onwards, goes beyond the conventional viewpoint of the second stage (Maylor, 2010). In this stage the attention was given to the changing and dynamic environment in which the projects are performed (Bosch-Rekveldt, 2011).

3.2.1 1950S – CONVENTIONAL PROJECT MANAGEMENT

The emergence of project management goes back to the 1950s in the Defence and Aerospace sectors which was less complex and little flexible in that timeframe (Morris, 1997). In later years Royce (1987) called this model the 'waterfall model' of project management because of the sequential format of phases. Its basic points are: fully specifiable systems, thoroughly and heavily planned, formal lines of communication and a command and control management style (Dybå and Dingsøyr, 2008). The assumption in this period is that project management is rational and linear based on causal relationships, that for example try to manage project's scope by decomposition of a project into tasks like work breakdown structure (Williams, 2005). The focus of project management in this period was to predetermine budget, time, and performance goals by detailed up-front planning, to provide an extensive list of tasks to be performed based on a "*blueprint-type scope description*" and to set up a plan based on scope description which is "*frozen and strictly controlled during execution*" (Koppenjan et al., 2011).

The concept of conventional project management is formed based on the transformation principle (Slack, Chambers and Johnston, 2007) in which the focus is on input and output, rather than the process (Koskela, 2000). This fits into an activity-based systems approach. In this way the project will be subdivided into smaller segments. Each segment will be defined into narrow tasks and controlled subsequently (Giezen, 2012; Koppenjan et al., 2011). Decomposition of project schedule is also suggested for managing detail complexity (Hertogh and Westerveld, 2010). "*In this WBS the project is divided into several sub-projects and for each sub-project a sub-project leader is assigned*" (Blom, 2014).

3.2.2 1990s – Prepare-and-commit approach

The third stage of project management history, starting in 1990s, recognises changing and dynamic project environment (Bosch-Rekveldt, 2011). In such situations, instead of making unreliable predictions and avoiding changes, changes need to be incorporated into the project (Priemus and van Wee, 2013). This is what Koppenjan et al. (2011) named as the "*prepare-and-commit*" approach which acknowledges scope changes as an inevitable part of any project, given the inherent existence of uncertainty and complexity of many infrastructure projects (Koppenjan et al., 2011). Literature indicates that project management should evolve in the direction of a prepare-and-commit approach (Geraldi, 2008; Geraldi et al., 2008; Koppenjan et al., 2011; Perminova et al., 2008) to be able to manage the complexity and uncertainty of projects (Atkinson et al., 2006). Geraldi (2008) noted that projects demand both mechanic (order) and organic (chaos) paradigms. Conventional project management intends towards mechanistic approach while organic approach acknowledges the complexity and uncertainty. It is recommended to have a right combination of both approaches to fit into complexity and uncertainty of the projects (Geraldi, 2008; Hertogh, Baker, Staal-Ong and Westerveld, 2008; Koppenjan et al., 2011). Such flexibility seems to be applied in Scrum and Agile approaches.

3.2.3 Agile project management and Scrum

Scrum was established by Jeff Sutherland in 1993, which its development was based on a so-called rugby approach introduced by Takeuchi and Nonaka (1986). This approach is characterized by having a multi-skilled team in which team members work together to develop a new product during the whole process (Takeuchi and Nonaka, 1986). Scrum was established based on the rugby approach. In 1995 he together with Ken Schwaber introduced this new tool at the OOPSLA conference (retrieved from Scrum Foundation website). The principles of Scrum were the same as the rugby approach including: embracing change in products according to changes in clients' requirements or the project development team, develop the product in short cycles which are called sprints, aiming at higher quality and increased customer satisfaction which results in higher degree of predictability for the customer (van Solingen and Rustenburg, 2010). In 2001, Agile project management was introduced with the same base as Scrum: four main values and 12 principles (Beck, 2001).

This new method was characterized by:

- Increase in the client's involvement (Cobb, 2011)
- Decrease uncertainty and improve risk management (Johansson, 2012)
- Adaption to change and collaboration between people through an interactive process that helps customers define their needs and requirements (Cobb, 2011; Collins, 2014; Dingsøyr et al., 2012)
- Achieve value for the client (Beck, 2001)
- Accelerate the feedback cycle (Collins, 2014)
- Produce a tangible product at regular intervals and delivering as rapidly as possible high-value products among others (Collins, 2014).

3.2.4 Agile Project Management for infrastructure construction projects

At this stage, Agile is only limitedly applied in construction projects and hence the knowledge about its applicability in the construction industry is confined. However, the construction industry has shown interest in this methodology (Demir, Bryde, Fearon and Ochieng, 2012). Despite the suggested potential of applying Agile in the construction industry (Johansson, 2012; Owen et al., 2006), there is hardly empirical research investigating this applicability (Maylor, 2010).

Agile is the umbrella name for the methodologies which aim at increasing flexibility by embracing change and close client collaboration. Apart from the main value drivers and a number of principles, it does not provide any implementation guideline. Therefore, for studying the practical applicability of Agile, it was decided to focus on Scrum as the most popular Agile tool (Agile-Methodology, 2014). The assumption here is that Scrum can be applied in other industries and type of projects rather than software development projects.

Bertelsen and Koskela (2004) state that complex systems have the capability of being self-organised and they do not require a detailed plan. Instead, the emphasis should be put on creating a clear objective in order to improve the reliability. This is in line with what Agile project management offers. Owen et al. (2006) researched whether Agile is applicable in the construction industry. They argue that embracing changes into the project has added value for the customer by incorporating change in short-term delivery processes in an iterative way by receiving feedback from the customer. The short-cycle iterative process enhances continuous learning for both the development team and the customer.

3.2.5 Comparing Agile (Scrum) to conventional project management

The reviewed literature on both management approaches (waterfall and Agile), is summarized in Table 3-1.

By comparing the overall characteristics of waterfall approaches to Agile project management it becomes apparent that Agile gives more flexibility to the process. Such flexibility goes beyond the process and has a positive influence on the project as well. Flexibility can be found in the horizontal character of a project organisation, incorporating changes, client involvement, self-steering teams, self-assigned tasks, informal and face to face communication among other aspects.

Agile Project management was born in IT (Information Technology) industry specifically for software development projects. The process of a software development mainly consists of front-end development. Comparing IT projects with construction projects it can be said that the FED of construction projects are similar to software development projects. Moreover, the early phases of construction projects are characterised by high uncertainty. Earlier it was mentioned that flexibility is required to manage uncertainty. Considering the characteristics of construction projects' early phases, the degree of uncertainty and the required flexibility, it is assumed that Agile fits well to the early phases (front-end development) of construction projects and less to the subsequent phases of a construction project. Agile and Scrum, intend not only to deliver value (instead of task performance) but also to maximise the value for the customer by incorporating changes in the project during the process. Hence the assumption here is that Scrum as a tool of Agile can be applied in FED phases of construction projects in order to add value to the customer.

Table 3-1: Comparison between waterfall (conventional) and Agile project management

	Conventional (waterfall) approach	Agile and Scrum (Dynamic project management approaches)
Project environment	Rational and linear project environment (Geraldi, 2008)	The recognition of the changing and dynamic project environment (Bosch-Rekveldt, 2011)
Project complexity	Not taking complexity into account (Baccarini, 1996; Geraldi, 2008; Hobday, 1998; Williams, 1999)	Taking complexity into Account (Hertogh and Westerveld, 2010)
Focus	Focus on planning and control (Atkinson et al., 2006) (Dybå and Dingsøyr, 2008)	Focus on value delivery (Beck, 2001)
Project's Goal flexibility	Achieving predetermined goals is the main focus (Aritua et al., 2009)	Changes regarding insights of the client and the project team are incorporated (Dingsøyr et al., 2012)
	Fully specifiable systems (Dybå and Dingsøyr, 2008).	
Management Style	Command and control approach (Koppenjan et al., 2011)	Prepare-and-commit approach (Koppenjan et al., 2011)
Control	Process centred (Nerur, Mahapatra and Mangalaraj, 2005)	People centred (Nerur et al., 2005)
Team composition	Different specialists work sequential based on prescribed processes on the new product development (Takeuchi and Nonaka, 1986).	Multidisciplinary team works together on the development of a new product from start to finish (Takeuchi and Nonaka, 1986).
Organisational type	Applied in hierarchical organisations (mechanistic organisation) (Nerur et al., 2005)	The steering has a more horizontal character (self-steering teams) (Nerur et al., 2005)
Attitude toward change	Changes and adaptability are limited (Williams, 2005)	Enhances the ability of teams and organisations to react to changes (Collins, 2014)
Communication	Formal lines of communication (Dybå and Dingsøyr, 2008; Nerur et al., 2005)	Informal communication (Nerur et al., 2005)
Problem solving		Detect problems as early as possible, and adaptation of process in case of problems which hamper the progress and goal achievement (Cobb, 2011; Koskela, Ballard, Howell and Tommelein, 2002)
Product delivery	Life cycle model (Nerur et al., 2005)	Iterative delivery (producing a tangible product at regular intervals and delivering as rapidly as possible high-value products among others (Collins, 2014))
Task assignment	Task assignment by project manager (Nerur et al., 2005)	Self-assigned tasks to individuals (Beck, 2001)
Steering of team	Central role of project manager	Self-organising project teams (Beck, 2001)
Measuring progress		Measuring progress on a daily basis (daily stand-ups). The progress and performance are tracked at the end of each Sprint, in the Sprint Review meeting (Sutherland & Schwaber, 2013)
Planning	Detail up-front planning (Cobb, 2011)	Iterative planning (Cobb, 2011)
Attitude toward client	Important (Nerur et al., 2005)	Critical (Nerur et al., 2005) Increase in the client's involvement (Cobb, 2011) Helps customers define their needs and requirements (Cobb, 2011; Dingsøyr et al., 2012)

3.3 RESEARCH METHODOLOGY

To fulfil the objective of this chapter; the comparison between conventional project management and Scrum in practice for infrastructure projects to understand the applicability of Scrum (Agile) for this sector, qualitative research (Creswell, 2009) was done after the in-depth literature study. From the literature it was concluded that there is a gap in research regarding the practical usage and the applicability of Agile project management and its tools for infrastructure construction projects. This research aims at bridging this gap by doing case study research to test the hypothesis: whether Agile Project Management and its commonly used tool, Scrum, is applicable for infrastructure construction projects in their early phases.

This research was performed in an engineering and consultancy company in The Netherlands. The company offers services in mobility and infrastructure, building and real state, area development, energy, water, industry and integrated services.

The empirical part of the research is considered as a deductive research (Blaikie, 2009). For the data gathering, multiple case studies (Yin, 2002) were selected to obtain data by means of semi-structured interviews. In total 20 interviews were performed, including respondent from 6 projects. All interviewees were at the project level and assigned to the project in different roles (Figure 3-1). The interview consisted of three parts: personal information, management approach questions and general questions about what interviewees think of the applied management method(s). Cases were selected from two different groups of projects: projects managed by use of conventional project management (3 cases) and those which were managed by applying Scrum (3 cases). In order to gain a rich perspective, at least two roles were interviewed per case. The complete interviewees' profile (per case) is given in Appendix B.

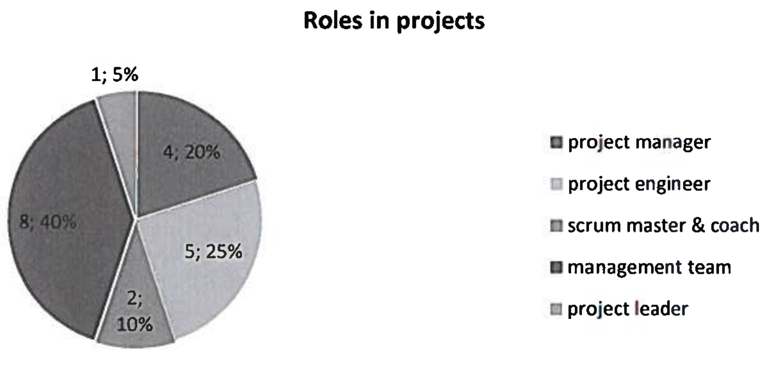


Figure 3-1: Roles of interviewees in projects N = 20

3.3.1 SCRUM AT THE STUDIED COMPANY

In mid-2013, the company started to use Scrum in some of their infrastructure projects. This methodology was already used within the ICT department of the company and it was decided to start the application of this methodology also in some stages of certain infrastructure projects. The duration that Scrum was used in the three cases and the scrum team size with some other characteristics of the selected projects are briefly reviewed in Table 3-2, as well as Scrum processes used in those projects (Table 3-3). As can be seen in Table 3-3 there is a certain degree of adjustment applied by the company in order to adapt the Scrum methodology to infrastructure projects. A more detailed comparison of applied Scrum in case studies versus Scrum theory is provided in the following sections.

Table 3-2: Projects using Scrum at the studied company

Project	Period during which Scrum has been applied	Number of people in Scrum team	Client	Type of contract	Project phase
Project A	≈6 months	Between 6 - 12	Public sector	Fixed-price	Engineering and Contracting
Project B	≈7 months	Between 5 - 15	Public sector	Fixed-price	Pre-design
Project C	≈6 months	Between 7 - 12	Public sector	Fixed-price	Pre-design

Table 3-3: Scrum Processes at the company

Phase	Scrum	Literature base	Scrum application by the company
Initiation	Backlog refinement	Formulation of stories	Establishment of technical specifications of the contract in tasks. They use the Work Breakdown Structure (WBS) of the project.
		Analysis of duration of stories	Determination of preliminary time estimate. These estimations are also done during the tendering procedure.
		Prioritizing and DoD	Prioritize stories; Formulate DoD (Duration of Done). Drafting product backlog. The duration of the sprints is defined together with the concrete needed deliverables. The Product owner defines what is needed for each sprint; the deliverables are related to complete pieces of the WBS.
	Sprint planning	Selection of work for sprint	Selection of work for sprint. In the WBS a selection of tasks is identified which are considered to be the most important tasks to be completed in the sprint.
		Planning poker	Planning poker is used. Sometimes it is difficult for a member of the team to assess properly the duration of a task in which they don't have any experience.
Design	Sprint	Division of tasks	The division of tasks is done according to the background and expertise of each person involved. The characteristic of Scrum teams in infrastructure projects is that they consist of very specific niches of knowledge.
		Daily stand up	This is what they call the daily Scrum. They are not done daily, since the team does not work full time on the project during the whole week (40 hours). Daily stand-ups are held around two times a week and last around 15 minutes.
		Removing impediments	Removing impediments, which is the task of the Scrum master. If the impediment has to do directly with the Client, the product owner takes the impediment to the client. Normally this process takes longer since the client is not physically present.
		Complete Scrum board	Complete Scrum board. Two different tools are used to keep track of their work: a physical board in the project room or software called 'Scrum wise'. Both tools have been somewhat underused since it does require the extra step to maintain the boards updated.
		Testing/ Review	Quality review of deliverables. This is considered an important step in order to assure that the task meets for 100% to the standards and may be presented to the client.
		Closing of sprint	Closing of sprint.
		Incomplete stories in PB	Incomplete stories in PB (product backlog).
	Extensions	Backlog refinement	Non-xistent
		Scrum of Scrums	Non-existent (when several Scrum teams are working on a project where a high number of team members are involved).
Delivery	Sprint review	Presenting results to client	Presenting results to the Product Owner
	Sprint retrospective	Evaluation of process	Feedback of the results by product owner to client

3.4 RESULTS & ANALYSIS

In this section the data derived from the interviews are presented together with cross-case data analysis. The analysis includes 1) comparison of the Scrum projects and the waterfall- managed projects in practice and 2) comparison between Scrum application in theory and Scrum application in the practice of the three cases.

3.4.1 COMPARISON OF THE SCRUM PROJECTS AND THE WATERFALL- MANAGED PROJECTS

Here the comparison of two management approaches in studied cases is elaborated. At least 2 interviews were performed per case. All interviews per case were analysed qualitatively and summarized in various tables in this section. Each set of 2 tables (one for Scrum projects and one for waterfall-managed projects) presents certain aspects of projects. After each set of tables a brief explanation is provided on the content of tables.

All six studied projects were infrastructure construction projects in their design and planning phase. In order, the following tables present: the overall project success of projects, whether project promises were met, what management methods/tools were used and what was expected by using Scrum in those three cases (Table 3-4 and Table 3-5). Furthermore, according to the main differences concluded from the literature study, project value, customer satisfaction and its conditions (Table 3-6 and Table 3-7), communication internally and externally (Table 3-8 and Table 3-9), team building process, task assignment (Table 3-10 and Table 3-11), rework, scope changes and problem solving (Table 3-12 and Table 3-13) were explored through the interviews, of which the results are summarized in this section.

Table 3-4: Overall project information and success for 3 Scrum projects

Overall Project info and success		Project A	Project B	Project C
Type of the project		Infrastructure - Construction	Infrastructure - Construction	Infrastructure -Construction
Activities to perform (phase of the project)		Survey studies and design	Reference design, planning and contracting including the budget estimate	Design and engineering
Project promise	time	Meet very tight deadlines	Delivered within accepted delays which was caused by the client	Delivered within time
	cost	Costs went out of control.	Over budget (because of outsourcing parts of the project to third parties)	Over budget (Lower offer to win the project)
	quality	High quality	High quality	Good quality
Overall project success	positive	Satisfied client, high-quality deliverables within tight deadline and satisfied team	Satisfied client, high-quality deliverables within accepted delays, within budget for the client	Overall was good.
	negative	Over budget (internally)	Over budget (internally)	Not successful regarding the relationship with the client
Applied PM methodology/standard		Scrum/system engineering/T shape model	Scrum	Scrum

Table 3-5: Overall project information and success for 3 waterfall projects

Overall Project info and success		Project D	Project E	Project F
Type of the project		Infrastructure – Construction	Infrastructure - Construction	Infrastructure - Construction
Activities to perform (phase of the project)		Survey studies and design	Managing contractor and design consultation	Survey studies and design
Project promise	time	Delay	Within time	Delay
	cost	Out of budget	Within budget (reimbursable contract)	Within budget from project manager and tripled budget from technical manager perspective.
	quality	Good Quality	Very good quality	Good quality
Overall project success	positive	Products were accepted with high quality.	Successful in terms of time and budget, collaboration with client and surroundings.	It was successful although it was not continued in the execution phase.
	negative	Not successful from time and budget point of view. Also part of the contract was dropped.	Not successful for contractors.	
Applied PM methodology/standard		No unified method.	Specific project management model (IPM).	No defined method/process.

Success of the project: The interview results show that using waterfall project management mostly resulted in late delivery (push delivery of products to the very last moment) which is in contrast with the projects where Scrum was applied. Sprint planning forced the Scrum teams to deliver tasks (products) in time.

Quality level: In both management approaches the project quality is high and accepted by the client. From all studied projects, it was concluded that delivering high-quality products is the company culture. Some of the interviewees point to this as an obstacle because delivering higher quality than what was expected from the client costs more money and time (interviewee AP2R1 and Interviewee AP3R7).

Type of contract: this is a key factor to consider if a project is successful or not. The three Scrum projects had fixed-priced contracts. One of the waterfall-managed projects was run with a reimbursable contract. For fixed-price contracts, regardless of management approach, there is higher pressure on the consultancy company to be within budget with a safe margin. A number of project managers point to contract type as an influential factor for using different management styles, basically because of budget limits.

The contract is an element that influences the applicability of Agile. An Agile contract is completely different than other contracts. Agile contracts give more room for flexibility.

Time: at the studied company, Scrum works really well in delivering the project (products) within the estimated time. Interviewees thought that this was because of the pressure to deliver products within short intervals called sprints (stage gates) while the 3 cases managed traditionally faced delays and scheduling problems.

Applied project management methodology: Apart from the fact that in three cases Scrum had been used as the main tool for application of Agile methodology, there was not a unified project management system at the studied company.

Table 3-6: Project's value and customer satisfaction for 3 Scrum projects

Project value and customer satisfaction	Project A	Project B	Project C
Project's value definition	Struggling with what value is but overall Client satisfaction.	No explicit value definition. Different roles have different opinions.	Two interviewees had no idea while the third one thinks of time as a value.
Achievement of Planned Value	Not applicable.	Not applicable.	Not applicable.
Conditions of customer satisfaction	Set client satisfaction criteria.	Set quality requirements but the overall client satisfaction conditions were asked but only in general.	It was the project manager's responsibility to check and ask.
Customer satisfaction controls	Product owner (project manager) was responsible to check the satisfaction of the client.		The client was asked to be the product owner but he only showed up once in sprint meeting. The team tried to manage the clients' satisfaction.

Table 3-7: Project's value and customer satisfaction for 3 waterfall projects

Project value and customer satisfaction	Project D	Project E	Project F
Project's value definition	No value perception/definition.	No value perception/definition.	One of the biggest projects in the country (from budget point of view and the exposure). But no explicit value definition.
Achievement of Planned Value	Not applicable	Not applicable	Not applicable
Conditions of customer satisfaction	Only quality requirements in the contract (responsibility of stakeholder manager to check the client satisfaction).	Evaluation of client satisfaction was done twice a year.	No explicit client satisfaction requirements. Mainly the deadline and budget were the success criteria for the client.
Customer satisfaction controls	Stakeholder manager had to check but there was no feedback from the client.	Have not been applied.	The client's opinion on project progress was checked on a regular basis.

Value: Neither in waterfall project management nor in Scrum, the value of the project for the projects' team was defined at the beginning of the project and traced during the project. This is remarkable for the Scrum projects since value definition is one of the Scrum (Agile) principles. In some of the studied cases team members implicitly think what the project's value could be. Interviewees limited the meaning of value towards financial benefits, if at all.

Conditions of customer satisfaction: generally speaking about client satisfaction, in the Scrum approach project managers asked the client about it, but in waterfall approach this was neglected. Even though in Scrum projects the clients were asked about their satisfaction conditions, it was not explicitly stated.

Table 3-8: Internal and external team composition for 3 Scrum projects

<table>
<tr><th colspan="2">Internal and external team</th><th>Project A</th><th>Project B</th><th>Project C</th></tr>
<tr><td colspan="2">Involved parties</td><td>3 main clients and few other direct stakeholders</td><td>2 main clients, locals, and third parties</td><td>A few including municipalities, province and locals.</td></tr>
<tr><td rowspan="2">Interaction among parties</td><td>negative</td><td></td><td></td><td>The team members are not aware of details.</td></tr>
<tr><td>positive</td><td>Every 4 weeks with main clients and in between if necessary and with other stakeholders.</td><td>The main interaction was with the main client on weekly basis. There was not much interaction with the other involved parties.</td><td>A lot of interaction between the main client and the project leader.</td></tr>
<tr><td rowspan="2">Team building process</td><td>negative</td><td>The heads of departments assign people to the project. The team was built of juniors because of lack of capacity. The Scrum master entered the team after the team was built.</td><td>The heads of departments assign people to the project. The selection was based on the technical background rather than team capabilities.</td><td>The team was built based on the availability of people (and at second, based on required disciplines).</td></tr>
<tr><td>positive</td><td>The team was multidisciplinary</td><td></td><td>The team was multidisciplinary enough. We had enough people.</td></tr>
<tr><td colspan="2">Team size</td><td>A core team of around 10 people and inconsistent team size to max 50 people.</td><td>A core team of 5 and 2 Scrum teams in total around 20 people. The team size at the peak point was around 40.</td><td>It changes along the way but one Scrum team of 10-12 people.</td></tr>
<tr><td colspan="2">Task assignment</td><td>By team members and acceptance of project manager</td><td>By team members and acceptance of project manager</td><td>By team members and acceptance of project manager</td></tr>
</table>

Table 3-9: Internal and external team composition for 3 waterfall projects

<table>
<tr><th colspan="2">Internal and external team</th><th>Project D</th><th>Project E</th><th>Project F</th></tr>
<tr><td colspan="2">Involved parties</td><td>Internal and external parties.</td><td>Internal and external including ministries, municipalities, province</td><td>Internal and external including 6-7 main and a few secondary stakeholders.</td></tr>
<tr><td rowspan="2">Interaction among parties</td><td>negative</td><td>With internal stakeholders the interaction was not optimal.</td><td></td><td>Not being involved in all meeting (no interaction with all involved parties).</td></tr>
<tr><td>positive</td><td>Good with external stakeholders</td><td>Overall was good.</td><td></td></tr>
<tr><td rowspan="2">Team building process</td><td>negative</td><td>Team size changes constantly. Selecting the team members based on the availability. Multitasking happened.</td><td>The selection was based on availability. Team size varied during the project.</td><td>The department manager based on the availability of people assign them to projects.</td></tr>
<tr><td>positive</td><td>The core team was constant during the project.</td><td></td><td></td></tr>
<tr><td colspan="2">Team size</td><td>A core team of 6 people and the team size at the peak point in time was around 40</td><td>9-10 people but varied</td><td>20-25 at the peak moment. The core team of 4-5 people.</td></tr>
<tr><td colspan="2">Task assignment</td><td>By project manager</td><td>By project manager</td><td>By project manager</td></tr>
</table>

Interaction and communication of the internal team: The internal communication and interaction were much efficient in Scrum projects rather than projects managed by the waterfall approach. Interviewee CP3R1 (project manager) and CP3R2 (technical manager) from the same project pointed to the integrality of team as an obstacle in conventional project management. *"One of the issues of project manager is to make the team work integrated. In Scrum there are lots of contacts among the people working on the project"* said Interviewee CP3R1. In some cases of the waterfall approach, the project team once a week worked together in one room to facilitate the communication and interaction.

Team building: theoretically team formation in the Agile approach is different than the waterfall approach. Regardless of the applied management approach, the team building process starts with a request from the project manager to the heads of the technical departments for required specialisms for the project. Basically the teams were built according to the availability of staff in their technical departments. The most important observed problem by the project managers is the lack of the right expertise at the technical departments to source their projects.

Team size: all interviewees in both management approaches (Agile and waterfall) indicated that team size had varied during the projects. Team size variation depended on the tasks that had to be done and the required effort (in terms of time) for doing the tasks. The variation in team size might influence the team integrity. It was concluded that in Scrum projects, because the team works together in one room or/and they have daily stand-ups, the integrity is higher than in the waterfall managed projects.

Table 3-10: Communication in 3 Scrum projects

Communication	Project A	Project B	Project C
Reporting	To clients based on the meetings. Within the team no official reporting (team worked two days a week together).	2 weeks cycle official reporting to the main client. Daily stand-ups and sprint planning sessions for internal team.	Team members had no opinion regarding the reporting to the client. There was no official reporting within the internal team.
Meetings	4 weeks cycle meetings with main clients.	Every 2 weeks with the main client.	Every few weeks with the client.

Table 3-11: Communication in 3 waterfall projects

Communication	Project D	Project E	Project F
Reporting	All reports had to go through the main client which makes it difficult. No official reporting within the team.		Every 4 weeks cycle reports to the client. Internal reporting based on the progress.
Meetings	Weekly meeting for the core team and each member of the core team had to communicate with his/her own team. for internal meetings the project manager had decided who be in the meeting.	Depending on the status of project; weekly to monthly. For interfaces with other parties every 2 weeks. Mostly weekly meeting for the technical team.	Meetings with external parties: Not with all involved parties but only with the client. Internal team: Normally monthly meetings which were challenging because not all could make it to be there.

Reporting to the client: Regardless of the project management approach, there were monthly progress reports as a normal company procedure or client request. The problem mentioned by the interviewees is when there are multiple stakeholders, creating bureaucratic processes. The amount of time and effort, needed for a report, can be multiplied when there are different stakeholders with different wishes.

Reporting within the internal team: In the Scrum teams, there was no reporting line because team members were working in the same room, having daily stand-ups. In the waterfall approach, internal reports were made whenever it was needed. Sharing the information in Scrum was perceived to be much easier than in the waterfall approach. This was facilitating the implementation of any small change, affecting others tasks.

Table 3-12: Rework, Scope changes and problem solving in 3 Scrum projects

Rework, Scope changes and problem solving		Project A	Project B	Project C
Rework	negative	Yes.	Lots of rework because of changes in client requirements.	
	positive		Less rework in Scrum because of an intense information exchange.	No. The product owner decides if the task is delivered right or not.
Scope changes		Yes, client requirements changed.	Yes, new information from external stakeholders, new information from site investigations, and changes in client requirements (in total 80 changes).	30 scope changes: changes in client requirements and unclarity of parts of the project. (Agreed extra budget and time for scope changes)
Time buffers		No buffer from the team point of view because of tight deadlines while the project manager (product owner) said there was a buffer.	No! Very tight deadlines.	No buffers because of tight deadlines. But there was an extra sprint considered in planning.
Problem solving		The product owner was responsible to solve the problems.	The product owner and Scrum master were responsible for problems.	The product owner was responsible for solving the problems.

Table 3-13: Rework, Scope changes and problem solving in 3 waterfall projects

Rework, Scope changes and problem solving		Project D	Project E	Project F
Rework	negative	because of the late response of the client on some tasks, reworks happened.	Because of the differences between demands and wishes.	Very much! Because the design was changed.
	positive			
Scope changes		Yes, different reasons; change of regulations, scope definition in the contract.	A lot. Mainly because of changes in client requirements. Not all scope changes were paid.	Yes, because of changes in client's wishes and also because the project was a pilot project.
Time buffers				No, very tight deadline
Problem solving		With help of system engineering The roles and responsibilities were clear	No defined process (mostly was based on collaboration between parties. Both sides put effort into solving the problems).	It has to be discussed with the project manager and he would say who is responsible for the solving the problem.

Estimation of duration of tasks: In the waterfall approach, everybody estimates how long it will take for a task to be ready and all estimates (based on the individuals' experience) are made at the beginning. While all estimates are made, everybody reacts to them. At the end, the estimated duration of tasks are agreed among the team members. In the waterfall approach, the one who is responsible for the task makes an estimate for the duration of the task. This is more an individual guess than a team guess.

Rework: It happened in all cases, because of various reasons. However, in the Scrum projects, there was less rework than in the waterfall approach because the whole team worked in the same place and sharing information was faster. "*When you do something wrong you miss only one day because you learn about it at the daily stand-up*" said one of the Scrum team members. The Scrum master (interviewee AP1R3) regarding the rework said: *"By having a really good product owner you can avoid rework; meaning that everybody knows what the client requirements. Scrum helps to empower the team instead of putting everything on the project manager's shoulder"*. Interviewee AP2R2 from Project B (with a high amount of rework because of changes in client requirements) said: *"The amount of rework is less in Scrum way because there is an intense way of sharing information. If rework is matter of different starting points or misalignments, it could be managed easier in Scrum way".*

Scope changes: From the *interviewees'* point of view, even though Scrum (Agile) would facilitate responding to change, still clarity of scope in the contract could decrease fundamental problems. From a theoretical point of view, coordinating changes in Scrum is simple, given the starting point of being flexible. Although the process of Scrum facilitates incorporating changes (including scope changes), there are other considerations to take into accounts such as contract conditions, consequence of change on project's budget and schedule, and fulfilment of client's requirements via the requested scope change.

Problem solving: We did *not* find differences between Scrum and waterfall approach managed projects in solving problems in practice. However, the theory of Scrum suggests a structured way for solving the problems (Cockburn and Highsmith, 2001; Rising and Janoff, 2000). Interviewee AP1R3 as an Agile coach confirmed the non-existence of problem-solving structure in Scrum teams. The product owners are responsible to solve the problems or refer problems to the right person to solve it, while in conventional project management the project manager is responsible for solving problems. Theoretically, in Scrum problems are called as impediments and once there is an impediment the Scrum master must get rid of that impediment and make sure that the team can continue on its way of doing tasks.

3.4.2 Comparison of Scrum in theory and application of Scrum in practice

Table 3-14 provides the comparison between Scrum in theory and in practice. The table shows if the theory and practice are aligned or not (three columns on the right). Alignment or misalignment of practice to theory does NOT imply better or worse project performance per se. The comparison only provides indications to understand to what extent the practice is in line with theory.

Table 3-14: Scrum in theory and practice (exploratory interviews' results)

Explored items		Scrum based on the theory	What is happening in practice at the company (3 projects)	Aligned	Misaligned	Neutral
The overall success of the project			Successful from the client point of view, successful from projects teams, not successful from the company point of view.	N/A		
Time		Time is fixed.	Mostly projects delivered within time, for those that delivered with delay, it was acceptable by the client because the client was the source of delay.	×		
Cost		Maximum budget is fixed.	One of the negative aspects of Scrum within the company; mainly because of learning costs.	N/A		
Quality			Accepted by the client, delivery of products with high quality (company strategy).	N/A		
Client satisfaction		Main value driver of Scrum.	Clients were satisfied.	×		
Conditions of client satisfaction		Conditions of client satisfaction should be known and addressed explicitly in the project.	There was a set of quality criteria as client satisfaction conditions but overall there was no common sense what the client satisfaction conditions are.		×	
Team	Team building	Scrum team should be constant /fixed and the project will be assigned to the team.	Few problems; first of all lack of capacity at the company, teams vary in size during the project, teams are not constant, in contrast with the principal team is being assigned to project.		×	
	Multidisciplinary team	Team should be multidisciplinary.	To some extent teams are multidisciplinary.	×		
	Multitasking in team	It should be avoided.	It happens always.		×	
	Integration	Working in one room rather than individually in separate offices.	Scrum teams were integrated. In case of multitasked people in the team, the level of integration decreases considerably.	×		
Exchange of information/ knowledge		Working in one room rather than individually in separate offices.	Easy/doable in face to face communication.	×		
Documentation		Proper/enough documentation over too much paperwork.	Enough for the project itself but not enough as lesson learned for another project. In case of multitasked people in the team, the amount of documentation increases.			×
Overall picture of the project		Visualising the overall project.	Scrum creates the big picture of the project. The inconsistency of the Scrum team is a problem here.		×	
Meeting	Within team	Daily stand-ups/sprints' meetings.	Different opinions. Examples are: difficult when a team member is a multitasker, waste of time, saves time according to team alignment.			×

Explored items		Scrum based on the theory	What is happening in practice at the company (3 projects)	Aligned	Misaligned	Neutral
	With stakeholders/client	Client involvement/participation in weekly/every sprint meeting.	Not enough client involvement/ no interest from client side to participate in all meetings.		×	
Value	Definition	Value should be defined at the beginning.	No definition of value.		×	
Value	Tracking	Value should be traced during the project.	Since there is no value definition there won't be any tracking of value.		×	
Planning	Product backlog	Work is done in small batches which are listed in the product backlog.	Product owner defines the product backlog.	×		
Planning	Sprints	Value orientation over process orientation; delivering something that has value for the client in 2 to 4 weeks' time.	It worked well in doing the tasks but there is doubt if Something that has value for the client delivered in each sprint.		×	
Planning	Duration of tasks	Realistic time planning by means of poker game.	Estimation of the duration of tasks (products) by poker game.	×		
Reporting	Within team	More face to face, less paperwork.	Informal face to face discussion rather than official reporting, digital Scrum board which updates regularly.			×
Reporting	With client	Client involvement/ close cooperation with client.	Monthly report to client/ NO client involvement in the Scrum process.		×	
Time buffers		Is needed.	Because of tight deadlines there were no planned buffers.	×		
Response to scope change		Responding to change (scope change).	In contrast with contract conditions, it results in request of extra budget and time.		×	
Problem solving		Problem solving should be planned/clear. Impediment resolving.	Not really planned; product owner/project manager was a source of problem solving.		×	

Now the comparison of theory and the practice of Scrum in the case studies is explained in more detail.

Expectations by using Scrum: The expectations were different by different roles. The project teams for all 3 Scrum projects were formed after the decision had been made to do the project in a Scrum way. As a consequence the team members had no explicit expectation from Agile project management. The expectations for them, after the introduction of Agile, mostly were regarding efficiency in terms of costs and time. At the higher level in the organisation, people wanted to be ahead of other competitors by using Scrum, which was the main driver for applying it.

Performance of Scrum projects: Mainly using Scrum lead to deliver a successful project for the client, however, from financial point of view for the consultant company, starting using Scrum was not successful. All 3 Scrum project delivered within time (or accepted delay) and high quality. But the budget for all of them was problematic. Interviewees pointed to different reasons, such as offering a very low price to win the project (interviewee AP3R2) or because of the introduction of Scrum and learning costs (interviewee AP3R1). Hiring people for Scrum teams (Scrum master and Scrum coach for example) and training the team cost a considerable amount of money for the company. Overall the Scrum projects were considered a success although the budget (internally) went out of control. The Scrum project C ended with unsatisfied client because of project scoping based on contractual agreements. Surprising, given that one of the Agile values is about collaboration instead of contract negotiation (Beck, Beedle, Bennekum, Cockburn, Cunningham, Fowler, Grenning, Highsmith, Hunt, Jeffries, Kern, Marick, Martin, Mellor, Schwaber, Sutherland and Thomas, 2001).

Value definition and value delivery: Although Agile aims at defining project value delivering it in iterations to the customer (client), none of the Scrum projects included proper projects' value definition. And obviously, when there is no value definition, the value delivery cannot be traced.

Conditions of client satisfaction: A happy client is one of the Agile goals. In all cases the project manager (or product owner) had the responsibility to check the client satisfaction but it was observed that the client satisfaction was not explicitly measured. Especially the team members had no opinion about if the project manager (product owner) had checked the client satisfaction or not (not transparent process). When it comes to quality acceptance, in most cases the client set minimum criteria in the contract. Since the conditions of client satisfaction were not explicit, it was impossible to check the clients' satisfaction regularly and at the end of the project.

Team building: As it was discussed before, assigning people to the projects is done by department (technical) managers in response to requests from project managers. At the studied cases, Scrum teams mostly were built up of juniors which has advantages such as showing interest in applying new things and approaches, but also disadvantages like training cost and little experience. Actually, team building for Scrum teams was one of the challenges in the company. Theoretically speaking, selecting people to build a team for just one project is not the right way in Scrum. In Scrum, the team should be constant (stable teams) over various projects and tasks are being assigned to a team (hence it is not a team that is assigned to a single task/project). Also, the Scrum team size should be constant for the whole project, but what happens typically is that there is a peak point in the project with the highest number of people in the Scrum teams and the team size varies considerably along the project life cycle. Interviewee AP1R3 as Scrum coach said: *"the team size was different between sprints. In Scrum, we like to have sustained pace with a constant number of people. Also to consider the team size was too big. It should be max 9 people to be able to work together effectively".*

From a Scrum point of view there should be the right people in the team to fit into the products' characteristics that should be delivered, but this did not happen in the projects that were investigated because of the lack of capacity in the company. Overall all interviewees from Scrum teams confirm that their teams were multidisciplinary although the selection of team members was based on availability rather than on required discipline.

Dependency of the Scrum team on Scrum master or Scrum coach: it was evident that Scrum teams are dependent on a Scrum master or Scrum coach in leading the Scrum process. *"Without Scrum master everything changes to the waterfall approach"* said interviewee AP1R1. The effect of a technical background of the Scrum master or Scrum coach is one of those things that needs to be investigated. For example, in a project the Scrum coach had no idea about the products and deliverables. *"To have a good Scrum team having a good Scrum master is necessary. And the best is when Scrum master has knowledge about the project"* said interviewee CP3R1 about the role of Scrum master, although he was a project manager in conventional way. Theoretically, the Scrum team should be a self-organised team, which was not observed in the studied Scrum projects (because of the newness of Scrum to the company).

Interaction between main parties in the project (main stakeholders): Although one of the main principles of Scrum is close interaction with the client, in the studied cases the clients were not willing or not interested to be present at the Scrum weekly sessions. Interviewee AP1R3 indicated *"Of course it is necessary to collaborate intensely with the customer (Agile manifesto: customer collaboration and contract negotiation). However the project manager tried to reach this goal and it was nice to see it, but the client did not show interest".* Generally there were cycle meetings every 4 weeks (and sometimes shorter) with the main client and if there were other stakeholders in the project, based on the priority, there were more frequent meetings to share the results and progress of the project with them. Rarely there was a meeting with all stakeholders together to discuss project matters. If there was such a meeting, the efficiency of the meeting was not good because of the high number of participants (mentioned by interviewee AP2R6).

Reporting to the client: In all Scrum projects the reporting to the main client (or other clients) was based on cyclic meetings. This was the responsibility of project manager (in the role of product owner).

Interaction among internal team: Using Scrum facilitated the interaction among the team members and sharing knowledge and information was much faster. People in Scrum projects were satisfied with sitting in one room working together on one project. Even though the preference of most people is working together in the same room, there is an obstacle which is being multitasked: when people work on different projects simultaneously, it is very difficult to arrange a weekday that everybody can sit together working on the same project. Working as a Scrum team and having daily stand-ups reduced the amount of reporting within the team. The face to face interaction facilitates the communications in the team and decreased the amount of documentation or other ways of communications (phone, email, ...).

Planning and time buffers: The project planning for the Scrum projects were based on the explained Scrum process in Table 3-4. In the Scrum way, there is a game (Poker) for estimating duration of tasks. The first estimate is made by the one who is going to do the tasks and next, other team members including the product owner (project manager) discuss if the estimated duration is enough/too much/too less. Scrum teams think this way of estimation is more reliable than making estimates by only one person. In Scrum timing estimates are only done for short intervals (sprints). In this approach, the pressure to deliver the task right on time is higher, which is confirmed by all interviewees' from Scrum project. They all believe that it worked really well in the projects. In most cases because of tight deadlines there was no buffer considered but in some cases there was one extra sprint planned as a time buffer.

The other thing to discuss regarding the scheduling, is the length of the sprints. In all cases that applied Scrum, the company planned bi-weekly sprints. But the efficiency of the bi-weekly sprint is dependent on the products that should be delivered at each sprint. *"The shorter the sprint, the better the team could focus on delivery of the result"* the Scrum coach (interviewee AP1R3) said. The idea is that at the end of the sprint something (product or partial project) should be delivered that has value for the customer, rather than just focussing on a 2 weeks sequence.

Scope changes: Embracing change is one of the four values of Agile (Beck et al., 2001). The Agile methodology facilitates the adaptation of changes in the project. Interviewee AP3R7 said: *"It was easy to handle changes in Scrum way because we add the change to product backlog"*.

3.5 Discussion

In previous sections the comparison between the theory and practice of Agile projects and the comparison between the practice of Agile projects and the projects which were managed in waterfall approaches were provided.

It was evident that not only literature stresses the differences between diverse management approaches but also practitioners recognise such differences in practice by giving some examples. *"When it comes to a multidisciplinary project, working together in one room (like in Scrum approach) is better than working individually in separate offices"*, *"project management methodology can help saving time and money"*, *"short feedback loops (in Scrum processes) end to better results"* said some of the interviewees. These statements empower the fact that project management methodology can influence project results. *"A Prince2 project is successful when the plan is executed successfully. A Scrum project is successful when the customer is happy about a great product but upfront you do not know what the products exactly look like. You have a vision and at the end of a sprint you learn how it will be achieved and maybe the plan should change"* as expressed by a project manager who has experience with both management methods.

Overall, a number of positive outcomes by using Scrum in the management of infrastructure construction projects were observed. The impression obtained during the interviews was that most of the practitioners who work in Scrum were generally very positive about it. In frequent occasions they expressed their positive opinion about the methodology. The following positive aspects were mentioned:

- Structure of work: Scrum presents a very structured way of working. The whole project is broken down into the product backlog, the members of the team know exactly the status of the project at any given moment.
- Creation of team spirit (team satisfaction): working together in the same room provides the team members an environment of continuous motivation.
- Interchange of knowledge: the mix of different specialties in the Scrum teams is key in order to achieve maximizing the value of the project, since in infrastructure projects the different niches of knowledge (examples: geotechnical and structural design) usually are treated and developed separately. But it is important to highlight that they do have interfaces that may impact greatly the end result of the project.
- Efficiency of work: there is a high level of intensity while working with Scrum. Tight sprint planning and more realistic estimated of tasks by using poker games makes the schedule become more efficient.
- Reduce the amount of rework (early detection of problems): the daily stand-ups present a great tool in order to detect in time if something is going wrong.
- Client satisfaction: since working in an Agile environment does require high client participation in the project always progresses in a manner that focuses on making the client happy. Procedures exist to quantify this outcome but the analysis of comparing the degree of satisfaction between Scrum projects and the waterfall projects has not been researched in this research.

There was also a number of challenges faced while Scrum had been used in practice. Some aspects of Scrum that were perceived as dilemmas and that might have affected the result of the project are mentioned:

- Multitasking of team: most often team members work in more than one project at the same time. The different work schedules of the team members collide in some cases makes it difficult for them to be present in all the events (daily stand-ups, review meetings, etc.). This affects the efficiency and also excess of required documentation/communication for those who cannot attend such events.
- Uncertainty about the benefits of Scrum: the team members were not always very certain about the real benefits of Scrum. Even though they received proper guidance throughout the project and were provided with proper information,

there was some wrong perception about the benefits of Scrum. The most noticeable was the fact that they preferred to use Scrum when the project is predictable while the literature states that Scrum is a way to better adapt to change (Highsmith, 2009).

- High number of Scrum 'meeting' or events: a cornerstone of Agile project management is the daily stand-ups, and if done correctly, they should be 15 minutes every day. If people work at the same time on different projects (multitasking) there are more daily stand-ups to attend. This might affect the efficiency in a negative way. There should be a balance between the amount of events needed and the intensity of the project (days per week).
- High level of commitment of the client: the client plays a key role in the Scrum process, especially with the feedback after each sprint. The client needs to be prepared to account for their participation if he accepted the Scrum methodology in order to exploit the corresponding benefits.
- Not considering life cycle analysis (cost of saved rework): this was one of the biggest challenges of innovation; there is still no quantitative analysis done on how Scrum affects the end results of the project (cost). Initially, the intensity in hours per advisor in Scrum projects is high in company standards, but in some waterfall managed projects there is need of rework, which involves extra time and additional costs. This gives room for future research on the efficiency of Scrum of overall projects considering the occurred rework in the project.
- Scrum with a strict contract: contracting in infrastructure is already quite standardised, especially dealing with public entities. In the Agile manifesto (Beck et al., 2001) says: "Customer collaboration over contract negotiation". However, it was often during the interviews stated that fixed-priced contracts provide no flexibility in using Scrum. This observed challenge is also recommended for further research.

By reviewing all observed positive aspects and faced challenges of Scrum and also looking back at the comparisons made between theory and practice it is concluded that the application of Scrum in practice is not fully aligned with theory, but still it showed positive results in some areas: especially scheduling, interactions, and communications. In all case studies it was observed that the applied project management is a hybrid version. The Scrum projects follow Scrum on the basis of a waterfall approach and the waterfall-managed projects adapt some features of Scrum (like the evaluation meetings or working in one room). In practice both approaches strengthen each other.

3.6 Managerial implications and scientific contribution

The use of Agile project management and its tools like Scrum is becoming more and more widespread. They also found their ways in other type of projects or industries than the one they originated from (Ambler, 2009; Conforto, Amaral, da Silva, Di Felippo and Kamikawachi, 2016; Johansson, 2012; Owen et al., 2006; Serrador and Pinto, 2015; van Waardenburg and van Vliet, 2013). In this Chapter we focused on the applicability of Agile and its widely-used tool Scrum in the construction industry for infrastructure projects, as some literature highlights the potential use of such management approach in the

Construction industry (Johansson, 2012; Owen et al., 2006). This research revealed that the adjusted Scrum process used in three projects in their early phases had resulted positively in some aspects such as communication and time efficiency. Also the comparison between the practice of Agile and the waterfall approach disclosed the shortcomings of the waterfall approach such as team integration and lack of communication. Such results will help practitioners in 1) realising the potential usage of Agile (Scrum) in practice by considering its advantages and 2) developing a hybrid version of a management approach in the waterfall-Agile spectrum to be fitted to their practice.

The application of Agile in the construction industry is not only very rare in current practice but also in project management literature. By using a case study research methodology (Yin, 2002), comparing the two different management approaches, this research contributes to the literature on project management. The comparison made between theory and practice of Scrum for infrastructure construction projects helps in further development of Scrum and the development of an overall Agile approach to better fit construction industry and its projects.

3.7 Conclusion

Based on the case studies in this chapter, it is concluded that the management method applied is influencing the project performance, also highlighting positive consequences of a more Agile approach compared to a conventionally waterfall managed project. Most interviewees recognised the differences between different management approaches in practice.

This chapter reveals that although Scrum (Agile) is new to the construction industry for infrastructure projects, it seems to work considerably well. This is suggested since the investigated projects were delivered successfully to the client, while applying the Scrum methodology. A common misunderstanding about Scrum (Agile) is that people think Scrum works well when the project is not complex and the scope of the project is clear, however, the contrary is true.

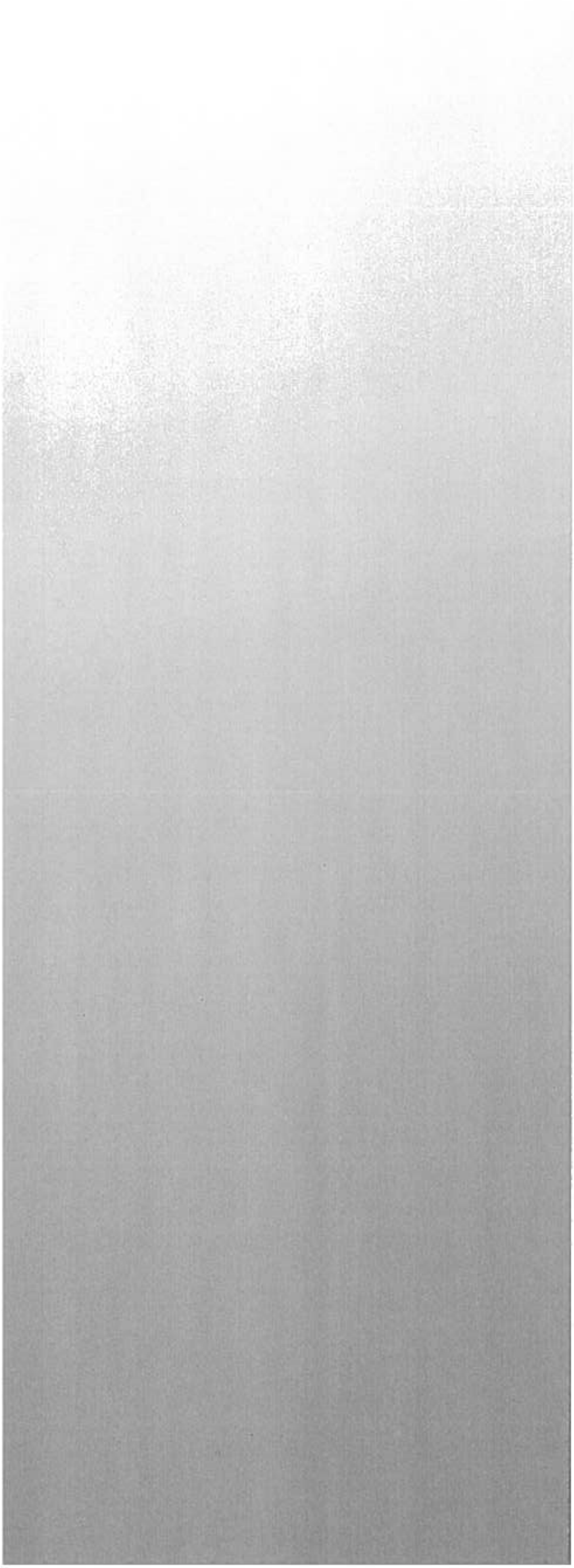
Our study shows that the achievements of using Scrum include: meeting very restricted deadlines, much shorter learning curve for juniors, team motivation, team happiness, client satisfaction, teamwork, short feedback loops, synergy in teamwork.

The full adaptation of Scrum, however, cannot be in place because the characteristics and requirements of projects in this industry (construction) differ from the industry where Agile originates from (ICT). Based on this, tailoring the Scrum (Agile) to fit to the type of project is required. Our interview results also show that conventional project management is still working well in some aspects and has deficiencies in other aspects. Ideally, there would be a fit-for-purpose project management approach, and we hypothesize that such a fit-for-purpose approach consists of a combination of conventional project management and Scrum. This hypothesis leaves room for further research (Section 9.7).

Some limitations were faced in this research. First, the lack of literature on the studied subject (Agile for infrastructure construction projects) and second the limited number of cases in which Agile project management had been used. This research was performed at a consultancy company who is mainly involved in the early phases of infrastructure construction projects. Access to the clients of those studied cases, for making a holistic view of the management of the projects, was the third limitation. This also gives room for further research into the integrity of applied project management system among all involved parties for any single project.

Concluding remark and next step

In this chapter it was concluded that Agile project management found its way to the construction industry in the context of infrastructure projects. Agile is known as a flexible project management methodology. It was also concluded that the application of such flexible project management methodology and its tool, Scrum, had a positive effect on project performance in some aspects. However, it is still not clear if the application of such flexible project management methodology can help to cope with project complexity. Therefore, Chapter 4 explores the relationship between Agile project management and project complexity.



Chapter 4: Do Lean & Agile project management help to cope with project complexity?

Abstract

Still, projects in the construction sector are delivered with time delays, cost overruns and dissatisfaction of stakeholders. One of the reasons for poor performance was assigned to project complexity. A combination of Lean construction and Agile project management is hypothesized as a possible solution to cope with project complexity.

After understanding the differences between Agile project management and conventional project management theoretically and in practice and exploring how these management methodologies and their tools (Scrum for example) are being used in practice in Chapter 3, in this chapter the focus is on the link between Lean & Agile (mainly Scrum) elements and project complexity. Agile is an umbrella name for the methodology, hence it is difficult to translate it to managerial actions. Therefore, Scrum as a tool of Agile has been chosen for testing the relationship between Agile and project complexity.

In this chapter we aim to understand if the implicit usage of Lean and Agile helps coping with complexity. The research was done by means of correlation analysis on data gathered from a structured questionnaire (67 responses). In total 51 significant correlations among 255 possible relations were found. To reduce the number of variables, factor analysis was performed. Correlation analysis on the defined factors showed 8 significant correlations among 25 relations. Several Lean and Agile elements were shown to significantly correlate to either reducing complexity or managing complexity. It was therefore concluded that these are promising to cope with complexity and improve project performance.

This chapter is based on the graduation research of Rianne Blom (Blom, 2014) and the paper presented at IPMA 2015 World Congress in Panama. The paper was published at Procedia-Social and Behavioural Sciences Journal (Sohi, Hertogh, Bosch-Rekveldt and Blom, 2016).

4.1 INTRODUCTION

Poor performance, such as time delays and cost overruns, are not uncommon in construction projects and the reasons behind these problems have attracted the attention of construction practitioners and researchers (Mansfield et al., 1994; Meng, 2012). Project complexity is claimed as one of the causes of cost overruns leading to poor performance and consequently project failure (Kaming et al., 1997). Studies show that causes of poor performance can be divided into external causes and internal causes (Meng, 2012). External causes, which are usually beyond the control of project teams, may include adverse weather conditions, unforeseen site conditions, market fluctuation, and regular changes while internal causes of poor performance may be generated by the client, the designer, the contractor, the consultant and various suppliers who provide labour, materials and equipment (Assaf and Al-Hejji, 2006). Hertogh and Westerveld (2010) also stress the influence of different interests of stakeholders and the way stakeholders interact. It can be argued that both external and internal causes happen because of project dynamics. Among all these efforts to find the reasons of poor performance, some scholars shed light on "the way that projects are being managed" as an important fact which could affect project performance and the successful delivery of the project (Gil and Tether, 2011; Olsson, 2006), (Hubbard, 1990), (Chan et al., 2004). Hertogh and Westerveld (2010) stated that the performance of megaprojects is influenced by their management. In a recent study in 2014, Davis claims that based on the literature, project management is immature as a research field although project management processes must be in place for a project to be successful (Davis, 2014).

Apart from the importance of project management in general, differentiation in size, uniqueness and complexity of projects put emphasis on the necessity of tailored management methods. Increasingly it is argued that nowadays a pure project management approach (the traditional project management approach) is no longer effective (Hertogh and Westerveld, 2010; Priemus and van Wee, 2013). Nevertheless, most of the current project management methodologies still seem to underestimate the influence of the dynamic environment (ibid). Based on above mentioned findings, the hypothesis of this research is if new management methodologies, Lean & Agile project management can help coping with complexity. Then it was decided to explore about the implicit usage of these methodologies and their influence on project complexity.

4.2 LITERATURE REVIEW

The literature study of this chapter presents the review on Lean and Agile project management. In Chapter 2 and Chapter 3 of this dissertation, the literature review on project complexity, project management, and the needs for improvements in project management already were provided. For avoiding duplication, only literature on Lean management and a brief recap on Agile project management are covered here.

4.2.1 LEAN MANAGEMENT

Since the 1950s, Lean production or Toyota production system principles have evolved and were successfully implemented by Toyota Motor Company (Aziz and Hafez, 2013). Several years later Womack and Jones studied this system and started calling the philosophy behind the system: Lean thinking (Womack and Jones, 2010). Lean thinking is a method to achieve more with less. It is based on five principles: value, value stream, flow, pull and perfection. Studies into the applicability of Lean Thinking to the construction sector resulted in the formation of Lean Construction. Lean construction is a way to design a production system to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value. Marhani et al. (2013) believe Lean construction is excellent in managing the construction process and achieving the project's goal by eliminating waste (Marhani, Jaapar, Bari and Zawawi, 2013). Eric Gabrial (1997) believes the Lean approach to project management has worked very successfully in potentially difficult and complex areas (Gabrial, 1997).

4.2.2 AGILE PROJECT MANAGEMENT

Another development in project management was the introduction of Agile project management. Agile approach was developed in the software industry but many other industries, including the construction industry, have also adapted the Agile approach. Agile is a collective term for methodologies (and practices) to increase the relevance, quality, flexibility, and business value of software solutions. These adaptive management approaches are specifically intended to address the problem that have historically plagued software development and service delivery activities in the IT industry- including budget overruns, missed deadlines, low-quality outputs, and dissatisfied users (Cooke, 2012). Although there is a broad range of Agile methodologies, all Agile methodologies share the same basic objectives including: replacing upfront planning with incremental planning that adopts to the most current information available, building in quality upfront, addressing technical risks as early in the process as possible, to minimize the impact of changing requirements, delivering frequent and continuous business value to the organisation, entrust and empower staff, encouraging ongoing communication between the business areas and project team members, and increase in the client's involvement (Cooke, 2012; Johansson, 2012).

Since Agile is an umbrella name, in itself, cannot be seen as a tool. In order to describe the more practical application of the Agile idea it was chosen to focus on one of the most applied and most popular Agile methods: Scrum (Agile-Methodology, 2014). For this research it was chosen to follow the guideline for Scrum as set up by Sutherland and Schwaber (2013).

4.3 RESEARCH DESIGN

Quantitative data was required to investigate the relation between the implicit usage of Lean and Agile elements to cope with project complexity. Several complex projects are used as cases. From these complex projects, team members are asked to fill out a questionnaire. In this questionnaire the participants are asked to assess the complexity of the project they are currently working on and to assess the implicit usage of Lean and Agile elements.

The data gathering is done by means of conducting a digital questionnaire. The software programme SurveyMonkey was used as format for the questionnaire. SPSS was chosen for analysing the data.

4.3.1 Questionnaire set up

The questionnaire consists of three parts. In the first part several general questions about the respondent are asked in order to assess whether their characteristics influence the way they assess the complexity of the project at hand or the implicit usage of Lean and Agile elements. The second part consists of several statements for assessing the complexity of the project at hand. Third part of the questionnaire consists of several statements for assessing the implicit usage of Lean and Agile.

For assessing the respondents' perceived project complexity, a framework based on the earlier mentioned TOE framework was used (Blom, 2014). The elements were translated into seventeen statements for which the respondents were asked to assess them on a five-point Likert scale ranging from totally disagree to totally agree.

For assessing the implicit usage of Lean and Agile the distinguishing elements of Lean and Agile from literature, were used as a basis. Selection of these elements was based on finding a proper answer to complexity criteria extracted from literature. For this set of statements again a five point Likert scale ranging from totally disagree to totally agree is used. This decision was made in order to keep the survey simple and quick to fill out. For this set of statements, agreeing with the statements means that the Lean and Agile ideal is applied, whilst disagreeing with the statements means that the Lean and Agile ideal is merely applied.

4.3.2 Respondents

The respondents are selected based on whether they are working on a complex project. Eventually the survey was sent to 120 possible respondents. There were 82 persons who filled out the questionnaire, yet only 67 actually completed the entire questionnaire. Therefore the total amount of respondents is 67, resulting in a good response rate of 56%. The questionnaire was conducted in Dutch, because all possible respondents are Dutch and although many of them would have a sufficient knowledge of English, we expected that the response would be higher and more accurate with a Dutch questionnaire. Figure 4-1 summarizes some characteristics of the respondents.

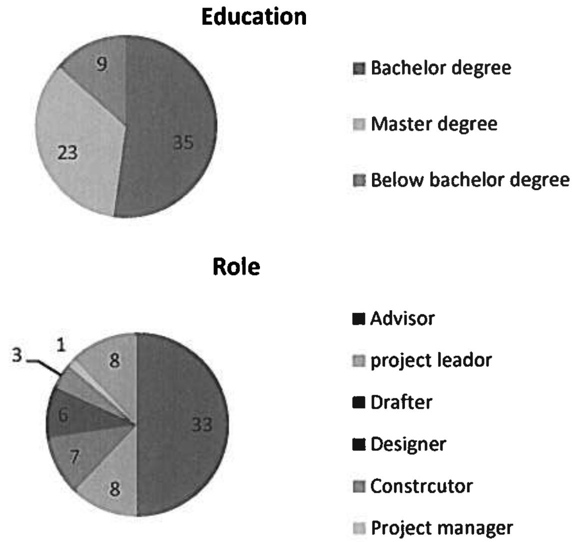


Figure 4-1: Characteristics correlation analysis respondents

4.4 ANALYSIS

Whether the Likert scale is an ordinal measuring scale or a ratio measuring scale is under ongoing debate (Jamieson, 2004). Due to the fact that adopting the ordinal scale ideal some valuable results might get lost, it was decided to treat the Likert scale as a ratio measuring scale for this research. Performing a correlation analysis for ratio variables is mostly done by means of Pearson's correlation. For this correlation a two-sided approach was adopted because regardless of the direction we looked for the relation itself not the direction of influence. The conceptual model as shown in Figure 4-2 was used as starting point for this correlation analysis.

The null hypothesis for this research implies there is no correlation, dependency or relation, between the complexity on the one hand and implicit usage of Lean and Agile on the other hand. The hypothesis to be researched implies there is a correlation, dependency or relation, between the two.

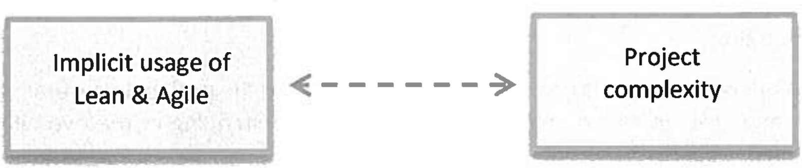


Figure 4-2: Conceptual model(the relationship between the implicit usage of Lean & Agile and project complexity)

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By means of a Pearson's correlation matrix all seventeen complexity statements and fifteen Lean and Agile elements were correlated, leading to a 15 x 17 matrix. Thus 255 correlations were calculated. In total 51 significant correlations were found. And for this analysis a correlation is assessed as significant when $\rho \leq 0.05$.

Subsequently, factor analyses are performed in order to identify underlying variables that explain the pattern of correlations within the observed variables. Factor analysis is often used in data reduction to identify a small number of factors that explain most of the variance observed in a much larger number of manifest variables.

4.5 Results

After running the correlation analysis, in order to group the sets of variables, factor analysis was done once for complexity elements and separately for Lean & Agile elements. Setting the extraction value on eigenvalue and NOT on the fixed factors, and using Varimax rotation ended up with 5 distinguished factors of complexity elements and 5 distinguished factors of Lean & Agile elements. These factors are extracted based on the percentage of variances. In the next step correlation analysis was done among the factors. There were 8 significant correlations among the 25 relations. Table 4-1 presents the results. Grey shaded boxes are those that have significant correlation.

Table 4-1: Correlation matrix between complexity and Lean & Agile factors

	Complexity 1 (technical complexity)	Complexity 2 (uncertainty)	Complexity 3 (organisational complexity)	Complexity 4 (stakeholder)	Complexity 5 (external complexity)
Lean & Agile 1 (structure & integration)	0.443**	0.205	0.594**	0.175	0.521**
Lean & Agile 2 (coordination)	0.079	0.092	0.173	0.157	0.261*
Lean & Agile 3 (planning)	0.249*	0.278*	0.325**	-0.093	0.112
Lean & Agile 4 (resource allocation)	0.147	0.195	0.196	-0.080	0.180
Lean & Agile 5 (communication)	0.226	0.120	0.431**	-0.173	0.198

**. Correlation is significant at the 0.01 level

*. Correlation is significant at the 0.05 level

The first significant correlation is between technical complexity and structure & integration elements of Lean and Agile. Based on this significant correlation in this relation it is assumed that:

- Working together as one team, instead of dividing the project in several parts and merging them at the end leads to a better understanding of the overall goals of the project.
- A more experienced project manager will advocate a project in which all team members work together. It is not assumed that the experience of the project manager will increase when all team members work together.

- Keeping the constructability of the project in mind makes that the project goals become clearer. This because in almost all cases the constructability of the project in fact makes up a big part of the goals of the project. Thus when the constructability is kept in mind, also a big part of the goals are kept in mind, and are thus clearer.
- A more experienced project manager is also better in taking the constructability into consideration.
- Using more standardisation in a project could lead to an increased level of experience of the project management. Since using more standardisation means that the project becomes more similar to other (previously performed) projects and which thus also means that the project management most likely already has some experience with a somewhat similar project.
- Cutting the project into smaller batches, or mini projects, with intermediate deliveries will lead to a better understanding of the goals of the project. For a mini project there are less goals, which can be made more clear compared to a large project where the vague overall goal mostly consists of many smaller goals.
- An increased level of smaller batches leads to an increased level of the project management's experience. This is meaningful because only few project managers have much experience with large projects, yet many have experience with smaller projects. Therefore cutting a large project into several mini projects with intermediate delivery will increase the level of experience of the project management.

The second significant correlation is between organisational complexity and structure & integration elements of Lean and Agile. This group of complexity elements consist of number of resources, contracts and communication links among them which can directly influence the technicality elements in management aspect because the work is being done by people and contractors and the communication among them influence the efficiency of the work. In this relation it is assumed that:

- In case all team members work together the availability of the resources increases. This because all team members also have and/or are specific resources. In case all team members work together each other's resources are better available to them compared to in case all team members work on individual projects.
- In case all team members of the project work together as one team, the communication level will increase. Team members will communicate more easily with other team members when they truly work together, instead of them all working on their own individual projects.
- In case the standardisation usage increases the amount of readily available resources also increases. This because using more standardisation also means that more standard resources are used. Since the availability of standard resources is higher compared to the availability of uncommon resources it seems plausible that using standardisation increases the amount and level of readily available resources.

- In case the project is divided into smaller batches, with intermediate delivery and thus also a feedback moment, the amount and level of communication in the project will increase.

The structure & integration elements of Lean and Agile has significant correlation with external complexity which includes the environmental aspects and availability of information in proper time. The structure of the project or constructability of it has an influence on environment and vice versa. The availability of information can affect the procedure of the project especially the pace. The wrong information or vague one can cause rework or failure. In this relation it is assumed that:

- Working together as one team will increase the amount of information available.
- In case the availability of information increases the level of taking the constructability into consideration increases. The availability of more information makes it easier to take the constructability into account.
- Coordination elements of Lean and Agile consist of daily meetings, information circulation, tracking of performance, and monthly/weekly detail planning. This group has significant correlation with external complexity elements. In this relation it is assumed:
- Visualising information and making this information insightful at any given moment inherently leads to the fact that information is available to all team members on any given moment of the day.

Planning elements of Lean and Agile have significant correlation with three groups of complexity elements named technical complexity, uncertainty, and organisational complexity. By this correlation it can be concluded that proper planning can reduce uncertainty and also technical and organisational complexity can mitigate. In this relation it is assumed that:

- The more experience the project management has, the more they will involve the team members in the planning process.
- Priority in tasks in planning influences the duration of the project. Looking at the significance of this correlation this seems very likely.
- Involving team members in the planning process leads to an increased level of communication. This because involving team members in the planning process in fact is an extra and high level communication moment.

And lastly there is significant correlation between communication elements of Lean and Agile with organisational complexity elements. Since organisational complexity is representative of number of people, contractors, and communication links, then the relation between them and communication elements in management is meaningful. It is concluded that when the number of people or contractors is increased then much efficient communication is needed to tackle complexity. In this relation it is assumed that:

- An increased level of awareness amongst the team members of who is doing what will lead to an increase in the availability of the resources. This because all team members also have and/or are specific resources. In case each team members is perfectly aware of what the other team members are doing, he is thus also aware of who entails which resources. Due to the fact that he is better aware of who entails which resources in general the availability of the resources increases as the awareness of the availability of the resources increases.

- In case the awareness of who is doing what increases, the level and amount of communication also increases. This correlation in fact is inherent, the awareness of who is doing what is caused by aligning this frequently. Aligning frequently increases the amount of communication.

Given these results, it is assumed that some of the Lean and Agile elements work in a way of reducing complexity while some others are managing the complexity (see Table 4-2). There are a few Lean and Agile elements that did not show significant correlations with complexity.

Table 4-2: Summary of correlation matrix

Element	Statement	Reduces complexity	Manages complexity	Unsure
Lean element 1	all specialists work together in the project, instead of the project being divided into parts and merging all the parts at the end of the process	X	X	
Lean element 2	all relevant alternatives are considered and worked out		X	
	the decision making process related to the alternatives is delayed as much as possible		X	
Lean element 3	the constructability of the project is taken into consideration	X	X	
Lean element 4	much information, like problems and corresponding action plan and the project's performance, is visualised and insightful to me at any given moment	X		
Lean element 5	standardisation is used in this project	X		
Agile element 6	I have selected the tasks I am performing myself		X	
Agile element 7	performance is tracked on a daily basis			X
Agile element 8	the team or sub-team meets on a daily basis			X
	amongst the team everyone is aware of who is doing what, since we often align this	X	X	
Agile element 9	the work is divided in smaller batches, which after completion are delivered to the customer so he/she can provide feedback	X		
merged element 10	I was involved in the planning process	X	X	
merged element 11	a detailed planning was not made at the beginning of the process, but a one week/month planning is made on a weekly/monthly basis		X	
	in the planning only tasks with high priority (according to the customer) and for which all prerequisites are met are included			X
merged element 12	Problems, even the smaller ones, are reported when they occur and made insightful to all team members			X

Also there are some other relations that were anticipated to be significant, but there was no significant correlation among them based on the data gathered from questionnaires:

- It was anticipated that coordination elements of Lean and Agile (daily basis meetings and tracking, visualised information, and decision making at the last responsible moment) has correlation with uncertainty elements of complexity.
- It was anticipated that communication elements of Lean and Agile (awareness of team members of what is happening in project, and problem reporting and solving) has significant correlation with external elements of complexity (availability of information, and impact on environment).
- Diversity of stakeholders, their expectations and goals influence the project complexity. This element of complexity can be managed by well-communication strategy which means it was anticipated that communication elements of Lean and Agile have significant correlation with the named element of complexity.

4.6 Discussion

Based on literal evidences, project management needs to evolve in some features that can fit into nowadays complex projects. Baccarini (1996) believes the construction industry has displayed great difficulty in coping with the increasing complexity of major construction projects (Baccarini, 1996). He states that certain project characteristics provide a basis for determining the appropriate managerial actions required to complete a project successfully and complexity is one such critical project dimensions (Baccarini, 1996). Cooke-Davies et al. (2008) argue that a paradigm shift is needed from the traditional project management concepts in order to deal with future project management challenges and requirements of modern practice. In this way, we decided to explore about the usage of new-born project management methods (Lean management & Agile project management) in construction projects as a possible response to this gap.

Why combination of Lean and Agile? Beside all positive aspects of Lean discussed in Section 4.2, Lean Construction has its limitations when looking at the changing and dynamic project environment. This is not only stipulated by Bertelsen (2002), but also Ward (1994) already concluded that Lean Construction does not provide a method to cope with a changing project environment (Bertelsen, 2002; Ward, 1994). This is why recent research is done into how a project could cope with this type of complexity. Agile has been put forward to fill this gap (Demir et al., 2012). Even though Agile methods are currently rarely applied in the construction industry, it does not mean that Agile methods are not applicable or successful in the construction sector (Owen et al., 2006). However, little is known about its application and success rate. Yet, the interest of the construction industry on the subject is rising (Owen et al., 2006). Since Lean Construction has its limitations related to the project environment, the construction sector is looking for (complementary) methods that do provide tools to handle this kind of complexity. But why are they searching in the direction of Agile methods? One of the main characteristics of complex systems is that they are capable of self-organisation (Bertelsen and Koskela, 2004). They do not need a detailed plan, but attention should be paid to creating a clear objective and the improvement of the reliability (ibid). This fits well with the Agile concept. Owen, Koskela, Henrich, & Codinhoto (2006) elaborately discussed the applicability of Agile Project Management to the construction sector in their paper: is Agile Project Management applicable to construction? Agile Project Management is based on the idea that change can be transformed into added value for the customer. The scope of the project, and a corresponding planning, are only defined as far as value for the customer at that moment is known and can be specified. This makes it possible to deliver value on the short-term. By receiving early and recurrent feedback, continuous learning will be achieved. This will lead to a continuous evolving of the value for the customer. This results in an end-value which satisfies the customer's requirements at the end of the process, instead of an end-value which meets the value as defined at the beginning of the process. To see change as something positive, as an opportunity to improve customer value, a more proactive organisation is required compared to Lean organisations (Owen et al., 2006).

4.7 Conclusion

Increasing complexity of projects, needs a tailored project management methodology in order to deliver complex projects successfully. In this Chapter we looked at the combination of Lean and Agile project management as a potential answer to this problem. The Lean approach has limitations in construction projects, as discussed before, but the combination of Lean and Agile was assumed to be a solution. Currently, Agile project management is rarely used in construction projects and the aim of this research was to explore if Lean and Agile methodologies could be used in this type of projects to influence the performance in a positive way by coping with complexity. Based on the results of correlation analysis it was concluded that the implicit usage of Lean and Agile elements can help to cope with project complexity. Hence the conceptual model of the research (Figure 4-2) is confirmed, regardless of the direction of the arrows. Finding out the direction could be a topic for further research (Section 9.7).

Concluding remark and next step

It was discussed that Agile has found its way in other industries including the construction industry. In this research we tested the relationship between combined elements of Lean management and Agile with project complexity. The idea was to test if the application of such management approaches could help managing project complexity. The proved relationships between different clusters of complexity and Lean & Agile gives direction for the application of these approaches.

In terms of managerial implications, as the research aimed at dealing with project complexity by applying Lean & Agile approaches, the first step is to understand the complexity of the project at hand. Table 4-3 elaborates on which elements belong to the clusters of project complexity. In order to deal with complexity, the project team should be aware in what way the project is complex: technically, organisationally and other types of complexity. Based on the project complexity, the right elements from Lean & Agile can be selected for the application. Needless to say: complexity evolves during the project, so project complexity should be evaluated at different stages during the project lifecycle. The results of the correlation analysis in this study help to choose the right elements from the Lean & Agile approaches.

Table 4-3: Complexity clusters with their contributing elements

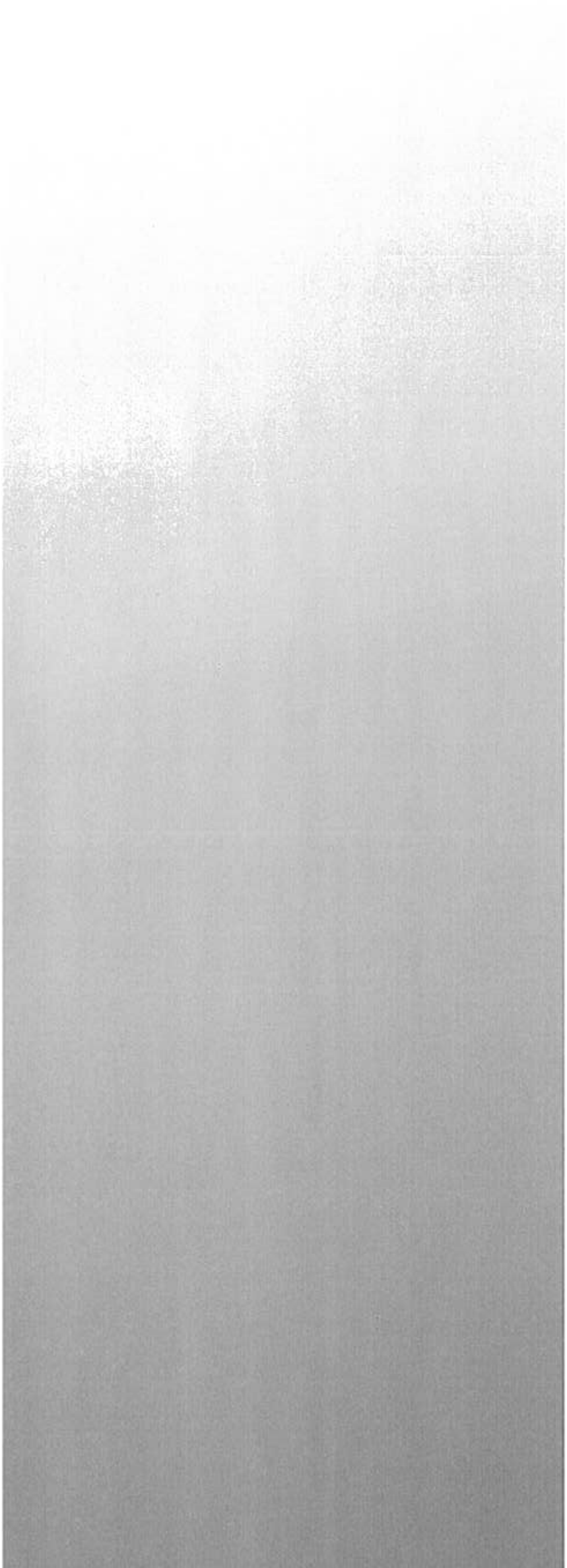
Cluster	Complexity elements
Technical complexity	Clarity of goals
	Changes in scope
	Number and variety of tasks
	Experience of the project management
	Dependencies between the different disciplines/sub-team
Uncertainty	Usage of new technologies
	Experience with used technologies
	Environmental and technological uncertainties
	Project duration
	Political influence
Organisational complexity	Availability of resources and skills
	Amount of contracts
	Level of communication
	Changes in organisation
Stakeholders	Conflicting interests, perceptions and interpretations of stakeholders
External complexity	Level of impact on the environment
	Availability of information

Table 4-4 elaborates on which elements belong to the clusters of the Lean & Agile approaches. For example, if the project is technically complex, 'structure and integration' elements together with 'planning' elements are helpful. Standardisation of processes and design, taking constructability into account, involvement of team members in planning processes are some elements that belong to the aforementioned clusters of Lean & Agile approaches to manage technically complex projects.

Table 4-4: Lean & Agile clusters with their contributing elements

Cluster	Lean & Agile elements
Structure & integration	Standardisation is used in this project.
	The constructability of the project is taken into consideration.
	All specialists work together in the project, instead of the project being divided into parts and merging all the parts at the end of the process.
	The work is divided in smaller batches, which after completion are delivered to the customer so he/she can provide feedback.
	All relevant alternatives are considered and worked out.
	The decision making process related to the alternatives is delayed as much as possible.
Coordination	The team or sub-team meets on a daily basis.
	Much information, like problems and corresponding action plans and the project's performance, is visualised and insightful to me at any given moment.
	Performance is tracked on a daily basis
	A detailed planning was not made at the beginning of the process, but a one week/month planning is made on a weekly/monthly basis.
Planning	In the planning only tasks with high priority (according to the customer) and for which all prerequisites are met are included.
	I was involved in the planning process.
Resource allocation	I have selected the tasks I am performing myself.
Communication	Amongst the team everyone is aware of who is doing what, since we often align this.
	Problems, even the smaller once, are reported when they occur and made insightful to all team members.

By proving the existence of the relationship between project complexity and elements of Lean and Agile project management, it is assumed that flexibility in project management has a positive effect on project performance (as the initial hypothesis in Chapter 1 stated). Although Agile project management is known as a flexible project management approach, flexibility in project management is not limited to Agile. Therefore, in the next Chapter, the enablers of flexibility in project management are identified more broadly.



Chapter 5: FLEXIBILITY ENABLERS

Abstract

In Chapter 1 it was discussed that project complexity is increasing and project management seems to be unsuccessful in dealing with project complexity. Accordingly, some literature suggests adding flexibility to project management for enabling it to deal with nowadays projects' complexity.

In Chapter 2 it was discussed how flexibility in project management was defined in the literature. It was also mentioned that in the same line of reasoning, some literature suggests adaptability to be added to project management. In Chapter 3 and 4, the evidence of flexibility in project management in literature and practice was reviewed. Flexibility was evident in the Agile project management methodology.

We believe, however, that flexibility is not only limited to Agile project management. Therefore, this chapter looks into literature to find enablers of flexibility in project management to propose a flexibility framework. Further, the framework is validated by means of interviews with practitioners. This will form the foundation for investigating the applicability of flexible project management in practice and its contribution to project performance (subsequent chapters).

5.1 INTRODUCTION

In dynamic environments almost all projects have some degree of dynamism (Collyer and Warren, 2009). There are a number of challenges that project management encounters in uncertain dynamic environments: planning for uncertain outcomes, balancing flexibility with reliability and accountability, balancing decision quality against decision speed, and timing scope freeze during rapid change (Gray and Larson, 2003). Some other challenges that would be faced in a dynamic environment are: product lifespan (shorter average mean time to be replaced by new product compared to static environment), rate of introduction of new materials, difficulty in finding and managing skilled labour, level of integration with customer industry, changing goals, effect on planning, morale, levels of interdependence, and dependency of business units with lower levels of dynamics (Collyer and Warren, 2009). Considering the environmental dynamism, even the projects within a portfolio require adaptive management to the projects' characteristics, which results in different levels of planning with different degrees of details (H Payne and Rodney Turner, 1999). The existence of dynamism, project complexity and uncertainty draw attention toward dynamic management approaches (Hertogh and Westerveld, 2010). Flexibility in project management can be considered as a way to cope with dynamism. The notion of flexibility is not new in literature (Bateson, 1972; Sager, 1990), but its recognition is growing in recent years (Olsson, 2006; Osipova and Eriksson, 2013; Wirkus, 2016; Wysocki, 2007; Yadav, 2016). Although it is suggested to increase project management flexibility, hardly any literature provides an indication of how flexibility can be enabled. Therefore, this chapter aims at identifying flexibility enablers.

In this chapter, project management flexibility is elaborated in addition to what was discussed about flexibility and adaptability in Chapter 2. The enablers of flexibility are extracted from literature and validated by experts.

In the next section (Section 5.2) a brief literature review is presented about flexibility in project management and flexibility at the organisation level. Also the flexible character of Agile project management is discussed. The literature review is concluded by presenting the derived enablers of flexibility. Next, the evaluation of the entire list of flexibility enablers via interviews with experts is discussed (Section 5.3). After presenting the data in Section 5.4, the interview results are analysed and discussed in Section 5.5. The chapter concludes with a list of flexibility enablers (Section 5.6) that serve as input for the next Chapters of this dissertation.

5.2 LITERATURE REVIEW

In this section flexibility in project management, flexibility in organisation, flexibility from Agile project management point of view and adaptability in project management are discussed. These four areas cover the current literature about project management flexibility.

5.2.1 Flexibility in project management

One of the early definitions of flexibility is provided by Bateson (1972). He defined flexibility as *"uncommitted potentiality for change"*. He argues the ability to harmonize with the environmental flexibility in advanced urban civilizations which has the highest degree of flexibility in his opinion. He emphasised that the context conditions should be taken into account while talking about flexibility.

Flexibility in the planning and implementation phase of a project may be accomplished not only by flexible decisions, but also through the possibilities for adjustments in the entire planning system: departing from plans, changing them, or side-stepping them altogether (Sager, 1990). Regarding flexibility in planning, Sager (1990) defines robustness, resilience and stability as other related qualities to flexibility. According to Gupta and Rosenhead (1968), robustness in sequential investment decisions is defined as *"Robustness of a decision or decisions must be measured in terms of the numbers of the good end-states for expected external conditions which remain as open options"*. Hashimoto, Stedinger and Loucks (1982) define resilience as the quality which describes *"how quickly a system is likely to recover or bounce back from failure once failure has occurred"*. Stability of a plan or a project was defined as *"the maximum deviation between predicted and realised value of the key variables which renders the planning product satisfactory"* (Sager, 1990).

Aaker and Mascarenhas (1984) argue while the intention of the control-oriented approach is reducing undesirable changes, flexibility enables incorporating required changes which might happen because of the uncertain and changing environment. Control versus flexibility approaches is what Koppenjan et al. (2011) defined as 'command-and-control' versus 'prepare-and-commit'. The difference between these two approaches lays in their attitude towards managing uncertainty and complexity. The command-and-control approach aims at eliminating the uncertainty and complexity by imposing strict planning and control over the process, while the prepare-and-commit approach aims at managing both uncertainty and complexity by close cooperation between the project actors and hence, increased flexibility. Sager (1990) stated that keeping options open is the crucial concern, and this is what flexibility is aimed at. Flexibility is also required for investment decisions, because most investment decisions are characterized by irreversibility and uncertainty about their future rewards (Huchzermeier and Loch, 2001).

Based on studying flexibility in case studies, Olsson (2006) states "while flexibility was frequently needed in studied projects, it was rarely prepared for" (Olsson, 2006). He recognises flexibility both in the process and in the products. About flexibility in the process, he states: *"Flexibility in decision process is based on an approach where decisions and commitments in the projects are made sequentially over episodes"* (Olsson, 2006). He identified three strategies to achieve flexibility in decision making processes: late locking of project concepts, continuous step by step locking of the project by a successive commitment to projects, and contingency planning.

Flexibility can be defined as a competence of the project manager, as discussed by Turner (2004): *"the project manager should be empowered with flexibility to deal with* *unforeseen circumstances as they see best, and with the owner giving guidance as to how they think the project should be best achieved"*. Flexibility may be described as a way of making irreversible decisions more reversible or postponing irreversible decisions until more information is available (Olsson, 2006). This refers to the following definition of flexibility of Husby et al. as: *"the capability to adjust the project to prospective consequences of uncertain circumstances within the context of the project"* (Olsson, 2006). Flexibility can be related to the degree of modularity in projects. Modularity refers to the possibility to divide the project into more or less independent sub-units (Olsson, 2006).

All these definitions have two main facts about flexibility in common: taking the dynamic context into account and readiness for changes. What can be concluded from these provided definitions is unanimity about 'ability to adapt to project context and to the dynamics of the environment'. This concluded commonality from the provided definitions, forms the base definition of flexibility for this research. Therefore the definition of project management flexibility in this research is: "the ability and readiness to deal with dynamics in a project".

5.2.2 Flexibility on organisational level

Flexibility is not only required at the project level, but also on the organisational level. Flexibility on the organisational level is mostly labelled as dynamic capability or adaptive capability. Dynamic capability is defined by Grindley and Teece (1997) as the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environment. Most of the literature on dynamic capability identify three main component factors of dynamic capability being absorptive, adaptive, and innovative capabilities (Biedenbach and Müller, 2012; Wang and Ahmed, 2007).

Absorptive capabilities are about organisational ability to utilize the external knowledge, facilitate learning and maintaining knowledge over time (Lane, Koka and Pathak, 2006). Innovative capabilities are about generating innovation whether for refining or significantly transforming the products and services (Biedenbach and Müller, 2012).

Adaptive capability is defined by different authors as "ability to identify and capitalize on emerging market opportunities" (Biedenbach and Müller, 2012). Adaptive capability has a relationship with continuous and reflective learning which can be also be implemented at the project level (Pisano, 2000). Two key factors regarding the adaptive capabilities Biedenbach and Müller (2012) found from interviews were understanding market and customers, and project and product adjustments. They believe adaptive capabilities in pharmaceutical R&D projects are in place if incremental innovation (incremental product development) is followed. In this context such projects are very similar to ICT projects were incremental development is used for improving the products based on customers' satisfaction and continuous improvement. McLain and Lee (1996) state proponents of adaptive management, and conclude these increase the knowledge acquisition rate, enhance information flow among policy actors, and provides opportunities for creating shared understanding. They believe that in uncertain conditions, effective management is not only about acquiring knowledge, but also about changing the behaviour in response to new understanding of the situation. Linkov et al. (2006) state that adaptive management acknowledges that uncertainty is inherent in any natural system. Godinho and Branco (2012) believe a non-adaptive policy will be adequate for the cases in which there is no managerial flexibility. In such condition the project manager cannot react to the way the project is developing. There are other researches done exploring adaptive management approaches in ecosystems and environmental decision making processes (Folke et al., 2005; McLain and Lee, 1996).

Since the dynamic capability concept focuses on the organisational level, it considers to be as out-of-scope for this research, but since adaptive capability is one of the main components of dynamic capability and has commonalities both on the project and the organisational level, it was decided to include it as relevant literature.

5.2.3 Flexibility in Agile PM

Agile Project Management is defined as "a style of project management that focuses on early delivery of business value, continuous improvement of the project's product and processes, scope flexibility, team input, and delivering well-tested products that reflect customer need" (Owen et al., 2006). Agile project management lets software project managers and employees adapt to changing circumstances, rather than trying to impose rigid formal controls, as in traditional linear development methods (Augustine, Payne, Sencindiver and Woodcock, 2005). According to Agile core values are: "high-quality deliverables are a result of providing customer value, team interactions and adapting to current business circumstances" (Layton, 2010). In contrast to Agile, traditional software development methodologies can be characterized as reflecting linear, sequential processes, which can be effective in developing projects with stable, known, consistent requirements (Augustine et al., 2005) therefore, traditional linear project management methodologies are mismatched with such dynamic systems. Highsmith (2002) stated that Agility is the ability to balance flexibility and stability. Agile methodologies have sought to focus on rapid iterative delivery, flexibility, and working software projects (Abrahamsson, Warsta, Siponen and Ronkainen, 2003). The Agile manager understands the effects of the mutual interactions among a project's various parts and steers them in the direction of continuous learning and adaptation (Augustine et al., 2005). Conventional project management approaches promise predictability, stability, and high assurance which is in contrast to Agile promises being higher customer satisfaction, lower defect rates, faster development times and a solution to rapidly changing requirements (Boehm and Turner, 2003).

An Agile-based framework includes several aspects (Augustine et al., 2005): being able to manage and adapt to changes, consider organisations as adaptive systems, understanding the limits of external control and a humanistic problem-solving approach. For such humanistic problem-solving approach all team members should be considered to be skilled and valuable stakeholders in team management. Moreover, the up-front planning should be minimized by stressing the adaptability and ability to change. It also relies on the autonomy of teams as the basic problem-solving ability.

In a nutshell, it can be said that Agile project management opts for embracing change by increasing flexibility. The increased flexibility will be in place by valuing the team and stakeholders and stressing the iterative and incremental processes over up-front planning and control mechanism.

5.2.4 ADAPTABILITY

By exploring literature in a research about rethinking project management, Svejvig and Andersen (2014) pointed to adaptive project management as one of the rethinking project management views. Adaptability is about readiness to change, based on feedback loops and information flows in a complex system (Aritua et al., 2009), ability to respond to market changes (Biedenbach and Müller, 2012), the way to cope with changes, risks and uncertainties, and the ability to adapt the response to contextual changes (Giezen, 2012).

In Chapter 2 it was discussed that some literature use the term 'adaptability' in project management (Aritua et al., 2009; Bown, Gray and Stead, 2013; Lévárdy and Browning, 2009; Linkov et al., 2006; McLain and Lee, 1996; Ourdev et al., 2008) which in some areas is the same as flexibility in project management (Godinho and Branco, 2012; Ourdev et al., 2008; Stoica and Brouse, 2013; Walker and Shen, 2002). 'Adaptive management' is also a known term in environmental studies especially in natural resource management (Armitage, Plummer, Berkes, Arthur, Charles, Davidson-Hunt, Diduck, Doubleday, Johnson and Marschke, 2009; Berkes, Colding and Folke, 2000; Pahl-Wostl, 2007; Tompkins and Adger, 2004; Walters, 1986). The main idea of adaptability is about being capable of learning from experience (Ourdev et al., 2008) regardless of the domain in which adaptability is used as a management characteristic.

Because 'adaptability' is more known as a term in organisation studies and natural resource management, it was decided to use the term 'flexibility' of projects in this research. However, the relevant literature which defined or identified adaptability where it can be applied at project level, is included in the literature reviews of this dissertation.

5.2.5 RECAP OF LITERATURE REVIEW

By doing literature review about flexibility and adaptability in project management, a list of literature references which directly define or identify sources of flexibility is extracted (Appendix). It was concluded that some literature only sheds light on the importance of flexibility in project management without explaining further what flexibility is (Koppenjan et al., 2011; Kreiner, 1995; Olsson, 2006). Some others define areas of flexibility (Geraldi, 2008; Osipova and Eriksson, 2013). A number of studies look into flexibility as one aspect like human resource management or scheduling among others (Chan and Chan, 2010; Gil and Tether, 2011; Gupta and Rosenhead, 1968; Kellenbrink and Helber, 2015).

Apart from flexibility, adaptability was introduced in literature in different areas (Armitage et al., 2009; Berkes et al., 2000; Lévárdy and Browning, 2009; Pahl-Wostl, 2007; Walters, 1986). Adaptive management is mainly a known term in natural resource management in literature. It also appears in the literature about organisational flexibility, generally known as 'dynamic capability' (Biedenbach and Müller, 2012; Lane et al., 2006). Although the ideas behind adaptive management and dynamic capability are the same as the idea of flexibility, their areas of attention are not in line with the scope of this research. Hence it was decided to stick to the term 'flexibility' in this research to be defined and identified further.

No literature was found which explicitly identified the enablers of flexibility for project management. Therefore it was decided to investigate these flexibility enablers, with the intention that this can be the base for a flexible project management framework. By enablers of flexibility the managerial actions which enable project management to become flexible are referred to. Although not mentioned explicitly in this way, by having a close look at 11 sources, we could extract a number of enablers. The list of flexibility enablers extracted from literature, is presented in Table 5-1. In this table it is shown that some enablers have been mentioned in more than one reference.

5.3 EVALUATION OF THE FLEXIBILITY ENABLERS

While no existing literature evaluated or validated flexibility enablers of project management, the next step of this research is aimed at evaluation of flexibility enablers via interviews with practitioners.

For the interviews, a semi-structured questionnaire was designed which consisted of three parts. The first part was about the profile of the interviewee such as role, educational background, etc. The second part included a table of flexibility enablers out of the studied literature, asking the interviewees if they agreed upon these enablers or not. The third part included some open questions regarding additional flexibility enablers, other than those from literature.

The interviewees were mostly project managers and project leaders. It was decided to interview people with a background in general project management and also some who have a background in Agile, because experienced people with the Agile methodology by default are familiar with flexibility concepts. The main criterion for selecting the interviewees was having relevant experience in project management of infrastructure projects.

In total 14 interviews were conducted. Apart from validating the flexibility enablers concluded from literature, the other goal of doing the interviews was to identify additional flexibility enablers which were not mentioned in the literature but recognised by practitioners. After 14 interviews it was evident that all items mentioned by practitioners as new enablers of flexibility, were in the list (albeit in slightly different formulation), hence indicating data saturation.

The interviewees' demography is shown in Figure 5-1. In total, 13 out of the 14 interviewees had an engineering background, mostly in civil engineering. Half of the interviewees were project managers. The others were involved in projects as senior manager, process manager, project director or other roles. The majority of interviewees (71%) work in the construction industry. About 62% of them had more than 20 years of working experience. Half of the interviewees had knowledge of Agile project management and 42% had used tools of Agile in practice.

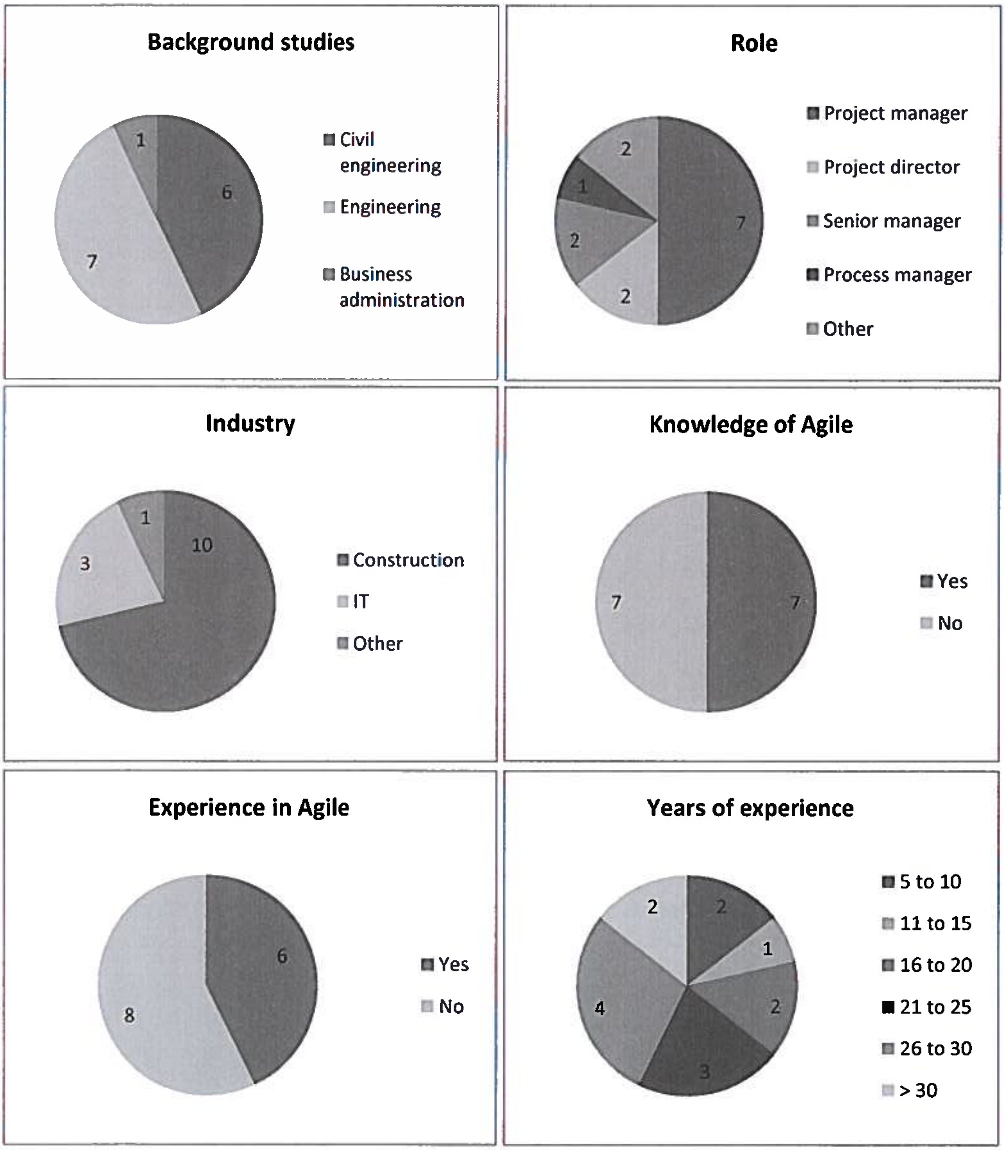


Figure 5-1: Demography of interviewees

5.4 Data

In this section the data from the interviews are presented in Table 5-2. At first, interviewees were asked to give an opinion whether the enablers derived from literature contributed to flexibility or were not applicable in their view. Next, they were asked to elaborate on why they think each enabler contributes to flexibility or not. The answers are summarized in Appendix D and analysed in Section 5.5.

All the enablers listed in Table 5-2 are extracted from the literature. The table shows how many interviewees agreed upon the applicability of each item as a flexible enabler.

Table 5-1: Flexibility enablers extracted from literature

(Koppenjan et al., 2011)	(Olsson, 2006)	(Priemus and van Wee, 2013)	(Atkinson et al., 2006)	(Giezen, 2012; Perminova et al., 2008)	(Osipova and Eriksson, 2013)	(Geraldi, 2008)	(Cobb, 2011)	(Huchzermeier and Loch, 2001)	(Chapman and Ward, 1996)	(Augustine et al., 2005)
Close cooperation among involved parties					Joint discussion between involved parties		Short feedback loops			
Broad task definition for best cooperation										
Contracts aim more toward functional scope realisation (functional scope definition)						Ability to define and change the scope and goals of the project (contract flexibility)				
Facilitate change as much as needed (Change is inevitable)	Embrace Changes	Recognising that change is inevitable			Changes suggested by the end-user					The ability to manage and adapt to change
Self-steering of the complete project team										
Open and demand-driven information exchange										
Shared interface management										
Functional-realisation based contract										
	Late locking	Making a decision at the last responsible moment						Postponing the design freeze		
	Continuous locking									
	Extensions	Considering all possible alternatives								
	Contingency planning								Contingency planning	
	Modularity			Standardisation						
		Seizing opportunities and coping with threats								
			Trust							
				Reflective learning						

(Koppenjan et al., 2011)	(Olsson, 2006)	(Priemus and van Wee, 2013)	(Atkinson et al., 2006)	(Giezen, 2012; Perminova et al., 2008)	(Osipova and Eriksson, 2013)	(Geraldi, 2008)	(Cobb, 2011)	(Huchzermeier and Loch, 2001)	(Chapman and Ward, 1996)	(Augustine et al., 2005)
					Possibility of changing roles between the employees					
					Higher degree of flexibility in schedule without delaying the date of completion	Ability to define and change the time constraints (schedule flexibility)				
					Joint project office	Ability to define and change where the tasks are performed (location flexibility)				
							Iterative planning			Minimize up-front planning
							Consensus building			Team autonomy
						Ability to define and change who is carrying out the project tasks (human resource flexibility)	Self-assigned teams and individuals			
						Ability to define and change the implementation process (tools and instrumental flexibility)				
										A view of organisations as adaptive systems
										Recognition of the limits of external control in establishing order
										Consider all members to be skilled and valuable stakeholders in team management

Table 5-2: Validation data for flexibility enablers

Literature				Interview results	
Category	Definition		Enabler	Applicable	NOT applicable
What	Ability to define and change the scope and goals of the project (contract flexibility)	1	Broad task definition	13	1
		2	Embrace Changes	13	1
		3	Facilitate change as much as needed (Change is inevitable)	13	1
		4	Functional-realisation based contract rather than predefined task execution (functional scope definition)	12	2
How	Ability to define and change the implementation process (tools and instrumental flexibility)	5	Self-steering of the complete project team (Steering is much more of a horizontal character: in a network of the client, management, contractors, and technology providers)	14	0
		6	The process of exchanging information is more open	14	0
		7	Unstructured information exchange	8	6
		8	Demand-driven information exchange between different groups	12	2
		9	Shared interfaces management among the actors involved, rather than a task mainly driven by the formal project manager	14	0
		10	Contingency planning	11	3
		11	Seize opportunities and coping with threats (resilience)	13	1
		12	Trust among parties involved in the project	14	0
		13	Use standardisation to an extent that fits with the project's context	12	2
		14	Visualise project planning and progress	14	0
		15	Consider all possible alternatives	11	3
		16	Network structure rather than hierarchical structure	13	1
		17	Continuous learning	13	1
Who	Ability to define and change who is carrying out the project tasks (human resource flexibility)	18	Consensus building amongst team members	13	1
		19	Stable teams	13	1
		20	Self-assigned individuals to tasks	14	0
		21	Consider all team member to be skilled in team management	10	4

Literature				Interview results	
Category	Definition		Enabler	Applicable	NOT applicable
		22	Consider all team member to be valuable stakeholder in team	10	4
When	Ability to define and change the time constraints for different tasks (schedule flexibility)	23	Make a decision at the last responsible moment or Late locking (redundancy)	11	3
		24	Short feedback loops	14	0
		25	Continuous locking (iterative)	12	2
		26	Minimize up-front planning	7	7
		27	Iterative planning	14	0
		28	Iterative delivery	14	0
Where	Ability to define and change where the tasks are performed (location flexibility)	29	Joint project office for project team	14	0
		30	Flexible desks	12	2

5.5 ANALYSIS AND DISCUSSION

The interview results are discussed to decide which items in the flexibility list are considered as an enabler, which ones should be removed, which ones need reformulation and which ones can be combined.

Before discussing the flexibility enablers one by one, it should be mentioned that the importance of project management flexibility is highlighted by practitioners during the interviews. For example, interviewee 4 stated: *"at some moment in the project, things happen that force the project team to be flexible. For example, when a contractor become bankrupt. Even if there is a very structured plan, it is not possible to continue".* He said: *"start the conversation with a client from the beginning to see where in the schedule there is flexibility. This helps to achieve better results. Investigate where flexibility can be achieved".* Interviewee 2 stated that although flexibility is limited by the time and budget restrictions, it is about the design, budget, time, leadership, team, etc.".

1. **Broad task definition:** 13 out of 14 respondents agreed that broad task definition is an enabler of flexibility. The single respondent who thinks 'broad task definition' is not applicable to flexibility believes there should be a balance between broad and specific. *"There is a difference between 'what are the tasks?' and 'what has to be done?' It should be very specific about what has to be realised"* he said. Overall it is concluded that task definition should not be too broad in order not to influence the decision making process. In other words, the task definition should be specific enough to make a clear picture of the requirements. As interviewee 1 said: at later stages of the project, a broad task definition is a disabler which can negatively influence project performance. Another important fact is differentiating between task and project goal. For defining the project goal, it helps if there is a broad task definition as mentioned by a number of the interviewees.
2. **Embrace change:** Only one respondent (from client side) thinks that 'embrace change' is not applicable as an enabler of flexibility. According to literature "changes in client requirements" is one of the main sources of change, especially scope change (Sharma, Sohl, Hertogh and Deketh, 2017). It was interesting to see that a client representative (project manager) believes there shouldn't be any change during the project. The rest of the interviewees agreed that embracing change is an enabler of flexibility. *"Normally it is not desirable to have change but when it is needed, you have to incorporate change"* says one of the respondents who agrees with embracing change. Interviewee 12 stated that change is not desirable, although it is inevitable. Interviewee 9 said that *"When you are doing a project in an Agile manner, it is targeted to take changes into considerations by defining the right timeframe to embrace change".*
3. **Facilitate change**: embrace change and facilitate change were included in the questionnaire as two separate flexibility enablers. However, most of the respondents indicated to see similarities between 'embrace change' and 'facilitate change'.

Interviewee 1 said *"In FED it is easier to take care of changes rather than in execution. Change request might result in rework (more cost and time). If the project goal and scope is not clear enough at the beginning, the probability of getting extra cost and time is higher. Decision gates are needed. Any form of change is a disruption in the project"*. About facilitating change, interviewee 12 said *"Change is not good. But you should convince why change is required instead of justifying the change. Stakeholders should stick to their agreement rather than changing their minds"*. This is arguable since the business case might be justified or the project goal changes along the way, as a source of complexity (Turner and Cochrane, 1993). Delivering what has been fixed at the beginning does not necessarily deliver value. It is concluded that 'embracing change' is an enabler of flexibility but it needs to be incorporated considering project restrictions.

4. **Functional-realisation based contract**: in total 12 out of the 14 respondents agreed that a functional-realisation based contract helps flexibility. It is mentioned that applicability of a functional-realisation based contract depends on project phases: *"In initiation or conceptual design he believes the contract could base on function but in execution phase it should be more task-realisation"*. Interviewee 9 agrees that it is not applicable: *"If there is no specification about the project, then the development team is not able to take the requirements of the stakeholders into account"*. Interviewee 1 said *"It can be an enabler of flexibility but also disabler depending on different factors like end-user satisfaction (who wants a project which functions well)"*. Also, it depends from which level it is looked at; from a decision makers point of view or a project developers point of view, as interviewee 9 indicated. Overall it can be said that functional-realisation based contract helps to be flexible in a way that it takes the goal of projects into account. For realising the function, the goals need to be translated into tasks (by the development team).
5. **Self-steering team:** all respondents agree about self-steering team as one of the flexibility enablers. At the same time, they mostly pointed out the fact that for decision making there is a need for hierarchy. One of the respondents believes that a self-steering team is essential, but that there should be some limits to that. *"You cannot keep letting everybody do whatever they like. There must be some kind of control on a higher level"*. Interviewee 7 indicates if there is no control from a higher level, the team will get stuck into short-term objectives. To proceed there should be some steering from a higher level than the team. *"As a project manager I would love to have a team which is able to steer itself but for example because the team is not directly connected to the client, it is not possible for them to be 100% self-steered"*, says one of the interviewees. Another scenario could be that everybody is happy with what was done, but the client (or any other party at the top layer) asks for something else. There is a need for top management to manage such things and also make flexibility happen. It is an element but not an ultimate element. Interviewee 4 indicated that *"Although self-steering is important for flexibility, there should be structures in order not to end up in a mess"*. It can be concluded that although self-

steering team enables flexibility, it should be structured for facilitating the decision-making process. The structure might resemble some level of hierarchy.

6. **Open information exchange:** all interviewees agreed that transparency in communication and sharing information is crucial for project success. They all stated that it enables flexibility in project management. Some interviewees highlighted the negative effects of not being open to exchang information. *"The more closed the process of information exchange is, the more effort is needed for steering the team"* claims one of the respondents. Interviewee 1 said that *"Information has different layers and the flow of information has to be managed"*. This is not declining open information exchange but wrong information might end up to project cancellation. Overall it can be said that transparency and short communication lines can be achieved if information exchange is open.
7. **Unstructured information exchange:** most of the respondents asked in what way the information exchange is unstructured. They agree the word "unstructured" gives a negative meaning. They mostly mentioned that even in open information exchange there is a structure. One of the interviewees believes the information exchange should be systematic even for unstructured information exchange. He thinks when there is a defined system for information exchange it becomes structured, while by NOT defining the communication lines, it becomes unstructured. At the same time, information exchange is structured and unstructured. *"If there is no structure in information exchange then it ends to hassle in decision making"*, is stated by one of the interviewees. Interviewee 12 said *"The question is how to manage information exchange knowing the fact that it is not always structured"*. The interview results show there must be a structure in some aspects for information exchange like format of the reports, while there shouldn't be structure in predefined communication lines. In total 6 out of 14 interviewees count 'unstructured information exchange' as a disabler. Also some others, who agreed that it can help flexibility, made it conditional to the situation, decision makers, etc. It was concluded that 'unstructured information exchange' is not considered a flexibility enabler.
8. **Demand-driven information exchange:** as described by an interviewee, the ideal situation is the existence of an information pool. In this case, all information goes to a shared information pool and every individual or team has access to all the information they need. However, some of the interviewees found it difficult to realise it in practice, although they agree upon the relevance of it to flexibility. Interviewee 4 stated that to have a better picture of the situation, sometimes it is better to provide extra information, rather than just what was demanded. The pitfall in this case might be the tendency of some team members NOT to publish the information which they do not like to share. It can be said that 'an intuitive relationship exists between trust and information exchange'. Interviewee 8 stated that for demand-driven information exchange parties should be encouraged to express what kind of information they want. Overall it can be concluded that demand-driven information exchange helps flexibility.

9. **Shared interface management:** all interviewees agreed that interface management is a shared task between all parties involved in the projects. They agreed that shared interface management enables project management flexibility. No downside or discussion was made by the interviewees regarding the relevance of 'shared interface management' to flexibility. Therefore, it is concluded that 'shared interface management' enables flexibility.
10. **Contingency planning:** 11 out of 14 interviewees agreed that 'contingency planning' helps to be flexible. An interesting observation was that two out of the three interviewees who think contingency planning is not applicable to flexibility, have an Agile background. *"Contingency planning is related to contractual risks"*, says one of them. The first perception made here is that Agile by its nature deals with risks and uncertainties, using iterative decision making processes. *"When you use Scrum to manage the process of developing the project, there is no need for contingency planning. For an inflexible project environment there should be contingency planning"*, says one of the interviewees. The relationship between contingency planning and contractual risks was expressed by Interviewee 14. Overall it was concluded that 'contingency planning' is flexibility enabler but it might be treated differently in a purely Agile context.
11. **Seizing opportunities and coping with threats:** it was mentioned by a number of interviewees that seizing opportunities and coping with threats is an important factor in management, but there should be a limit to it. Without putting a limit, the project might deviate from its main objectives. Different perceptions about seizing opportunities and coping with threats were observed during the interviews. *"If it is about the scoping the project, it should be avoided but if it is about reacting to change, it is helpful"* said interviewee 14 who has a background in Agile. This indicates that 'seizing opportunities and coping with threats' is not always desirable. Still, it was concluded that this is an enabler of flexibility.
12. **Trust:** all interviewees unanimously agreed that an important factor in any project that should be handled by different parties is trust. One of the interviewees believed trust is in place if people think of partnering relations. He found building trust with governmental party much more difficult than with other parties. Another respondent with a background in Agile and Scrum points to the importance of trust in the Scrum process. *"Better not to use Scrum if there is no trust"*, he said. A number of interviewees mentioned 'trust' as a precondition for open information exchange. It can be said that 'trust' enables flexibility in project management as it is confirmed by all interviewees.
13. **Using standardisation to an extent that fits with the project's context in order to achieve reflective learning:** 12 out of the 14 interviewees agreed that 'standardisation' helps flexibility. It is mentioned by some that 'standardisation' is in contrast to flexibility if you only look at the literal meaning of the word 'standardisation'. Interviewee 13 mentioned that 'standardisation' helps if bureaucracy is prevented. It should not add to the level of control.

14. **Visualising project planning and progress**: the interview results show that visualising the planning and progress of the project helps the project team to better understand the status of the project and also the velocity of progressing. One of the interviewees emphasized the relation between visualising the project planning and the change absorption capability. He believes when planning and progress are visualised it is easier to understand the effects of change. Also it is mentioned that it helps team commitment. The interviewees who work in an Agile way mentioned that 'visualising' is an essential element of Agile. Overall it is concluded that 'visualising' is an enabler of flexibility.
15. **Considering all possible alternatives:** although 11 out of the 14 interviewees agreed about the applicability of this enabler, they all deliver the same message: considering all possible alternatives is killing! For managing uncertainties they agree that it is good to keep a limited number of alternatives on-board, but not too many. Considering all possible alternatives takes so much time, efforts, and money. Interviewee 14 (Agile background) believes that the alternatives which can deliver value must be taken into account. *"You must dare to decide in time among the alternatives"* says another interviewee. This indicates that the focus should be on one single option. Interviewee 7 said that there are always time restrictions, that preserve to keep all options open. Also it was mentioned that the level of analysis for each alternative should be limited. Overall it was concluded that having alternative helps flexibility, but only a limited number of alternatives. Too many alternatives are destructive. Hence this enabler was reformulated to 'possible alternatives' for the later steps of the research.
16. **Network structure rather than hierarchical structure:** 13 out of the 14 interviewees agreed that network structure is adding to project management flexibility. Some of the respondents questioned the decision-making process within the network structure. *'Although the network structure works better in establishing flexibility, the hierarchical structure has much clearer structure for decision making'*, was mentioned by an interviewee. Some of the interviewees valued network structure as a strong factor for being flexible in project management.
17. **Continuous learning:** *'If there is no room for learning then there wouldn't be any flexible project management'*, stated one of the interviewees. On the contrary: *"It is a nightmare because everybody thinks he/she is working on a unique project"*, said another interviewee. Because of this attitude, people would have less tendency to capture lessons learned from previous projects and they won't use it in other projects. Interviewee 2 mentioned that people should learn from experiences for being able to adjust to the situation. Overall 'continuous learning' is regarded as an enabler of flexibility.
18. **Consensus building amongst team members:** consensus building is important in project management, as indicated by all interviewees. But also there are some pitfalls. First of all people should avoid group-thinking. There might be consensus among the team members but this agreement should not come from only blindly following others. Interviewee 9 mentioned the importance of considering competencies of people in decision making processes: people have different competencies. Therefore

in decision making we should take the competencies (for example technical competence) of those who are involved in the process into consideration. Interviewee 4 mentioned that consensus at the end is essential but it should not kill the discussion among pros and cons. Therefore, 'consensus among team members' is treated as a flexibility enabler.

19. **Stable teams:** 13 out of the 14 interviewees agreed on this item as flexibility enabler. But also some challenges for stable teams were pinpointed. One of the interviewees indicated that in stable teams it is not sure that teams are built up of the best persons to do all tasks. For some tasks we need to involve others. However, this problem can be overcome by having multi-disciplinary teams. Interviewees with a background in Agile and Scrum put much emphasis on this, because stable teams is one of the common features of Agile and Scrum. The challenge in having stable teams in a project-oriented organisation is when they have fewer projects to do. In such a situation it would be very expensive for the organisation to have stable teams. It can be argued that literally 'stable' is in contrast to flexibility. Interviewee 8 mentioned that for team dynamics it is not good to have a stable team for a long time. Still, it was concluded that 'stable teams' in general enables flexibility.
20. **Self-assigned individuals to tasks:** all interviewees agreed on the relevance of this item to project management flexibility. *"It makes team members feel confident and also responsible for what they do"* said an interviewee. The pitfall here could be that not the right people assign themselves to the right tasks, as indicated by Interviewee 7.
21. **Consider all team members to be skilled in team management:** 10 out of the 14 interviewees found this item applicable as an enabler of flexibility of project management. The 4 interviewees who don't agree found decision making as the problem here. An obvious example, in this case, is the absence of a Scrum master in Scrum teams, as mentioned by one of the interviewees. If the team is dependent on the Scrum master they cannot perform their tasks the way they do in presence of the Scrum master. It is argued by some interviewees that team management is a competency which not necessarily everybody should have. Since most of the interviewees agreed on relevance this as flexibility enabler, it is counted as an enabler.
22. **Consider all team members to be valuable stakeholder in team:** most of the respondents responded positive as every individual is seen as a valuable resource in the team. It is about feeling proud of being involved in the team and being valued. One of the interviewees who disagreed with this item stated that 'stakeholder' in project management literature refers to parties who are related to the project rather than to individuals in the team. The intention of this item is to value team members, as also indicated by some of the interviewees. Hence it was decided to include this as a flexibility enabler.
23. **Making a decision at the last responsible moment or Late locking (redundancy):** in the original questionnaire 'late locking' was included as a separate item. The interviewees, however, did not distinguish between these two. 11 out of the 14

interviewees agreed on the relevance of this item to flexibility. But they also indicated that it should not be misunderstood by postponing the decisions. Interviewee 7 said that even for locking the decisions at the last responsible moment there should be some limits. He stated it is better to make a decision in an earlier stage that allows for flexibility. For going through stages, decisions should be locked as soon as possible as a number of interviewees mentioned. Also it was observed that using word late in 'late locking' gives a negative perception. However, none of the interviewees suggested any other synonym for this item. This item remains the same and counted as flexibility enabler.

24. **Short feedback loops:** all interviewees agreed that short feedback loops help to be flexible. This is aimed to check and control the process and the output on short intervals (daily basis). Interviewee 4 stated that it is an enabler because it helps in understanding what we have done and what can be improved. This item also counted as an enabler of flexibility.
25. **Continuous locking (iterative):** 12 out of the 14 interviewees agreed that continuous locking helps flexibility. As an exception, Interviewee 4 mentioned that 'locking' does not help flexibility because there is no intention to get back to what was locked. In general, this item was not questioned and it is counted as an enabler of flexibility.
26. **Minimize up-front planning:** it was argued in a number of interviews that having up-front planning highly depends on the phase of a project. If the management follows a waterfall approach, for some phases up-front planning is needed. The point here is on 'minimizing' the up-front planning to maximize flexibility. Most of the interviewees agreed upon the fact that for the execution phase up-front planning is more important rather than in the initiation or design phase. One of the interviewees (with Agile background) indicated it is essential since it gives responsibility to the development team to plan for each iteration. *"Still you can make a detailed up-front planning but you must allow the project to deviate from this plan. If you made the plan and try to stick to it, it is killing. But to have a planning helps a lot"*, says an interviewee with a conventional project management background. Interviewee 2 stated that this could help flexibility but always all clients look for loads of detailed plans upfront. Overall, 7 out of the 14 interviewees agreed that minimizing up-front planning enables flexibility. The other 7 interviewees generally mentioned that there should be 'enough' up-front planning. At the end it was decided to keep this item as flexibility enabler.
27. **Iterative planning:** planning has different levels. It should be decided which level of planning is needed for which stage of the project. All interviewees agreed that iterative planning helps flexibility. No argument was made during the interviews regarding this item. Hence it counts as flexibility enabler.
28. **Iterative delivery:** all interviewees agreed upon the relevance of 'iterative delivery' to project management flexibility. Interviewee 3 mentioned that it is not always possible to deliver iteratively. In Agile methodology, a project will be delivered in batches which has value for the client (Beck, 2001). Interviewee 4 stated that iterative delivery

helps understanding clients' opinions regarding the project. It is concluded that 'iterative delivery' is a flexibility enabler.

29. **Joint project office for project team (co-located project team):** in the main questionnaire 'joint project office' and 'co-location of project team' were included separately. However, all interviewees see these two items as the same. They all agreed that a 'joint project office' helps to be flexible because it shortens the communication lines. For example, interviewee 14 stated that *"joint project office increases the amount of communication"*. Needless to say that for projects which are located in remote areas or project teams that are spread in different locations, the first intention is to try to co-locate them. If not possible to co-locate, virtual ways of communication can be helpful. Therefore, 'joint project office' refers to co-locating of the project team either physically or virtually, which helps to shorten communication lines.
30. **Flexible desks:** 12 out of the 14 interviewees agreed that 'flexible desks' enables flexibility. Interviewee 8 suggested that flexible desk is helping flexibility as long as people who work on the same project sit together. He stated that in some organisations, a flexible workplace is aiming at reducing the energy consumption and it does not relate to project management but more to the organisation. It was concluded that 'flexible desks' is also a flexibility enabler.

Using the data from the interviews, it was concluded that 26 of the flexibility enablers of Table 5-2 were confirmed by practitioners. Based on their arguments, some of the enablers were merged together (facilitating change and embracing change as one enabler, open information exchange and demand-driven information exchange as one enabler, joint project office and co-location of the project team as one enabler). Based on the discussions, 'unstructured information exchange' was removed from the list. 'Late locking' was also removed from the list of flexibility enablers. Interviewees confirmed that 'locking at the last responsible moment' is the same as 'late locking'.

In the last part of the interview, interviewees were asked to add flexibility enablers which were not included in the literature list. After analysis of the data, it was concluded that the enablers mentioned by the interviewees are mostly the same as the existing enablers in the questionnaire, albeit in somewhat different formulations. Table 5-3 presents the enablers added by the interviewees and links them to the identified enablers from literature.

Four enablers that were suggested by the interviewees could not be linked to the literature list of flexibility enablers: reduce complexity, cooperation measurement, attitude of being flexible and open to ideas, and broad knowledge. These, however, are not added to the list, because of the following reasons. 'Reduce complexity' is mentioned by only one interviewee. According to literature, complexity cannot be always reduced but it should be managed (Hertogh and Westerveld, 2010). 'Cooperation measurement' is mentioned once as an enabler of flexibility but we do not believe it is related to flexibility, because cooperation (Lu and Hao, 2013; Wang, Chen, Fu and Zhang, 2017) and collaboration (Suprapto, Bakker and Mooi, 2015a) have other predecessors or enablers. 'Broad knowledge' is also only mentioned once. This element was not added because the idea is that the team members should have the right knowledge rather than broad knowledge. A project team should be multidisciplinary, based on the required knowledge and skills. A multidisciplinary team as a success factor for projects (Fortune and White, 2006) is not about having broad knowledge but about having the (complimentary) required knowledge for the project. The next enabler mentioned by an interviewee was 'attitude of being flexible'. In our opinion, having the attitude is not project management related but an inherent characteristic of an individual. As mentioned before, by enablers of flexibility the managerial actions that increase flexibility are meant. Hence, no new items were added to the list of flexibility enablers.

Table 5-3: Flexibility enablers suggested by practitioners versus the ones in the framework

Flexibility enabler added by interviewees	**Existing flexibility enablers in the framework**
Open communication for all parties involved	Open information exchange Short feedback loops Joint project office
Committed team members	Stable teams Self-assigned tasks to individuals Consider team members as valuable stakeholders
Aligned with project goal	Functional-realisation based contract
Respect	Trust
Scope changes should be part of the discussion	Embracing change
Stakeholder alignment	Open information exchange Trust Joint project office Short feedback loops
Good and enough communication	Short feedback loops Open information exchange
Communication with client	Short feedback loops Trust Open information exchange
Team coaching	Consider team members skilled in team management
Short communication lines	Short feedback loops Joint project office Flexible desks
Deliver value at all times	Iterative delivery
Integration	Trust Joint project office Shared interface management Self-steering team
Reduce complexity	-
Cooperation measurement	-
Attitude of being flexible and open to ideas	-
Broad knowledge	-

The analysis of data gathered from the interviews both on the evaluation of the existing flexibility enablers and the suggested enablers by the interviewees resulted in a list of 26 enablers. The refined list of flexibility enablers, clustered in five areas of flexibility (what, how, who, when and where) with their explanation is provided in Table 5-4.

Table 5-4: Flexibility enablers and their explanation

#	Category	Flexibility enabler	Explanation
1	What	Broad task definition	Scope of the project should be defined into broad tasks rather than by highly-detailed work packages.
2		Embrace and facilitate change	Instead of being resistance toward change, it is needed to develop a relaxed approach toward change.
3		Functional-realisation based contract rather than predefined task execution	The focus is more on defining functions rather than including detailed specifications in the contract (functional scope definition).
4	How	Self-steering of the complete project team	Steering has a horizontal character in a network of client, team, contractors, stakeholders, etc.
5		Open and demand-driven information exchange among different groups	The exchange of information among the involved parties should be open in order to avoid any probable issue because of lack of information. Information exchanges due to demand (request).
6		Shared interface management	Managing the interfaces is a shared task for the actors involved, rather than a task mainly driven by the formal project manager.
7		Contingency planning	In addition to a set of defined base plans, a set of alternative plans is required. Contingency plans reflect anticipated potential departures from the defined plans for a project. Alternatives can be used if the defined plans cannot be executed.
8		Seizing opportunities and coping with threats	The ability of the decision-making process to deal with unexpected influences without risking indefinite delays or stalemates in the process by identifying opportunities and threats.
9		Trust	Involve all stakeholders in decision making, share incomplete information, information visible to all stakeholders.
10		Standardised process and design	Using standardisation to an extent that fits with the project's context in order to achieve reflective learning. Having simple standard process/design/layout/... in order to be used for similar cases.
11		Visualised project planning and progress	For easy and better understanding of project planning and progress it is important to have big-enough figures, charts, diagrams hanging on a wall or by using boards. This provides a common place for discussions over the project.
12		Possible alternatives	Considering an alternative plan/solution for cases that something happened unexpectedly and the ongoing plan cannot be continued, helps to reduce the delays caused by unknown unknowns.
13		Network structure rather than hierarchical structure	To avoid traditional (and destructive) hierarchy in project organisation for decision-making process, it is better to establish a network as a project organisation structure.
14		Continuous learning	Capturing lessons learned and using them in future projects in respect to their context.
15	Who	Consensus amongst team members	Consensus among team members facilitates the decision-making processes.
16		Stable teams	The teams are stable and tasks will be assigned to existing teams and their team members rather than every time building new teams and members to be assigned to tasks.

#	Category	Flexibility enabler	Explanation
17		Self-assigned individuals to tasks	Individuals decide what tasks they will do. In traditional management, tasks are assigned by management.
18		Consider all team members to be skilled in team management.	Team priority rather than individual priority.
19		Consider all team members to be valuable. stakeholder in the team.	Valuing team members in the team.
20	When	Locking at last responsible moment	An exploring iterative front-end process in which decisions are made at the latest possible moment.
21		Short feedback loops	By having short-term (e.g. daily) meetings, it can be possible to react to tasks that were done by others on short intervals rather than when the task going to be delivered.
22		Continuous locking (iterative)	Decisions are made and locked iteratively during the process in the front-end phase. It can be done for example by using a stage gate model.
23		Iterative planning	Instead of defining all task at the beginning, only those tasks that should be performed in the iteration will be defined at the beginning of the iteration.
24		Iterative delivery	Project split up into smaller subprojects or products. Each subproject will be delivered to the client when it is done, while considering the whole.
25	Where	Joint project office	The possibility for the project team to work together in one place (project team including client, consultant, contractor, or multi contractors, multi consultants, etc.).
26		Flexible desks	The possibility for individuals of the project team to select a place to work in order to sit together with others who work on the same assignment (task) from one project.

5.6 Conclusion

This chapter aimed at identifying flexibility enablers from literature and validating them via interviews with practitioners, as well as identifying flexibility enablers which might not been mentioned in the literature but were recognised by practitioners. It was revealed that flexibility in project management was highlighted in literature and also practitioners emphasized the necessity of flexibility in practice. While the importance of flexibility is recognised, it should be defined and further explored for its enablers. The first step was to define what flexibility is meant here. After reviewing the definitions given in literature and taking the goal of this research into account, flexibility is defined as: *The ability and readiness to deal with dynamics in the project*. By doing a literature study and after conducting interviews with 14 practitioners, a list of 26 flexibility enablers was composed. The analysis of data gathered from the interviews both on the evaluation of the existing flexibility enablers and the suggested enablers by the interviewees resulted in a list of 26 enablers.

For better understating of flexibility enablers, it was decided to cluster them. Since the qualitative data from the interviews do not provide enough input for clustering the enablers, literature was used to cluster the enablers. Two main sources suggested the areas of flexibility in project management (Geraldi, 2008; Osipova and Eriksson, 2013). The research by Osipova and Eriksson (2013) supports and adjusted the areas of flexibility suggested by Geraldi (2008). Therefore, it was decided to cluster the 26 enablers in the five areas of flexibility (what, how, who, when and where) suggested by Osipova and Eriksson (2013). The refined list of flexibility enablers, clustered in five areas of flexibility (what, how, who, when and where) with their explanation is provided in Table 5-4. This table will be used as an input for the next steps of the research.

Concluding remark and next step

Flexible project management approaches in literature and practice were studied in Chapter 3 and Chapter 4. It was concluded that existing flexible management approaches have positive effects on project performance in some aspects, like team integration and client satisfaction. Also some challenges were observed, like multitasking of team members. These exploratory researches proved that the hypothesis regarding the positive effect of flexible project management on project performance is correctly formulated. However, this hypothesis should be tested by means of quantitative research (Chapter 8). In order to perform this quantitative research, the enablers of flexibility were identified in this chapter.

After understanding what the enablers of flexibility are, it is important to know how practitioners look at these enablers. In Chapter 6 the practitioners' perspective regarding project management flexibility will be investigated by means of Q-study.

Chapter 6: PRACTITIONERS' PERSPECTIVES ON FLEXIBLE PROJECT MANAGEMENT

Abstract

Literature defines two main streams in project management: mechanistic and organic. Mechanistic reflects the traditional waterfall approach and organic reflects a more adaptive approach. The organic approach became known by the awareness of dynamic project environments and changing requirements. The organic approach is characterized by flexibility. Accordingly, scholars and practitioners tried to define flexibility and find ways to make project management more flexible. However, scientific literature about practitioners' perspectives on making project management flexible is lacking. Therefore this research explores practitioners' perspectives on project management flexibility by the use of Q-methodology. The scope of the research was narrowed down to the front-end phase of infrastructure projects. Two types of organisations were targeted: client and consultancy organisations. Data was gathered from 43 respondents from 6 organisations (3 client and 3 consultancy organisations) in The Netherlands.

The results of the study reveal three distinct perspectives on flexibility for both organisation types (client and consultant): flexibility by Trust, flexibility by Scope management, and flexibility by Proactive management. These perspectives partly support defined flexibility categories in literature. Further research could focus on exploring the perspectives in different project phases, operationalizing the perspectives in practice and team composition taking into account these perspectives.

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6.1 INTRODUCTION

Project management as we know it today, was born in the 1950s in the defence and aerospace sectors, which were little flexible and little complex at that time (Morris, 1997). The "new-born" project management was based on rational, linear approach and causal relationships (Williams, 2005). Such an approach, also named as conventional project management, was putting the emphasis on the extensive front-end analysis to predetermine time, budget and performance goals. This extensive front-end analysis results in a highly detailed scope description which includes the tasks that have to be performed, and controlled strictly in the subsequent phases of the project (Koppenjan et al., 2011). The PMBOK guide as one of the well-known project management guidelines defines conventional project management (Koskela and Howell, 2002). Based on the PMBoK, there are two types of processes which a project goes through: project management processes and product-oriented processes (PMI, 2013). The first focuses on creating a smooth flow of the end-product design, execute and delivery, while the latter focuses on the specification of the end product. The attention of the PMBOK guide is mainly paid to the project management processes rather than to the product-oriented processes (Project Management Institute, Inc., 2013). Literature also states that the intention of conventional project management is mainly on the hard paradigms of project management (Aritua et al., 2009) including time, cost and scope description by means of tools like WBS (work breakdown structure) or CPM (critical path method). The need for new theories which also take the soft paradigms of the project management into account, was highlighted in the literature (Winter et al., 2006).

The fact that projects are embedded in an environment that is characterised by its dynamics is more recognised recently (Bosch-Rekveldt, 2011). Collyer and Warren (2009), in their paper on project management for dynamic environments, used the term 'dynamic' to represent the 'constantly changing characteristic'. It can be said that all projects confront a certain degree of dynamism. Such dynamism cause changes which make the predictions unreliable (Priemus and van Wee, 2013). Koppenjan et al. (2011) argue that to deal with such situations a 'prepare and commit' approach is required which acknowledges the unavoidable scope changes and the uncertainty and complexity of the projects. Other researches (Geraldi, 2008; Koppenjan et al., 2011; Perminova et al., 2008; Yadav, 2016) argued that project management should evolve or mature in this direction, without completely losing the conventional origins. This is in line with what Geraldi (2008) mentioned as the required combination of both order and chaos approaches by the projects where the order approach is reflected by a conventional project management and the chaos approach by the awareness of complexity and uncertainty. Combining these approaches asks for a degree of flexibility to keep the balance between the two approaches (Geraldi, 2008; Koppenjan et al., 2011).

Burns and Stalker (1961) already recognised these two approaches as a mechanistic and an organic approach, almost 60 years ago. A mechanistic approach is known by a high level of control, strict hierarchical structures and the importance of individual knowledge and skills, in the context of stable environments. Unlike the first approach, the organic approach is required for changing and dynamic environments. Dynamic environments ask for a network structure, team and individual commitment and effective communication which are the characteristics of the organic approach.

Hertogh et al. (2008) noted that there should be a fine balance between control and interaction. Unconstructive bureaucracy can be caused by the high degree of control which is imposed to the project by project management (Buuren et al., 2010; Rijke et al., 2014). Projects' efficiency and effectiveness would be hampered by such an excessive control. Too much control will lead to circular bureaucracy and inflexibility (Lycett et al., 2004; Platje and Seidel, 1993).

Increasingly it is argued that nowadays a pure project management approach (the traditional project management approach) is no longer effective (Hertogh and Westerveld, 2010; Priemus and van Wee, 2013). Nevertheless, most of the current project management methodologies still seem to underestimate the influence of the dynamic environment (ibid).

Bringing all that was discussed in this section together, project management is an emerging field, both in practice and research, with attention for moving from conventional project management (mechanistic) toward a more flexible approach which takes the organic nature of a project into account. In this movement, it is important to know the practitioners' point of view regarding such a flexible approach. Or, in other words, what practitioners find most/least important in "flexible" project management. Hence this chapter aims at exploring different perspectives on project management flexibility among practitioners.

This chapter first presents a literature review on project management and (more) flexible project management in Section 6.2. Next, the research methodology for exploring the perspectives is explained in Section 6.3. The data collection and analysis is covered in Section 6.4. Section 6.5 presents the discussion and finally, the conclusions are drawn in Section 6.6, including suggestions for further research.

6.2 LITERATURE REVIEW

This section provides the literature review which will form the base of the research. It starts with a brief introduction to project management and its two main distinct approaches (mechanistic and organic). Next flexibility as a new evolvement in project management will be discussed. The section will be concluded by providing the formed base for the empirical research.

6.2.1 PROJECT MANAGEMENT

"Project management is the disciplined application of certain knowledge, techniques, tools and skills to create a unique product or service" (PMI, 2013). Klein, Biesenthal and Dehlin (2015) believe *"Project management is complex and therefore a fruitful ground for*

creative, spontaneous and intuitive application of particular theories to meet the stated objectives in a constantly changing environment". With all the growth in project management science, in a recent study in 2014, Davis claims that project management is not well-developed in the field of research, although it is required for successful delivery of projects (Davis, 2014). That there is room for improvement in project management practice is also stated by Sanjuan and Froese (2013). They recognise two contributing factors to poor PM practices: being unaware of the differences between own practice and best practices in project management and, being unaware of the value offered by the project management. Fernandes et al. (2015) believe that realising effective project management still is a challenge, although project management has developed and spread significantly in science, visibility and importance as a powerful way to reach better project and (project-oriented) organisation's performance (Fernandes et al., 2015).

The project manager can choose from a range of tools, techniques and approaches to manage any particular project: from very ad hoc to methodologies that completely and formally define all processes (Fernandes et al., 2015). However, different requirements based on different project types are not acknowledged by conventional project management (Kenny, 2003). Differentiation in projects' size, uniqueness and complexity potentially emphasise the necessity of a tailored management method. The choice of which particular processes will be employed in any situation is left to the judgment of the individual project manager (Kenny, 2003).

Different scholars highlighted the recognition of required flexibility in project management: Smith and Irwin (2006) by questioning the ability of traditional approaches in dealing with complexity and uncertainty (Smith and Irwin, 2006). Harvett (2013) by emphasizing the need for a move towards an 'uncertainty management paradigm', Priemus and van Wee (2013) by arguing the ineffectiveness of a pure project management approach for nowadays projects, (Hertogh and Westerveld, 2010) by emphasizing the required balance between control and interaction, Klein et al. (2015) by recognising that mechanistic, absolute and universal conventional project management does not suit to address modern-day complexity, and Collyer and Warren (2009) by emphasising the required project management for dynamic environments.

Among the existing PM methodologies, a number of them are widely known, like PMBOK (Project Management Body of Knowledge), PRINCE2 (PRojects IN Controlled Environments), P2M (A Guidebook for Project and Programme Management for Enterprise Innovation). These PM methodologies are known as traditional waterfall approaches.

The development of Agile project management in IT (information technology) is providing new views on flexibility in other industries (Collins, 2014; Owen et al., 2006; Serrador and Pinto, 2015). The recognition of agility was leading to the introduction of new updates in some of the abovementioned well-known PM guides by combining the strength of both approaches. For example, PRINCE2 in 2015 introduced a new update which is a hybrid version of waterfall and Agile (AXELOS, 2015).

To conclude the developments in project management: conventional project management approaches and practices are based on causal and linear relationships, which is proven to be ineffective in successfully managing project characterised by complexity and uncertainty during the project lifecycle (Harvett, 2013). The inflexibility of project management shows to be a deficiency in current practice and consequently, adding/increasing flexibility in project management attracts scholars' and practitioners' attention. Section 6.2.2 further elaborates on recent literature about flexibility in project management.

6.2.2 Flexibility in Project management

Apart from highlighting the necessity of flexibility in project management (section 6.2.1), a few other aspects strengthen the idea of making project management more flexible:

- During the project life-cycle, unknown unknowns will be (partly) transformed to knowns, which is called progressive elaboration. As a result, project scope and consequently time, cost and relevant plans should be adapted periodically. It means that more information will be obtained during the project lifecycle and corresponding actions should be taken (Dloi, 2014).
- Changes are inevitable and (partially) should be incorporated in the project. There is a direct relationship between the contract duration and the required changes in terms of number, size and effect of the imposed changes (Hertogh et al., 2008; Lycett et al., 2004).
- Project managers are challenged to keep their projects focused and at the same time support their organisation's need to adapt to changes and uncertainty in the business environment (Olsson, 2006).

The above aspects emphasise the need for flexibility in project management. What is this flexibility? Flexibility can be defined as a competence of the project manager, as discussed by Turner (2004): *"the project manager should be empowered with flexibility to deal with unforeseen circumstances as they see best, and with the owner giving guidance as to how they think the project should be best achieved"*. Flexibility may be described as a way of making irreversible decisions more reversible or postponing irreversible decisions until more information is available (Olsson, 2006). This refers to the following definition of flexibility of Husby et al. as *"the capability to adjust the project to prospective consequences of uncertain circumstances within the context of the project"* (Olsson, 2006). Flexibility is also related to the possibility of dividing the projects into smaller independent parts, which is called modularity (Olsson, 2006).

All these definitions pinpoint similar facts about flexibility. What can be concluded from these provided definitions is unanimity about 'adaptation to project circumstances and to the dynamics of the environment'. This concluded commonality from the provided definitions, forms the base definition of flexibility for this research.

Some scholars go a step further and have researched the areas in which project management can become flexible from a theoretical point of view. In her research about the balance between order and chaos, based on a literature review, Geraldi (2008) found four categories of flexibility (what, who, how and when). She then based on practice, grouped flexibility of project management into six categories, adding "how much" and "where" to the general categories: what (scope and goals of project), how (process of project), who (team of project), when (scheduling of project), how much (budget responsibility and the hierarchical level of decisions), and where (where the task has to be realised). Osipova and Eriksson (2013) recognised five categories using the categorization suggested by Geraldi (2008): what, how, who, where, and when. This latter categorization was used to cluster the flexibility enablers in our study.

6.3 ENABLERS OF FLEXIBILITY

For fulfilling the objective of this research, finding practitioners' perspectives on project management flexibility, it is required to provide them with a list of activities/actions that, if applied in practice, will help to make project management flexible. Practitioners are asked to prioritize the items in the list. For deriving the list, an extensive literature study and interviews with practitioners were conducted.

Compiling the enablers of flexibility in project management mentioned in the literature, a list of 30 enablers was derived. The entire list was validated by means of a semi-structured interview with 12 practitioners. Qualitative analysis of the interviews resulted in the final list of 26 flexibility enablers. These enablers are presented in Table 6-1. The 26 enablers of flexibility were clustered into five categories as discussed in section 6.2.2. Categorizations are used for exploring patterns among the practitioners' perspectives. In the results' sections (section 6.5.1), in the figures different patterns are used to differentiate the categories of flexibility enablers.

Table 6-1: Flexibility enablers

Category		Flexibility enablers	Main Source
What	1	Broad task definition	(Koppenjan et al., 2011)
	2	Embrace change as much as needed	(Olsson, 2006), (Priemus and van Wee, 2013)
	3	Functional-realisation based contract	(Koppenjan et al., 2011)
How	4	Self-steering of the complete project team	(Koppenjan et al., 2011)
	5	Open information exchange among different groups	(Koppenjan et al., 2011)
	6	Shared interface management	(Koppenjan et al., 2011)
	7	Contingency planning	(Olsson, 2006)
	8	Seizing opportunities and coping with threats	(Blom, 2014)
	9	Trust among involved parties	(Atkinson et al., 2006)
	10	Standardise the process and design	(Giezen, 2012; Perminova et al., 2008)
	11	Visualised project planning and progress	(Beck et al., 2001)
	12	possible alternatives	(Priemus and van Wee, 2013)
	13	Network structure rather than hierarchical structure	(Beck et al., 2001)
	14	Continuous learning	(Giezen, 2012; Perminova et al., 2008)
Who	15	Consensus amongst team members	(Cobb, 2011)
	16	Stable teams	(Beck et al., 2001)
	17	Self-assigned individuals to tasks	(Cobb, 2011)
	18	Team priority over individual priority	(Beck et al., 2001)
	19	Team members as stakeholders	(Beck et al., 2001)
When	20	Late locking	(Olsson, 2006) (Huchzermeier and Loch, 2001)
	21	Short feedback loops	(Cobb, 2011)
	22	Continuous locking (iterative)	(Olsson, 2006)
	23	Iterative planning	(Cobb, 2011)
	24	Iterative delivery	(Beck et al., 2001)
Where	25	Joint project office	(Osipova and Eriksson, 2013)
	26	Have flexible desks	(Osipova and Eriksson, 2013)

6.4 RESEARCH METHODOLOGY

In this section, first an overview of Q-methodology as the used research methodology is provided. Next, the profile of respondents (P-set) who participants in the research is discussed.

6.4.1 Q-METHODOLOGY

After a thorough literature study on flexibility in project management and interviews with practitioners, 26 elements of flexibility were concluded. In order to apply these flexibility elements in practice it is important to know what practitioners find most/least important among these elements, or more precisely, what ranking practitioners give to certain elements. To reach this target, the Q-methodology was chosen as a research methodology. By Q-methodology a great deal of emphasis is put on the importance of having an inquiring attitude (exploratory research) rather than simply testing one's reasoning (hypothesis testing) (Anderson, 2004). Q-methodology allows a researcher to explore the subjectivity of human being opinion on a complex problem which is done by giving weight (importance to statements in Q-sorting exercise) (Donner, 2001). Thereby the results of a Q methodological study are the possible viewpoints of a population (Van Exel and De Graaf, 2005). Q-methodology was created by psychologist-physicist William Stephenson in the 1950s to study the human subjectivity in a scientific way (Stephenson, 1953). Q-methodology is a mix-method research approach as claimed by Davis and Michelle (2011). It systematically uncovers and analyses the subjective individuals' viewpoints to find out the similarities and differences. This exploratory and interpretation-intensive methodology is suitable for studying small populations of respondents (Brown, 1980). The methodology is fortified by the statistical analysis combining correlation analysis with factor analysis. Unlike survey studies, all voices of respondents are 'heard' and are considered in the analysis in Q-methodology (Matinga, Pinedo-Pascua, Vervaeke, Monforti-Ferrario and Szabo, 2014).

Q-methodology relies on a small sample (Brown, 1980; Cuppen, Bosch-Rekveldt, Pikaar and Mehos, 2016; Gilbert Silvius, Kampinga, Paniagua and Mooi, 2017; Suprapto, Bakker, Mooi and Moree, 2015b) of purposively selected respondents rather than random sampling or large sample sizes. A small sample of respondents is sufficient as far as they represent plausible diverse opinions regarding the topic under investigation (Brown, 1980). Donner (2001) stated that even one participant is worthy of review and hence meaningful but discernible groups can be found with as few as a dozen participants. The number of participants (P-set) usually is smaller than the Q-set (Brouwer, 1999). The aim is to have four or five persons defining each anticipated perspectives which are often two to four.

Q methodology can be used in any research field where the objective is to study the subjectivity of human being on the research topic, including attitude measurement (Stephenson, 1953, 1965). Q-methodology has been used in different research fields since 1960s (Baker, Thompson and Mannion, 2006; Donner, 2001; Koops, Bosch-Rekveldt, Coman, Hertogh and Bakker, 2016; Militello and Benham, 2010; Suprapto et al., 2015b; van Exel, Baker, Mason, Donaldson, Brouwer and Team, 2015; Van Marrewijk et al., 2008; Webler, Danielson and Tuler, 2009).

To apply Q-methodology, a number of steps should be taken. Gathering the statements (Q-set) is the first step. The statements are often presented as multiple possible answers to a given umbrella question. The Q-statements of this study are those 26 elements of flexibility derived from the literature study and interviews. For the umbrella question, the respondents were given a sentence that they should complete while doing the sorting exercise. For this study respondents were asked to do the sorting by completing the following sentence: *"In order to make project management in the planning phase of infrastructure projects more flexible, it is important to have/do _ _ _ _"*. In the second step, each respondent sorts the statements by giving them a value that ranges from "least agree" to "most agree". The sorting will be done by placing the statements in a predefined scoring sheet which is in the form of a quasi-Normal distribution. Each person uses his/her own subjective criteria to evaluate the relative agreement on each statement. Since the same Q-sorting exercise is given to different people, a researcher can look at the patterns of responses to uncover and name distinct 'points of view'. The analysis of data will be done by means of factor analysis using a software programme named PQMethod (Schmolck, 2012). The outputs of Q-analysis consist of (Suprapto et al., 2015b):

- Which criteria or statement were rated at the same level (either high, low or neutral) by most participants.
- Which statements are distinguishing, meaning that they were agreeable to some participants and disagreeable to others.
- What are the distinct subgroups (or perspectives) within the set of participants who have a similar pattern of responses?

6.4.2 P-SET

Since the scope of this research is narrowed down to the front-end development phase of infrastructure projects in the construction industry, the sample of respondents is limited to those who have experience in this phase of such projects. In most projects there are two main parties involved in this phase; client and (engineering and management) consultant. It can be the case that a design & build contractor takes the role of a consultant but this is not very common yet. Therefore only respondents from clients and consultants were targeted.

In order to investigate the differences between these two roles in projects, the same number of respondents from each group was targeted. To also investigate the potential influence of organisation culture, three different organisations were invited for each role (client and consultant). From each organisation, a minimum of 6 respondents was required. Data was gathered from 44 respondents in total. Since one of the respondents did not complete the questionnaire correctly, 43 questionnaires were included in the data analysis. 22 out of the 43 respondents belonged to consultancies and 21 respondents to client organisations.

6.5 FACTOR ANALYSIS

In this section the analysis of the gathered data is presented. For comparing the perspectives of clients to consultants, it was decided to run the analysis in parallel for each data set. Such split enables to study a potential link between identified perspectives and organisational culture or project role (client/consultant).

Using the earlier mentioned PQMethod software for factor analysis, principal component analysis and varimax rotation were chosen to extract the factors. According to Kline (1994), "a factor is a dimension or construct which is a condensed statement of the relationships between a set of variables". In order to find the right number of distinguished perspectives (factors) in our study, different factor-solutions were extracted. Table 6-2 summarizes the results of factor analysis from 2 to 8-factor solution per data set.

Next the number of meaningful factors (perspectives of practitioners towards flexible PM in our study) were identified. According to Brown (1980) some rules should be applied. Each acceptable factor should be defined by at least two significant Q-sorts (Suprapto et al., 2015b) whereby:

- A Q-sort x is loaded significantly at $p<0.05$ on a factor y if its factor loading, $f_{xy} > (1.96/\sqrt{N})$ where N is the number of statements. For our setup, this results in $f_{xy} > 0.38$.
- Its highest square factor explains more than half of the common variance.

Also the following criteria apply:

- Amount of non-loaders preferably is low (non-loaders are those respondents who do not belong to any of the extracted factors),
- Amount of confounders preferably is low (confounders are those respondents who belong to more than one extracted factor),
- Cumulative % of the explained variance is more than 50%.

Table 6-2: Summary of factor analysis for client and consultant data

	Number of factors for	2	3	4	5	6	7	8
Client	Cumulative % of explaining variance	45	54	62	69	76	80	84
	Number of acceptable factors	-	3	4	5	4	3	3
	Number of defining sorts	-	17	18	15	16	14	14
	Number of non-loader(s)	-	1	-	-	-	-	-
	Number of confounder(s)	-	3	3	6	5	7	7
Consultant	Cumulative % of explaining variance	41	51	60	68	75	80	95
	Number of acceptable factors	-	3	4	4	6	3	3
	Number of defining sorts	-	19	18	18	19	13	12
	Number of non-loader(s)	-	2	-	-	-	-	-
	Number of confounder(s)	-	1	4	4	3	9	10

First, the client data set is discussed. According to the cumulative explained variance, for this dataset, the minimum acceptable number of factors is 3. The 6, 7 and 8-factor solutions show a low number of acceptable factors (based on the criterion of at least 2 defining sorts per factor). Hence the preferred solution has 3, 4 or 5 factors. Based on the low number of defining sorts, the 5-factor solution is rejected. For a decision between the 3 and 4-factor solution, distinguishing statements were analysed. It was concluded that the 3-factor solution has more distinct factors than the 4-factor solution. Hence the 3-factor solution was selected for the client data set.

Now the consultant dataset is discussed. Based on the information given in Table 6-2, also for this data set the minimum acceptable number of factors is 3, given the cumulative explained variance. The 5, 7 and 8 factor solutions show a low number of acceptable factors compared to extracted factors (based on the criterion of at least 2 defining sorts per factor). Next the distinguishing statements for each solution were analysed. The 3-

factor solution has more distinct factors than the other acceptable solutions. Hence the 3-factor solution was selected for the consultant data set.

In the next section the 3 perspectives of the client organisations and the 3 perspectives of the consultant organisations are elaborated in more detail.

6.5.1 CLIENT PERSPECTIVES AND CONSULTANT PERSPECTIVES

In this section first the derived perspectives of client organisations are described, followed by a description of the derived perspectives of the consultancy organisations.

6.5.1.1 Client perspectives

Based on the factor analysis, the client respondents are grouped into three perspectives. The perspectives are named inspired by the distinguishing statements and the ranking of the flexibility enablers in the perspectives. The 3 perspectives are: Trust, Scope flexibility by contract flexibility and Proactive management.

Perspective 1: Trust

Figure 6-2 shows the ranking of flexibility enablers given by the 7 respondents who form Perspective 1. Trust is the most important enabler of flexibility for these people. Respondent 3 believes 'a good project result starts with trust'. 'Short feedback loops' and 'open information exchange' are other high-ranked enablers which inherently help in building 'trust' among parties and team members. Statement 10, 'standardisation of process and design' is given least importance in this perspective. Respondent 2 states: 'standardisation focuses on defaults instead of content /process'. Respondent 18 states: 'Flexibility demands tailor-made processes and products'. Also 'self-steering of team' is ranked low in this perspective. Respondent 10 believes: 'For flexibility direction/process, control is required. I wonder if this could happen with self-steering teams'. The observation made by this respondent regarding the required control for being flexible is also mentioned in the literature (Cobb, 2011). Cobb (2011) believes that there is no contrast between control and flexibility (agility). In his opinion, the contrast is between being 'over controlled' and flexibility.

Different patterns were used to differentiate between the clusters of flexibility in the following figures.

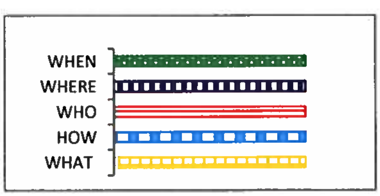


Figure 6-1 shows the used colours (patterns) for each cluster of flexibility enablers.

Figure 6-1: Patterns used for clusters of flexibility enablers

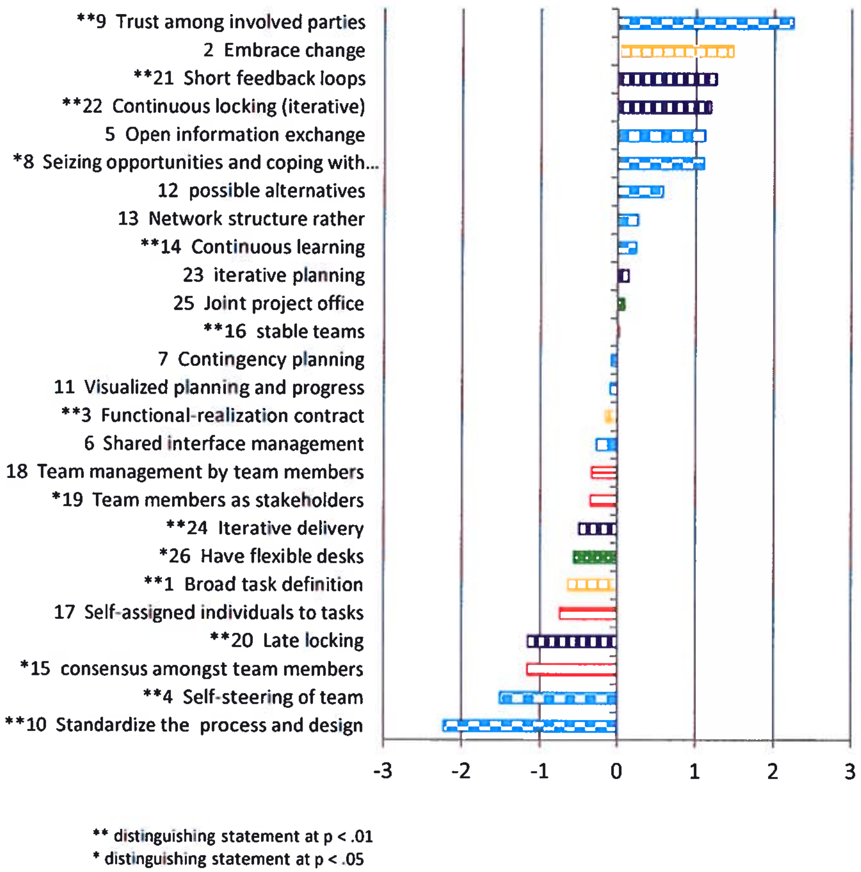


Figure 6-2: Ranking of flexibility enablers from perspective 1 point of view

Level of education, field of study, work experience and current position for the respondents in Perspective 1 presented in Appendix E. BSc and MSc respondents loaded on this Perspective, with a diverse background in terms of field of study. The total years of experience for the respondents in this perspective ranged from 11 to 30. The dominant position in this perspective is 'project manager' (5 out of 7 respondents).

Perspective 2: Scope flexibility by contract flexibility

The second perspective of client respondents is summarized by 'flexibility through scope management and contractual flexibility' (5 respondents). The ranking of the flexibility enablers in this perspective is shown in Figure 6-3.

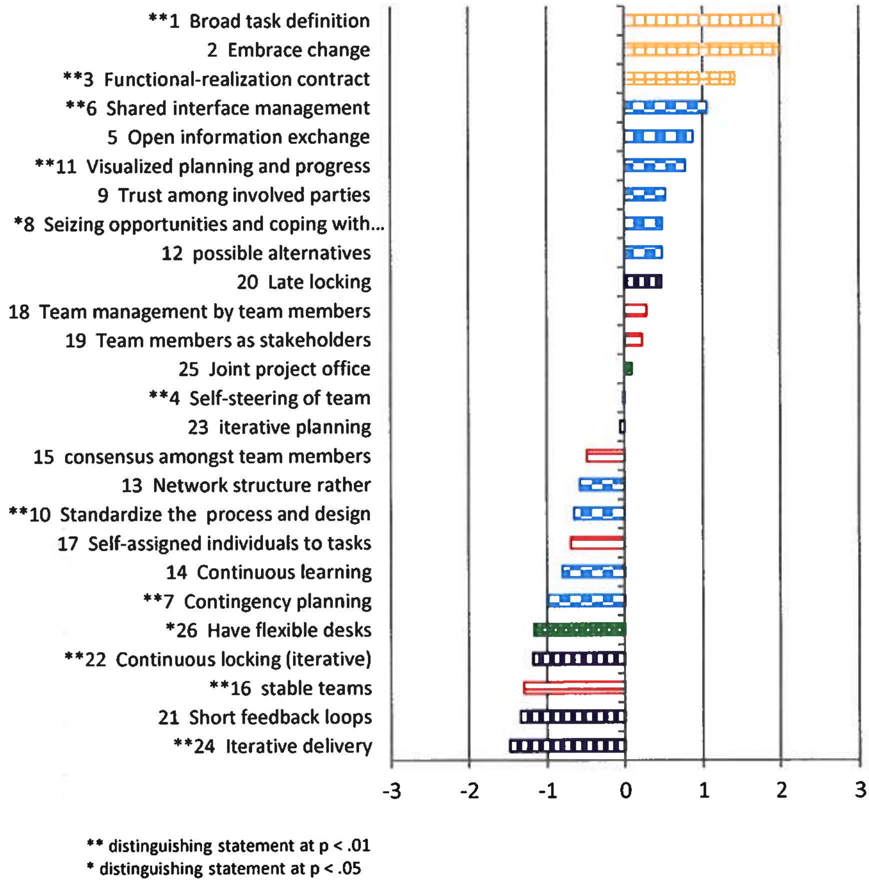


Figure 6-3: Ranking of flexibility enablers from clients' perspective 2 point of view

This perspective gives the highest rank to those enablers which contribute to scope flexibility by contract. The statements of 'broad task definition' and 'functional-realisation contract' are among them. Respondent 9 states: 'broad task definition offers space at the highest abstraction level to ask or drop parts to provide value for money as much as possible to all stakeholders'. Regarding functional-realisation contract he also states: 'think as much as possible in terms of values instead of solutions and prevent speed thinking'. Respondent 8 states: 'functional specification does not provide a specific solution and increases flexibility with regard to the final solution'. Flexibility enablers of planning like 'iterative delivery' and 'continuous locking' are ranked low. Respondent 9 states: 'iterative delivery limits the solution for the remaining parts of the project at an early stage'.

The dominant role of respondents in perspective 2 is on management level (project manager, programme manager, project leader/director and assistant project manager). Total years of experience of respondents range from 11 to more than 30 (see Appendix E).

Perspective 3: Proactive management

Perspective 3 is characterised as 'proactive management'. In total 7 participants form this perspective. The ranking given to flexibility enablers by this perspective is shown in Figure 6-4. 'Seizing opportunities and coping with threats' is the most important enabler of flexibility from their viewpoint. 'Contingency planning' is also important for this perspective. These flexibility enablers emphasise the way that management could be proactive. Another distinguishing enabler ranking high in this perspective is 'stable teams'.

Respondent 4 believes that 'seizing opportunities and coping with threats' is working closely with enabler number 2 'embracing change'. He believes that by seizing opportunities the project team can look for the bigger project goal and they also could turn threats to opportunities. Respondent 7 states that 'contingency planning' keeps the project team sharp about the project by reminding them the question: "do we do the right things or is plan B maybe good or even better?" Respondent 14 states 'good opportunities and risk management help you to look forward to see where you should anticipate changes and helping you determine where you will be flexible in the future'.

'Joint project office' is ranked low from this perspective point of view. Respondent 17 states' by having joint project office you create an island for your project'. 'Functional-realisation contract' is one other low ranked enabler. Respondent 12 states 'functional specification should provide room for change. But the process of reaching a package of functional requirements within the set-time is often so tight'.

The profiles of the respondents who form this perspective are very diverse (Appendix E). Overall their dominant function is 'project manager' and the dominant duration of working experience is 21 to 25 years.

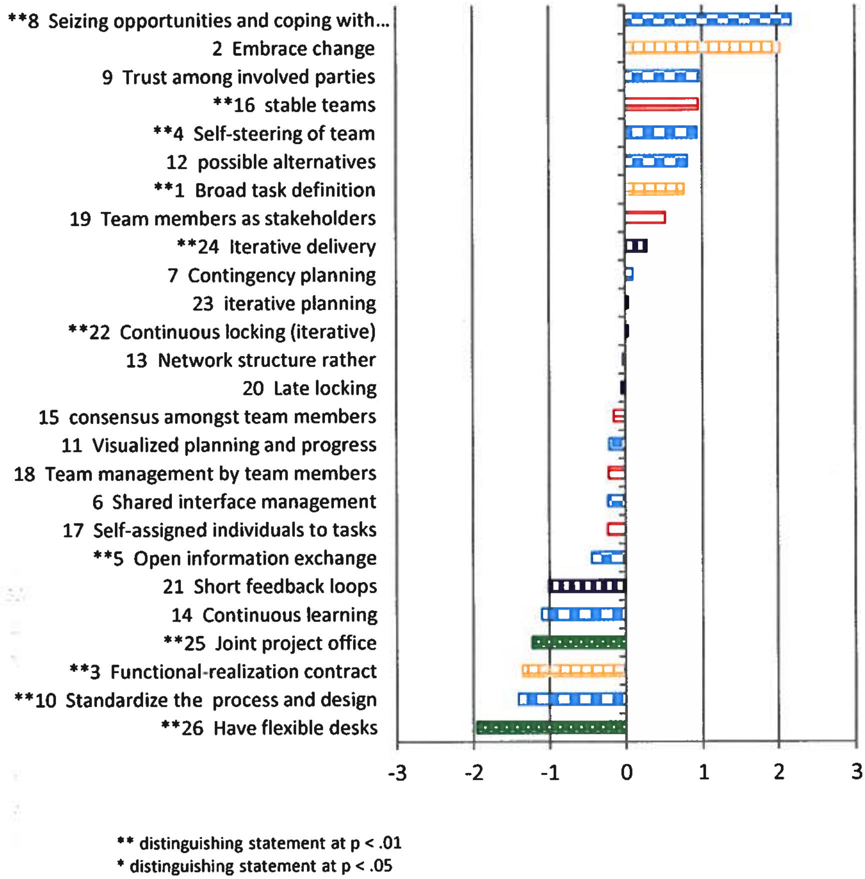


Figure 6-4: Ranking of flexibility enablers from clients' perspective 3 point of view

6.5.1.2 Consultant perspectives

The respondents from the consulting organisations are also grouped into three perspectives: Trust, Scope flexibility by contract flexibility and Proactive management

Perspective 1: Trust

In total 7 out of 20 respondents loaded on this perspective. The ranking of flexibility enablers from perspective 1 point of view is shown in Figure 6-5. This perspective finds 'trust' the most important enabler of flexibility. Respondent 25 states 'If there is little/no trust, a situation arises where one party try to control the others. Then flexibility in processes will be hampered'. 'Short feedback loops' also ranked high. Respondent 26 states 'Short feedback loops allow you to quickly change. Therefore, there will be little loss of time when something goes wrong'.

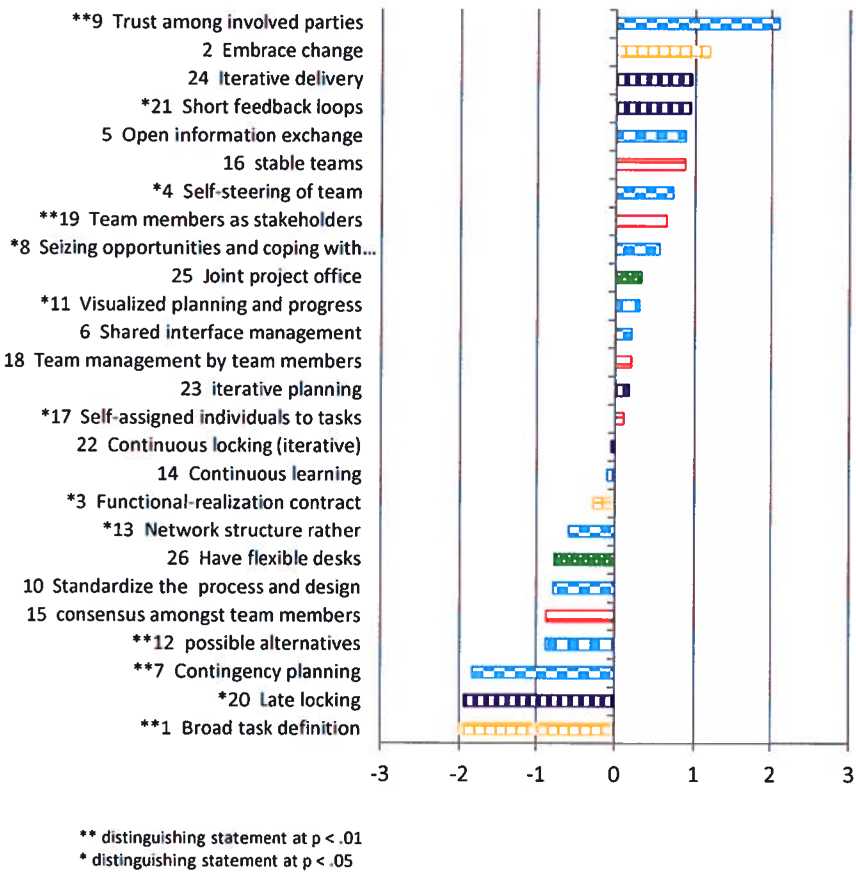


Figure 6-5: Ranking of flexibility enablers from consultants' perspective 1 point of view

For perspective 1 flexibility in contractual agreements is not important as we can see from Figure 6-5 (enablers 3 and 1 were ranked low). Respondent 32 explained: 'Detailed work packages make it possible to determine the lead time. Hence little uncertainty, and planning at maximum flexibility'. 'Late locking' is also ranked very low from perspective 1 point of view. Respondent 30 illustrated: 'fixing the design at early stage gives flexibility in the process later'.

For this perspective the respondents are very diverse in terms of current position. The total years of experience ranges from none to 25 years. The respondents have educational background in only two fields; civil engineering and environmental sciences while civil engineering is the dominant background study for this perspective (see Appendix E).

Perspective 2: Scope flexibility by contract flexibility

Perspective 2 of the consultant data is similar to perspective 2 of the client data. Both find contractual flexibility very important. 'Embracing change' is the highest ranked enabler from their viewpoints. Respondent 44 stated: 'an open attitude towards change is necessary to be flexible. Flexible project management stands or falls with the willingness of project team members to change'. He also explained that 'functional specification is important because this encourages to look for the best design and use the creativity and knowledge of the project team members. If everything is precisely described, it leaves no room for flexibility'. Respondent 40 illustrated 'It is important to know what needs to be done. This translates into a functional specification and clear requirements for deliverables, services, etc. The way in which these products, services, etc. are delivered is to the project manager'.

Enabler #20, 'making decision at the last responsible moment' is ranked low. Respondent 40 stated: 'It's not a good idea to make decisions at a late moment. Meanwhile, decisions are also needed. If you do not take it, then you introduce big risks'. 'Stable team' which is a distinguishable statement for this perspective is ranked low. Respondent 44 mentioned: 'It's nice if the core team is constant. But fresh blood is also important because it prevents tunnel vision and challenges again to think further (are we still on the right track?)'. 'Iterative delivery' is also ranked very low. Respondent 38 stated: 'delivery in parts directly limits variations /alternatives with those delivered parts, with which the flexibility decreases instantly'.

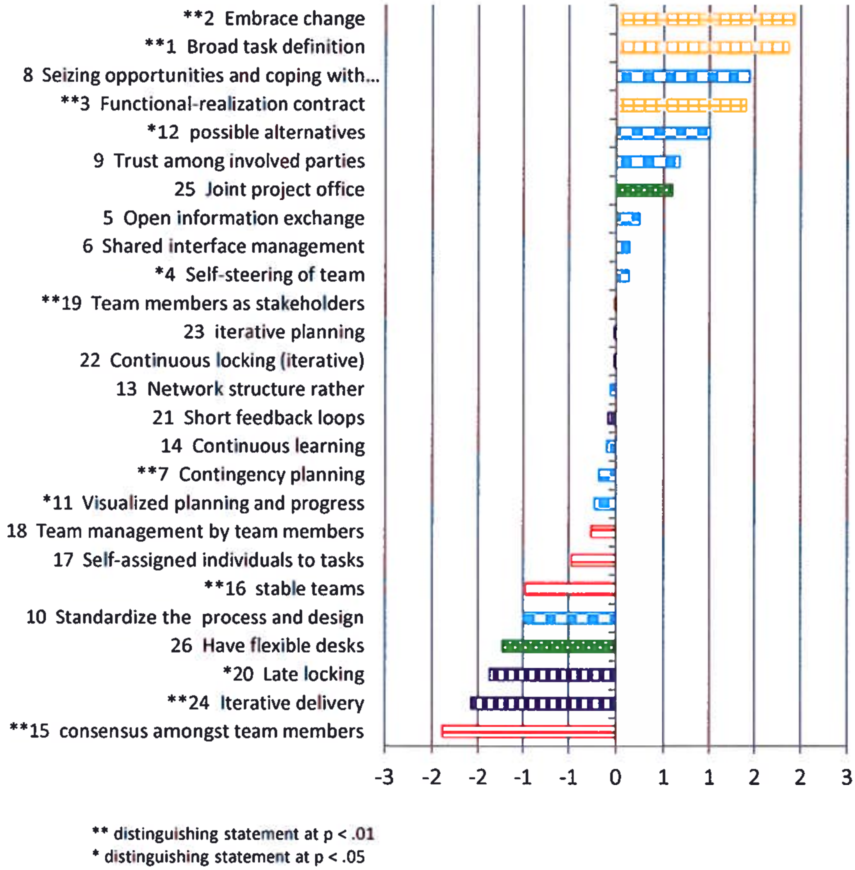


Figure 6-6: Ranking of flexibility enablers from consultants' perspective 2 point of view

According to the demography of respondents in this perspective (Appendix E), the total years of experience and the current position of respondents are diverse while their field of study is limited to civil engineering and planning.

Perspective 3: Proactive management

Perspective 3 in the consultant data set gives a high ranking to enablers which contribute to proactive management such as 'possible alternatives', 'contingency planning' and 'seizing opportunities and coping with threats'. The ranking perspective 3 gives to flexibility enablers is shown in Figure 6-7. Respondent 33 explained about the statement of 'possible alternatives': 'Flexible management does not mean you should not have a plan. It is important to consider some scenarios: what if ...? So that it can be quickly dealt with deviations'. Unlike other perspectives 'continuous locking' ranked very high prom perspective 3 point of view. Respondent 37 stated 'In a plan study there are many external influential factors. By iterative locking of decisions, they can be kept updated'. 'Functional realisation contract' is a low-ranked enabler of flexibility from perspective 3 point of view. Respondent 33 stated 'The specifications do not affect the manner of management'.

20% of respondents from consultancy organisations are in this perspective. As can be seen from the figure in Appendix E, there is no outstanding characteristic which describes the respondents of this perspective.

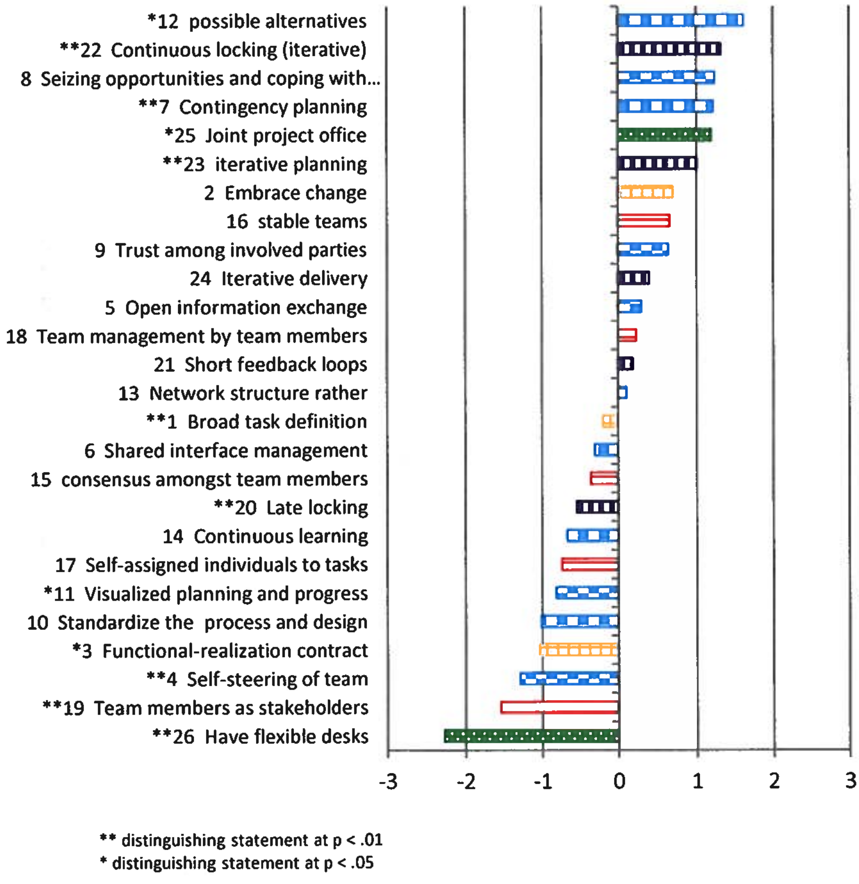


Figure 6-7: Ranking of flexibility enablers from consultants' perspective 3 point of view

06

6.6 Discussion

Having presented the perspectives identified in data subsets (client and consultant respondents), now the perspectives of the two data subsets are compared. Next the overall ranking given to the flexibility enablers by each group of respondents is discussed. Finally, the findings are connected to current literature.

6.6.1 Comparison of perspectives between client and consultant respondents

As mentioned in Section 6.4, the respondents were selected from client and consultancy organisations since these organisations play the biggest role during the front-end phase of infrastructure projects. The analysis resulted in three perspectives per dataset (see section 6.5.1). These perspectives showed considerable parallels, which are now discussed in more detail.

The Perspective 'Trust' appears in both datasets (Perspective 1 in the client respondents and Perspective 1 in the consultant respondents) which means 'trust' and its related enablers ranked high as distinguishing statements for a group of practitioners regardless of the fact that they work for client or consultant organisation (Figure 6-2 and Figure 6-5). However, also some differences were found. All team-related enablers ranked relatively low from clients' point of view but from consultants' point of view some of these enablers (like enabler #16 'stable teams') ranked high. One other main difference between these two is regarding enabler #4 'self-steering of team'. For consultant respondents it was ranked medium-high but for client respondents it was ranked very low. Hence the consultant respondents intend to keep working with the same team for different projects which for them contributes to flexibility. Client respondents find it less important to have stable teams. Both 'stable teams' and 'self-steering teams' are recommended by Agile project management (Beck et al., 2001; Cobb, 2011). So to conclude: the way the project team is organised seems much more important for respondents from consultancy respondents than for the client respondents who share opinions in the 'trust' perspectives.

The second shared perspective between both datasets was 'Scope flexibility by contractual flexibility'. Looking at the overall ranking of flexibility enablers of this perspective, there are not many differences between the client respondents and the consultant respondents in the corresponding perspectives. The enablers #20 'late locking' and #11 'visualised planning and progress' were the two that ranked differently (high for the client and low for the consultant respondents). 'Visualised planning and progress' is more important for the client respondents than for the consultant respondents. Although the client typically is not the party who performs the project, they like to have the overview of what is happening in the project at a glance. The enabler #20 'late locking' incorporates the changes that might happen during a project. Client respondents rank it higher than consultant respondents, probably because they favour a more open attitude in fixing the design and the plan.

The third perspective for both datasets was 'Proactive management'. The enablers that contribute to a proactive approach, such as 'seizing opportunities & coping with threats', 'possible alternatives' and 'contingency planning' ranked high in this third perspective. Also some differences were found. For consultant respondents, the 'when' category of the enablers ranked higher compared to the client respondents' viewpoint. This means that consultants favour a more iterative approach in their scheduling. In a case study research on scrum projects, it was found that clients showed less interest in participation in scrum meetings (Jalali Sohi et al. (2016)) while the client collaboration is a core value in Agile (Beck et al., 2001) and client collaboration would be accomplished by intense involvement in the process. This implies that although close collaboration among parties is desired, the iterative process is not favourable as a way to operationalize close collaboration. From the category of 'where', enabler #25 'joint project office' was another outstanding difference. Client respondents seem to have less willingness in having a joint project office. This might be also related to the fact that most people at client organisations are multitasking and have to deal with different projects at the same time. Indeed, in earlier research multitasking was observed to be a problem in practice (Jalali Sohi et al., 2016).

The overall conclusion made by comparing the two subsets of data (clients and consultants) reveals that although the same three perspectives exist in both client and consultant organisations, there are differences in parallel perspectives. For example, if the perspective 'trust' is the shared perspective for both groups of respondents, not necessarily the same importance is given to all flexibility enablers.

Looking back at the demography of the respondents per perspective it is concluded that there is no relationship between the identified perspectives and the profile of the respondents. A distribution of respondents from each organisation throughout the perspectives was observed, though. The three perspectives of clients have representatives from all client organisations. The distribution of respondents from consultancies into perspectives has some patterns: Table 6-3 shows that 6 out of 9 respondents from consultancy organisation 1 are belonging to perspective 1. Also 5 out of 6 respondents from consultancy organisation 2 belong to perspective 2. This suggests an influence of the organisational culture of consultancies on their view regarding flexible project management. For example consultancy organisation 2 has no respondents in perspective 3 'proactive management' and they mostly loaded in perspective 2 'scope flexibility by contractual flexibility'. The resulting hypothesis here is that the management culture in such organisation puts less emphasis on 'interactive management' or 'trust' than the other two perspectives. This could be a future research direction.

Table 6-3: distribution of respondents per organisation per perspective

	Perspective 1	Perspective 2	Perspective 3
Client organisation 1	3	1	2
Client organisation 2	2	3	3
Client organisation 3	2	1	2
Consultancy organisation 1	6	2	1
Consultancy organisation 2	1	5	-
Consultancy organisation 3	-	2	3

6.6.2 OVERALL RANKING OF FLEXIBILITY ENABLERS

Previously it was discussed that there are three corresponding perspectives per data subset. Hence the overall ranking of flexibility enablers per dataset must be rather similar. Figure 6-8 illustrates the overall ranking each group of respondents (clients or consultants) gave to the flexibility enablers. It can be seen that indeed the defining enablers were given similar priority but some were ranked differently. For example, enabler #25 'joint project office' is ranked high for consultants but low for clients.

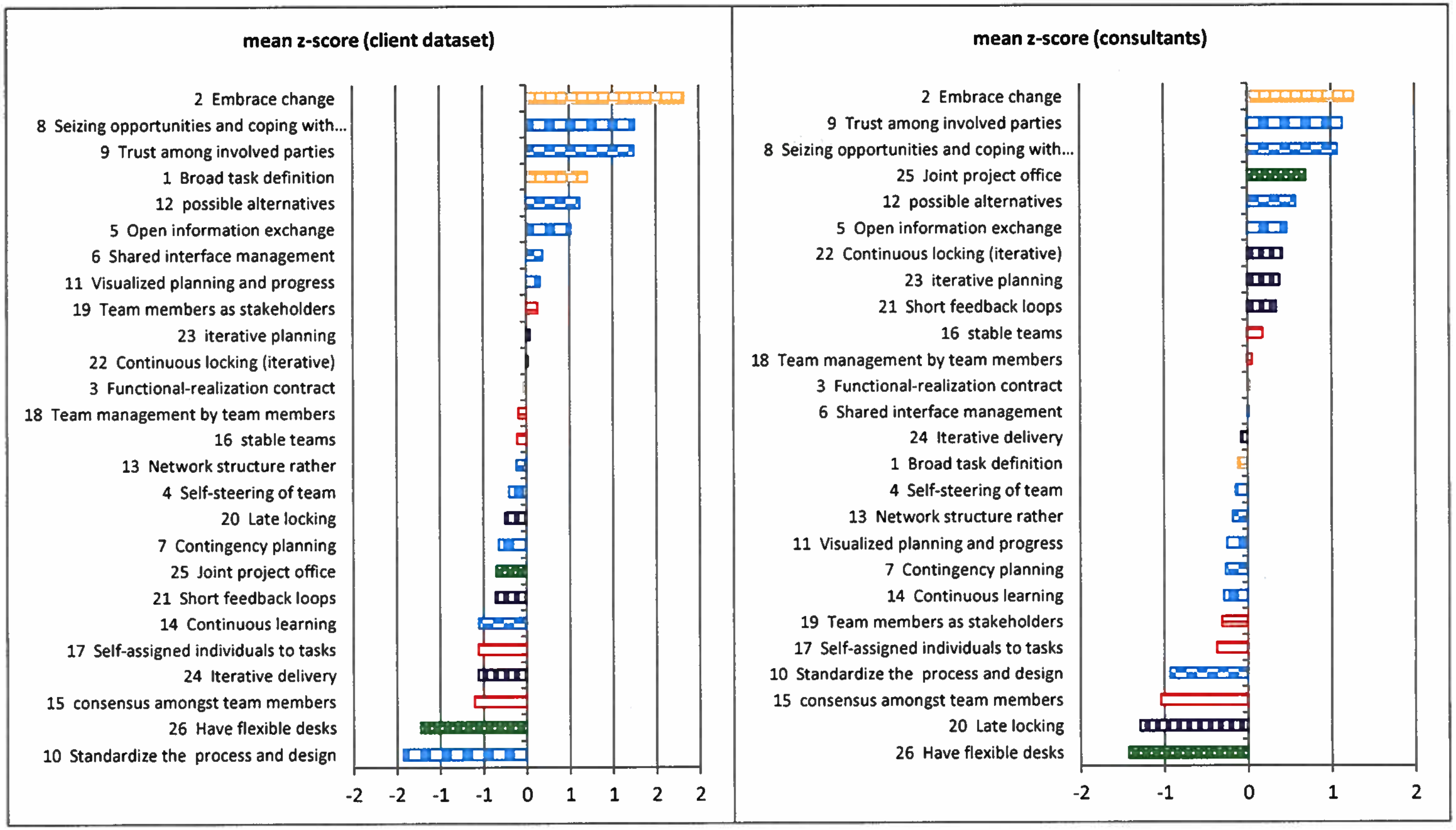


Figure 6-8: Overall ranking of flexibility enablers from the two data-sets' point of view

The three top-ranked enablers from clients' point of view are 'embrace change', 'seizing opportunities and coping with threats' and 'trust'. The enabler 'embracing change' was ranked high in all perspectives which means unanimously respondents from client organisations believe for flexible project management it is needed to embrace change. The enablers 'seizing opportunities and coping with threats' and 'trust' both appeared as distinguishing statements for separate perspectives. Even though 'trust' as such was a distinguishing statement for one of the perspectives, it was ranked relatively high also for the other perspectives. The same applies for 'seizing opportunities and coping with threats'. It can be said that regardless of the existence of different perspectives in any organisation, the top three enablers of flexibility are the aforementioned ones.

The three top-ranked flexibility enablers from consultants' point of view are the same ones as the client respondents' point of view, albeit in a different order; 'embrace change', 'trust' and 'seizing opportunities and coping with threats'.

The top-ranked enablers and also derived perspectives for both clients and consultants are the same. Based on this observation it can be concluded that the general mind-set of practitioners who work in client and consultant organisations regarding flexibility in project management has the same line of thoughts. This empowers the hypothesis that the role of the organisation (client or consultancy) as such has no influence on the studied subject (flexible project management). Particular company culture, however, could influence the results.

6.6.3 Scientific contribution and managerial implications

In this section the contribution of this research to the theory of project management and its applicability in practice is discussed.

Some research highlights the necessity of studying the flexibility of project management specifically for infrastructure projects in the construction industry (Geraldi, 2008; Koppenjan et al., 2011; Olsson, 2006; Walker and Shen, 2002). But very little research is done on how flexible project management can be defined or implemented. An important step is to identify the mind-sets of practitioners regarding flexibility. By using Q-methodology as a powerful research method to study the subjectivity, we looked into the practitioners' perspectives on the flexibility of project management. By contributing to bridging the gap in the literature, this research forms the base for further studies on the appropriateness of flexible project management.

Understanding the different practitioners' perspectives sometimes misleads to giving priority to certain statements (in this research the flexibility enablers) which should not be the case. Still, the results help in understanding the different viewpoints that exist on the studied topic, including their similarities and differences. The existence of different perspectives hence is not conflicting but should be considered as complementary.

The results of this study reveal three perspectives per organisation type, rather similar for client respondents and consultant respondents. This yields a first managerial implication: The existence of these similar perspectives facilitates the relationship between client and consultant. Next to that, as it was discussed in section 6.6.2, the overall ranking of flexibility enablers are almost the same for both clients and consultants (same top three enablers and same perspectives).

The first shared perspective for both clients and consultants was 'trust'. We can say that 'trust' as such is a must-have property for flexible project management since it turns out as a perspective for both parties. It is not only 'trust' as a single enabler but existence of a group of related enablers (for example 'open information exchange'). The second shared perspective was 'scope flexibility by contractual flexibility'. This group intends more toward flexibility in hard aspects of project management and more specifically in project scope definition and contracting. The third shared perspective was 'proactive management' which is distinguished by predictive management actions such as 'seizing opportunities and coping with threats', 'possible alternatives' and 'contingency planning' among others.

From the common five identified categories of flexibility (what, who, how, when and where) by literature (Geraldi, 2008; Osipova and Eriksson, 2013) only the 'what' or scope category reveals as a perspective in the current study. The other four clusters of flexibility enablers suggested by literature did not appear as perspective of practitioners indicating the difference between the practical view and the theory regarding the clusters of flexibility enablers.

Based on the project context, one of these identified perspectives might contribute the most to the practice. This way practitioners can choose the perspective which is the best fit to the project context and consequently put the emphasis on the implementation of high-ranked flexibility enablers of that specific perspective.

6.7 Conclusion

Literature pinpoints the necessity of being flexible in project management but so far little research was done on the implication of flexibility in practice. We believe that if we want to embed flexibility in the practice of project management we should first know what different practitioners' mind-sets are regarding this concept. In this exploratory research, Q-methodology was applied on data from 43 respondents (6 different organisations in The Netherlands), exploring perspectives of practitioners on project management flexibility. For this study two types of organisations were targeted; client and consultancy organisations. This decision was made because the scope of the research was limited to the front-end phase of infrastructure projects and this phase normally is done by consultancy organisations in request of clients.

Three similar perspectives were revealed per organisation type, implying that clients and consultancy organisations have similar mind-sets regarding flexible project management. The three perspectives are: 'trust', 'scope flexibility by contractual flexibility' and 'proactive management'. Although the perspectives are the same for clients and consultants, there are some differences in the counterpart perspectives. This can be explained because of different demands and requirements in client and consultant organisations. In the Perspective 'trust' the team related enablers (category of who) relatively ranked higher for consultants compared to clients. In the Perspective 'scope flexibility by contractual flexibility' the team related enablers ranked relatively higher for clients. In the third Perspective, 'proactive management', the enablers which belong to the category of 'when' ranked relatively higher for consultants rather than for clients.

We observed that there is no relationship between the profile of respondents and the perspectives they belong to. The only observed relationship was between the organisational culture and the perspectives for consultancy organisations.

Practitioners can benefit from the research results by understanding the different perspectives and priorities in flexibility enablers. For empowerment of each perspective it is recommended to operationalize the enablers which ranked high for such perspective. Scholars can further develop research into how to embed flexibility enablers into practice, considering the different perspectives and their commonalities. Also further research is suggested into the influence of the project phase on the perspectives identified. Last but not least, the inclusion of contractors as a third dataset could be considered. This study was performed in The Netherlands and in Dutch organisations. Consequently the derived perspective cannot be considered as exhaustive representation of all possible country cultures which might influence the results. Such limitation leaves room for future research on cultural differences.

Concluding remark and next step

In Chapter 5 the enablers of flexibility were identified. Apart from identification of those enablers, it is important to know what the practitioners' mind-sets are regarding project management flexibility: what they find as most important enablers, what as least important and how many different mind-sets (perspectives) exist among them. This chapter concluded that three main perspectives exist among practitioners, no matter if they belong to client organisations or consultancies. It is important to recognise these perspectives and their priorities in order to make project management flexible. Each perspective gives priority to certain enablers but how different perspectives work together for the best performance is important to know.

In this study participants were also asked if they recognise any other flexibility enablers that are not included in the list. Because this was not part of the paper on which this chapter is based, (exploring practitioners' perspectives), it was not included in the main part of the chapter. Therefore these suggested enablers are now discussed here.

Table 6-4 presents the suggested enablers and indicates how often each enabler was mentioned by different practitioners. At first the suggestions were clustered. In the next step, these enablers were mapped against the existing enablers in the framework to see if there is any overlap(see Table 6-4).

- 'Risk management', 'room for mistakes' and 'planning buffers' are items which are related to contingency planning, according to literature (Chapman and Ward, 1996; Pich, Loch and Meyer, 2002), and this enabler already exists in the framework.
- A number of items were mentioned regarding the stakeholders and specifically clients in the project, like 'involvement of stakeholders', 'weekly meeting with clients' and some others. Although these items exist in the framework in other forms like 'short feedback loops' and 'self-steering team including clients and other parties', they were mentioned by seven practitioners. Hence it was decided to add a new enabler regarding stakeholders to the framework: 'close involvement of stakeholders'.
- 'Flexibility in contract' was mentioned once but this is already part of the framework as 'functional-specification based contract'.
- The next cluster of suggested enablers was the cluster of exchange and availability of information. These enablers also exist in the framework in the enablers 'open information exchange' and 'demand-driven information exchange'.
- Four items were mentioned about governance and decision making. It was decided to add a new enabler to the framework named 'interactive decision making'.
- 'Examples of projects', 'recognition of pitfalls' and 'project follow-ups' are items related to 'learning' as suggested in the literature (Hartmann and Dorée, 2015; Sense, 2011; Yap, Abdul-Rahman and Chen, 2017) which already exist in the framework as 'continuous learning'.
- Next, items mentioned by practitioners were related to the teamwork aspect of projects, more specific about team size and team spirit. 'Team atmosphere' and 'team behaviour' as mentioned by practitioners are represented in the framework by 'considering team members as valuable stakeholders' and 'considering team members to be skilled in team management'. These enablers emphasize valuing the team members. The other item mentioned by a practitioner was 'small project team'. There was one item suggested by a practitioner about 'independency from a strong coach'. This was also reflected in the research in Chapter 3 where the dependency of Scrum teams on the Scrum master was discussed. It was decided to add an enabler to the framework of flexibility as 'delegation of responsibilities to the team' which represents the independency of team members from the management layer.
- 'Budget flexibility' was mentioned a few times. However, it is assumed that budget is project related although managing the budget is project management related. Flexibility in the budget is also represented in the form of 'contingencies' which exist in the framework. Hence these items were not added to the framework.
- A few items were mentioned regarding the skills of team members like 'creative thinking', 'knowledge of agile' and some others. Choosing the right people with

right skills to build multidisciplinary project team is suggested in the literature (Fong, 2003; Ratcheva, 2009) however, those aforementioned skills are not part of the project management process as such. Therefore they cannot be considered as flexibility enablers.

- The item 'programme of scenarios' as mentioned once by a practitioner is already represented by 'possible alternatives' in the framework.
- The other item suggested by a practitioner was 'digital workspace'. One of the enablers in the framework is 'visualisation of planning and progress'. Visualisation can be done either digitally or in the form of paper posters. The importance of communication tools to enhance the feedback loops and efficient communication is stressed in Agile methodologies especially in Scrum (Berczuk, 2007). Two examples of visualisation tools are Burndown Charts (Agarwal and Majumdar, 2012) and Kanban board (Murino, Naviglio and Romano, 2010; Polk, 2011). Hence, 'digital workspace' was not considered as a new flexibility enabler.
- A few items were mentioned about quality requirements, project duration and project goals. These ones are project-related factors and represented in the concept of project complexity frameworks (Bakhshi et al., 2016; Bosch-Rekveldt, 2011).
- A 'Customized process' was mentioned by a practitioner. The overall idea behind the framework of flexibility enablers is customizing the process of project management. Therefore, this item was not treated as a new enabler to be added to the framework.
- The last suggested item by a practitioner was about management support which is reflected in literature in various aspects (Kanwal, Zafar and Bashir, 2017; Liu, Wang and Chua, 2015; Young and Jordan, 2008; Young and Poon, 2013). Although mentioned by only one member, realising the importance of management support, it was decided to add this as a flexibility enabler to the framework.

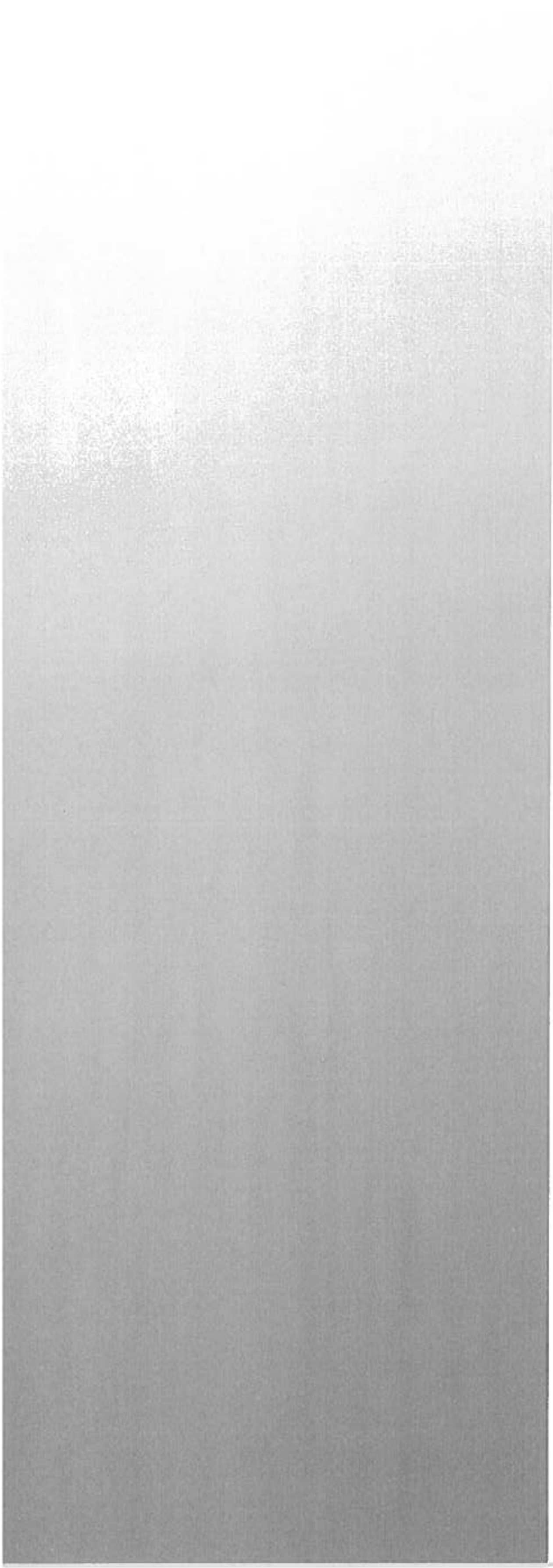
In total four new enablers were added to the framework of flexibility: 'close involvement of stakeholders', 'interactive decision making', management support' and delegation of responsibilities to team'.

In chapter 5, the extracted flexibility enablers from the literature were validated by performing interviews with practitioners which resulted in a list of 26 flexibility enablers (Table 5-4). This list was used as the input for the current chapter (practitioners' perspectives). Since the concept of flexible project management is new in literature, it was decided to ask practitioners if they knew any other flexibility enablers. After the analysis of suggested enablers by practitioners, four new enablers were added to the list of 26 enablers concluded from Chapter 5. Now the list of enablers (in total 30) is complete, the next step is to explore the current practice of project management regarding flexibility: to what extent is it flexible? This question is answered in Chapter 7.

Table 6-4: Flexibility enablers suggested by practitioners in Q-study

Items	#	Cluster	Overlap with existing enablers in the framework
Risk management & allocation	2	Contingency planning	7, 8
Room for mistakes	1		7
Planning buffers	2		7
Involvement of stakeholders	2	Stakeholder involvement	4, 21, 25
Goals of stakeholders	1		3, 21
Integrated project meetings	1		25
Freedom from client	1		
Weekly meeting with client	1		21
Mandate from client/project leader	1		
Flexibility in contract	1	Contracting	1, 3
Transparent communication	3	Exchange (availability) of information	5
External feedback	1		
More information	1		5
Informing the directors about progress regularly	1		11, 5
Good record of project phases	1		14
Good understanding of environment, politics,...	2		5, 14
Governance	1	Decision making	13, 4
Flexibility in own organisation	1		13
Interactive decision making	1		
Smooth, short decision-making, managing consequences	1		22
Examples of projects (knowledge)	1	learning	14
Recognise pitfalls	1		21
Project follow-ups	1		10, 14
Team atmosphere	1	Teamwork	18, 19
Being critical to other team members	1		18, 19
Small project team	1		Project related
Team behaviour (independent from a strong coach)	1		18, 19, 13
Flexibility in budget	3	Budget flexibility	Project related
Make stakeholders be responsible for costs	1		Project related
Strict control of cost by the client	1		Project related
Creative/design thinking	1	Skills	Based on project requirement
Being positive (thinking)	1		Based on project requirement
Knowledge level of team members	2		Based on project requirement
Knowledge of agile/scrum	2		Based on project requirement
Programme of scenarios (sensitivity analysis)	1	Alternatives	12
Digital workspace with up-to-date info	1	Visualisation	25, 11
Adjustment of planning	1	Iterative planning	23
Stage gates in the process for control	1		22, 24

Items	#	Cluster	Overlap with existing enablers in the framework
Flexible milestones	1		23, 24
Lean planning	1		23
No defined quality requirements	1	Project quality	Project related
Quality requirements of products	1		Project related
Enough time	1	Project time	Project related
Explicit project goals	1	Project goals	Project related
Customized process	1	Process	
Management support	1	Support	



Chapter 7: HOW FLEXIBLE IS PROJECT MANAGEMENT IN PRACTICE?

An exploratory research into project management of infrastructure projects in construction industry

Abstract

Nowadays, flexibility of project management attracts practitioners' and scholars' attention as a must-have quality to enable managing project complexity. Increased complexity of infrastructure projects needs such management approach which takes the (increasing) complexity into account. Literature sheds light on the importance of flexibility in project management while the practice of project management in the construction industry seems to be less flexible. The gap between what literature advises and what practice does, triggered us to look into the practice and see whether it aligns with literature or not. Hence the objective of this research was to explore the flexibility of project management in practice in the front-end phase of infrastructure projects. By means of a semi-structured questionnaire we asked practitioners to rate their last-completed project based on its management flexibility. In order to do so, we gave the participants a list of 26 identified flexibility enablers from literature and asked them first to pick (in general) the 5 most important and 5 least important flexibility enablers. Next we asked them to rate the project management of the selected project based on those 10 picked enablers. Qualitative analysis of data gathered from 44 respondents from The Netherlands reveals that the practice of project management has some degree of flexibility which implicitly has been taken into action. Our research results can help practitioners to take the full advantage of flexibility in project management by making (more) explicit what they do implicitly. For further research it is recommended to test the practical applicability of flexibility enablers in case studies, explicitly investigating the suggested links to project performance.

In Chapter 6 the practitioners' perspectives regarding flexible project management were explored. After knowing what is important for practitioners to make their management more flexible, it is necessary to know the status of current project practice regarding its flexibility. The answer to this question is given in this chapter.

This chapter was presented at IPMA2017 world congress in Astana and was published in conference proceedings (Jalali Sohi, Bosch-Rekveldt and Hertogh, 2017a).

7.1 Introduction

Project management evolved in different directions since it was born in 1950s. In general two streams of project management can be distinguished; rigid (known as traditional project management) and flexible project management. This is in line with what already was proposed by Burn and Stalker (1961) as mechanistic and organic approaches. The earlier is known by imposing a high level of control over project, hierarchical organizational structures and the importance of individual knowledge and skills. This approach is suitable for relatively stable environments. However, in uncertain and changing environments another approach is required which asks for flexibility: an organic approach. Unlike the mechanistic approach, the organic approach asks for a network structure, spread of commitment and informative communication. Morris (1997) believed that the industry where project management was born in, was little flexible and less complex. Williams (2005) noted that the project management at that time was rational and normative. This type of project management was very much based on upfront prediction and hard control over the project lifecycle (Koppenjan et al., 2011). However nowadays project seems to become more complex (Bosch-Rekveldt et al., 2011). Consequently the "traditional" project management would not anymore fit nowadays projects' characteristics (Winter et al., 2006). This emphasised the need for the second stream in project management being flexibility.

Different scholars point to flexibility of project management as new evolvements in the field (Geraldi, 2008; Olsson, 2006). The management of large engineering projects requires both the focus on planning and control and the ambition to be flexible given the complexity and uncertainty that characterizes these kind of projects (Koppenjan et al., 2011). However, control and flexibility impose contradictory requirements upon the management of these projects. It is argued that project success is at risk when project managers do not succeed in meeting the requirements of control and flexibility (Koppenjan et al., 2011). In order to deliver successful projects, it is required to have a balanced combination of both approaches, as discussed by Floricel and Miller (2001). The control (robust) approach to deal with anticipated uncertainties and a dynamic approach to manage unforeseen and unexpected circumstances which require flexibility. In the same line of reasoning, Aaker and Mascarenhas (1984) argue that the control approach is required for managing undesirable changes while flexibility, in contrast, aims at managing the uncertainty and complexity which are caused by environmental dynamics. Flexibility can be different in different project phases.

Other research has revealed that the practice in project-based organizations is dominated by a mechanistic approach, no matter what the project context is (Keegan and Turner, 2002) which would threaten flexibility and innovation. In contrast to what Keegan and Turner (2002) mentioned, Brown and Eisenhardt (1997) argued that two approaches often are combined in practice. Hence research indicates the presence of both mechanistic and organic approaches in practice.

Collyer and Warren (2009) distinguished few challenges that are recognisable in dynamic environments:

- Product lifespan (shorter average mean time to failure compared to static environment),
- Rate of introduction of new materials
- Difficulty finding and managing skilled labour
- Level of integration with customer industry
- Changing goals
- Effect on planning
- Morale
- Levels of interdependence
- Dependency of business units with lower levels of dynamics

Olsson (2006) emphasises the flexibility in different phases of projects. He split the project lifecycle into three phases being front-end, planning, and execution. Based on literature research, he claims the value of flexibility in the front-end phase is obvious, while it is undesirable in the execution phase.

Although scholars pinpoint the importance of adding flexibility to project management, there is not much research done in exploring the flexibility in current practice of project management. Hence it was decided to investigate how flexibility is incorporated in the front-end development phase in current construction projects. The objective of this chapter is to explore what practitioners find important for making project management (more) flexible and how they applied flexibility enablers in projects they were involved in.

This chapter covers a literature review on the topic under investigation in Section 7.2. It is followed by elaborating on the research methodology in Section 7.3. Next, the research results are discussed in Section 7.4 followed by qualitative analysis and discussion in Section 7.5. Finally, conclusions of the research are drawn in Section 7.6.

7.2 LITERATURE REVIEW

In this section a brief literature review is provided regarding the need for making project management more flexible, the definition of flexibility in project management and the enablers of flexibility. Projects by definition are unique (OGC, 2009; PMI, 2013). Such uniqueness, together with an ever-changing environment, increases the uncertainty which projects face during their lifecycle. Project managers are challenged to keep their projects focused and at the same time support their organisations' needs to adapt to changes and uncertainties in the business environment (Olsson, 2006). The dynamics that projects face highlight the necessity of flexibility in project management. Few challenges that Project management encountered in uncertain dynamic environments are (Collyer and Warren, 2009):

- Planning for uncertain outcomes;

- Balancing flexibility with reliability and accountability;
- Balancing decision quality against decision speed;
- Timing scope freeze during rapid change.

Project management approaches based on traditional linear development methodologies are mismatched with dynamic systems (Augustine et al., 2005). A 'command and control' approach will no more be effective in managing nowadays complex projects and has to be replaced by a 'prepare and commit' approach (Koppenjan et al., 2011). Turner (2004) stated that flexibility is a required competence for project managers to deal with unforeseen circumstances of projects. Managerial flexibility showed value in the context of uncertain R&D projects, as management can repeatedly gather information about uncertain project and market characteristics and based on this information, change its course of action (Huchzermeier and Loch, 2001).

Flexibility became more known to practitioners and scholars by the introduction of Agile project management since it is characterized by flexibility (Dybå and Dingsøyr, 2008). Agile project management enables software project managers and employees to adapt to changing circumstances, rather than imposing rigid formal controls, as happens in traditional linear development methods (Augustine et al., 2005).

It becomes clear that flexibility is a required quality of project management to empower it to deal with dynamism that each project has to cope with. Hence it is important to define the flexibility of project management. Flexibility can be defined as *"the capability to adjust the project to prospective consequences of uncertain circumstances within the context of the project"* (cited by (Olsson, 2006)). Olsson (2006) described flexibility as a way of making irreversible decisions more reversible or postponing irreversible decisions until more information is available.

Next to defining flexibility, it is important to know how it can be part of project management. In other words, how can project management become (more) flexible. Based on the studied literature, a list of flexibility enablers was extracted. These enablers are assumed to increase the flexibility of project management, if applied in a project. The entire list of 26 enablers (Appendix F) was used as input for this research (Jalali Sohi, Hertogh and Bosch-Rekveldt, 2017b).

Some scholars take steps further and identified the areas where flexibility can be applied. Geraldi (2008) according to literature review and also her own experience and research, grouped flexibility of project management into six categories: what (scope and goals of project), how (process of project), who (team of project), when (scheduling of project), how much (budget responsibility and the hierarchical level of decisions), and where (where the task has to be realised). Further on Osipova and Eriksson (2013) recognised only the five categories of what, how, who, where, and when. In the research by Jalali Sohi et al. (2017b) 'trust' was recognised as an additional category for applying flexibility based on practitioners' point of view. Looking into practitioners' perspectives they found that 'trust' is the most important leading factor of flexibility for a group of practitioners.

Recapping the literature review, for this research, our definition of flexibility is 'minimizing the excessive upfront planning to more iterative planning aiming at providing readiness for adapting to project's environment dynamics'.

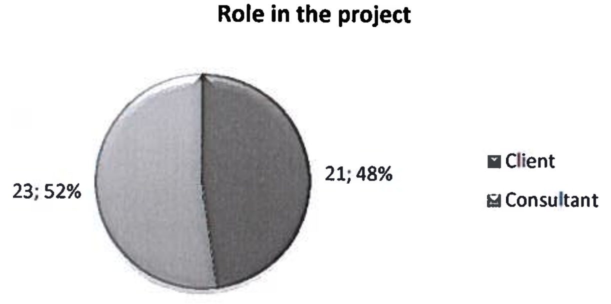
7.3 RESEARCH METHODOLOGY

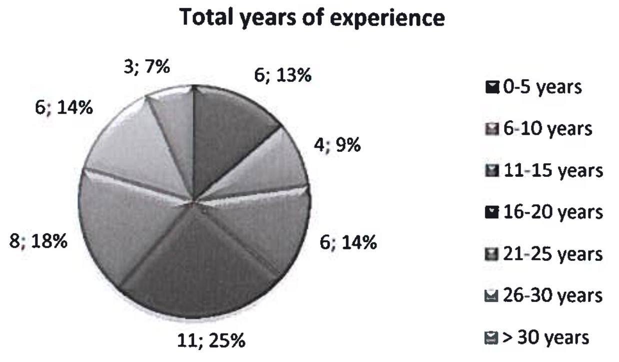
The data of this research is partly derived from a previous research in finding practitioners' perspectives on studied subject (flexibility in project management) by use of Q-methodology (see chapter 6). Using Q-methodology (Brown, 1980), 44 respondents were asked to rank the statements based on their importance according to a scoring sheet. For this study, we are only interested in the highest and lowest ranked statements. From the used scoring sheet it was possible to extract the top 5 and the bottom 5 statements ranked by each of the respondents. The top 5 statement are those that from the respondent point of view have the highest importance for making project management more flexible. The bottom 5 statements are those that have least importance for making project management more flexible, relative to the other statements.

After all data was gathered, the occurrence of each statement (flexibility enablers) was counted in the top 5 and bottom 5 statements. The maximum number each statement could appear among the top or bottom 5 selected statements was 44 (equal to the number of participants). For this chapter, it was decided to elaborate on statements which appeared more than 30% of the times.

Apart from the data that was derived from the Q-study research, in an extra step all respondents were asked to select the last completed project they were involved in and answer a few questions regarding that project. The semi-structured questionnaire included questions regarding a brief introduction to the project (scope, costs, time frame), the overall score the respondent would give to the management of the selected project and the rating of the project management according to their top 5 and bottom 5 ranked statements. Qualitative analysis was performed on this data.

The study was performed in The Netherlands. The demography of respondents is presented in Figure 7-1. Since the focus of the study was on the Front-end phase of infrastructure projects in the construction industry, the respondents were from client and consultancy organisations. Front-end development (FED) refers specifically to the phase in which the necessary information to approach a project is developed (Gibson Jr et al., 2006). Its main goal is to create the best possible picture of the project, so the owner can objectively make an investment decision. The outcomes of FED are the projects needs and constraints, such as objectives, planning, risks, etc. (Bosch-Rekveldt, 2011). The choice of front-end development phase was because it can be argued that the degree of flexibility can be higher in this phase rather than the other phases. As a project progresses, the level of flexibility decreases. In total 44 respondents from 6 Dutch organisations participated in this research; 3 client organisations and 3 consultancy firms.





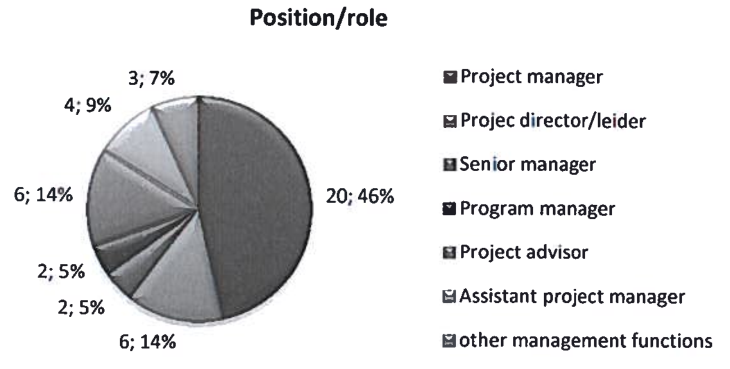


Figure 7-1: Demography of respondents

7.4 RESULTS

Table 7-1 presents how often each flexibility enabler appeared in the top 5 selected statements by the respondents. According to this table, enablers number 2, 9, 8, 1 and 12 (ordered in % of occurrence) are the ones mentioned by more than 30% of the respondents in their top 5 flexibility enablers. In Q-methodology, respondents give ranking to statement (in this research, flexibility enablers) according to a scoring sheet. For this study the scoring sheet ranged from -4 (the least important item) to +4 (the most important item). In Table 7-1 columns 2 to 4 labelled as P4, P3 and P2 show the top 5 enablers in descending order. Table 7-2 presents how often each flexibility enabler was mentioned in the bottom 5 selected flexibility enablers from the practitioners' point of view. According to the table, enablers number 26, 10, 20, 15 and 7 in order are the ones which were mentioned by more than 30% of respondents in their bottom 5 enablers of flexibility. In Table 7-2 columns 2 to 4 labelled as M4, M3 and M2 shows the low ranked enablers in ascending order (column M4 shows the lowest ranked enablers).

For these top 5 and bottom 5 flexibility enablers, the practical application was investigated based on the extra questionnaire as described above. The results are provided in Table 7-3 for top 5 and in Table 7-4 for bottom 5 enablers, showing a wide spread per flexibility enabler. Next, we will elaborate on these results. It was decided not only to investigate the high-ranked enablers but also pay attention towards the low-ranked ones to see whether the practice is in favour of only top-ranked enablers or that the low-ranked ones are also applied in practice.

Table 7-1: Occurrence of statements in the top 5

#	Enablers	P4	P3		P2		SUM	% of occurrence
1	Broad task definition	6	2		4	4	16	36,4
2	Embrace and facilitate change as much as needed	8	7	7	1	5	28	63,6
3	Functional-realisation based contract	1	3	4	2	1	11	25,0
4	Self-steering of the complete project team		2		2	2	6	13,6
5	Open and demand-driven information exchange		3	2	1	3	9	20,5
6	Shared interface management	2		2	1	2	7	15,9
7	Contingency planning		2	1		2	5	11,4
8	Seizing opportunities and coping with threats	6	2	5	5	3	21	47,7
9	Trust	11	7	3	1	1	23	52,3
10	Standardised process and design				2	1	3	6,8
11	Visualised project planning and progress	1	1	1	1	1	5	11,4
12	Possible alternatives	4	2	2	5	1	14	31,8
13	Network structure rather than hierarchical structure				1		1	2,3
14	Continuous learning				1		1	2,3
15	Consensus amongst team members					1	1	2,3
16	Stable teams	3	1	2		2	8	18,2
17	Self-assigned individuals to tasks		1		1	2	4	9,1
18	Consider all team members to be skilled in team management				1		1	2,3
19	Consider all team members to be valuable stakeholder in team		1	3	1	2	7	15,9
20	Late locking			2	2	3	7	15,9
21	Short feedback loops		2	3	1	2	8	18,2
22	Continuous locking (iterative)	1	2	3	3	1	11	25,0
23	Minimize up-front planning with iterative planning		1	1	1		3	6,8
24	Iterative delivery		3	2	1	3	9	20,5
25	Joint project office for project team	1	1	1	5	1	9	20,5
26	Flexible desks						0	0,0
Missing					1	1	2	4,5
SUM		44	44	44	44	44	220	

Table 7-2: Occurrence of statement in the bottom 5

#	Enablers	M4	M3		M2		SUM	% of occurrence
1	Broad task definition	3	2	1	1	2	9	20,5
2	Embrace and facilitate change as much as needed						0	0,0
3	Functional-realisation based contract		3	2	3	1	9	20,5
4	Self-steering of the complete project team	1	2	1	3	1	8	18,2
5	Open and demand-driven information exchange		1		1	3	5	11,4
6	Shared interface management			5	1		6	13,6
7	Contingency planning	4	4	2	2	1	13	29,5
8	Seizing opportunities and coping with threats						0	0
9	Trust			1		1	2	4,5
10	Standardised process and design	9	2	3	3	4	21	47,7
11	Visualised project planning and progress		1	1	2	1	5	11,4
12	Possible alternatives		1	1	1		3	6,8
13	Network structure rather than hierarchical structure	2	1	1	2	1	7	15,9
14	Continuous learning		2	3	3	1	9	20,5
15	Consensus amongst team members	3	1	5	5	3	17	38,6
16	Stable teams		3	1		2	7	15,9
17	Self-assigned individuals to tasks	4	3	1	1	3	12	27,3
18	Consider all team members to be skilled in team management			3		1	4	9,1
19	Consider all team members to be valuable stakeholder in team	1	1	2	1		5	11,4
20	Late locking	5	5	2	4	3	19	43,2
21	Short feedback loops	1	1		3	4	10	22,7
22	Continuous locking (iterative)	1	1	1	1	1	5	11,4
23	Minimize up-front planning with iterative planning		1	1	3	1	6	13,6
24	Iterative delivery	3	2	4		2	11	25,0
25	Joint project office for project team		2	1			3	6,8
26	Flexible desks	7	5	2	3	6	23	52,3
Missing					1	1	2	4,5
SUM		44	44	44	44	44	220	

Table 7-3: Projects' data on top 5 flexibility enablers

	Enabler 2: **embracing change**	**Enabler 9:** **trust**	**Enabler 8:** **seizing opportunities and coping with threats**	**Enabler 1:** **broad task definition**	**Enabler 12:** **possible alternatives**
positive	Mostly it was applied well with good results. examples were 'being open to stakeholders requests' and 'open to scope changes'.	There are cases in which trust was high and project team invested on building trust with other involved parties. Even if trust was minimal at the beginning, it was improved during the project. Overall practitioners were positive about trust.	In most cases opportunities were taken into account and threats were prevented/managed.	There are very few cases in which scope had been defined broadly but not all ended in good results. there was an example in which extra budget was required because of broad scope definition.	In most cases practitioners considered 'alternatives' which ended in good results. For keeping alternatives open, there were always conditions such as likelihood of usage.
Neutral			There was an example where this enabler was not applicable. The respondent did not explain why it was not applicable.	In some cases in which scope definition was not fully detailed and not completely broad. The average score was given to this rejects regarding the 'broad scope definition'.	There was also a project in which practitioners thought it was not applicable to have 'alternatives'.
Negative	It was applied in practice although the application was sometimes very limited and scored low. Some difficulties with the client over applying changes.	There are a few examples that level of trust was low in the projects. Some practitioners find it difficult to build trust. One example is 'discussion over budget because of lack of trust'.	There are very few cases where this enabler was poorly applied or not applied at all.	Projects' scope seems to had been defined in details in most of the projects. In some cases even with detailed scope definition, participants gave a relatively high score to it. In another project since the scope was clear from the start, there was no need for 'broad scope definition'.	There were projects in which alternatives/ scenarios were not considered. Sometimes there was another approach like 'weekly management risks' follow-ups" to mitigate the problems rather than considering different alternatives upfront.

Table 7-4: Projects' data on bottom 5 flexibility enablers

	Enabler 26: flexible desks	**Enabler 10: standardised process and design**	**Enabler 20: late locking**	**Enabler 15: consensus amongst team members**	**Enabler 7: contingency planning**
Positive	Mostly in organisations where Scrum have been used, 'flexible desks' was a known term and used for Scrum projects. There are also other organisations where 'flex working spaces' is introduced.	There were projects in which 'standardisation' was applied in a certain area such as quality requirements, contracts, tendering, etc. For such applications the respondents were positive about it.	There were very positive opinions about how 'late locking' was applied in some projects. One example is about involving stakeholders more in making the decisions by applying 'late locking'. Or when the requested changes are very probable and happen gradually during the project.	There are cases where consensus was applied and the results were satisfactory. In projects in which there was a joint project interest, consensus was not an issue.	There are also cases where 'contingency planning' was applied with good results but there is not any project that practitioners score the application of this enabler very high. Overall in 'positive' extreme 'contingency planning' scored average.
Neutral	In some other cases 'flexible desks' have not been applied and the project team had no opinion about it.				There are cases in which 'contingencies' were considered but there is no data explaining the results.
Negative	In most cases, the project team has not used 'flexible desks'. Some find it not important to have flexible desks and some other believe it is not possible to have flexible desks. Even in a project with flexible desks, project team prefers to work in their own working spaces.	In general, practitioners were negative about applying 'standardisation' in their projects; because projects are not 'standard', or deviation from 'standard' happen very often.	There were projects in which 'locking at the last responsible moment' were not applied or poorly applied; for example in a project where the design of the project was well known at early stage.	Number of cases where 'consensus' was not in place in teamwork quality is relatively high compared to those where it was applied. examples are: people often disagree with each other, or in necessary occasions decisions have to be made by individuals.	Overall 'contingency planning' was not applied in many cases. One of the reasons which were mentioned is 'it plays not an important role in the planning phase of projects'

7.5 DISCUSSION

The flexibility enabler "Embracing change" was top-ranked from practitioners point view (64%). As can be seen in Table 7-3, also in practice there was evidence of being open to change. Most of the respondents (who give higher importance to this enabler) scored it high according to what had been done in the last project they were involved in. Although it appeared that the practice of project management is open to change, also some difficulties were recognised. Respondent 34 stated that the client was not on the same page as the development team regarding the openness to changes. Respondent 3 mentioned that they were open to requests from stakeholders. Respondent 44 stated that there were lots of discussions with stakeholders regarding the changes and they experienced contradictory interests of people within the organisation, but in the end that turned out to be helpful. He mentioned that the overall discussion ended not in a very innovative solution but consensus was reached upon the selected solution. Respondent 14 mentioned that as the project had progressed, it became less flexible toward changes. He emphasised that changes in scope were logistically more difficult and/or undesirable. Overall, this enabler of flexibility was applied in practice ranging from moderate to good, according to the respondents. This suggests the applicability of this enabler in practice.

The statement of 'Trust' was the second highest ranked enabler of flexibility in project management. How 'trust' was implemented in practice, however, was less evident. Some of the practitioners scored it high in their last project, while others scored it very low. Respondent 15 stated that the project was heavily built on trust (hence positive!). Respondent 17 noted that at the beginning of the project trust was minimal and it improved during the project. This observation emphasises the point that 'trust' is being built along the way, rather than all at once at the beginning of the project. Respondent 24 stated that the level of trust was low and all parties insisted on their own interests (hence negative!). Respondent 26 mentioned that there was lots of discussion regarding the budget which was the case because of the low level of trust among the parties involved.

The next important enabler of flexibility was 'seizing the opportunities and coping with threats'. Overall, the practitioners who ranked this enabler high, scored it also high in the practice of the project they were involved in. Respondent 38 stated that the project team gave maximum consideration to taking the opportunities and preventing the threats. Respondent 18 experienced the same. Some practitioners indicate that the opportunities or threats were taken into account in very specific matters. There were also some practitioners who ranked this enabler high, but they noted that it was not applicable to their projects.

A 'broad scope definition' was another highly ranked enabler of flexibility in project management. The application of this enabler in practice was shown to be contradictory. The answers of the respondents ranged from not applied to applied well. Some practitioners mentioned that the scope definition is a progressive process during the project, while some others mentioned that scope was defined into details upfront.

Respondent 15 mentioned that the scope of the project which he was involved in was defined little by little to the end of the project.

Keeping 'alternatives' or 'more scenario's' open is another highly ranked flexibility enabler. Overall, the practitioners were very positive about how this enabler was applied in their last project. Respondent 38 mentioned that they have kept those alternatives on board which were likely to be useful in later stages of the project. Hence it is wise to perform sensitivity analysis on the likelihood of usage when considering to keep alternatives open.

On the other extreme, the least important flexibility enabler from the practitioners' point of view was 'flexible desks'. As the term itself suggests, 'flexible desks' is about having the freedom to choose where to sit in the organisation, based on the project they currently work at. The idea is that this helps in making communication lines shorter (Gibson, 2003). However, practitioners ranked it as the least important enabler (see Table 7-4). Respondent 4 noted that in principle they had flexible desks at their organisation but in fact, everybody preferred to stick to their own working places, regardless of the specific project employment. Another interesting observation was related to (perceived) differences in one organisation. Respondents 17, 20, 21 and 31 work in the same organisation but they had totally different experiences regarding flexible desks; their answers were ranging from not applied to applied and further to highly applied. This means that even in one organisation, different teams seem to work under different working conditions.

'Standardisation of process and products' is the next flexibility enabler that was ranked low. We observed different perceptions regarding standardisation. Most of the practitioners perceived 'standardisation' as a fact that is contradictory to 'flexibility', while the idea of having standardised processes and products is to give flexibility to the team to choose and act upon circumstances according to the best practices of standard processes or products. Respondent 3 stated that projects are not standard and hence it is not possible to have standardised process or products. Respondent 12 noted that in principle there was 'standardisation' but it was not easy to realise it, especially in tendering. Respondent 18 mentioned that there was a standard process but frequently they deviated from it. Respondent 26 emphasised the need for standard iterative processes, like what Scrum suggests, but he scored the project very low regarding the application of this item. Respondent 29 mentioned that in his project there were standard contact forms and a standard tendering process. Overall, how 'standardisation' was applied in practice, was scored above average.

The enabler 'locking the decisions at the last responsible moment' was another low ranked flexibility enabler. Like 'standardisation', practitioners had different perceptions regarding this enabler. Some interpreted it as postponing the decisions to later moments which will result in delays. However the idea behind 'late locking' or 'locking at last responsible moment' is avoiding 'premature convergence' (Hertogh, 2014). There were not so many positive remarks about this enabler, expect respondent 18 who noted that 'late locking' provides the base for involving the people from surroundings of the project more closely in the process. The application of 'late locking' might also depend on how clear the project goals and scope are defined. Respondent 16 indicated that because the design of the project was known at the very early stage of the project, there was no need for 'late locking'. This is also debatable from the viewpoint of having all the required information: only if the necessary information is available, decisions can be made.

'Consensus among team members' is the next low ranked enabler of flexibility. Some practitioners believe that consensus is difficult to be reached because of the diversity of people involved in the project. In the same line of reasoning in practice the 'consensus' was either 'not applied' or on the other extreme scored 'well'. Respondent 29 believes that people not always agree with each other. Oppositely respondent 18 noted that because there was a joint project interest for all team members, consensus was never an issue. Hence it can be said that consensus is highly dependent on people attitude rather than project-specific characters. Eisenhardt, Kahwajy and Bourgeois (1997) stated: *"the absence of conflict is not harmony, it's apathy"*. In our opinion, even though conflicts can play a constructive role, consensus has to be reached for decisions.

The other flexibility enabler which was ranked low by about 30% of respondents is 'contingency planning'. Apparently, some practitioners could not distinguish between the enablers of 'contingency plan' and 'considering alternatives', although the latter was among the highly ranked enablers. For those people, 'alternatives' are in the same area as 'contingencies'. There is discussion in literature about the distinction between 'contingency plan' and 'alternatives'. According to Pich et al. (2002) 'contingency plan' (and other similar risk management activities) gives the project manager the ability to take an action in presence of risks which have been identified but the circumstances are uncertain. 'Alternatives' are options to be considered to deal with each unacceptable risk (Straub and Welke, 1998).

Overall it became clear that flexibility enablers of project management are relatively applied in practice. According to this research, not only the enablers of flexibility which ranked high by practitioners, but also those enablers which ranked low (low importance) have been applied in practice. Therefore it can be said that project management in practice is flexible which is not reflected in literature. The degree of flexibility depends on various

7.6 CONCLUSION

According to literature, 'flexibility' is a quality which adds value to project management. This becomes more important when projects are complex and more difficult to predict. In this research we investigated the practitioners' opinion on what they find important to make project management more flexible and also what they find least important. Apart from this, the ultimate goal of this research was to see whether the project management of infrastructure projects in the construction industry currently is flexible or not.

The research results revealed that different practitioners have different experiences. Even in one organisation, different project teams work in different working environments regarding the management approach, ranging from flexible to rigid. Also looking at a specific project, it was observed that they were flexible in some aspects and not at all flexible in the others. For example respondent 20 scored 'trust' very high, 'broad task definition' low, 'contingency planning' low, 'flexible desks' high. It shows that in one project handled with one team, some flexibility enablers are well applied and some other not.

As can be seen from Table 7-1 and Table 7-2, some of the enablers ranked high by some respondents and at the same time ranked low by others. Among the flexibility enablers considered in this research, 'embracing change' and 'seizing opportunities and coping with threats' were the two enablers which were ranked high on average by all practitioners (not appeared among the bottom 5 enablers). On the other hand 'flexible desks' and 'consensus among team members' as two other flexibility enablers had not appeared as top 5 enablers of flexibility. The rest of enablers range from very important from some practitioners' point of view to least important from the others' point of view.

Overall it can be concluded that the current practice of project management has some degree of flexibility, albeit very implicit. To make full advantage of flexibility, it has to become explicit. In our view, conscious application of flexibility could add value to project management processes and ultimately to the project result. This research can help practitioners to judge whether they are flexible in practice or not and also to see what flexibility aspects are important for their projects. For further research it is recommended to test the practical applicability of the enablers in case studies, explicitly investigating the suggested links to project performance.

Concluding remark and next step

In this chapter, it was concluded that the practice of project management in the context of infrastructure construction projects has some degree of flexibility but the practitioners are not generally aware of such flexibility. During the data gathering phase of this research, it was observed that in general practitioners cannot explain how they put flexibility in their practice. However, they could recognise the list of flexibility enablers given to them for ranking. The main contribution of this chapter to practice is to enhance the practitioners' knowledge regarding the flexibility of their management approach by the recognition of flexibility enablers and the reflection of their practices regarding these enablers. For making any change (in this case in the management approach) there should be an awareness of the current situation. If the intention is on making project management more flexible, the flexibility degree of practice should be understood; what flexibility enablers have been applied, which are the most common ones, if the project team recognises those enablers or not, etcetera.

So far the enablers of flexibility were identified (Chapter 5), the practitioners' perspectives were explored (Chapter 6) and the flexibility in current practice was studied (Chapter 7). The next step is to quantitatively test the effect of flexibility on project performance to answer the research sub-questions 5 and 6. Chapter 8 will present this part of the research.

Chapter 8: The effect of project management flexibility on project performance (The mediating role of flexibility)

Abstract

Literature in project management suggests making project management flexible to deal with project dynamics and subsequent project complexity. Project dynamics is assumed to be the source of project complexity. Hence the assumption in literature is that flexibility in project management helps to deal with project complexity. Despite the fact that literature suggests adding flexibility to project management, its effect on project performance has not been investigated empirically. Not only the effect of flexibility on project performance, but also the role of flexibility on the impact of project complexity on project performance is unknown. Therefore, in this chapter, the first objective is to investigate the effect of flexibility on project performance and secondly, if flexibility mediates the effect of complexity on performance. Six hypotheses regarding the relationships between flexibility areas (named: what, how-attitude, how-organisation, who, when and where) and project performance, one regarding the effect of complexity on performance and six other hypotheses regarding the mediating effect of flexibility areas on the relationship between complexity and performance were formulated (in total 13 hypotheses). The statistical analysis using PLS-SEM method on data gathered from 111 surveys resulted in: flexibility of 'how-attitude' and 'how-organisation' have a positive significant effect on project performance. 'How-attitude' contributes to the flexibility of project management processes by having an 'open attitude', 'wide approach' and 'proactive attitude' while 'how-organisation' puts the emphasis of flexibility on 'facilitate planning', 'outer organisation' and 'inner organisation'. Project complexity has contrary effect on project performance. Flexibility of 'how-organisation' mediates the effect of project complexity on project performance.

After the literature study (Chapter 2), the evidence of flexibility in literature and practice was reviewed (Chapter 3 and Chapter 4). Next the enablers of project management flexibility, the practitioners' perspectives on flexibility and practice of project management regarding its flexibility were studied (Chapters 5 to 7). By now we know the enablers of flexibility, what practitioners find important regarding project management flexibility and how flexible is the practice of project management in the context of infrastructure construction projects. The next step is to explore the effect of project management flexibility on project performance. This chapter aims at studying this effect.

8.1 INTRODUCTION

Project management is a growing subject in different disciplines in the field of research. Fernandes et al (2015) believe that realising effective project management still is a challenge although project management has developed and spread significantly in science (Fernandes et al., 2015). Sanjuan and Froese (2013) claim that weak project management practices continue to be commonplace, particularly among project owner organisations (Sanjuan and Froese, 2013). In their eyes, one of the contributing factors to poor PM practices is that project organisations are unaware of and unconvinced about the value offered by various PM practices. Project management practices can be recognised as tools, techniques, methodologies and processes. Methodology can be understood as a definition of simply group tasks or something formal (Matos and Lopes, 2013) which can be self-made by the development team or usage of an existing one or mix of them. The implementation of project management methodologies varies from very ad hoc to completely formal, defined approaches (Fernandes et al., 2015).

Literature defines two main streams in project management: mechanistic and organic (Burns and Stalker, 1961). Mechanistic reflects the waterfall (conventional) approach and organic reflects a more adaptive approach. Conventional project management is approached in a rational, normative and positivist manner so that complexity is addressed by an extensive up-front planning (Klein et al., 2015). The conventional project management approaches are characterised by mechanistic, absolute and universal factors, which show ineffectiveness in dealing with complexity of today's projects (Klein et al., 2015). The basis of conventional project management is on a mechanistic, mono-causal, non-dynamic, linear relationships considering a discrete view of human nature and societies and their perceptions, knowledge, and actions (Saynisch, 2010). Cooke-Davies et al. (2008) argue that a paradigm shift is needed from the conventional project management concepts in order to deal with future project management challenges and requirements of modern practice. Klein et al. (2015) believe *"Project management is complex and therefore a fruitful ground for creative, spontaneous and intuitive application of particular theories to meet the stated objectives in a constantly changing environment"*. This implies that in a dynamic environment particular project management theories (fit-for-purpose project management) can help in achieving projects' objectives.

Koppenjan et al. (2011) refer to a mechanistic approach as command-and-control and organic approach as prepare-and-commit. A conventional management approach, like the command-and-control perspective, is characterized by a strong focus on front-end analysis and designed to overcome uncertainty and complexity. The front-end results in predetermined outcomes by a strictly frozen plan (like fully specified scope description) to achieve those predicted outcomes. In addition schedule and budget should be frozen and strictly controlled during execution. The alternative is a more organic approach like the prepare-and-commit perspective on project management. In this approach overcoming uncertainty and complexity is a constant and shared task, with less excessive focus on the front-end. It is inevitable that the scope will change because of the unknowns and the learning curve of the client (Koppenjan et al., 2011). The awareness that projects are embedded in a changing and dynamic environment is being recognised since the 1990s (Bosch-Rekveldt, 2011). It was argued that all projects have some degree of dynamism represented by 'constantly changing characteristic' which requires dynamic management approaches (Collyer and Warren, 2009). It is claimed that construction projects are embedded in complex, dynamic environments involving many unpredictable components and characterized by a high degree of uncertainty (Ourdev et al., 2008).

Flexibility relates to the ability of a development method to "create change, or productivity, reactively, or inherently embrace change in a timely manner, through its internal components and its relationship with its environment" (Dingsøyr et al., 2012). The value of managerial flexibility lays in obtaining new information from the project and its uncertainties and consequently change its course of action (Huchzermeier and Loch, 2001).

It is argued that nowadays a pure project management approach (conventional project management approach) is no longer effective (Hertogh and Westerveld, 2010; Priemus and van Wee, 2013). Several researches indicate that a combination of two management approaches is needed (Boehm and Turner, 2003; Geraldi, 2008; Hertogh and Westerveld, 2010; Koppenjan et al., 2011). Still, most of the current project management methodologies seem to underestimate the influence of the dynamic environment. Combining both approaches means that a certain degree of flexibility is needed or, in other words, a balance needs to be found between controlling complexity and uncertainty and maintaining flexible in order to cope with complexity and uncertainty (Geraldi, 2008; Koppenjan et al., 2011). However pure approaches either purely mechanistic or purely organic, are hardly used in practice as it is mentioned by Brown and Eisenhardt (1997).

A study by Ahrens and Chapman (2004) showed that control systems can simultaneously support flexibility by doing a case study research in which a combined management approach was used. They found that although the management is mechanistic, operational management is used through intensive discussion and analysis aiming at flexibility. Floricel and Miller (2001) argued that achieving high project performance requires such combined approach: a robust and control-oriented approach to manage the anticipated uncertainty and a flexible, or governable approach to manage the unforeseen and unexpected circumstances. Recently Eriksson, Larsson and Pesämaa (2017) studied the effect of adaptation on time performance. They operationalised adaptation into 1) scope and content changes, 2) solving unexpected problems and 3) delivering a product that satisfies new and changing demands. They conclude that the adaptation in project management contributes significantly to time performance in a positive direction.

It was evident from the literature that conventional project management needs to gain flexibility to deal with dynamics of nowadays projects, especially when it comes to early project phases of infrastructure construction projects. Those dynamics are known as sources of uncertainty and complexity. The effect of such management flexibility on project performance in the domain of infrastructure construction projects has not been studied empirically. Therefore the first objective of this research is to study the effect of project management flexibility on project performance. Adding flexibility into the practice of project management is assumed to improve project performance by better dealing with project complexity. Hence apart from the direct effect of flexible project management on project performance, the secondary objective of this research is to study the mediation role of flexible project management on the relationship between project complexity and project performance.

After the introduction, a brief literature review is provided in Section 8.2. To achieve the formulated research objectives a number of hypotheses were formulated in Section 8.3 of this dissertation: six hypotheses to test the effect of flexible project management on project performance, one hypothesis to test the effect of project complexity on project performance and six hypotheses to test the mediating role of flexible project management on the effect of project complexity on project performance. Next, the research methodology is discussed in Section 8.4. The research results are explained in Section 8.5. The mediating role of flexible project management is illustrated in Section 8.6. The discussion including the takeaways and research limitations is presented in Section 8.7. The conclusions of the research are provided in Section 8.8.

8.2 LITERATURE

The literature review for this chapter includes flexible project management, project performance and project complexity. However, all three were already covered in Chapter 2 of this thesis. On top, Chapter 5 illustrated project management flexibility more in-depth by extracting the enablers of flexibility from literature and validating them by practitioners. To avoid duplication, in this chapter the literature review only briefly covers project complexity and project performance, extra to what was explained in Chapter 2.

8.2.1 PROJECT COMPLEXITY

In Chapter 2 of this dissertation an introduction was given about project complexity, its history and the importance of studying project complexity. Here some more support from literature is provided.

The importance of studying project complexity lays in different facts. It is argued that many subsequent decisions in the practice of managing projects are influenced by the complexity of the project as a key independent variable (Geraldi et al., 2011). Several scholars investigated complexity, either aiming at defining project complexity or finding the sources of complexity in projects.

Sheard (2012) defined complexity as "the inability to predict the behaviour of a system due to a large number of constituent parts within the system and dense relationships among them". Kermanshachi, Dao, Shane and Anderson (2016a) based their research on the following definition of complexity: "project complexity is the degree of interrelatedness between project attributes and interfaces, and their consequential impact on predictability and functionality".

Bosch-Rekveldt (2011) identified 47 elements of complexity in large engineering projects grouped in three categories being technical, organisational and external. Geraldi et al. (2011) proposed a framework of complexity with five dimensions being: structural, uncertainty, dynamics, pace and socio-political complexity. They believe recognition of these five dimensions help individuals and organisations to be prepared to respond to each dimension. In their eyes, by understanding complexity it is possible to develop the management competences. Li and Guo (2011) mentioned that complexities in managing mega construction project can be derived from three aspects being technical, social, and managerial. While technical complexity determined by the design and technologies employed in the design and construction processes, social aspects determined from the inadvertent impact of mega projects on the environment and social systems within their location of implementation, and managerial complexity is caused by the business and governance aspects of projects. In a very recent research, Kermanshachi et al. (2016b) identified and ranked the top 30 complexity indicators by use of the Delphi method through participation of 10 Subject Matter Experts. They conclude that "peak number of participants on the project management team during engineering/design phase of the project", "magnitude of change orders impacting project execution", and "frequency of the workarounds" are the top three complexity indicators. Nguyen, Nguyen, Le-Hoai and Dang (2015) studied the complexity of transportation projects. They identified 36 factors of complexity and by doing factor analysis, they conclude six components of project complexity for transportation projects. Then by using Fuzzy Analytic Hierarchy Process method each component and parameter was given a weight. According to their research socio-political complexity was the most defining component of complexity. The six components are socio-political complexity, environment complexity, organisational complexity, infrastructural complexity, technological complexity, and scope complexity. This research is mainly focused on the execution phase of transportation projects and consequently the respondents were from contractor and client sides. Bakhshi et al. (2016) believe complexity becomes one of the important factors in the projects' failure. By means of a systematic literature review from 1990 to 2015 they conclude a list of 127 independent complexity factors in 7 categories.

Another research stream on project complexity is studying the relationship/effect of another project aspect on project complexity or vice versa. For example, Reid Robert, Guillermo and John Riker (2013) did a research studying the relationship between project complexity and communication. They believe the construction industry delivers increasingly complex projects but struggles to leverage the information technology to facilitate the communication in these projects.

Apart from the effect of flexible project management on project performance, it is important to know whether such an effect exists while project complexity is taken into account. To test this effect, in later stages of this research project complexity needs to be measured. Since project complexity is not the primary focus of the research, a project complexity model is taken from literature. Some criteria were considered to select from existing project complexity models in the literature: the availability of the model for use, ease of use, the level of detail and the relevance of the model to the project types in the current research (infrastructure construction projects). Considering the mentioned selection criteria, the TOE framework developed by Bosch-Rekveldt (2011) and the complexity model developed by Kian Manesh Rad et al. (2017) were selected and compared to each other. By this comparison it was evident that the two models have much in common (see Appendix G). After the comparison it was decided to use the TOE framework (Bosch-Rekveldt, 2011), because of the applicability of the model to the context of infrastructure projects, easy to understand, level of detail (three categories and 47 elements). 'Availability of information' was missed in TOE framework which was included in the model by Kian Manesh Rad et al. (2017). At the end 22 elements of complexity used in the survey to measure project complexity (Table 8-1).

Table 8-1: Project complexity elements adapted from Bosch-Rekveldt (2011)

label	complexity elements
ComplexA	Clarity and certainty of project goals
ComplexB	Clarity and certainty of tasks and their dependencies
ComplexC	Project size according to project cost
ComplexD	Number of contracts
ComplexE	Technical certainty
ComplexF	Quality requirements
ComplexG	Stability of project environment
ComplexH	Lack of trust
ComplexI	Size of project team
ComplexJ	Conflicting politics/standards/regulations
ComplexK	Availability of required experiences in the organisation
ComplexL	Number of involved external stakeholders
ComplexM	Number/remoteness of location of locations
ComplexN	Compatibility of PM tools/methods
ComplexO	Required disciplines and their interfaces
ComplexP	Company strategies/internal-support
ComplexQ	Market competition
ComplexR	Project duration
ComplexS	Organisation risks
ComplexT	Information availability
ComplexU	Variety of languages/nationalities
ComplexV	Number of financial resources

8.3 Project performance

In Chapter 2 it was discussed why performance measurement is important and how it has been investigated during the past years. Here some additional literature on project performance measurement is summarized in order to select a performance measurement model for this part of the research. It was also mentioned In Section 2.7 that there is a difference between project success and project management success (Radujković and Sjekavica, 2017a). Therefore it is important to specify where the focus of this research is. This research investigate the effect of flexibility of project management on project performance. Therefore the performance measurement discussed here is about project performance and not project management performance.

A wide variety of measures to evaluate the outcome of a project (performance measurement) has been identified in project management research field (Cao and Hoffman, 2011). Project performance measurement helps project managers to improve managerial decision making (Lauras, Marques and Gourc, 2010). Marques, Gourc and Lauras (2011) state that any decision support system needs performance evaluation. A number of researches proposed frameworks to measure project performance (Cao and Hoffman, 2011; Lauras et al., 2010; Marques et al., 2011; Yun, Choi, de Oliveira and Mulva, 2016). There are researches which focused on developing performance measures for the construction industry (Chan and Chan, 2004; Costa, Formoso, Kagioglou, Alarcón and Caldas, 2006; Rankin, Fayek, Meade, Haas and Manseau, 2008; Yeung, Chan, Chan, Chiang and Yang, 2012). Cox, Issa and Ahrens (2003) concluded six highly significant performance indicators in literature for construction projects being quality control, on-time completion, cost, safety, cost per unit, and units per man-hour. Skibniewski and Ghosh (2009) proposed nine critical key performance indicators applicable in construction firms as cost, time, defects, client satisfaction, safety, profitability and productivity. The literature states that performance measurement is more difficult for a complex project with a great number of performance indicators (Lauras et al., 2010). It is also argued in the literature that most of performance evaluation models are useful for post evaluation when the project is finished while phase-based evaluation has value for improvement (Yun et al., 2016). Apart from key performance indicators, success criteria are often used to measure the end-project results. A number of researches have investigated the success criteria for different project contexts or considering different project's phenomena (Bryde and Robinson, 2005; Cserháti and Szabó, 2014; Khan, Turner, Maqsood and Hill, 2013; Tabish and Jha, 2011). Some other research looked into the practitioners' perspectives regarding success criteria (Koops et al., 2016).

Among the researches on project performance measurement and success criteria (Bryde, 2003; Khan et al., 2013; Lim and Mohamed, 1999; Müller and Turner, 2007; Shenhar et al., 2001; Shrnhur, Levy and Dvir, 1997; Xu and Yeh, 2014) there are commonalities, although each research suggested a different framework based on the focus of research. Since project performance is not the primary focus of this research, it was decided to select an appropriate model from literature suggesting a firm framework for measuring project performance. Such a framework was found in the model of Khan et al. (2013) (see Table 8-2). This model proposes a comprehensive list of 25 indicators clustered in five categories (efficiency, organisational benefits, project impact, future potential and stakeholder satisfaction). The 25 indicators incorporate formatively to the five first-order constructs.

Table 8-2: Project performance measures (success criteria) adopted from Khan et al. (2013)

Label	Success criteria
Project efficiency	
Performance A	Finished on time
Performance B	Finished within budget
Performance C	Minimum number of agreed scope changes
Performance D	Activities carried out as scheduled
Performance E	Met planned quality standard
Performance F	Complied with environmental regulations
Performance G	Met safety standards
Performance H	Cost effectiveness of work
Organisational benefits	
Performance I	Learned from project
Performance J	Adhered to defined procedures
Performance K	End product used as planned
Performance L	The project satisfies the needs of users
Performance M	New understanding/Knowledge gained
Project impact	
Performance N	Project's impacts on beneficiaries are visible
Performance O	Project achieved its purpose
Performance P	End-user satisfaction
Performance Q	Project has good reputation
Future potential	
Performance R	Enabling of other project work in future
Performance S	Motivated for future projects
Performance T	Improvement in organisational capability
Performance U	Resources mobilized and used as planned
Stakeholder satisfaction	
Performance V	Sponsor satisfaction
Performance W	Steering group satisfaction
Performance X	Met client's requirement
Performance Y	Met organisational objectives

8.4 HYPOTHESES

8.4.1 THE EFFECT OF FLEXIBILITY ON PROJECT PERFORMANCE

As shown in Section 8.1, the literature suggests that project management needs to become more flexible to deal with project complexity. But the question here is whether project management flexibility has an effect on project performance or not. Secondly, if such an effect exists, would it be positive or negative. Therefore this research aims at studying the effect of project management flexibility on project performance, including the effect of project complexity on performance. According to what literature suggests regarding the necessity of making project management more flexible (Ahrens and Chapman, 2004; Geraldi, 2008; Kreiner, 1995; Olsson, 2006; Osipova and Eriksson, 2013; Wirkus, 2016; Wysocki, 2007; Yadav, 2016) a main hypothesis to be tested was formulated as: 'flexible project management has a positive effect on project performance'. But since this hypothesis seemed to be very vague and broad, it was decided to break this hypothesis down into more hypotheses based on the suggested areas of flexibility in literature. After conducting the in-depth literature review on project management flexibility, two main sources were found with recommended areas of flexibility in project management (Geraldi, 2008; Osipova and Eriksson, 2013). Defined areas of flexibility by these two sources are mostly the same since one (Osipova and Eriksson, 2013) builds upon the research by Geraldi (2008). Therefore, using the five areas of flexibility (what, how, who, when and where) as suggested by Osipova and Eriksson (2013), five hypotheses were formulated regarding the relationship between project management flexibility and project performance. These five hypotheses are:

> H1. Project management flexibility in terms of project scoping and contracting (what) has a positive effect on project performance.
>
> H2. Project management flexibility in terms of process (how) has a positive effect on project performance.
>
> H3. Project management flexibility in terms of project team organisation (who) has a positive effect on project performance.
>
> H4. Project management flexibility in terms of scheduling the project and task delivery (when) has a positive effect on project performance.
>
> H5. Project management flexibility in terms of location of team (where) has a positive effect on project performance.

Each area of flexibility includes a number of flexibility enablers (26 in total) which were identified in earlier research (Jalali Sohi et al., 2017b), see Chapter 5. To these 26 flexibility enablers, four additional enablers were added, see also Chapter 6. The entire list of flexibility enablers, therefore, includes 30 enablers (listed in Appendix H).

The sixth hypotheses is about the effect of project complexity on project performance. In Section 8.1 it was mentioned that some literature shed light on the flexibility of project management because of managing the project's complexity. Antoniadis, Edum-Fotwe and Thorpe (2011) studied the effect of socio-organisation complexity on project performance. Zhu and Mostafavi (2017) proposed a framework for assessing project performance based on its complexity. Wei, Zongzhong and Jiajun (2013) studied the effect of project complexity on project efficiency in case of infrastructure projects. Bosch-Rekveldt (2011) studied the moderation role of project complexity on the effect of front-end activities on project performance. These researches confirm that project complexity has an effect on project performance. So apart from the relationship between flexible project management and project performance, the effect of project complexity on project performance will be studied. This resulted in the following hypothesis:

> H6. Project complexity has a contrary effect on project performance (the less complex the project, the better the project performance).

How these hypotheses are tested is explained in Section 8.5.

8.4.2 THE MEDIATING ROLE OF FLEXIBLE PROJECT MANAGEMENT

Apart from studying the effect of flexible project management on project performance including the effect of project complexity, the research aims at testing if flexible project management mediates the effect of project complexity on project performance (the conceptual model proposed in Chapter 1). Hence the structure of input-mediator-output was adapted to build the research model. Literature indicates that project management is in place to manage project complexity (Bosch-Rekveldt, 2011; Reilly, 2000; Smith and Irwin, 2006; Van Marrewijk et al., 2008). It can be done by choosing the appropriate management approach (Hertogh and Westerveld, 2010) or for example by application of right tools and practices such as VIPs (value improving practices (Bosch-Rekveldt, 2011). While project complexity implies a negative effect on project performance, proper project management may mediate a negative effect. The idea is that flexible project management mediates a negative effect of project complexity on project performance.

It was discussed in Section 8.4.1 that enablers of flexibility in project management were clustered in five areas (what, how, who, when and where). Considering those five areas, five hypotheses regarding the mediation relationships are formulated:

> H7. The negative effect project complexity has on project performance is mediated by flexibility of 'what'.
>
> H8. The negative effect project complexity has on project performance is mediated by flexibility of 'how'.
>
> H9. The negative effect project complexity has on project performance is mediated by flexibility of 'who'.
>
> H10. The negative effect project complexity has on project performance is mediated by flexibility of 'when'.
>
> H11. The negative effect project complexity has on project performance is mediated by flexibility of 'where'.

8.5 METHODOLOGY

As mentioned before, although flexibility in project management is suggested in literature, rarely any empirical research has been done checking the statistical (inter)relationships between the two constructs: flexible project management and project performance. Because of the fact that the research topic is not well-developed in literature, the choice of a proper research methodology is an important factor for acceptability of the results. The two possible options were regression analysis and Structural Equation Modelling (SEM). Since this research is underdeveloped, it was decided to use a research methodology which is suitable for such a research context. Hence it was decided to use SEM method to test the hypotheses.

8.5.1 SEM

SEM (Structural Equation Modelling) is a multivariate statistical technique largely employed for studying relationships between latent variables (or constructs) and observed variables (Qureshi and Kang, 2015). Latent variables are those of interest to test but not directly measurable whereas observed variables (sometimes called as indicators) are those which directly can be measured. The possibility of SEM to model complex dependencies and latent variables (Nachtigall, Kroehne, Funke and Steyer, 2003) was regarded as the main advantage and the main reason for using SEM. SEM is based on two multivariate techniques: factor analysis and multiple regression analysis. SEM assists in the estimation of multiple and interrelated dependence relationships, possesses the ability to represent unobserved concepts in these relationships and accounts for measurement error (Hair, Black, Babin and Anderson, 2010; Qureshi and Kang, 2015). SEM is used to estimate multiple latent constructs while also minimizing the measurement errors.

There are two main modelling approaches in SEM: PLS (partial least square) and CB (covariance based) approaches (Hair, Hult and Christian, 2013a; Hair, Ringle and Sarstedt, 2013b). For this research SEM-PLS was chosen because:

- Covariance-based SEM (CB-SEM) is primarily used to confirm (or reject) theories (i.e., a set of systematic relationships between multiple variables that can be tested empirically). In contrast, PLS-SEM is primarily used to develop theories in exploratory research when the proposed model is not yet well-established in any other research before. PLS-SEM focuses on explaining the variance in the dependent variables when examining the model (Hair et al., 2013a).
- PLS-SEM allows the researcher to check/use both reflective and formative constructs. CB-SEM has less flexibility to accommodate different modes of measurement in a single analytical model (Becker, Klein and Wetzels, 2012; Hair et al., 2013a).
- For small sample sizes PLS-SEM is more suitable (Hair et al., 2013a).
- The estimation procedure for PLS-SEM is an ordinary least squares (OLS) regression-based method rather than the maximum likelihood (ML) estimation procedure for CB-SEM. This means that PLS-SEM uses available data to estimate the path relationships in the model with the objective of minimizing the error terms of the endogenous construct.
- PLS-SEM generally makes no assumption about the data distributions (normal or non-normal) (Hair et al., 2013a; Hair et al., 2013b).
- The focus of PLS-SEM is more on prediction rather than on explanation (Hair et al., 2013a).
- PLS-SEM has greater statistical power which means PLS-SEM is more likely to render a specific relationship significant when it is in fact significant in the population (Hair et al., 2013a).

According to the often-cited 10 times rule (Hair et al., 2013a), the sample size for testing a model using SEM-PLS should be equal to the larger of:

1. 10 times the largest number of formative indicators used to measure a single construct, or
2. 10 times the largest number of structural paths directed at a particular in the structural model.

The rule of thumb is equivalent to saying that the minimum sample size should be 10 times the maximum number of arrowheads pointing at a latent variable anywhere in the PLS path model.

The maximum number of arrows pointing to a latent variable (or construct) in the research model here is seven. Taking the 10 times rule, the minimum number of data points should be equal to 70.

8.5.2 SURVEY SET UP

An online survey was designed for collecting data in order to statistically test the relationships between flexible project management and project performance. The survey consisted of several parts. The respondents were asked to answer the questions based on the last finished project they played a significant role in. Hence the survey started with some general questions regarding the project. Next, the three main parts of the survey consisted of questions regarding the complexity of the project, the management of the project (in terms of flexibility) and the performance of the project. Finally some questions were asked about the profile of respondents. The survey is presented in Appendix I.

In the first round, a very comprehensive survey was designed and launched, aimed at gathering as much as possible data for the research. However, it resulted in a low response rate because of the required time to complete the survey. To increase the number of respondents, it was decided to shorten the survey by removing the open questions asking for more explanation of applied project management in practice.

8.5.3 SAMPLE AND DATA COLLECTION

The focus of this study was on infrastructure projects in the construction industry in their early phases (front-end phases). Hence the target population to be involved in the research were those practitioners who have relevant working experience in early phases of infrastructure construction projects. This includes practitioners working at client organisations, consultancies and contractors. Although most often contractors are involved in later project phases (execution).

The invitation for participation was sent to a large number of practitioners and they were asked to distribute the link to the online questionnaire among their colleagues who fulfilled the requirements of participation. Therefore it was not possible to trace back how many practitioners received the invitation. In total 160 people opened the survey. In total 111 respondents completed the survey (69% of those who opened the survey). The time frame of data collection was April until October 2017.

Figure 8-1 presents the demography of respondents. Role-wise the majority of respondents were project managers and the rest played a role in projects as project directors, engineers, project manager assistants or project consultants among others. Years of working experience of respondents ranged from very few (less than five) to more than 30 years. Since the scope of the research was focused on infrastructure construction projects, the majority of respondents had civil engineering or architecture background studies. They work either for public, private or both sectors.

The respondents indicated that the front-end phases of their projects ranged from less than six months to more than 24 months (see Figure 8-2). The projects were mostly public projects which is understandable since the domain of research was infrastructure projects.

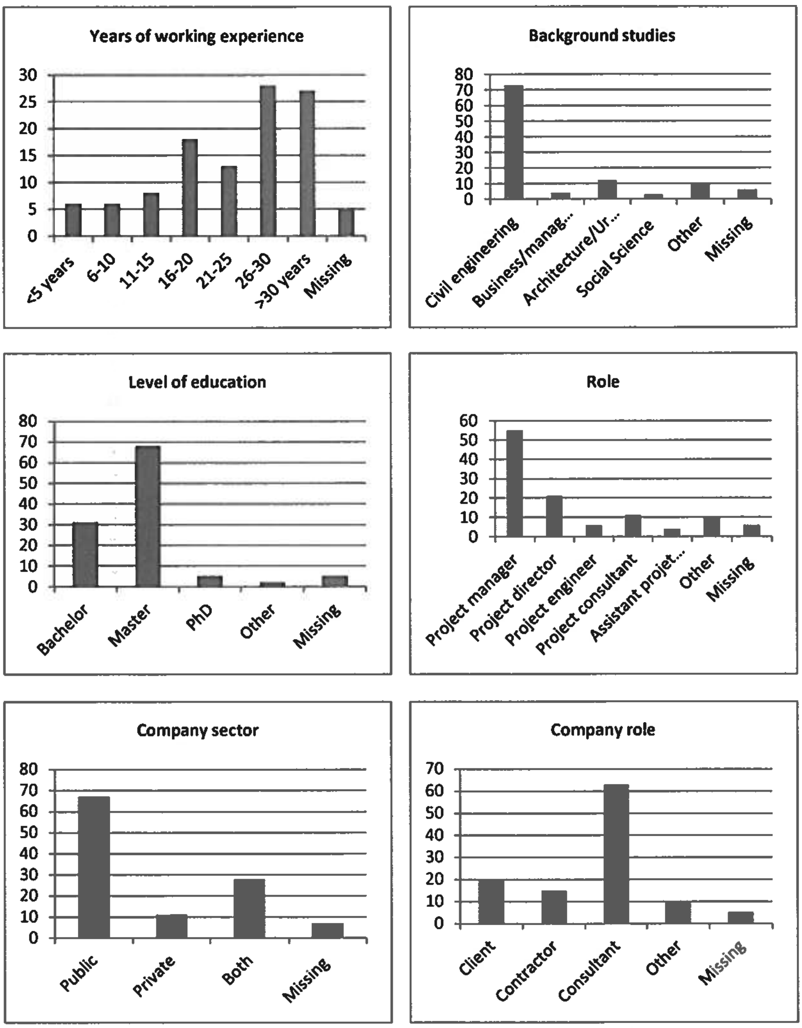


Figure 8-1: Demography of respondents

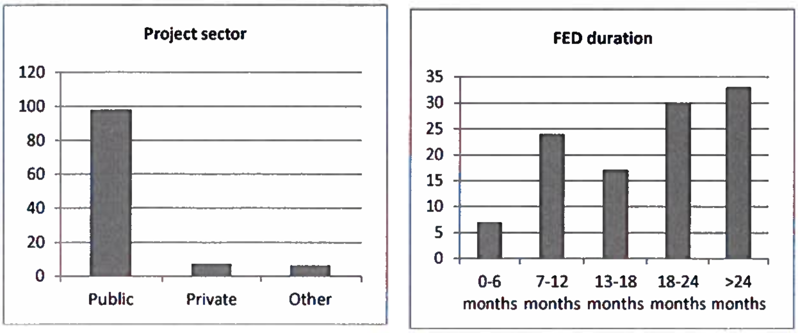


Figure 8-2: Projects' duration and sector

The measurement scale used for the measuring the indicators (observed variables) was a 5-point Likert scale (Strongly disagree, disagree, neutral, agree, strongly agree). Beside the scale, there were two other possible answers: 'Do not know' and 'Not applicable'. These two answers were treated as missing values. In total 254 missing values were detected out of 8547 values, which is equal to 2.97% of the total amount of values. In order to select an appropriate missing value treatment method, it is necessary to identify the pattern of missing values (Hair et al., 2010). By using SPSS the data were tested to determine whether the missing values in the dataset were Missing Completely at Random (MCAR). The null hypothesis is that the missing values are missed completely at random. The missing value analysis via Little's test (Little and Rubin, 2014) results in Chi-Square=4151.335, df=4070 and sig=0.183. Since the Chi-Square is not significant, the null hypothesis cannot be rejected, meaning that the missing value is Missed Complete at Random. Hair et al. (2013a) recommended using mean replacement for missing values in order to not to reduce the number of data points, which was applied accordingly.

8.5.4 MEASURES (INDICATORS)

For both dependent (project performance) and independent variables (flexible project management), a number of indicators were used to measure the latent variables indirectly. For the independent variables (flexible project management) the clusters of flexibility as suggested in the literature (Osipova and Eriksson, 2013) were used as latent variables and the indicators found from literature (Jalali Sohi et al., 2017b) were used to form the latent variables. All the indicators were treated as second-order formative measures contributing to the five first-order constructs (what, how, who, when and where). The whole research model including the latent variables and indicators for the independent variables, control variables and dependent variables can be found in Appendix J.

All first-order constructs (indicators) for both independent and dependent variables were treated as formative constructs. In both variables the indicators cause the constructs (formative), not the constructs cause the indicators.

8.6 RESULTS – MODEL EVALUATION

For the analysis of the measurement model and the structural model the software SmartPLS 2.0 was used.

The research model consists of two models:

1. measurement model which evaluates if the indicators (measures) belong to their latent variables
2. structural model which tests the hypotheses (the relationship between the latent variables).

Sometimes in literature the measurement model is called as the outer model and the structural model as the inner model. The measurement model is elaborated and validated in Section 8.6.1. Next, the structural model is evaluated in Section 8.6.2

8.6.1 MEASUREMENT MODEL

For evaluating a formative measurement model it is recommended to test the collinearity of indicators and to test if the indicators contribute to their latent variables (Hair et al., 2013a). For testing the collinearity (or multicollinearity) the Variance Inflation Factor (VIF) test was performed using SPSS software. Needless to say that the multicollinearity was checked only for the independent variables (project management flexibility) because the indicators for the dependent variable (project performance) and control variable (project complexity) were taken from literature. None of the indicators exceeded the threshold value of 5. Thus collinearity was not an issue. Next, the indicators were tested on their contribution to their latent variables. It is important to note that the coefficients of the formative indicators (outer weights) are influenced by other relationships in the model (Hair et al., 2013a). The more formative indicators in one construct, the smaller the outer weights of each indicator (Hair et al., 2013a). This means that it is very likely that the indicators become nonsignificant when there are a relatively high number of them contributing to one latent variable. For tackling this problem, Cenfetelli and Bassellier (2009) suggested to group the indicators in smaller constructs. For testing the contribution of indicators to their constructs, an iterative process was applied by eliminating single indicators with negative values or small coefficients in each round of analysis. The assessment of the measurement model is provided in Appendix K.

8.6.1.1 Flexibility indicators

In this section the evaluation of flexibility enablers (indicators) is presented (see Table 8-3).

There are three indicators forming the latent variable of 'what' (the enablers contributing to flexibility in terms of scope of the project): broad task definition, embracing change, functional-realisation based contract. Among the three, 'embracing change' had a negative coefficient value to the construct. Therefore in the second step this indicator was eliminated. The two other indicators had coefficient values in the relevant range (0.3 to 0.9).

There are 14 indicators contributing to the latent variable of 'how'. As suggested by Cenfetelli and Bassellier (2009), to reduce the complexity of the model it is suggested to group the indicators into sub-constructs. The 14 indicators were grouped into six smaller constructs. The first construct is labelled as 'outer organisational structure' and includes three indicators; 'horizontal steering character among the parties', 'shared interface management' and 'trust'. The second construct is labelled as 'wide approach' and includes two indicators; 'open information exchange' and 'possible alternatives'. The third construct is named as 'facilitate planning' and includes two indicators; 'visualising progress and planning' and 'capturing the lessons learned from the project'. The fourth construct is named as 'proactive approach' and includes two indicators; 'contingency planning' and 'seizing opportunities and coping with threats'. The fifth construct is labelled as 'open attitude' and includes two indicators; 'close involvement of stakeholders' and 'interactive decision making'. The sixth and last construct within the latent variable of 'how' is named as 'inner project organisation' and includes two indicators; 'network internal structure' and 'management support'. With the 6 smaller constructs, the coefficients were all in the relevant range except for the indicator, 'standardised process'. Based on Hair et al. (2013a), the significance of the indicator on the construct was checked. The effect was not significant and the indicator was removed from the measurement model.

To reduce the complexity of the model, the latent variable 'how' was replaced by two latent variables 'how-attitude' and 'how-organisation'. The split of six sub-constructs between 'how-attitude' and 'how-organisation' was based on the conceptual relatedness of sub-constructs to each other. Among the six sub-constructs, 'open attitude', 'wide approach' and 'proactive attitude' form latent variable 'how-attitude'. 'Inner organisation', 'outer organisation' and 'facilitate planning' are the ones which relate to organisational factors. Hence they formed latent variable 'how-organisation'.

The latent variable of 'who' (flexibility in terms of people who perform the project) was formed by six indicators. Again it was decided to group the indicators into smaller constructs. The indicator 'self-assigned tasks to individuals' had a negative effect on the latent variable so it was decided to eliminate this indicator. The first construct is labelled as 'team structure' which includes three indicators: 'delegation of responsibilities to team', 'consensus among team members' and 'stable project team'. The second construct is named as 'team collaboration' and includes two indicators; 'considering all team members to be skilled in team management' and 'considering team members as valuable stakeholders'. The coefficients of these indicators were in the relevant range.

The latent variable of 'when' (flexibility in terms of scheduling) was formed by five indicators. Two indicators, 'locking decisions at the last responsible moment' and 'minimize upfront planning' were negatively contributing to their sub-construct. The indicator 'iterative delivery' also showed a negative coefficient value to the latent variable. It was decided to eliminate these three indicators from the measurement model.

The latent variable of 'where' (flexibility in terms of project team location) was formed with two indicators, 'joint project office' and 'flexible desks'. The coefficient values (0.984 and 0.141) of both indicators were outside the relevant range (0.3 to 0.9). Therefore the outer loading was checked for both indicators. 'Flexible desks' had an outer loading smaller than 0.5 and was not significant, the other outer loading was significant. Hence the indicator 'flexible desks' was eliminated. Consequently the latent variable of 'where' is formed by one indicator.

The final list of flexibility enablers of which the contribution to the latent variable was confirmed by the analysis is presented in Table 8-3.

Table 8-3: Confirmed flexibility enablers to the 5 areas of flexibility

Category		Label	Flexibility enablers
What		FlexA	Broad task definition
		FlexC	Functional-realisation based contract
How	How-attitude	FlexAB	Interactive decision making
		FlexAD	Close involvement of stakeholders
		FlexE	Open information exchange among different groups
		FlexL	possible alternatives
		FlexG	Contingency planning
		FlexH	Seizing opportunities and coping with threats
	How-organisation	FlexK	Visualised project planning and progress
		FlexN	Continuous learning
		FlexD	Self-steering of the complete project team
		FlexF	Shared interface management
		FlexI	Trust among involved parties
		FlexAA	Management support
		FlexM	Network structure rather than hierarchical structure
Who		FlexR	Team priority over individual priority
		FlexS	Team members as stakeholders
		FlexAC	Delegation of responsibilities to team level
		FlexO	Consensus amongst team members
		FlexP	Stable teams
When		FlexU	Short feedback loops
		FlexV	Continuous locking (iterative)
Where		FlexY	Joint project office

8.6.1.2 Project performance indicators

The same process was performed for the validation of the formative indicators to the five second-order variables of project performance (the dependent variable). At first, the indicators with more than 5% missing values were eliminated as suggested by Hair et al. (2013a). From the 25 indicators, 11 indicators had more than 5% missing values. The remaining 14 indicators were checked on their contribution to their constructs. Among all, 'finished within budget' had a negative coefficient value. The negative sign of the coefficient value means that the indicator does not contribute to the construct in the same direction as the other indicators belonging to the same construct. Hence this indicator was eliminated. It can be said that the cost performance criteria (finished within budget) might belong to another construct. However, it is out of the scope of this research to regroup the performance criteria. The rest of indicators were kept in the model although some had small coefficients and were not significant. This was decided because 'project performance' was not the primary focus of the research and the constructs were taken from earlier research. According to Hair et al. (2013a) it is possible to retain indicators with small positive coefficients if a prior research already proved the inclusion of indicators to their constructs. In this case the five constructs of project performance were concluded from an exploratory factor analysis (Khan et al., 2013). At the end the five constructs of project performance were formed by 13 indicators (see Table 8-4).

Table 8-4: Confirmed performance indicators (success criteria) to their constructs

Construct	Label	Success criteria
Project efficiency	Prf A	Finished on time
	Prf C	Minimum number of agreed scope changes
	Prf D	Activities carried out as scheduled
	Prf E	Met planned quality standard
	Prf F	Complied with environmental regulations
	Prf H	Cost effectiveness of work
Organisational benefits	Prf I	Learned from project
	Prf J	Adhered to defined procedures
	Prf M	New understanding/Knowledge gained
Project impact	Prf O	Project achieved its purpose
Future potential	Prf S	Motivated for future projects
	Prf T	Improvement in organisational capability
Stakeholder satisfaction	Prf X	Met client's requirement

8.6.1.3 *Project complexity indicators*

After checking the missing values, 'diversity of project management tools/methods' and 'diversity of languages and nationalities' had more than 5% missing values. Hence both were eliminated from the measurement model. Not all complexity elements' coefficients were positive on their constructs. The elements with negative coefficients were removed from the measurement model. At the end 11 indicators defined three constructs of complexity. For simplifying the interpretation of results, the data from the complexity variables were scaled reversely meaning that in the range of 1 to 5, 1 corresponded to more complex situations and 5 corresponded to less complex situations. The confirmed elements of complexity and their constructs (clusters) are presented in Table 8-5.

Table 8-5: Confirmed elements of complexity to their constructs

Cluster	Label	Complexity element
Technical Complexity	Cmplx A	Clarity and certainty of project goals
	Cmplx B	Clarity and certainty of tasks and their dependencies
	Cmplx R	Project duration
Organisation complexity	Cmplx D	Number of contracts
	Cmplx H	Lack of trust
	Cmplx I	Size of project team
	Cmplx K	Availability of required experiences in the organisation
	Cmplx T	Information availability
External complexity	Cmplx G	Stability of project environment
	Cmplx P	Company strategies/internal-support
	Cmplx V	Number of financial resources

8.6.1.4 *Formative-formative measurement model*

The whole model includes a formative-formative measurement model since the lower order and higher order constructs are all formative. A formative-formative type of model, apart from the logic behind the model, is useful to structure complex formative constructs with many indicators into several sub-constructs (Becker et al., 2012). For assessing the effect of sub-constructs on the second order constructs, the repeated indicator approach (Becker et al., 2012) was used. For the PLS-SEM algorithm the analysis was performed using the inner path weighting scheme. To check the effect of sub-constructs on the latent variables (in this case 'how-attitude ', 'how-organisation' and 'who') bootstrapping of 5000 subsamples as suggested in the literature (Hair et al., 2013a) was performed. Bootstrapping is a nonparametric resampling method based on the main sample which does not impose the normality of sample distribution (Preacher and Hayes, 2008). In each bootstrap, a subsample with the same size (or bigger) as the main sample with replacement is drawn (Hair et al., 2013a). The results revealed that all the sub-constructs' weights are significant on their latent variables (Figure 8-3). Also, the three sub-contracts of project complexity (technical, organisational and external) as well as the five sub-constructs of project performance (efficiency, organisational benefit, project impact, future potential and satisfaction) have loaded significantly on their latent variables (project complexity and project performance).

8.6.2 STRUCTURAL MODEL

Using software SmartPLS version 2,0, (Ringle, Wende and Will, 2005) the structural model was evaluated to test the hypotheses. The analysis was performed by calculating the paths' coefficients and signs using a path weighting scheme. There are three structural model weighting schemes: the centroid weighting scheme, the factor, and the path weighting scheme. The path weighting scheme is the recommended one since it provides the highest R^2 value for endogenous latent variables (Hair et al., 2013a). Next, to determine the significance of the paths' coefficients, bootstrapping with 5000 subsamples for 111 cases was performed. The two-stage modelling process (Hair et al., 2013a) was followed: in the first stage, the measurement model was evaluated and in the second stage the structural model is being evaluated (testing of hypotheses). In the previous section, the multicollinearity among the indicators was checked. Hereby multicollinearity among the latent variables was checked using SPSS software. All VIF values range from 1.077 to 2.649 which are below the threshold value of 5. Then multicollinearity was not an issue.

The coefficient of determination R^2 and predictive relevance Q^2 were checked for the structural model. The Q^2 value of project performance as the dependent variable was greater than zero (Q^2= 0.534) which means that the predictive relevance of the structural model is met. A Q^2 value above zero indicates that the structural model has a positive significant level of predictive validity on the dependent variable, which is 'project performance' in this case. The R^2 value of the dependent variable (project performance) is 0.560 which means the structural model accounts for 56% of the variance in project performance. This proves the predictive accuracy of the structural model.

8.6.2.1 *The effect of project management flexibility on project performance*

The full structural model is presented in Figure 8-3. The results of the analysis revealed that both latent variables 'how-attitude' and 'how-organisation' have positive significant effects on project performance (H2-1: 0.352, $p<0.001$ and H2-2: 0.282, $p<0.05$). This means that hypothesis 2 (project management flexibility in terms of process (how) has a positive effect on project performance) is supported by the statistical analysis. The other four hypotheses were rejected. Although the hypotheses regarding the positive effect of 'what', 'who', 'when' and 'where' were rejected, all of these latent variables showed a positive effect on project performance.

As can be seen in Figure 8-3, complexity (as a control variable) has a significant effect on project performance. As it was discussed in the previous section, complexity indicators were scaled reversely, so the positive sign of the relationship indicates that a 'less complex project' results in 'better project performance'.

8.6.2.2 *The relative effect of first-order constructs (sub-constructs)*

It was discussed that for the sake of reducing the model complexity, the indicators belonging to the latent variables 'how-attitude', 'how-organisation' and 'who' as well as the control variable 'project complexity' and the dependent variable 'project performance' were grouped in sub-constructs. Now the relative effect of sub-constructs on their latent variables is explained.

The latent variable of 'how-attitude' is formed formatively by three sub-constructs: 'open attitude', 'wide approach' and 'proactive attitude'. The effects of these three sub-constructs are almost the same (coefficients are 0.383, 0.385, 0.397).

The latent variable of 'how-organisation' is also formed formatively by three sub-constructs: 'facilitate planning', 'outer organisation' and 'inner organisation'. Among the three, 'facilitate planning' and 'outer organisation' had slightly stronger effects (0.462 and 0.446) on their latent variable than 'inner organisation' (0.377).

The latent variable of 'who' is formed formatively by two sub-constructs: 'team structure' and 'team collaboration'. The effect of both sub-constructs are very close to each other (0.573 and 0.566).

8.6.3 Alternative structural models

The path coefficients and significant results from SEM-PLS analysis are calculated relatively (i.e. in comparison to other relationships in the model). It might be the case that by removing the most dominant significant path from the model, other paths become significant. Hence it was decided to test the hypotheses individually. Apart from the revealed significant effect of 'how' flexibility on project performance, the effect of 'what', 'who', 'when' and 'where' were checked separately.

As shown in Figure 8-4, the results revealed that every single relationship is significant when the other relationships are removed from the structural model, hence indicating the importance of each of these constructs (see Section 8.8, discussion).

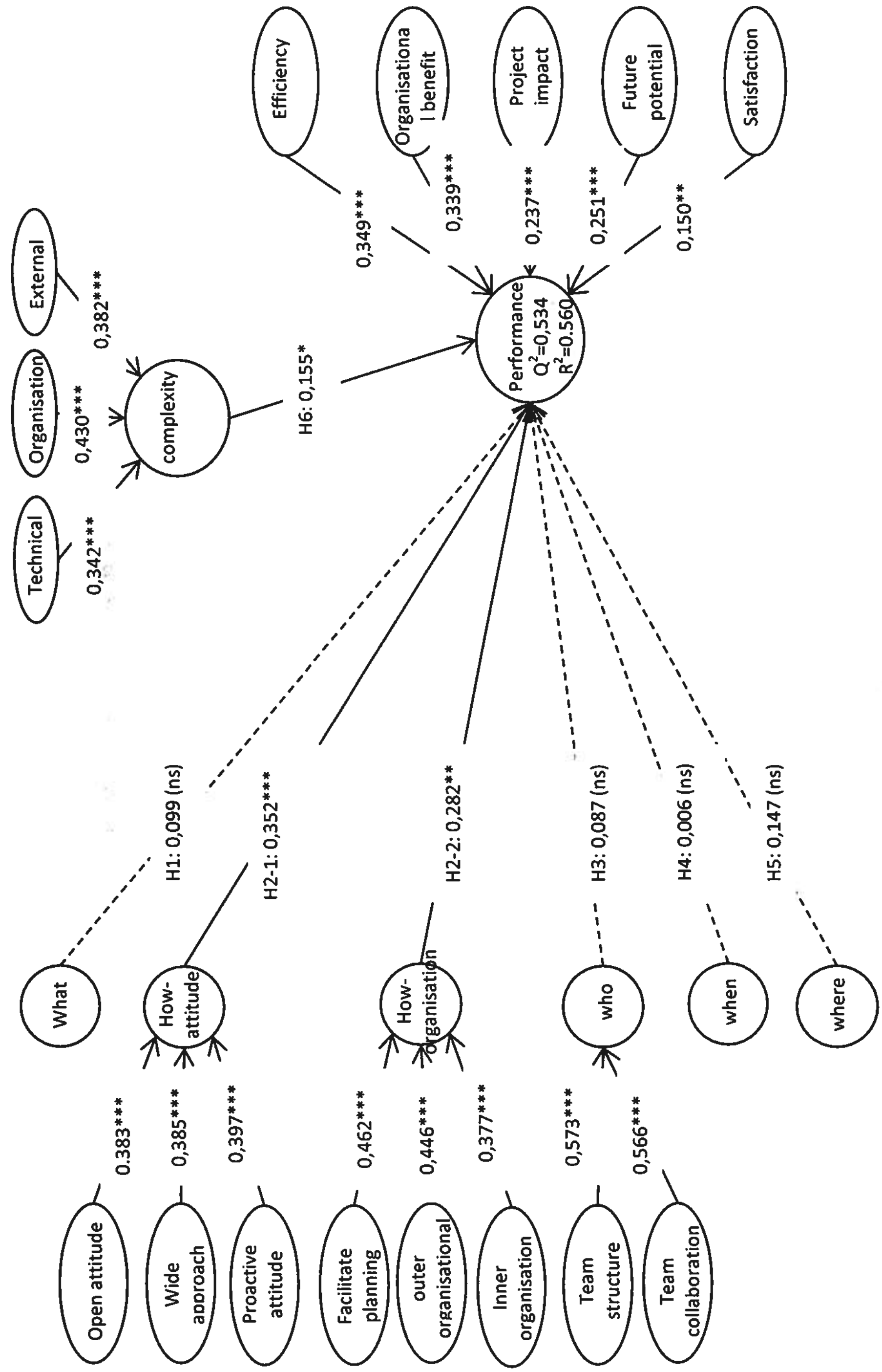
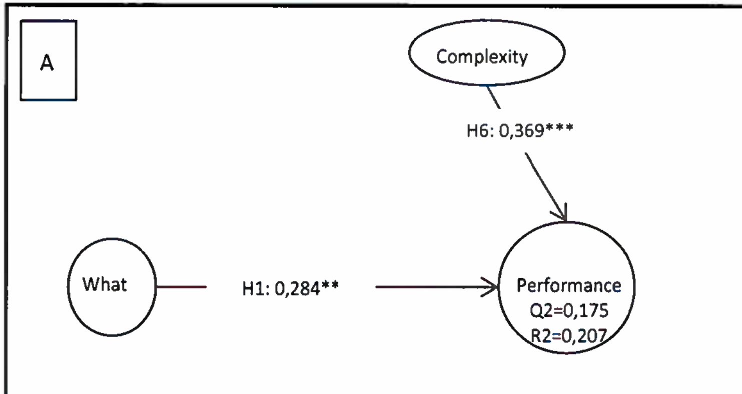
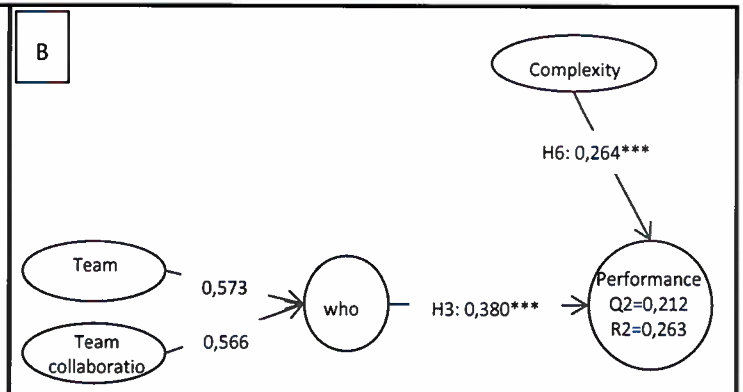


Figure 8-3: Structural model

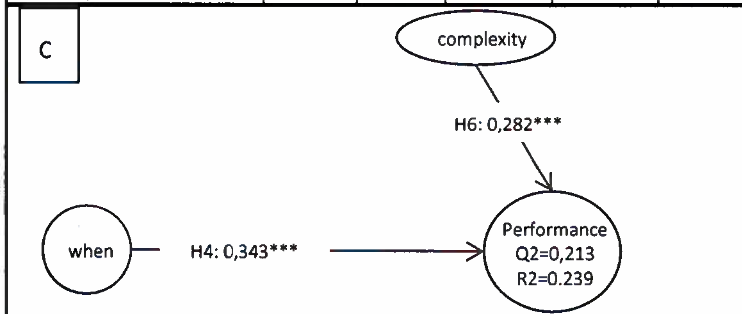
(*: p<0.05 (t>1.96), **: p<0.01 (t>2.58), ***: p<0.001 (t>3.29), ns=not significant)



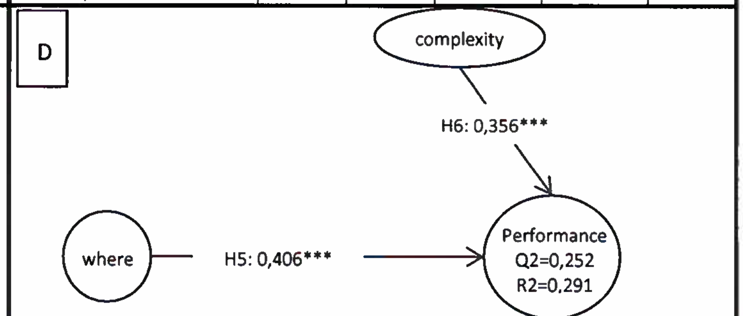
	Original Sample	Sample Mean	Standard Deviation	Standard Error	T-value
complexity -> performance	0.3691	0.3685	0.0674	0.0674	5.4737
What -> performance	0.2835	0.2846	0.0859	0.0859	3.3015



	Original Sample	Sample Mean	Standard Deviation	Standard Error	T-value
complexity -> performance	0.2637	0.2628	0.0677	0.0677	3.8968
Who -> performance	0.3802	0.38	0.0778	0.0778	4.8843



	Original Sample	Sample Mean	Standard Deviation	Standard Error	T-value
complexity -> performance	0.2821	0.2836	0.0668	0.0668	4.2257
when -> performance	0.3434	0.3426	0.0771	0.0771	4.4559



	Original Sample	Sample Mean	Standard Deviation	Standard Error	T-value
complexity -> performance	0.3557	0.3531	0.0694	0.0694	5.1253
where -> performance	0.4058	0.4063	0.0887	0.0887	4.577

Figure 8-4: Alternative structural models

A: flexibility of ‘what’, B: flexibility of ‘who’, C: flexibility of ‘when’ and D: flexibility of ‘where’ (**: $p<0.01$ ($t>2.58$), ***: $p<0.001$ ($t>3.29$))

8.7 RESULTS: MEDIATION EFFECT OF PROJECT MANAGEMENT FLEXIBILITY

To test the mediation effect of flexible project management on the relationship between project complexity and project performance the bootstrapping approach was used. Literature suggests for 5000 bootstrap samples (Hair et al., 2013a). Following the process recommended by Hayes (2013) SPSS software using a macro code (PROCESS) was used for evaluation of the mediation effect. Since there are six flexibility areas acting as mediator, multiple mediation effects applies.

The analysis of bootstrapping of 5000 subsamples of 111 cases with 95% confidence intervals revealed that the mediation effect exists (total indirect effect coefficient= 0.1419, lower limit confidence interval=0.0245 and upper limit confidence interval= 0.2657) (see Table 8-6). Knowing the fact that mediation exists is not enough since the model includes multiple mediators. Hence it is important to know which mediator(s) mediate(s) the relationship.

Table 8-6: Mediation effect of flexibility areas on project performance

	Total effect		Direct effect		Indirect effect			
	Coeff.	p	Coeff.	p	point estimate		95% CI-LL	95% CI-UL
complexity -> Performance	0.252	0.0001***	0.11	0.042*				
Complexity -> 'what' flexibility -> performance					a_1b_1	-0,003	-0,024	0,013
Complexity -> 'how-attitude' flexibility -> performance					a_2b_2	0,040	-0,012	0,108
Complexity -> 'how-organisation' flexibility -> performance					a_3b_3	0,090	0,024	0,169
Complexity -> 'who' flexibility -> performance					a_4b_4	0,015	-0,011	0,049
Complexity -> 'when' flexibility -> performance					a_5b_5	0,001	-0,030	0,029
Complexity -> 'where' flexibility -> performance					a_6b_6	0,000	-0,029	0,028

It was found that project complexity has a significant relationship with project performance in an opposite way. It means that the lower complex the project, the better the project performance (coeff.=0.252, p=0.000 and t-value=3.971). Also it revealed that project complexity has significant effect on three flexibility areas: 'how-organisation' (coeff.=0.4934, p=0.000, t-value=5.222), 'who' (coeff.=0.3201, p=0.011, t-value=2.597) and 'when' (coeff.=0.2647, p=0.24, t-value=2.285). Among these three paths only 'how-organisation' has a significant effect on project performance (coeff.= 0.181, p=0.003, t-value=3.090). Because both a_3 and b_3 paths are significant, 'how-organisation' flexibility might play the mediator role in the relationship between project complexity and project performance. The mediation effect exists when the confidence interval does not include the value of *zero*. As it can be seen in Table 8-6, the results of bootstrapping analysis with 5000 subsamples on 95% confidence intervals revealed that 'how-organisation' flexibility mediates the effect of project complexity on project performance (coeff.= 0.09, CI=0.024 to 0.169). In addition, the results indicate that the direct effect of project complexity on project performance after including the mediation effect is still significant but smaller in coefficient value (coeff.= 0.110, p=0.043, t-value=2.051). This means that the mediation effect is partial mediation rather than full mediation (Figure 8-5).

The existence of mediation effect means that if 'how-organisation' flexibility applies in practice, the negative effect of project complexity on project performance becomes less.

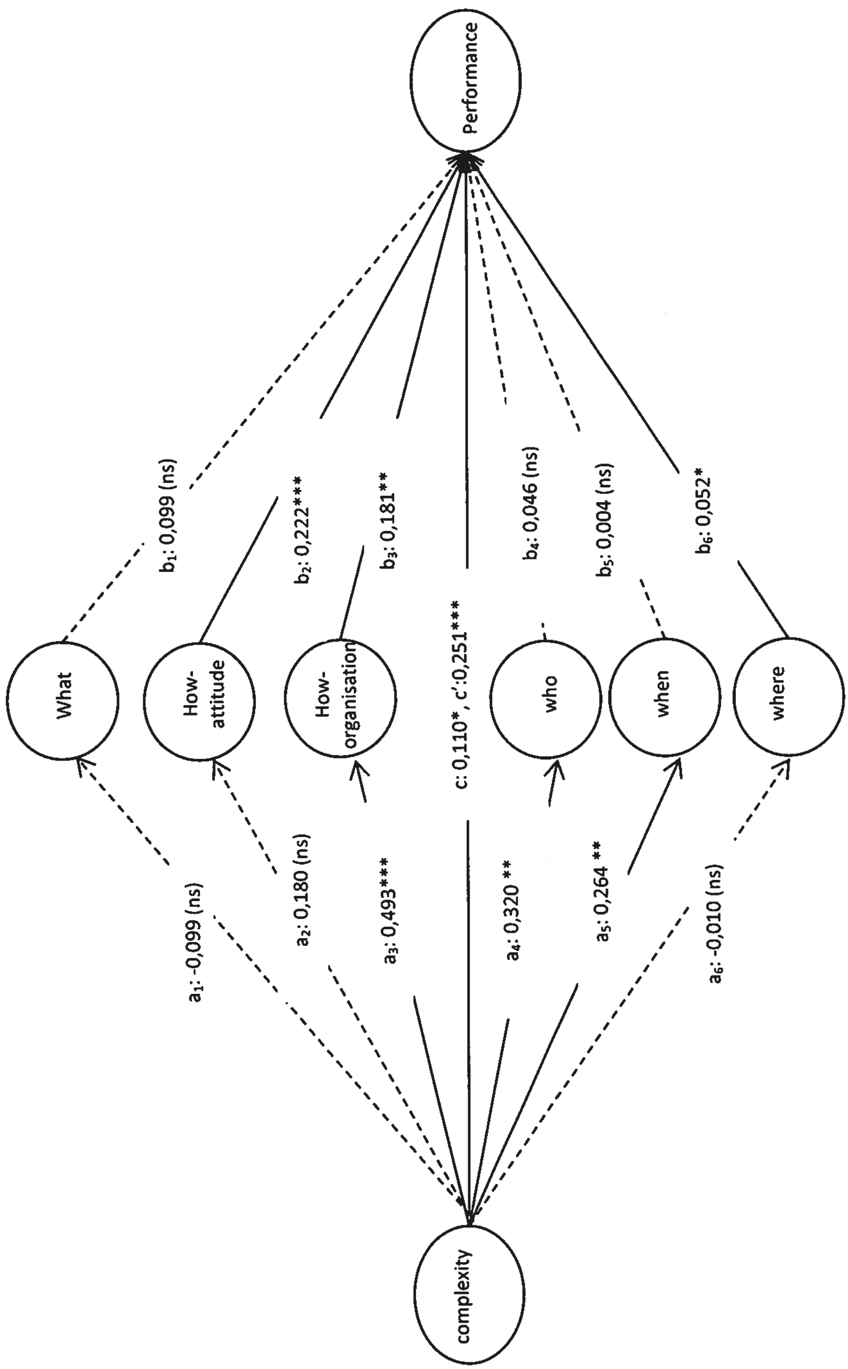


Figure 8-5: The mediation role of flexible project management

8.8 Discussion

Project management literature suggests to embed flexibility into the practice of project management (Geraldi, 2008; Geraldi et al., 2008; Osipova and Eriksson, 2013) to make it fit for nowadays complex projects (Hertogh and Westerveld, 2010). But so far, hardly any research had studied the effect of project management flexibility on project performance taking into account the project complexity. Therefore this research aimed at exploring the effect of project management flexibility on project performance considering the effect of project complexity on performance. This was done by means of statistical analysis using PLS-SEM.

In this section, the validation of latent variables and its indicators including the sub-constructs (Section 8.8.1) is discussed. Next, the validation of the structural model is discussed in Section 8.8.2 and the mediating role of flexible project management in Section 8.8.3. Further, the scientific contribution and managerial implications of the research (Section 8.8.4) and the limitations faced in the research are discussed (Section 8.8.5).

8.8.1 Defined constructs

Since the primary focus of this research is on validation of flexibility measures hereby we discuss the elimination of seven indicators. 'Embracing change' was weighted negatively on its latent variable which is 'what' flexibility. 'Embracing change' is one of the core values of Agile project management which is known as a flexible project management approach (Cobb, 2011). However, in context of infrastructure construction projects 'embracing change' especially when it comes to scope changes is less favourable (Jalali Sohi et al., 2017a; Jalali Sohi et al., 2017b; Sharma et al., 2017). Whyte, Stasis and Lindkvist (2016) in their research addressed challenges regarding the flexibility of managing changes in the context of complex projects. 'Standardised processes and design layout' weighted not significantly on 'how' flexibility. From earlier research, it was evident that 'standardisation' is interpreted differently by practitioners (Jalali Sohi et al., 2017b). They believe that 'standardisation' kills flexibility although the idea of 'standardisation' is to provide flexibility in terms of choosing the right 'standard' based on the situation (Giezen, 2012).

'Self-assigned tasks to individuals' was weighted negatively on its latent variable 'who' flexibility. Research shows that 'self-assigned tasks to individuals' was ranked relatively low from practitioners' perspective based on its importance to make project management more flexible (Jalali Sohi et al., 2017b). This explains why it is not weighted significant on its construct but the fact that it weighted negatively might be because it belongs to a different flexibility construct. But since PLS-SEM does not exploratory factor analysis, it is impossible to confirm it. Two indicators, 'locking decisions at the last responsible moment' and 'minimize upfront planning' were negatively contributing to the latent variable 'when' flexibility. This could have been expected given earlier results (Jalali Sohi et al., 2017b) that showed very different interpretations of practitioners for these enablers. Indicator 'iterative delivery' is also weighted negatively on 'when' flexibility. 'Flexible desks' is weighted not significant on 'where' flexibility. These two indicators were also ranked relatively low from practitioners perspective in earlier research. Overall it can be said that the seven indicators which did not positively significant contributed to their constructs might contribute to other constructs. Hence it is only possible to check whether the indicators belong to their latent variables or not. This requires further research to validate the significance of these seven indicators on other flexibility constructs.

It was said before that for sake of simplifying the research model, where the latent variables were formed by a relatively higher number of indicators, the indicators were clustered to sub-constructs. As it was mentioned in Section 8.6.2.2, all sub-constructs' effect was significant on their latent variables. And it was evident that the effect size of sub-constructs belonging to each latent variable were almost the same. In such condition, no priority can be given to any of the sub-constructs belonging to one latent variable. Only in case of latent variable 'how-organisation' the effect size of 'inner organisations' is smaller than the other two sub-constructs (outer organisation and facilitate planning). This means that 'how-organisation' flexibility is influenced relatively higher by 'outer organisation' and 'facilitate planning' rather than by 'inner organisation.

8.8.2 EVALUATING THE HYPOTHESES

Among the six hypotheses regarding the existence of positive relationships between project management flexibility and project performance (see Table 8-8), only two were supported; 'how-attitude' and 'how-organisation' (see Table 8-7). In general we can say that flexibility of 'how' has a significant positive effect on project performance. The significant positive relationship here means that the higher the flexibility of 'how', the better the project performance. The existence of this significant relationship is supported by the literature. Suprapto et al. (2015a) conclude that relational attitude, joint team capability and collaborative practices have a significant positive effect on project performance through the mediation effect of teamwork quality. 'Interactive decision making' and 'close involvement of stakeholders' in our research model could be seen as equivalent to 'joint working' and 'team integration' in their research model. The effect of 'management support' on project performance is also confirmed in their research model (in the positive effect of relational attitude which includes senior management commitment as a sub-construct).

Several studies, including the research performed by Ping, Xiaoyan, Zhaofang and Lamei (2016), prove that 'trust' also has a positive effect on project success. They also mentioned that asymmetric information between the parties has a relationship with an opportunistic view (trust). 'Asymmetric information' partly supports the idea of 'open information exchange' in our research model. Other research proved that adequacy of available information plays an important role in uncertainty and complexity of projects (Pich et al., 2002). Ralph, SangHyun, Carl, Samin and Seungjun (2016) researched the effectiveness of shared interface management on dealing with project complexity. The effect of interface management was proven in dealing with project complexity in their research. It is also evident that project complexity affects project performance (Bosch-Rekveldt, 2011). This can confirm why 'Shared interface management' in our research model was significantly weighted in its construct and consequently the significant relationship of its latent variable with project performance. The role of lessons learned on performance is also highlighted in the literature (Cooper, Lyneis and Bryant, 2002). Hence it is concluded that the empirical results in this study (the existence of a significant positive relationship between 'how' flexibility enablers and project performance) are supported in literature studying the effects of individual indicators on project performance.

Table 8-7: Flexibility of 'how' including its constructs and enablers

How	How-attitude	Open attitude	Interactive decision making
			Close involvement of stakeholders
		Wide approach	Open information exchange among different groups
			possible alternatives
		Proactive attitude	Contingency planning
			Seizing opportunities and coping with threats
	How-organisation	Facilitate planning	Visualised project planning and progress
			Continuous learning
		Outer organisation	Self-steering of the complete project team
			Shared interface management
			Trust among involved parties
		Inner organisation	Management support
			Network structure rather than hierarchical structure

The other four hypotheses, regarding the relationships between flexibility of 'what', 'who', 'when' and 'where', were not supported by statistical analysis using the complete model. It was mentioned that the path coefficients in PLS-SEM are calculated relatively (in comparison to all paths in the model). Hence by removing any (combination) of the paths from the model, the overall results would be different as indeed shown when testing the hypotheses individually (Section 8.6.3). It was evident that the single relationships of the flexibility clusters (latent variables) were all positive and significant. What does this mean? First of all, because the analysis is done relatively, the dominant relationship reveals as significant in the complete model. Hence, compared to the most dominant one (the how enablers), the other relationships are not significant. Secondly, this result could be influenced by the complexity of the whole model (structural and measurement). The main model consists of latent variables with a different number of indicators ranging from 1 to 7. The latent variable with more indicators might come out as significant compared to the latent variable with only one indicator. In this model the latent variable of 'where' was formed with only one indicator, the latent variable of 'what' with two indicators and the latent variable of 'when' also with two indicators. These numbers of indicators per latent variable are low compared to the latent variable of 'how-attitude' with six indicators and 'how-organisation' with seven indicators. The third reason might be because of the sample size. Although the sample size was enough according to the 10-times rule, it might not be enough taking into account the overall model's complexity.

The relative importance of 'how' flexibility over the other four areas of flexibility was also confirmed in Chapter 7 of this dissertation. The research on exploring the practitioners' perspectives on flexible project management showed that indicators related to the flexibility enablers of 'where' ranked low compared to other indicators (Jalali Sohi et al., 2017b). The same applies to the flexibility enablers of 'when'. The overall ranking of the indicators belonging to the flexibility enablers of 'what' is lower compared to the flexibility of the 'how' enablers but higher compared to the flexibility of 'where' (Jalali Sohi et al., 2017b).

The 'what' flexibility was formed by indicators regarding the scope definition and contractual flexibility. The research by Suprapto, Bakker, Mooi and Hertogh (2016) showed that 'contract types' has no direct relationship to project performance. Although this research did not point explicitly to contractual flexibility, the contract types in the sample were different in terms of flexibility (reimbursable contracts are much more flexible than lump-sum contracts).

The effect of project complexity on project performance revealed to be significant. The complexity indicators were scaled reversely and the sign of relationship was positive. This means that the less complex the project, the better the project performance. This was previously confirmed in other researches (Antoniadis et al., 2011; Bosch-Rekveldt, 2011). Complexity was considered as a control variable in the whole research model. The existence of this relationship together with the effect of 'how' flexibility means that while complexity has a contrary significant effect on project performance, the flexibility of 'how' has a positive effect on project performance.

Table 8-8: Overview of hypotheses and the results

#	Hypothesis	Results of testing
1	Project management flexibility in terms of project scoping and contracting (what) has a positive effect on project performance.	Rejected
2	Project management flexibility in terms of process (how-attitude) has a positive effect on project performance.	Supported
3	Project management flexibility in terms of process (how-organisation) has a positive effect on project performance.	Supported
4	Project management flexibility in terms of project team organisation (who) has a positive effect on project performance.	Rejected
5	Project management flexibility in terms of scheduling the project and task delivery (when) has a positive effect on project performance.	Rejected
6	Project management flexibility in terms of location of team (where) has a positive effect on project performance.	Rejected
7	Project complexity has a contrary effect on project performance.	Supported
8	The negative effect project complexity has on project performance is mediated by flexibility of 'what'.	Rejected
9	The negative effect project complexity has on project performance is mediated by flexibility of 'how-attitude'.	Rejected
10	The negative effect project complexity has on project performance is mediated by flexibility of 'how-organisation'.	Supported
11	The negative effect project complexity has on project performance is mediated by flexibility of 'who'.	Rejected
12	The negative effect project complexity has on project performance is mediated by flexibility of 'when'.	Rejected
13	The negative effect project complexity has on project performance is mediated by flexibility of 'where'.	Rejected

8.8.3 Mediating role of Flexible project management

While the negative effect of project complexity on project performance was confirmed, it is important to know if flexible project management can mediate this effect. Overall six hypotheses were formulated regarding the mediation effect of flexibility. In Section 8.8.2 it was discussed that both 'how-attitude' and 'how-organisation' have a significant positive effect on project performance. But the mediation analysis revealed that only 'how-organisation' can mediate the effect of project complexity on project performance among all possible mediation effects (see Table 8-8). This means that if indicators belonging to 'how-organisation' flexibility would be applied in practice the negative effect of project complexity is significantly mediated. However, it is not possible to tell the effect of which complexity category (technical, organisation or external) or which complexity aspects will be mediated because complexity was treated as one single independent variable.

8.8.4 Scientific contribution and managerial implications

So far, no literature was found on evaluating the direct effect of project management flexibility on project performance. This research contributes to filling this gap and provides a base for further exploration of flexible project management.

Prior research showed that project management in the practice of infrastructure construction projects has some degree of flexibility but implicitly (Jalali Sohi et al., 2017a) see also Chapter 7. By this research it was proven that among the five areas of flexibility (what, how, who, when and where) the 'how' flexibility had a significant effect on project performance. Translating this into practice means that if practitioners would increase the flexibility in terms of 'how' in their management practice, their project performance could improve significantly. This can be operationalized by embedding the indicators of 'how' flexibility in their daily practice. For example, when stakeholders are closely involved and decisions are made interactively with them, there is an 'open attitude' among the parties in the project which improves the performance by improving stakeholders satisfaction (Edelenbos and Klijn, 2006). By seizing the opportunities and coping with threats and considering contingencies, the risk management improves which also affects project performance positively. These were a few examples that show how the indicators belonging to 'how' flexibility contribute to better project performance.

From the research, it was also concluded that the four other areas of flexibility have a positive effect on project performance, but not significant compared to flexibility of 'how'. This suggests that if the other flexibility indicators belonging to the 'what', 'who', 'when' and 'where' categories are applied in practice, the project performance would be improved, albeit <u>not</u> significantly. This only applies for the indicators which showed a positive contribution to their latent variables. An example is to define the scope of the project in terms of broad tasks, rather than pre-defined work packages (flexibility of what). Defining detailed work packages is not adding value to the project, given the risks that might occur and scope changes that might happen in the project. By defining broad tasks, there is still room to manoeuvre. Other examples are related to delegating responsibilities to the team level, establishing stable project teams and building consensus among team members (team structure in flexibility of who). These are assumed to improve teamwork conditions and consequently the project performance might improve positively.

Project complexity as a control variable was shown to have a contrary significant effect on project performance. Hence in case the project is complex, still the effect of 'how' flexibility on project performance is significant. This implies that the positive effect of 'how' flexibility on project performance exists while the project has any degree of complexity.

8.8.5 LIMITATIONS

This part of the research faced some limitations. The first limitation is about the number of data points (sample size) and the hypotheses. A considerable sample size was required to test the relationships between the areas of flexibility (what, how, who, when and where) and the five clusters of project performance. Hence it was decided to simplify the model by including project performance as one dependent variable with five sub-constructs rather than using the five categories of success criteria as dependent variables. Considering the 10-times rule, a sample size of 250 respondents (5 (clusters of flexibility) × 5 (clusters of project performance) × 10) would have been required to test all possible relationships among flexibility clusters and project performance clusters. Further research could focus on testing the effect of each flexibility area on each cluster of performance measures.

The second limitation of the research was the lack of supporting literature. The concept of flexibility in project management and its effect on project performance is not well-developed in the literature. To tackle this limitation, PLS-SEM was used, which is appropriate for underdeveloped research models.

Next, this research was performed in the Netherlands. Therefore the research result might be influenced by the Dutch culture. Further research is suggested to test the research model including an international sample size.

Next, as literature indicates (Bosch-Rekveldt, 2011), project complexity evolves during the project. Accordingly, the effect of project management flexibility might be different throughout the project lifecycle. In this research, the data was collected considering completed front-end phase of the project. Further research could focus on different stages of the project considering the degree of complexity.

Although it was concluded that only 'how' flexibility has a significant effect on project performance, it was revealed that all flexibility areas have significant positive effects if tested individually. Further research can evaluate the in-depth effect of each area of flexibility on project performance.

Because of uneven distribution of data from public and private sector, the role of the respondents, the project duration and the profile of the respondents, it was not possible to include any of these as control variables in the model. Further research can explore the effect of the specific project sector, the role of respondents, and the project duration on the relationship between flexibility and project performance.

PLS-SEM only performs confirmatory factor analysis. It might be the case that those indicators which were not weighted significantly on their constructs (and hence were removed from the measurement model) actually belong to other constructs. Consequently, subsequent research on exploratory factor analysis for flexibility indicators is required.

8.9 Conclusion

This research aimed at evaluation of the relationships between project management flexibility and project performance, the effect of project complexity on project performance and the mediating role of flexible project management. Earlier researches suggested an increased flexibility of project management (Geraldi, 2008; Koppenjan et al., 2011; Olsson, 2006; Osipova and Eriksson, 2013; Walker and Shen, 2002; Wirkus, 2016; Wysocki, 2007) but they did not explore the effect of such flexibility on project performance, which was explored in this chapter.

Using the SEM-PLS method, statistical analysis was performed on the data gathered from 111 surveys. PLS-SEM was chosen because it well fitted the research as the topic is not well-developed and PLS-SEM is appropriate for small sample sizes. Seven hypotheses were tested; six hypotheses regarding the relationship of the flexibility areas (what, how-attitude, how-organisation, who, when and where) on project performance and one hypothesis regarding the effect of project complexity on project performance. From all formulated hypotheses, two were supported. The flexibility of 'how' was shown to have a significant positive effect on project performance: the higher the flexibility of 'how', the better the project performance. Project complexity as a control variable also was shown to have a significant effect on project performance but in opposite direction: the less complex the project, the better the project performance. The control effect of project complexity in the model means that the flexibility of 'how' has a significant positive effect on project performance, even if the project is complex.

The hypotheses regarding the relationship between 'what', 'who', 'when' and 'where' flexibility and project performance were not supported in the overall model, but when tested individually, all effects turned out to be significant. This might happen because PLS-SEM calculates the significance of existing paths in the model relatively (in comparison to each other) and not all latent variables (flexibility areas) had the same amount of indicators. Further research can explore the significance of each of these four relationships. Given the individual significant results, one might consider applying them in practice, still.

The mediating role of flexible project management on the relationship between project complexity and project performance was studied. The results showed that only 'how-organisation' flexibility mediates the negative effect of project complexity on project performance.

This research contributes to filling the gap in literature about the relationship between project management flexibility and project performance. Practitioners can benefit from it by embedding the flexibility indicators belonging to 'how' flexibility into their practice, as it is further elaborated in Chapter 9.

Next step

After exploring the enablers of flexibility in project management in Chapter 5, practitioners' perspectives regarding the flexible project management (Chapter 6), the evidence of project management flexibility in practice (Chapter 7), and effect of flexibility on project performance (Chapter 8) were studied. It was also studied whether flexibility measures played a mediating role in the effect of project complexity on project performance. The final step of this research is bringing all these aspects together and translating it into a practical framework to answer the main research question.

Chapter 9: CLOSURE

Abstract

Increased project complexity, project dynamics and changes in clients' requirements are a few examples that suggested the necessity of flexibility in project management to deliver successful projects. Therefore this research aimed at investigating how project management could become flexible and whether such flexibility would improve project performance.

The main research question was: *how could flexibility in project management improve project performance in complex infrastructure projects in their early phases?* This main question was answered by proposing a flexibility framework. This framework comprises four stages: understanding the current situation, practitioners' perspectives on flexible project management, choosing enablers to become flexible, applying selected enablers to improve project performance and managing project complexity.

This chapter starts by recapping the results of all chapters and bringing them together. Further, it elaborates on the answer to the main question by answering all research sub-questions. Also, research limitations, scientific contribution and managerial implications are explained. Finally, recommendations for further research are given.

9.1 Bringing it together

Throughout this PhD research six research sub-questions were answered in different chapters. Hereby the achieved results in all chapters are recapped in the form of a framework called as the 'Flexible project management framework' (Figure 9-1). The framework includes four steps that logically follow each other in an iterative way. Here the four steps of the framework are explained by linking each to the referred chapter of the thesis (see also Table 9-1).

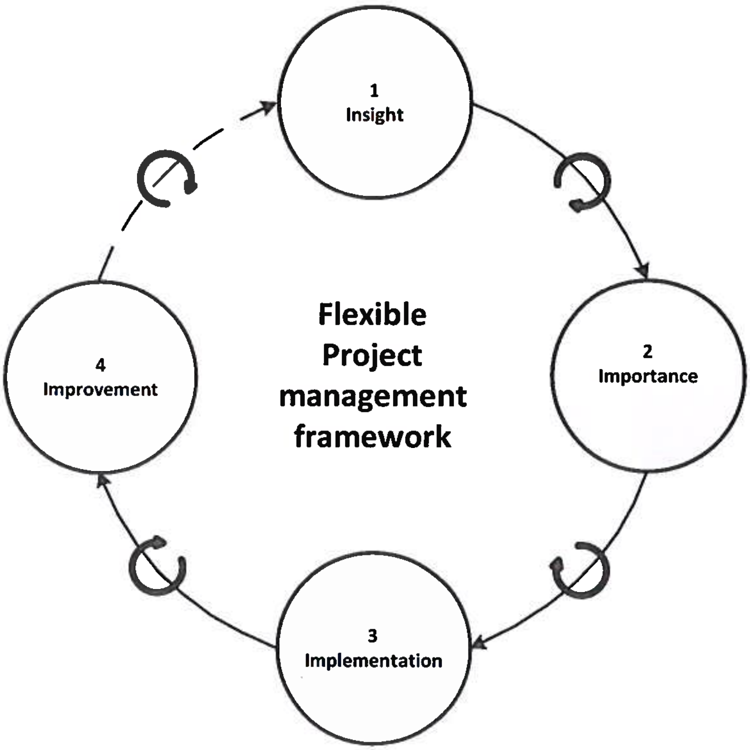


Figure 9-1: Flexible project management framework (main steps)

- Step 1: Insight

  As the name suggests, the goal of this step is to create insight about the project complexity and applied project management approaches in current practice. Project complexity is important to be understood and investigated to be managed well. It was mentioned in Chapter 2 that there should be a fit between project complexity and project management. As discussed in Chapter 3, two main extremes are recognised in project management: a pure waterfall approach versus a pure Agile approach. Practitioners can apply either the pure approaches or any hybrid version. Whatever approach is applied, it is important to be aware of where the current approach fits in the spectrum from pure waterfall to pure Agile.

This step is directly linked to Chapter 3 where the comparison between waterfall project management and Agile project management was made and Chapter 4 in which the relationship between Agile project management and project complexity was investigated.

- Step 2: Importance

This step is about investigating the practitioners' perspectives regarding flexible project management. The input of this step comes from Chapter 6. Based on what practitioners find important to make project management more flexible, three distinct perspectives were derived: flexibility by 'Trust', 'Scope flexibility by contractual flexibility' and flexibility by 'Proactive management'. Each perspective gives higher priority to certain flexibility enablers. One of the most outstanding results of this study was that the perspectives of practitioners who work as clients were the same as perspectives of practitioners who work at engineering consultancy organisations. In this step of the framework, it is suggested to understand which of these perspectives exist in the project team in order to facilitate collaboration.

Different perspectives might co-exist in any project team and perspectives might change over time. The goal is to understand which perspectives exist (make it explicit) and what is felt important for the project. While the first step in the framework was about creating insight in the awareness of the applied project management approach, the second step is about creating awareness of the practitioners' mind-sets.

- Step 3: Implementation

By getting insight in the awareness of what is in place for the project management and what the mind-sets of people are, the foundation for making project management flexible is ready, but this needs to be implemented. Statistical analysis (Chapter 8) showed that in total 23 enablers of flexibility contribute positively to five areas of flexibility (what, how, who, when and where). The proved contribution of these enablers to their flexibility area means that if they are applied in practice, the project management approach becomes flexible.

The implementation of enablers belongs to the flexibility of 'what', is about the scoping of the project: defining the project's scope into broad tasks rather than detailed work packages and based on the required function. Delivering tasks not necessarily results in delivering the function. The emphasis should be put on the function in order to deliver the value.

The implementation of enablers belonging to the flexibility of 'how', is about the attitude and the organisation.

In terms of attitude: decisions should be made interactively with the close involvement of stakeholders, information exchange should be open between the parties involved in the project and also information sharing should be enhanced, alternatives should be evaluated in terms of their relevance and the most relevant ones need to be kept on board, a proactive approach regarding opportunities and threats is required and also considering contingencies helps to deal with unforeseen circumstances.

In terms of organisation: the project team is suggested to be self-steered rather than being steered only by a project manager, managing interfaces as a shared task rather than being done by a project manager, building and maintaining trust among the involved parties, establishing management support from top management in the organisation and reducing the hierarchy in the organisation to form a more flat type of project organisation.

The implementation of enablers belongs to the flexibility of 'who', is about how to organise project team in terms of collaboration and structure.

In terms of team collaboration: establishing the mindset of team priority over individual priority and valuing team members by considering them as valued stakeholders in the team

In terms of team structure: delegating responsibilities to team members, reaching consensus in key decisions among the team members and establishing stable team rather than building the team per project.

The implementation of enablers belonging to the flexibility of 'when', is about having short feedback loops and locking (fixing decisions) continuously in an iterative way.

The implementation of enablers belonging to the flexibility of 'where', is about establishing a joint project office (either physically or virtually) for the project team.

- Step 4: Improvement

In this step, two approaches will be taken. The first approach is to aim for improving project performance regardless of the complexity of the project at hand. In Chapter 8 it was proven that flexibility of how (including 'how-attitude' and 'how-organisation') has a positive significant effect on project performance. It means that if 'how' flexibility is applied in practice, the performance of the project will improve significantly. The second approach is to deal with project complexity by making project management flexible. To do so, it is suggested (again based on statistical analysis) to apply specifically 'how-organisation' flexibility enablers in practice.

'How-attitude' flexibility enablers include: interactive decision making, close involvement of stakeholders, open information exchange among different groups, contingency planning, seizing opportunities and coping with threats, visualised project planning and progress. 'How-organisation' flexibility enablers include self-steering of the complete project team, shared interface management, trust among involved parties, standardise the process and design, possible alternatives, network structure rather than hierarchical structure, continuous learning and management support.

Step 3 was about practitioners' perspectives. What do these perspectives mean for step 4? The three distinct perspectives (trust, scope flexibility by contractual flexibility and proactive management) all include some high ranked enablers from the groups of 'how-attitude' and/or 'how-organisation' flexibility enablers. For example, in the perspective of 'trust' from the clients' point of view, 'shared interface management, 'open information exchange', 'visualised planning and progress', 'seizing opportunities and coping with treats', and 'possible alternatives' were ranked high. In the perspective of 'scope flexibility by contractual flexibility' from consultants' point of view, 'seizing opportunities and coping with treats', 'possible alternatives' and 'open information exchange' are three examples of flexibility enablers which ranked high. In the perspective of 'proactive management' from the clients' point of view, 'seizing opportunities and coping with treats', 'trust', 'self-steering of team' and 'possible alternatives' are ranked high. It can be seen that the same enablers like 'trust' ranked high in different perspectives.

So improving project performance seems possible regardless of the adopted perspective in step 3. Understanding the different perspectives among team members for any project is recommended in order to prioritize the application of flexibility enablers.

In the explanation of the steps (see also Table 9-1), it was mentioned that the framework has an iterative character. This appears not only in the sequence of the steps but also backward moves are possible. The iterative character of the framework helps continuous improvement in the practice as it is indicated in the literature about Agile project management (Augustine et al., 2005; Cobb, 2011).

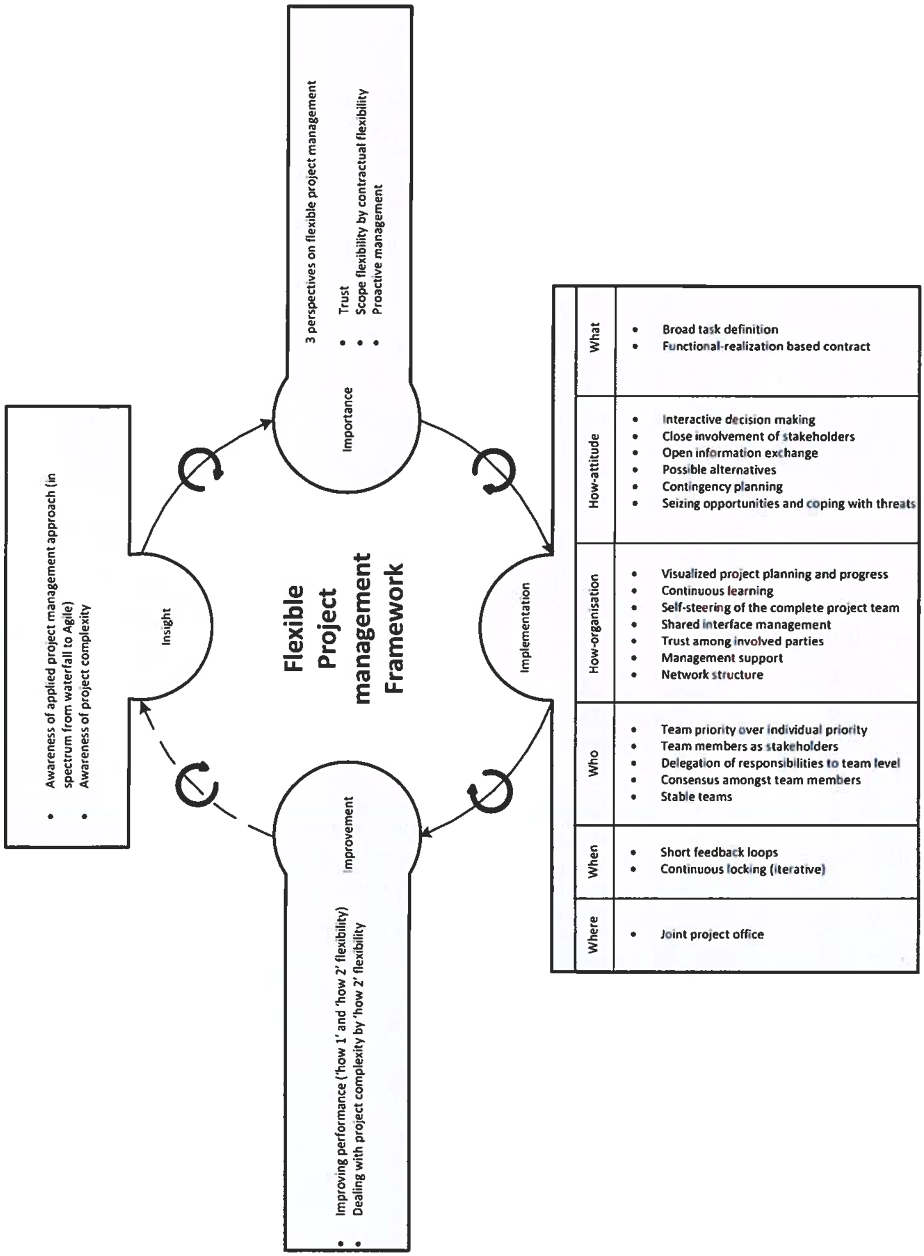


Figure 9-2: Flexible project management framework

Table 9-1: Flexible project management framework (steps, goal, main findings)

Step	Name	Goal	Main findings	Based on
Step 1	Insight	Creating insight in the awareness of applied project management approach Awareness of project complexity	Comparison between waterfall and Agile Correlation analysis	Chapter 3 Chapter 4
Step 2	Importance	Creating awareness of people mind-sets in what is important in making project management flexible	3 distinct perspectives: Trust Scope flexibility by contractual flexibility Proactive management	Chapter 6
Step 3	Implementation	Implementing a flexibility strategy	Framework of flexibility enablers: 23 enablers in 5 areas of flexibility	Chapter 8
Step 4	Improvement	Improving project performance regardless of project complexity	Flexibility of 'how-attitude' and 'how-organisation'	Chapter 8
		Improving project performance by dealing with project complexity	Flexibility of 'how-organisation'	

Terryn, Boelens and Pisman (2016) stated that developments in terms of projects become increasingly complex which makes the future of such developments hardly predictable. They argue that the existing theories and frameworks for evaluation and planning of such complex developments do not take into account the complexity and uncertainty. According to them, these frameworks have linear or circular logic, focussed on several feedback loops and assumed causal links in organisation, planning process and performance. What they propose as a solution is a situational approach based on the nature of planning issues and playing field. They believe where the playing field is highly dynamic, undefined and volatile, the developments needs to be highly open, flexible and innovative (Boussauw and Boelens, 2015; Terryn et al., 2016). In such conditions a co-evolutionary approach would be required. This, however, is not conflicting with the flexibility framework as presented in Figure 9-1.

In our research, the idea of flexibility in project management acknowledges the importance of iterative processes for the achievement of improvements based on short feedback loops.

Therefore the flexibility framework developed in this research, follows an iterative process, in a circular manner. The framework includes multiple and reverse arrows which acknowledge the iteration in any direction depending on the situational circumstances and required improvement actions.

9.2 CONCLUSIONS

As the title suggests, this research looked into flexibility of project management in the context of infrastructure projects in the construction industry. The objective of the research was to propose a project management flexibility framework based on relationships between project complexity, flexibility enablers and project performance by answering the main research question: *How could flexibility in project management improve project performance in the early phases of complex infrastructure projects?*

9.2.1 ANSWERS TO SUB-QUESTIONS

In order to answer the research main question several sub-questions are answered. Finally, the main question is answered.

1. *What is the evidence of project management flexibility in literature and practice?*

Chapter 2, Chapter 3 and Chapter 4 all provide partial answers to this sub-question, based on different starting points. Chapter 2 presents a literature study, Chapter 3 is based on exploratory case studies and Chapter 4 applies statistical analysis on data gathered from practitioners.

In Chapter 2, based on the literature review, it was discussed that flexibility is not new in project management but its recognition is increasing in recent years. Literature about project management flexibility goes in different directions: some articles highlight the importance of being flexible in project management, some other articles define flexibility and/or the areas in which project management can be flexible. The other direction in which flexibility is pinpointed is the required balance between control and flexibility in project management. Yet hardly any literature was found that investigates what enables flexibility, or in other words, how project management can become flexible.

One of the clearest evidence of flexibility in project management is Agile project management. Agile was born in IT (Information Technology) industry for software development projects. Agile believes that changes are inevitable and should be incorporated. To incorporate changes, project management needs to be flexible. Flexibility is the outstanding characteristic of Agile project management. In recent years the use of Agile spreads into other industries, the construction industry being one of them. Although Agile proved to be successful in the IT industry, its success in the construction industry is not proven yet. In searching for flexibility in project management practice, the use of Agile in the construction industry was investigated (Chapter 3 and Chapter 4).

Chapter 3 looked into the application of Scrum as an Agile tool in the early phases of infrastructure construction projects. This chapter had two objectives. First, projects which were managed using Scrum were compared to projects which were managed based on a waterfall approach. Second, practical application of Scrum was compared to what the theory suggests. Qualitative research was done on data gathered from 6 cases (3 Scrum projects and 3 waterfall projects) from one company in The Netherlands. Based on the comparison between Scrum-managed projects and waterfall-managed projects it was concluded that the application of Scrum resulted in a few achievements: meeting very strict deadlines, shorter learning curve for juniors, team motivation, team happiness, client satisfaction, short feedback loops and synergy in teamwork. Apart from these achievements, also challenges were faced in the application of Scrum: multitasking of team members, uncertainty about the benefits of Scrum, a high number of Scrum events (including meetings), and the level of client commitment to the Scrum process, life-cycle analysis and contractual agreements.

The research showed that the waterfall management approach performed well in some aspects like quality of end products, and has deficiencies in other aspects such as internal communication among team members, team integration, meeting restrict deadlines among others. Ideally, a fit-for-purpose project management approach would be available, and we hypothesize that such a fit-for-purpose approach could consist of a combination of conventional project management (waterfall) and Scrum.

To fulfil the second objective of this exploratory study a comparison was made between the theoretical application of Scrum and how it was applied in practice. Distinct differences were found in some aspects such as making the condition of client satisfaction explicit, team building process, visualising project planning and progress, close involvement of client, value definition and delivery and responding to change. The misalignment of theory and practice of Scrum enlightens a possible hypothesis: the full application of Scrum in infrastructure construction projects is not possible. This is because of differences between the context of infrastructure construction projects and software development in the IT industry where Scrum was developed. Such assumptions need further investigation, however, based on the research results, it was recommended to tailor Scrum to fit the type of projects in the construction industry.

In Chapter 4 the relationship between Lean & Agile project management and project complexity was explored. The objective of this chapter was to explore if flexible management approaches like Agile and some parts of Lean can help to cope with project complexity. Aspects of lean management which were assumed to contribute to flexibility were included in this part of the research, because Lean management and more specifically Lean Construction, has been introduced and used in the construction industry as a new management method aims at reducing waste (Aziz and Hafez, 2013; Marhani, Jaapar and Bari, 2012). Quantitative research was performed on data gathered from 67 completed surveys. First, factor analysis was performed to cluster the variables (project complexity elements and Lean and Agile elements) in more defined groups. Complexity elements were clustered into five categories labelling as: technical complexity, uncertainty, organisational complexity, stakeholders and external complexity. The lean and Agile elements were clustered into five categories labelled as: structure and integration, coordination, planning, resource allocation and communication. Next, the relationships between clusters of complexity and Lean and Agile were investigated by correlation analysis. Among the 25 possible relationships, eight significant, positive relationships were found. Based on this research it was concluded that elements of Lean and Agile like standardisation, self-assigned tasks to individuals, considering possible alternatives and visualised planning were implicitly applied in practice. Their application was implicit since the practitioners could not recognise them as Agile and Lean management practices. Their implicit usage showed a relation with project complexity and thus it can be said that elements of Lean and Agile could help to cope with project complexity.

2. *What are project management flexibility enablers?*

Based on a combination of literature review and interviews with practitioners, Chapter 5 provides the answer to this sub-question.

Although literature highlights the importance of flexibility in project management (Kreiner, 1995; Olsson, 2006; Sager, 1990) and shed light on the balance between control and flexibility (Geraldi, 2008; Osipova and Eriksson, 2013; Wysocki, 2007), yet no scientific publication provided an inclusive list of flexibility enablers. With enablers, the managerial actions that can be applied in practice are meant. Accordingly, flexibility enablers refer to the managerial actions that, if applied in practice, allow project management to become flexible.

Hence the enablers were extracted from various sources in literature, each highlighting specific research areas. The flexibility enablers were grouped based on the areas of flexibility suggested in the literature (what, how, who, when and where) (Osipova and Eriksson, 2013). The five areas and their definitions are presented in Table 9-2. Because no prior research investigated the validity of flexibility enablers, it was decided to validate them by means of interviews with practitioners. In this phase 14 interviews were performed. After qualitative data analysis, the list of enablers was refined to 26 flexibility enablers in the earlier mentioned five areas of what, how, who, when and where.

Table 9-2: Areas of flexibility and their definitions (Osipova and Eriksson, 2013)

Areas of flexibility	Definition
What	Ability to define and change the scope and goals of the project (contract flexibility)
How	Ability to define and change the implementation process (tools and instrumental flexibility)
Who	Ability to define and change who is carrying out the project tasks (human resource flexibility)
When	Ability to define and change the time constraints for different tasks (schedule flexibility)
Where	Ability to define and change where the tasks are performed (location flexibility)

'What' flexibility is the ability to be flexible in terms of project goals and scope. Three enablers belong to 'what' flexibility: broad task definition, embrace and facilitate change, and functional realisation based contract.

'How' flexibility is the ability to be flexible in terms of the implementation process. The identified enablers in this area are: self-steering project team, open and demand-driven information exchange, shared interface management, contingency planning, seizing opportunities and coping with threats, trust, standardised process and design, visualised project planning and progress, possible alternatives, network structure, and continuous learning.

'Who' flexibility is the ability to be flexible in the project team. The identified enablers in this area are: consensus among team members, stable teams, self-assigned individuals to tasks, considering all team members to be skilled in team management, and considering all team members as valuable stakeholders in the team.

'When' flexibility is defined as the ability to be flexible in terms of scheduling. The main driver here is the iterative process of scheduling. This area of flexibility includes enablers: locking at the last possible moment, short feedback loops, continuous locking, iterative planning and iterative delivery.

'Where' flexibility is defined as the ability to be flexible in terms of location of the project team. The only two verified enablers in this area are: joint project office and flexible desks.

3. *What are the practitioners' perspectives regarding flexible project management?*

After the identification of the flexibility enablers in Chapter 5, the next step was to identify the practitioners' perspectives regarding flexible project management in Chapter 6 using Q-methodology. This methodology allows for studying topics with a subjective character. To study the differences between client and consultancy organisations three organisations from each were selected. In total 43 practitioners (21 from client organisations and 22 from consultancies) were participating in the research.

The data analysis revealed 3 parallel perspectives per organisation type (client and consultancy). The first perspective appears in both organisation types named as 'Trust' which means trust and its related enablers ranked high as distinguishing statements for this group of practitioners regardless of the fact that they work for client or consultant organisation. However, also some differences were found. High-ranked and low-ranked flexibility enablers from each perspective's point of view are presented in Table 9-3. All team-related enablers ranked relatively low from the clients' point of view, but from the consultants' point of view some of these enablers ranked high. It can be said that the way the project team is organised seems much more important for respondents from consultancy organisations than for the client organisations who share opinions in the 'trust' perspectives.

The second shared perspective was 'Scope flexibility by contractual flexibility'. Looking at the overall ranking of flexibility enablers of this perspective, not many differences between the client respondents and the consultant respondents in the corresponding perspectives were found.

The third perspective for both organisation types was 'Proactive management'. The enablers that contribute to a proactive approach, such as 'seizing opportunities & coping with threats', 'possible alternatives' and 'contingency planning' ranked high in this third perspective for both respondent groups. Also, some differences were found. For consultant respondents, the 'when' category of the enablers ranked higher compared to the client respondents. This suggests that these consultants favoured a more iterative approach in their scheduling. Another difference was found in the category of 'where': client respondents showed less willingness in having a joint project office.

Looking back at the demography of the respondents per perspective it is concluded that there is no relationship between the identified perspectives and the profile (including role, background studies, years of experience, knowledge of agile) of the respondents. A distribution of respondents from each organisation throughout the perspectives was observed. The three perspectives of clients have representatives from all client organisations. The distribution of respondents from consultancies into perspectives did have some patterns. For example, respondents from consultancy organisation 1 were represented mostly in perspective of 'trust', while respondents from consultancy organisation 2 were represented in perspective of 'scope flexibility by contractual flexibility'. This suggests an influence of the organisational culture of the consultancies on their view regarding flexible project management.

The overall ranking of flexibility enablers was the other outcome of this exploratory research (see Figure 6-8 in Chapter 6). The three top-ranked enablers from the clients' point of view were 'embrace change', 'seizing opportunities and coping with threats' and 'trust'. The three top-ranked flexibility enablers from consultants' point of view were the same ones as the client respondents' point of view, albeit in a different order: 'embrace change', 'trust' and 'seizing opportunities and coping with threats'.

The top-ranked enablers and also the derived perspectives for both clients and consultants are the same. Hence the general mind-set of these practitioners working for client or consultant organisations regarding flexibility in project management seems similar. This empowers the hypothesis that the role of the organisation (client or consultancy) as such has no influence on the studied subject (flexible project management). Particular company culture, however, could influence the results.

From the common five identified categories of flexibility (what, who, how, when and where) by literature (Geraldi, 2008; Osipova and Eriksson, 2013) only the 'what' or scope category reveals as a distinct perspective in the current study. The other four clusters of flexibility enablers suggested by literature did not appear as a distinct perspective of practitioners, indicating a difference between the theoretical and a practical view regarding the clusters of flexibility enablers.

Table 9-3: High-ranked and low-ranked flexibility enablers from different perspectives' point of view (N=43)

		Perspectives		
		Trust	**Scope flexibility by contractual flexibility**	**Proactive management**
Clients organisations	High-ranked flexibility enablers	• Trust • Short feedback loops • Continuous locking • Seizing opportunities and coping with threats • Continuous learning	• Broad task definition • Functional-realisation based contract • Shared interface management • Visualised planning and progress • Seizing opportunities and coping with threats	• Seizing opportunities and coping with threats • Stable teams • Self-steering team • Broad task definition • Iterative delivery
Clients organisations	Low-ranked flexibility enablers	• Standardised process and design • Self-steering team • Consensus among team members • Late locking • Self-assigned individuals to tasks • Broad task definition • Flexible desks • Iterative delivery • Consider team members as important stakeholders	• Iterative delivery • Stable teams • Continuous locking • Flexible desks • Contingency planning • Standardisation of process and design • Self-steering team	• Flexible desks • Standardisation of process and design • Functional-realisation based contract • Joint project office • Open information exchange • Continuous locking
Consultant organisations	High-ranked flexibility enablers	• Trust • Short feedback loops • Self-steering team • Consider team members as important stakeholders • Seizing opportunities and coping with threats • Visualised planning and progress • Self-assigned individuals to tasks	• Embrace change • Broad task definition • Functional-realisation based contract • Possible alternatives • Self-steering team	• Possible alternatives • Continuous locking • Contingency planning • Joint project office • Iterative planning
Consultant organisations	Low-ranked flexibility enablers	• Broad task definition • Late locking • Contingency planning • Possible alternatives • Network structure • Functional-realisation based contract	• Consensus among team members • Iterative delivery • Stable teams • Visualised planning and progress • Contingency planning	• Flexible desks • Consider team members as important stakeholders • Self-steering team • Functional-realisation based contract • Visualised planning and progress • Late locking • Broad task definition

4. *How flexible is the practice of project management?*

The answer to this research sub-question was provided in Chapter 7. The input for this chapter consisted of the identified flexibility enablers resulting from Chapter 5. The practitioners who participated in this part of the research were the same as the ones who participated in the Q-study described in Chapter 6 (research sub-question 3). Those respondents were also asked to rate their last completed project based on their top 5 and bottom 5 selected flexibility enablers (see Table 9-4).

Table 9-4: Top 5 and bottom 5 flexibility enablers from practitioners' perspective (N=43)

Top 5 flexibility enablers	• Embracing change • Trust • Seizing opportunities and coping with threats • Broad task definition • Possible alternatives
Bottom 5 flexibility enablers	• Flexible desks • Standardisation of process and design • Late locking • Consensus amongst team members • Contingency planning

The flexibility enabler 'Embracing change' was highest ranked from practitioners' point of view. Most of the respondents (who give high importance to this enabler) scored it high according to what had been done in the last project they were involved in. A high score to this flexibility enabler means that the practitioners were open to change in their last project. Although it appeared that the practice of project management is open to change, also some difficulties were recognised like incorporating scope changes considering required extra time and money. Overall, this enabler of flexibility was applied in practice ranging from moderate to good, according to the respondents. This suggests the applicability of this enabler in practice.

The statement of 'Trust' was the second highest ranked enabler of flexibility in project management. How 'trust' as an enabler of flexibility was implemented in practice, however, was less evident. Some of the practitioners scored it high in their last project, while others scored it very low. They indicated that sometimes the project starts by trusting involved parties while in some cases there is no trust when the project starts. They mentioned that trust is mostly built along the way.

'Seizing the opportunities and coping with threats', 'broad scope definition' and keeping 'alternatives' open were the next three high-ranked flexibility enablers. Although there were evidence that they were applied in practice, their application was shown to be contradictory. For example, there is an intention to define project scope in details rather than broad tasks. However, in some cases where the project goal is not clear, it is not possible to define the project scope into details. In such cases, the broad task definition is the ultimate solution rather than the preferred choice. Some practitioners were positive about the existence of such enablers in practice, while others could not relate to them or find these enablers not applicable.

On the other extreme, the least important flexibility enabler from the practitioners' point of view was 'flexible desks'. As the term itself suggests, 'flexible desks' is about having the freedom to choose where to sit in the organisation, based on the project they currently work at. The idea is that this helps in making communication lines shorter (Gibson, 2003). However, practitioners ranked it as the least important enabler. In one organisation, different teams seem to work under different working conditions, some use flexible desks for some projects while working in individual offices for some other projects.

'Standardisation of process and products' is the second lowest ranked flexibility enabler. Different perceptions were observed regarding standardisation. Most of the practitioners perceived 'standardisation' as a fact that is contradictory to 'flexibility', while the idea of having standardised processes and products is to give flexibility to the team to choose and act upon circumstances according to the best practices of standard processes or products.

'Locking the decisions at the last responsible moment', 'consensus among team members' and 'contingency planning' in order were the other low ranked flexibility enablers.

Overall it became clear that flexibility enablers of project management are applied in practice: 'broad task definition', 'embracing change' and 'late locking' for example. According to this research, not only the enablers of flexibility which were ranked high by practitioners, but also those enablers which were ranked low (low importance) have been applied in practice. Therefore it can be said that project management in practice is to some degree flexible, which is not reflected in literature. It is implicit since practitioners recognise the application of some flexibility enablers without explicitly naming them.

5. *How does flexible project management contribute to project performance?*

The answer to this sub-question was given in Chapter 8. In total six hypotheses were formulated to test the relationship between flexible project management ('what', 'how-attitude', 'how-organisation', 'who', 'when' and 'where') and project performance. Project complexity was taken into account in the research model as a control variable, to test its effect on project performance, resulting in the formulation of the seventh hypothesis: 'project complexity has a contrary effect on project performance'. Using the SEM-PLS method, statistical analysis was performed on data gathered from 111 surveys.

From the 30 indicators of flexibility enablers, 23 had significant coefficients on their latent variables or sub-constructs. For project complexity 11 out of the 22 selected elements from the TOE framework suggested by Bosch-Rekveldt (2011) were confirmed positively in their latent variables. For project performance, 13 out of 25 were confirmed in their five latent variables.

Among the six hypotheses regarding the existence of positive relationships between project management flexibility and project performance, two were supported; 'how-attitude' and 'how-organisation'. Hence flexibility of 'how' has a significant positive effect on project performance. The significant positive relationship here means that the higher the flexibility of 'how', the better the project performance. For example, 'trust' is one of the enablers belonging to flexibility of 'how'. The positive relationship in case of 'trust' means that the higher the level of trust among the parties involved in the project, the better the performance of the project and the higher the chance for delivering a successful project.

The other four hypotheses, regarding the relationships between flexibility of 'what', 'who', 'when' and 'where', were not supported by statistical analysis using the complete model. In addition, to analyse the whole model, analyses were performed using partial models, testing each hypothesis individually. It was evident that the single relationships of the flexibility clusters (latent variables) with performance were all positive and significant. For example, flexibility of 'who' had a significant positive effect on project performance, when it was analysed excluding other flexibility areas. The same results were achieved for flexibility of 'what', 'when' and 'where'. What does this mean? First of all, because the analysis is done relatively, the dominant relationship reveals as significant in the complete model. Hence, compared to the most dominant one (the 'how' enablers), the other relationships are not significant. Secondly, this result could be influenced by the complexity of the whole model (structural and measurement).

6. *How does flexible project management contribute to the effect of project complexity on project performance?*

The answer to this sub-question was also given in Chapter 8.

While the assumed negative effect of project complexity on project performance was confirmed, it is also important to know if flexible project management can mediate this effect. The mediation analysis revealed that only 'how-organisation' can mediate the effect of project complexity on project performance. This means that if indicators belonging to 'how-organisation' flexibility are applied in practice, the negative effect of project complexity will significantly be mediated. However, it is not possible to specify which complexity category (technical, organisation or external) or which complexity aspects will be mediated. Since complexity was treated as one single independent variable, the mediation results indicate that the overall effect of complexity will be mediated by 'how-organisation' flexibility. The reason why complexity was treated as a single variable rather than three variables (technical, organisational and external) is because of the number of the data points. This was addressed as a research limitation.

The mediation effect of 'how-organisation' flexibility implies that if the enablers belong to this cluster of flexibility would be applied in complex projects, the performance of the project would less be affected negatively by project complexity. For example, 'management support' as an enabler belongs to flexibility of 'how-organisation'. The negative effect of complexity would be diminished by having 'management support'. This also applies to the other six enablers belonging to the flexibility of 'how-organisation': 'visualised project planning and progress', 'continuous learning', 'self-steering of the complete project team', 'shared interface management', 'trust among involved parties' and 'network structure rather than hierarchical structure'.

9.2.2 THE ANSWER TO THE RESEARCH MAIN QUESTION

The research main question was: *how could flexibility in project management improve project performance in the early phases of complex infrastructure projects*?

By answering the research sub-questions the answer to the main research question was found. The answer was presented in the form of a framework for flexible project management as presented in Section 9.1. To recall briefly: the first stage is to get insight into the current situation in terms of the applied project management approach and project complexity perception. The idea is to understand if any flexible approach (like Agile project management) is being applied or not. In this stage, the preconditions for making project management flexible should be explored. The second stage is understanding what is important for flexible project management from practitioners' point of view (creating awareness for the different perspectives). The third stage is making project management flexible. The input of this stage is the list of 23 verified flexibility enablers in five areas of flexibility (what, how, who, where, and when) from Chapter 8. The fourth stage is narrowing down the flexibility enablers to those that improve project performance. It was proven that flexibility of 'how' among all five areas of flexibility had a positive significant relationship with project performance. At this stage, it is recommended to apply the enablers from the 'how' flexibility (grouped into 'how-attitude' and 'how-organisation'). If the intention is to improve the project performance for complex projects, it is recommended to apply the enablers from 'how-organisation' flexibility including 'visualised project planning and progress', 'continuous learning', 'self-steering of the complete project team', 'shared interface management', 'trust', 'management support' and 'network structure'.

9.3 VALIDITY

A mixed research methodology (Creswell, 2009) was used in this research, including qualitative and quantitative approaches. In Chapter 3 the application of different management approaches was studied qualitatively by case studies. Chapter 4 explored the relationship between the application of Lean & Agile management and project complexity by means of quantitative research. Chapter 5 investigated the enablers of flexibility in project management by an in-depth literature review, followed by qualitative research on data gathered from interviews by practitioners. Q-methodology was used in Chapter 6 to study the practitioners' perspectives. Q-methodology is a mixed-methods approach including both qualitative and quantitative methods (Van Exel and De Graaf, 2005). Chapter 7 looked into the application of flexibility enablers in practice which also was done using both qualitative and quantitate data analysis. In Chapter 8 where the effect of flexibility on project performance was studied, a quantitative research method was used to analyse the data gathered from a survey study.

The validity of the research can be investigated in terms of internal validity, external validity, construct validity and reliability (Creswell, 2009; Tashakkori and Teddlie, 1998; Yin, 2002).

The internal validity is about the causal relationships between variables (Creswell, 2009; Tashakkori and Teddlie, 1998). Looking at the different stages of this research, the internal validity is less concerned in Q-study (Chapter 6) since the Q-methodology is an exploratory research (Brown, 1980). This also applies for Chapter 5 in which the enablers of flexibility were explored. The validity of the causal relationship needs to be addressed in Chapter 4 (the relationship between Lean and Agile management and project complexity) and Chapter 8 (the effect of flexibility on project performance). For both chapters, the applied analysis methods tested the causal relationships between the cause (management approach) and effect (project performance).

External validity is about the sampling and the generalizability (Tashakkori and Teddlie, 1998). According to Tashakkori and Teddlie (1998) the generalizability of the research results is amongst others based on the sample size and its representation. In total 256 practitioners participated in the study, from more than 15 different organisations in the infrastructure construction industry, showing broad coverage of the field.

The reliability of the research is about the possibility of repeating this research by another researcher, resulting in the same outcomes. In the case of qualitative research (Chapters 3, 5 and 7) an interview protocol was applied. Further, all the interviews were recorded and transcribed, sorted in a data file and analysed subsequently. All these steps ensure the reliability of the research. The construct validity is about the degree to which the test measures the construct because the construct cannot be observed directly (Creswell, 2009; Tashakkori and Teddlie, 1998). To tackle the construct validity different strategies were used. In case study research (Chapter 3) the interviewees were asked to complement their answers to the interview questions by providing their general view and additional insights on the subject. Interviewing a minimum of two interviewees per project also contributed to construct validity. In Chapter 5, a number of interviews with experts were performed to evaluate the flexibility enables. In order to ensure the construct validity, it is recommended to use experts' opinions on the subject (Tashakkori and Teddlie, 1998). In Chapter 8 the survey included some control variables to enhance the construct validity.

As it was explained earlier, this research was performed using a mixed methods approach by choosing qualitative, quantitative, or a mix of both (like Q-methodology) for different sub-studies. Triangulation was applied wherever possible. In Chapter 1 it was mentioned that this research was performed following the post-positivism paradigm. Although post-positivism research primarily aims at quantitative research (Tashakkori and Teddlie, 1998), a qualitative research approach was embedded in different stages to strengthen the overall validity of the research.

9.4 Limitations

In Chapter 3, exploratory research was performed by studying the application of Agile in early phases of infrastructure construction projects. Given the newness of the topic, the main limitation was the availability of projects in the construction industry, which Agile project management already had applied. As a result, only a limited number of cases could be studied, still providing a first view from practice. Secondly, in these cases we mainly focused on the perspective of the client and consultancy organisations because they are currently the main actors in the project organisation in the front-end phase, hence providing a narrow view on the applied management approaches. Future research could focus on expanding this narrow view to a more holistic view by including more actors, like contractors.

In Chapter 6 (exploring the practitioners' perspectives on flexible project management) also some limitations were faced. The study was performed in The Netherlands, within Dutch organisations. Therefore the concluded perspectives represent a Dutch view on flexible project management. To extend this view, future research could be done into cultural influences in a more international context.

In Chapter 8 (studying the effect of flexible project management on project performance) also some limitations were faced. The number of data points (sample size) was one of the limitations. People seem tired of participating in surveys, but still, over 100 responses were gathered. To match the number responses (data points) to the formulated hypotheses, the research model was simplified by reducing the number of hypotheses. This reduction was done by including project performance as one dependent variable with five sub-constructs rather than using the five categories of success criteria as dependent variables. The same applied for including project complexity as one control variable. Rather than distinguishing the three dimensions of project complexity of the Toe framework (technical, organisational and external), project complexity was treated as one single variable defined by three sub-constructs.

This research looked into the effect of flexibility in project management on project performance. Because the focus of the research was on the front-end phase, only project performance before the operation phase was measured, following literature suggestions that value creation in front-end positively contributes to overall project performance (Hutchinson and Wabeke, 2006). There was no reliable source in literature which proposed a framework to assess the performance of infrastructure projects in their early phases. How to measure project performance of the front-end phase could be a direction for future research.

In terms of analysis, a limitation was found in the application of PLS-SEM. PLS-SEM only performs confirmatory factor analysis. For clustering the flexibility enablers into other clusters rather than defined flexibility areas in literature, however, exploratory factor analysis was required, which was bypassed by time-consuming trial and error analysis. The impossibility of PLS-SEM to perform exploratory factor analysis is considered as a limitation of this research.

The applicability of the proposed framework is the other research limitation since it was not investigated. All the stages of the framework were confirmed in different steps of the research either statistically or by doing qualitative analysis, however, the applicability of the overall proposed framework requires further research.

9.5 SCIENTIFIC CONTRIBUTION

It is recognised that project complexity is increasing (Bakhshi et al., 2016; Bosch-Rekveldt, 2011). Different management approaches were suggested for managing projects based on their complexity (Hertogh and Westerveld, 2010). These management approaches can be categorized into two main management streams: a mechanistic stream and an organic stream. Some other scholars stated that pure approaches, either mechanistic or organic, are not performing well (Geraldi, 2008; Huchzermeier and Loch, 2001; Koppenjan et al., 2011; Kreiner, 1995; Olsson, 2006; Osipova and Eriksson, 2013; Wysocki, 2007). Therefore a fine balance in the spectrum of management approaches is required (Hertogh et al., 2008). Such balance is referred to as flexibility in the literature (Geraldi, 2008; Osipova and Eriksson, 2013). While literature acknowledges the need for flexibility in project management, it hardly identifies the enablers of flexibility and its effect on project performance. This research bridges this gap in the literature in several ways.

First, it recognises existing flexible project management elements in practice (Chapter 3 and Chapter 4). Despite the fact that Agile has been applied in the construction industry, limited research was performed studying its applicability and its transformation when it immigrates from IT industry to construction industry (Johansson, 2012; Owen et al., 2006). By means of case study research comparing different management approaches, this research contributes to filling the gap between practice and theory. Also, it partly confirms the research done by Owen et al. (2006) where they conclude Agile has potential in predesign and design phases of construction projects.

The comparison made between theory and practice of Scrum for infrastructure construction projects helps in further development of the tool of Scrum and the development of an overall Agile approach to fit infrastructure construction projects. This is in line with what scaled Agile frameworks opt for (Ambler, 2009), but then aimed at the construction industry.

Chapter 5 focused on finding the enablers of flexibility. While no literature explicitly identifies an extensive list of flexibility enablers in project management, in Chapter 5 the enablers of flexibility were explored and validated. The results of this chapter contribute to project management literature in the identification of these flexibility enablers. Prior researches defined the areas of flexibility (Geraldi, 2008; Osipova and Eriksson, 2013). This chapter aimed at going a layer deeper to identify what the flexibility enablers are and allocating them to the areas of flexibility.

The results of the Q-study (Chapter 6, exploring the practitioners' perspectives), contribute to theory building in various ways. Needless to say that no single research had looked into this topic before. For this research, the perspectives of client and consultant organisations were explored and compared. However, many other parties play roles in any projects such as contractors, JVs, subcontractors, etc. The current research could be extended to exploring the perspectives of other parties involved in the projects. Above that, the revealed perspectives partly support the identified areas of flexibility by Osipova and Eriksson (2013), as one of their areas (flexibility of 'what') came out as a distinguished perspective in our research. One of our perspectives, 'trust' confirms the importance of 'trust' as earlier investigated in literature (Benítez-Ávila, Hartmann, Dewulf and Henseler, 2018; Chow, Cheung and Chan, 2012; Kalkman and de Waard, 2017; Ning, 2017; Ping et al., 2016; Rezvani, Chang, Wiewiora, Ashkanasy, Jordan and Zolin, 2016).

The sub-study where the flexibility of practice was studied (Chapter 7) contributes to the literature by providing the evidence of flexibility in the field. The revealed five most important flexibility enablers, next to how they were applied in practice, open up a few research areas for improving the application of those top-ranked enablers. It was revealed that not only the top-ranked enablers, but also the low ranked enablers were applied in practice to some extent. This supports the literature on the application of individual flexibility enablers in practice like 'flexible desks' (Gibson, 2003) and 'contingency planning' (Pich et al., 2002). For example 'embracing change' came out as the top-ranked flexibility enabler. The practice showed some evidence of how 'embracing change' was applied in different ways such as by having a proactive attitude towards stakeholders requirements or being open towards requested scope changes. However, the operationalisation of 'embracing change' in the practice of project management needs further investigation.

Very recently Eriksson et al. (2017) studied the effect of flexibility-focused project management on projects' time performance. Apart from their research little attention was given to the effect of flexibility on project performance, although literature has highlighted the flexibility in project management (Geraldi, 2008; Olsson, 2006; Walker and Shen, 2002). The contribution of Chapter 8 lays on the revealed significant positive relationships between flexibility areas and project performance. These results confirm the proved effect of adaptation on project performance by Eriksson et al. (2017). Secondly, the insignificant relationships turned out to be significant where they were analysed solely. This suggests the relative importance of all identified flexibility areas with their enablers.

The mediating role of flexibility on the effect of project complexity on project performance was not found in the literature. Research by Eriksson et al. (2017) studied the direct relationship between adaptive management, project complexity and time performance. Although studying the direct relationship between these three variables is important, it is different than studying the mediating role of flexibility as was done in Chapter 8. It was concluded that 'how-organisation' flexibility plays such a mediating role. This contributes not only to knowledge development regarding flexible project management but also to knowledge management regarding the management of project complexity. The suggested model by Hertogh and Westerveld (2010), mapping project management approaches to project complexity is supported by our findings. Flexible project management fits into their dynamic management, which would be suited for managing projects with high detail and high dynamic complexity. However, in our study not all flexibility enablers played a mediating role. Still, it provided evidence of the mediation effect which could help further development of the detail / dynamic model.

9.6 MANAGERIAL IMPLICATIONS

In Section 9.3 it was mentioned that literature suggests making project management flexible to manage nowadays projects (Geraldi, 2008; Olsson, 2006; Osipova and Eriksson, 2013; Wysocki, 2007). However, how flexible project management is in practice had not been reflected in literature. In different stages of this research it was tried to provide a better understanding of practice by means of case study research and collecting data from practitioners, based on their projects.

Earlier literature highlights the potential usage of a flexible project management approach in the construction industry (Johansson, 2012; Owen et al., 2006). In Chapter 3, we focused on the applicability of Agile and Scrum in the construction industry for infrastructure projects. This research revealed that the adjusted Scrum process used in the early phases of three projects positively affected aspects like communication and time efficiency. The comparison between the practice of Agile and the waterfall approach disclosed some shortcomings of the waterfall approach in the areas of team integrity and communication.

If a company would have the intention to apply Agile or use Scrum in the context of early phases in infrastructure construction projects, practitioners would benefit from this case study research by working on powerful aspects of Scrum like: teamwork quality, interchange of knowledge, rework reduction, increased efficiency and client satisfaction. Still, attention should be paid to address the following challenges: multitasking of the team members, a high number of Scrum meetings, client commitment level, life cycle analyses and uncertainty about the benefits of Scrum.

Although our research showed that the industry can benefit from Scrum, it was suggested to find the best management fit. Such management fit lays somewhere in the spectrum from pure Agile to pure waterfall management. There is no single recipe for such fit. The decision is up to the project manager (together with the team), based on the project characteristics and requirements. For example, if the communication among team members should improve, some aspects of Scrum like daily-stand ups will be helpful. Likewise, close involvement of the client is a key to success (Lim and Mohamed, 1999; Sanvido, Grobler, Parfitt, Guvenis and Coyle, 1992) especially if the project goal is unclear. The client involvement will improve by use of Scrum. Note that close involvement of the client also can be present in a waterfall approach, but it is more emphasized and valued in Scrum.

The Q-study revealed similar (parallel) practitioners' perspectives for client and consultant organisations. Knowing that practitioners' perspectives are the same in these organisations could facilitate their collaboration. Three main mindsets for becoming flexible in project management were found: 'trust', 'scope flexibility by contractual flexibility' and 'proactive management'. Based on the project at hand, a project team could benefit from knowing these different mindsets. The team members together with the project manager can work on the application of the flexibility enablers which they ranked high.

After recognition of the required flexibility for project management in the particular project, the first step is to embed this required flexibility. This research identified a number of flexibility enablers in five areas of flexibility (what, how, who, when and where) that can help to make project management flexible. The enablers which significantly contribute to five areas of flexibility are presented in Table 9-5.

Table 9-5: 23 flexibility enablers assigned to 5 areas of flexibility

Category			Flexibility enablers
What			Broad task definition
			Functional-realisation based contract
How	How-attitude	Open attitude	Interactive decision making
			Close involvement of stakeholders
		Wide approach	Open information exchange among different groups
			possible alternatives
		Proactive attitude	Contingency planning
			Seizing opportunities and coping with threats
	How-organisation	Facilitate planning	Visualised project planning and progress
			Continuous learning
		Outer organisation	Self-steering of the complete project team
			Shared interface management
			Trust among involved parties
		Inner organisation	Management support
			Network structure rather than hierarchical structure
Who		Team collaboration	Team priority over individual priority
			Team members as stakeholders
		Team structure	Delegation of responsibilities to team level
			Consensus amongst team members
			Stable teams
When			Short feedback loops
			Continuous locking (iterative)
Where			Joint project office

Practitioners can decide in which area the flexibility is required or should be optimised. The next step is to apply the enablers that belong to that area of flexibility.

The intention for making project management flexible might come from the desire to improve project performance. Based on the results of our study, the focus then should be on the 'how-attitude' and 'how-organisation' flexibility enablers (see Table 9-5). By applying these enablers, project performance is expected to improve regardless of the complexity of the project. An open and proactive attitude, a wide approach, facilitate planning, outer and inner organisation are the constructs in the 'how' category of flexibility.

Apart from improving project performance, the intention for making project management flexible might come from the desire to better manage the project complexity. If this is the case, then the application of the following elements is suggested: 'how-organisation' flexibility including self-steering of the complete project team, shared interface management, trust among involved parties, standardise the process and design, possible alternatives, network structure rather than hierarchical structure, continuous learning and management support.

All explained here is the summary of the proposed flexibility framework as defined in Section 9.1. In this framework, an iterative way of recognising, applying, learning and improving is suggested. Based on the specific project context, the focus of the practitioners might be at any stage of this framework. However, no matter what is the starting point, it is about an iterative way of recognising, applying, learning and improving. The value will be gained when project management flexibility is improved upon experience and learning.

To summarise the managerial implications, it is suggested to practitioners to carefully pay attention to (no specific order):

- Finding the balance between Agile and waterfall management approaches based on the specific project context. By understanding how complex the project is, the practitioners can choose the right management approach. This management approach can be a hybrid version of waterfall management and Agile project management. For example, by planning the project into iterations (short or long), organising co-located teams, focusing on value delivery rather than task delivery and establishing stable teams, they can become more Agile.

- Improving the practice of Agile (Scrum) based on the observed benefits such as structure of work, team spirit, interchange of knowledge, rework reduction and challenges like multitasking and intensity of scrum meetings.

- Applying addressed Lean and Agile management elements to manage project complexity. This includes: standardising the process, taking constructability of the project into account in design, dividing the work into small batches, deliver iteratively, giving feedback on a short basis (daily), having open information exchange with short communication lines, tacking the performance on a daily basis, locking the decision as the last responsible moment, planning the project in levels given the priority, involve the team members in planning process, facilitating the communication within the development team and having a clear problem solving process.

- Recognition of different practitioners' perspectives ('trust', 'scope flexibility by contractual flexibility' and 'proactive management') about making project management flexible and giving priority to the one (including its high-ranked enablers) which fits the project context based on its requirements and complexity.

- Making project management flexible by applying flexibility enablers from Table 9-5. In general making project management flexible can be done by enabling the flexibility in terms of the scope of the project (what), in terms of project processes (how), the project team (who), project scheduling (when) and the location the project team is organised (where).

- Focusing on enablers from 'open attitude', 'wide approach' and 'proactive attitude' to increase flexibility in terms of 'how-attitude'.

- Focusing on 'facilitate planning', 'outer organisation' and 'inner organisation' to increase flexibility in terms of 'how-organisation'.

9.7 RECOMMENDATIONS FOR FURTHER RESEARCH

The newness of the studied topic of flexibility in project management leaves room for further research, even after this study. This is recognised in a few directions: the application of Agile, flexible project management and management of project complexity.

- The application of Agile

The known flexible project management approach (Agile project management) could deserve more research attention, given the popularity it has achieved in various contexts rather than the IT (Information Technology) world. Despite the fact that prior research indicated the new directions on Agile methods (Abrahamsson et al., 2003), the applicability of Agile project management in the construction industry has not been widely researched. Owen et al. (2006) research the applicability of Agile in construction. Not much research followed his research direction in recent years. This gives direction for further research on the applicability of Agile in the construction industry, not only in early project phases but also in the execution phase.

It was mentioned that a balance between Agile and waterfall management is required. This research does not recommend the full application of Agile project management, no matter what. Instead, careful consideration is suggested to choose a project management approach that fits the specific project at hand. Further research into the operationalisation of so-called 'fit-for-purpose' project management is suggested to find the contextual variables that determine the approach to apply.

- Flexible project management

Exploratory research into practitioners' perspectives in this research was focused on Dutch organisations. Therefore the results might have been influenced by the culture. The recommendation given here is to study the effect of culture on practitioners perspectives regarding flexible project management. This can be achieved by doing the research including respondents from different countries.

Regarding flexibility, the literature which identifies the areas of flexibility is limited. The statistical analysis did not confirm the contribution of a few flexibility enablers to their assigned areas. It might be the case that those enablers belong to different areas of flexibility. This was one of the limitations faced by using PLS-SEM (research-method related limitation). Further research needs to investigate clustering of flexibility enablers by means of exploratory factor analysis using other research methods.

Although flexibility of 'how' proved to have a significant positive effect on project performance, the other flexibility areas had significant positive effect when analysed individually. This triggers further research on the relative effect of each flexibility area including its enablers on project performance.

Moreover, the effect of identified areas of flexibility on different aspects of project performance like efficiency, effectiveness, satisfaction, etc. is valuable to be researched. In this research, because of limited data points, project performance was treated as one dependent variable. Eriksson et al. (2017) researched the effect of three measures of adaptability (successfully managed scope and content changes, successfully solved unexpected problems and successfully delivered products that satisfy new and changing demand) on time performance. Further research can investigate the relationships between different clusters of flexibility enablers with different aspects of project performance.

The scope of this research was narrowed down to the early project phases (FED). It was observed during the interviews that flexibility seems to decrease when the project progresses. For example, one of flexibility enablers is keeping 'possible alternatives'. As projects progress into the execution phase, it may not be efficient to keep alternatives open and the decision needs to be made for the best option. This limited the degree of flexibility. Although this sounds obvious, this assumption needs to be tested and investigated thoroughly.

The applicability of the proposed flexibility framework in practice was one of the research limitations. This gives room for further research on the application of the framework and adjustments in case it is required.

- The management of project complexity

Different research suggested various categorization of project complexity elements (Bakhshi et al., 2016; Bosch-Rekveldt, 2011; Kian, Sun and Bosché, 2016). Prior research suggested different management approaches including dynamic management based on the type and degree of project complexity (Hertogh and Westerveld, 2010). However, in this research for making the research model simpler to test, project complexity was treated as one control variable. It is recommended to study the relationships between different categories of project complexity and flexible project management. This helps in managing the complexity by understanding if any specific area of flexibility has a significant effect on any category of complexity.

REFERENCES

Aaker, D.A., Mascarenhas, B., 1984. The need for strategic flexibility. Journal of Business Strategy, 5, 74-82.

Abdul-Kadir, M.R., Price, A.D.F., 1995. Conceptual phase of construction projects International Journal of Project Management, 13.

Abrahamsson, P., Warsta, J., Siponen, M.T., Ronkainen, J., 2003. New directions on agile methods: a comparative analysis, Software Engineering, 2003. Proceedings. 25th International Conference on. Ieee, pp. 244-254.

Achterkamp, M.C., Vos, J.F.J., 2008. Investigating the use of the stakeholder notion in project management literature, a meta-analysis. International Journal of Project Management, 26, 749-757.

Agarwal, M., Majumdar, R., 2012. Tracking scrum projects tools, metrics and myths about agile. Int J Emerg Technol Adv Eng, 2, 97-104.

Agile-Methodology, 2014. What is Scrum?

Ahadzie, D.K., Proverbs, D.G., Sarkodie-Poku, I., 2014. Competencies required of project managers at the design phase of mass house building projects. International Journal of Project Management, 32, 958-969.

Ahrens, T., Chapman, C.S., 2004. Accounting for flexibility and efficiency: A field study of management control systems in a restaurant chain. Contemporary accounting research, 21, 271-301.

Ambler, S.W., 2009. The agile scaling model (ASM): adapting agile methods for complex environments. Environments.

Anderson, D.R., 2004. Female executives in biotechnology: A contextual approach to understanding their work environments. Operant Subjectivity, 28, 33-57.

Antoniadis, D.N., Edum-Fotwe, F.T., Thorpe, A., 2011. Socio-organo complexity and project performance. International Journal of Project Management, 29, 808-816.

Aritua, B., Smith, N.J., Bower, D., 2009. Construction client multi-projects – A complex adaptive systems perspective. International Journal of Project Management, 27, 72-79.

Armitage, D.R., Plummer, R., Berkes, F., Arthur, R.I., Charles, A.T., Davidson-Hunt, I.J., Diduck, A.P., Doubleday, N.C., Johnson, D.S., Marschke, M., 2009. Adaptive co-management for social–ecological complexity. Frontiers in Ecology and the Environment, 7, 95-102.

Artto, K., Ahola, T., Vartiainen, V., 2016. From the front end of projects to the back end of operations: Managing projects for value creation throughout the system lifecycle. International Journal of Project Management, 34, 258-270.

Artto, K.A., Lehtonen, J.-M., Saranen, J., 2001. Managing projects front-end: incorporating a strategic early view to project management with simulation. International Journal of Project Management, 19, 255-264.

Artto, K.A., Wikström, K., 2005. What is project business? International Journal of Project Management, 23, 343-353.

Assaf, S.A., Al-Hejji, S., 2006. Causes of delay in large construction projects. International Journal of Project Management, 24, 349-357.

Atkinson, R., 1999. Project management: cost, time and quality, two best guesses and a phenomenon, its time to accept other success criteria. International Journal of Project Management, 17, 337-342.

Atkinson, R., Crawford, L., Ward, S., 2006. Fundamental uncertainties in projects and the scope of project management. International Journal of Project Management, 24, 687-698.

Augustine, S., Payne, B., Sencindiver, F., Woodcock, S., 2005. Agile project management: steering from the edges. Communications of the ACM, 48, 85-89.

AXELOS, 2015. PINCE2 Agile. The Stationary Office (TSO), United Kingdom

Aziz, R.F., Hafez, S.M., 2013. Applying lean thinking in construction and performance improvement. Alexandria Engineering Journal, 52, 679-695.

Baccarini, D., 1996. The concept of project complexity. International Journal of Project Management, 14, 201-204.

Baker, R., Thompson, C., Mannion, R., 2006. Q methodology in health economics. Journal of health services research & policy, 11, 38-45.

Bakhshi, J., Ireland, V., Gorod, A., 2016. Clarifying the project complexity construct: Past, present and future. International Journal of Project Management, 34, 1199-1213.

Bakker, H., Arkesteijn, R., Bosch-Rekveldt, M., Mooi, H., 2010. Project success from the perspective of owners and contractors in the process industry, Internatinal Project Management Association (IPMA), Istanbul.

Bateson, G., 1972. Ecology and flexibility in urban civilization. Steps to an ecology of mind, 494-505.

Beck, K., 2001. Manifesto for agile software development

Beck, K., Beedle, M., Bennekum, A.v., Cockburn, A., Cunningham, W., Fowler, M., Grenning, J., Highsmith, J., Hunt, A., Jeffries, R., Kern, J., Marick, B., Martin, R.C., Mellor, S., Schwaber, K., Sutherland, J., Thomas, D., 2001. www.agilemanifesto.org.

Becker, J.-M., Klein, K., Wetzels, M., 2012. Hierarchical latent variable models in PLS-SEM: guidelines for using reflective-formative type models. Long Range Planning, 45, 359-394.

Benítez-Ávila, C., Hartmann, A., Dewulf, G., Henseler, J., 2018. Interplay of relational and contractual governance in public-private partnerships: The mediating role of relational norms, trust and partners' contribution. International Journal of Project Management, 36, 429-443.

Berczuk, S., 2007. Back to Basics: The Role of Agile Principles in Success with an Distributed Scrum Team, Agile 2007 (AGILE 2007), pp. 382-388.

Berkes, F., Colding, J., Folke, C., 2000. Rediscovery of traditional ecological knowledge as adaptive management. Ecological applications, 10, 1251-1262.

Bertelsen, S., 2002. Bridging the gap–towards a comprehensive understanding of lean construction. IGLC-10, Gramado, Brazil.

Bertelsen, S., Koskela, L., 2004. Construction beyond lean: a new understanding of construction management, Proceedings of the 12 th annual conference in the International Group for Lean Construction.

Biedenbach, T., Müller, R., 2012. Absorptive, innovative and adaptive capabilities and their impact on project and project portfolio performance. International Journal of Project Management, 30, 621-635.

Blaikie, N., 2009. Designing Social Research. Wiley.

Blom, J.A., 2014. Embracing change: The road to improvement?, Integral Design and Management. Delft University of Technology Delft.

Boehm, B., Turner, R., 2003. Balancing agility and discipline: A guide for the perplexed. Addison-Wesley Professional.

Bosch-Rekveldt, M., 2011. Managing project complexity: A study into adapting early project phases to improve project performance in large engineering projects, Technology, policy and management. Delft University of Technology

Bosch-Rekveldt, M., Jongkind, Y., Mooi, H., Bakker, H., Verbraeck, A., 2011. Grasping project complexity in large engineering projects: The TOE (Technical, Organizational and Environmental) framework. International Journal of Project Management, 29, 728-739.

Boussauw, K., Boelens, L., 2015. Fuzzy tales for hard blueprints: the selective coproduction of the Spatial Policy Plan for Flanders, Belgium. Environment and Planning C: Government and Policy, 33, 1376-1393.

Bown, N.K., Gray, T.S., Stead, S.M., 2013. Co-management and adaptive co-management: Two modes of governance in a Honduran marine protected area. Marine Policy, 39, 128-134.

Brouwer, M., 1999. Q is accounting for tastes. Journal of Advertising Research, 39, 35-35.

Brown, S.R., 1980. Political Subjectivity: Applications of Q Methodology in Political Science. Yale University Press, New Haven, CT.

Browning, T.R., 2014. Managing complex project process models with a process architecture framework. International Journal of Project Management, 32, 229-241.

Bryde, D.J., 2003. Modelling project management performance. International Journal of Quality & Reliability Management, 20, 229-254.

Bryde, D.J., Robinson, L., 2005. Client versus contractor perspectives on project success criteria. International Journal of Project Management, 23, 622-629.

Burns, T.E., Stalker, G.M., 1961. The management of innovation.

Buuren, A.v., Buijs, J.-M., Teisman, G., 2010. Program management and the creative art of coopetition: Dealing with potential tensions and synergies between spatial development projects. International Journal of Project Management, 28, 672-682.

Cantarelli, C.C., Molin, E.J.E., van Wee, B., Flyvbjerg, B., 2012. Characteristics of cost overruns for Dutch transport infrastructure projects and the importance of the decision to build and project phases. Transport Policy, 22, 49-56.

Cao, Q., Hoffman, J.J., 2011. A case study approach for developing a project performance evaluation system. International Journal of Project Management, 29, 155-164.

Cenfetelli, R.T., Bassellier, G., 2009. Interpretation of formative measurement in information systems research. MIS quarterly, 689-707.

Chan, A.P., Chan, A.P., 2004. Key performance indicators for measuring construction success. Benchmarking: an international journal, 11, 203-221.

Chan, A.P., Scott, D., Chan, A.P., 2004. Factors affecting the success of a construction project. Journal of Construction Engineering and Management, 130, 153-155.

Chan, H.K., Chan, F.T.S., 2010. Comparative study of adaptability and flexibility in distributed manufacturing supply chains. Decision Support Systems, 48, 331-341.

Chapman, C., Ward, S., 1996. Project risk management: processes, techniques and insights. John Wiley.

Chow, P.T., Cheung, S.O., Chan, K.Y., 2012. Trust-building in construction contracting: Mechanism and expectation. International Journal of Project Management, 30, 927-937.

Christoph, A.J., Konrad, S., 2014. Project Complexity as an Influence Factor on the Balance of Costs and Benefits in Project Management Maturity Modeling. Procedia - Social and Behavioral Sciences, 119, 162-171.

Cicmil, S., Williams, T., Thomas, J., Hodgson, D., 2006. Rethinking Project Management: Researching the actuality of projects. International Journal of Project Management, 24, 675-686.

Cobb, C.G., 2011. Making sense of agile project management: Balancing control and agility. John Wiley & Sons.

Cockburn, A., Highsmith, J., 2001. Agile software development, the people factor. Computer, 34, 131-133.

Collins, G., 2014. Agile Project Management, Project Management, Planning, and Control. ElSEVIER, pp. 523-538.

Collyer, S., Warren, C.M.J., 2009. Project management approaches for dynamic environments. International Journal of Project Management, 27, 355-364.

Conforto, E.C., Amaral, D.C., da Silva, S.L., Di Felippo, A., Kamikawachi, D.S.L., 2016. The agility construct on project management theory. International Journal of Project Management, 34, 660-674.

Cooke-Davies, T., Cicmil, S., Crawford, L., Richardson, K., 2007. Mapping the strange landscape of complexity theory, and its relationship to project management. project management journal, 38, 50-61.

Cooke-Davies, T., Cicmil, S., Crawford, L., Richardson, K., 2008. We're Not in Kansas Anymore, Toto: Mapping the Strange Landscape of Complexity Theory, and Its Relationship to Project Mangement. Engineering Management Review, IEEE, 36, 5-21.

Cooke, J.L., 2012. Everything you want to know about agile IT governance publishing

Cooper, K.G., Lyneis, J.M., Bryant, B.J., 2002. Learning to learn, from past to future. International Journal of Project Management, 20, 213-219.

Costa, D.B., Formoso, C.T., Kagioglou, M., Alarcón, L.F., Caldas, C.H., 2006. Benchmarking initiatives in the construction industry: lessons learned and improvement opportunities. Journal of Management in Engineering, 22, 158-167.

Cox, R.F., Issa, R.R., Ahrens, D., 2003. Management's perception of key performance indicators for construction. Journal of Construction Engineering and Management, 129, 142-151.

Crawford, L., 2014. measuring performance, in: Fifth (Ed.), Gower handbook of project management. Gower publishing company, Farnham, England.

Creswell, J.W., 2009. Research design: Qualitative, quantitative, and mixed methods approaches. Sage.

Crotty, M., 1998. The foundations of social research: Meaning and perspective in the research process. Sage.

Cserháti, G., Szabó, L., 2014. The relationship between success criteria and success factors in organisational event projects. International Journal of Project Management, 32, 613-624.

Cuppen, E., Bosch-Rekveldt, M.G.C., Pikaar, E., Mehos, D.C., 2016. Stakeholder engagement in large-scale energy infrastructure projects: Revealing perspectives using Q methodology. International Journal of Project Management, 34, 1347-1359.

Dao, B., Kermanshachi, S., Shane, J., Anderson, S., 2016. Project Complexity Assessment and Management Tool. Procedia Engineering, 145, 491-496.

Davis, C.H., Michelle, C., 2011. Q Methodology in audience research: Bridging the qualitative/quantitative 'divide'? Journal of Audience & Reception Studies, 8, 559-593.

Davis, K., 2014. Different stakeholder groups and their perceptions of project success. International Journal of Project Management, 32, 189-201.

Delei, Y., Qinghua, H., Lan, L., Jianxun, X., Guangdong, W., Investigating the Relationship between Project Complexity and Success in Complex Construction Projects.

Demir, S.T., Bryde, D.J., Fearon, D.J., Ochieng, E.G., 2012. Re-conceptualizing Lean in Construction Environments–„the case for "AgiLean" Project Management", 48th ASC Annual International Conference Proceedings. Birmingham: Associated Schools of Construction, 11th-14th April 2012, Birmingham, UK.

Dingsøyr, T., Nerur, S., Balijepally, V., Moe, N.B., 2012. A decade of agile methodologies: Towards explaining agile software development. Journal of Systems and Software, 85, 1213-1221.

Dloi, H., 2014. Managing scope and configuration, Gower handbook of projetc management Gower publishing company, Farnhem.

Dobbs, R., Pohl, H., Lin, D.-Y., Mischke, J., Garemo, N., Hexter, J., Matzinger, S., Palter, R., Nanavatty, R., 2013. Infrastructure productivity: how to save $1 trillion a year. McKinsey Global Institute, 88.

Donner, J.C., 2001. Using Q-sorts in participatory processes: An introduction to the methodology. Social Development Papers, 36, 24-49.

Dunović, I.B., Radujković, M., Škreb, K.A., 2014. Towards a New Model of Complexity – The Case of Large Infrastructure Projects. Procedia - Social and Behavioral Sciences, 119, 730-738.

Dybå, T., Dingsøyr, T., 2008. Empirical studies of agile software development: A systematic review. Information and Software Technology, 50, 833-859.

Edelenbos, J., Klijn, E.-H., 2006. Managing Stakeholder Involvement in Decision Making: A Comparative Analysis of Six Interactive Processes in the Netherlands. Journal of Public Administration Research and Theory, 16, 417-446.

Eisenhardt, K.M., Kahwajy, J.L., Bourgeois, L., 1997. How management teams can have a good fight. Harvard business review, 75, 77-86.

Eriksson, P.E., Larsson, J., Pesämaa, O., 2017. Managing complex projects in the infrastructure sector — A structural equation model for flexibility-focused project management. International Journal of Project Management, 35, 1512-1523.

Fernandes, G., Ward, S., Araújo, M., 2015. Improving and embedding project management practice in organisations — A qualitative study. International Journal of Project Management, 33, 1052-1067.

Floricel, S., Michela, J.L., Piperca, S., 2016. Complexity, uncertainty-reduction strategies, and project performance. International Journal of Project Management, 34, 1360-1383.

Floricel, S., Miller, R., 2001. Strategizing for anticipated risks and turbulence in large-scale engineering projects. International Journal of Project Management, 19, 445-455.

Flyvbjerg, B., 2011. Over budget, over time, over and over again: Managing major projects. Over and Over Again: Managing Major Projects.

Flyvbjerg, B., 2014. What you should know about megaprojects and why: An overview. project management journal, 45, 6-19.

Flyvbjerg, B., Holm, M.S., Buhl, S., 2002. Underestimating costs in public works projects: Error or lie? Journal of the American planning association, 68, 279-295.

Folke, C., Hahn, T., Olsson, P., Norberg, J., 2005. Adaptive governance of social-ecological systems. Annual Review of Environmental and Resources, 30, 441-473.

Fong, P.S.W., 2003. Knowledge creation in multidisciplinary project teams: an empirical study of the processes and their dynamic interrelationships. International Journal of Project Management, 21, 479-486.

Fortune, J., White, D., 2006. Framing of project critical success factors by a systems model. International Journal of Project Management, 24, 53-65.

Freeman, M., Beale, P., 1992. Measuring project success. Project Management Institute.

Gabrial, E., 1997. the lean aooroach to project management. International Journal of Project Management, 15, 205-209.

Geraldi, J., Maylor, H., Williams, T., 2011. Now, let's make it really complex (complicated): A systematic review of the complexities of projects. International Journal of Operations & Production Management, 31, 966-990.

Geraldi, J.G., 2008. The balance between order and chaos in multi-project firms: A conceptual model. International Journal of Project Management, 26, 348-356.

Geraldi, J.G., Turner, J.R., Maylor, H., Söderholm, A., Hobday, M., Brady, T., 2008. Innovation in project management: Voices of researchers. International Journal of Project Management, 26, 586-589.

Gibson Jr, G.E., Wang, Y.-R., Cho, C.-S., Pappas, M.P., 2006. What is preproject planning, anyway? Journal of Management in Engineering.

Gibson, V., 2003. Flexible working needs flexible space? Towards an alternative workplace strategy. Journal of Property Investment & Finance, 21, 12-22.

Giezen, M., 2012. Keeping it simple? A case study into the advantages and disadvantages of reducing complexity in mega project planning. International Journal of Project Management, 30, 781-790.

Gil, N., Tether, B.S., 2011. Project risk management and design flexibility: Analysing a case and conditions of complementarity. Research Policy, 40, 415-428.

Gilbert Silvius, A.J., Kampinga, M., Paniagua, S., Mooi, H., 2017. Considering sustainability in project management decision making; An investigation using Q-methodology. International Journal of Project Management, 35, 1133-1150.

Godinho, P., Branco, F.G., 2012. Adaptive policies for multi-mode project scheduling under uncertainty. European Journal of Operational Research, 216, 553-562.

Gray, C., Hughes, W., 2001. Building design management. Routledge.

Gray, C., Larson, E., 2003. Project management: the managerial approach. 2nd. ED, McGraw-Hill, Irwin.

Grindley, P.C., Teece, D.J., 1997. Managing intellectual capital: licensing and cross-licensing in semiconductors and electronics. California management review, 39, 8-41.

Gupta, S.K., Rosenhead, J., 1968. Robustness in sequential investment decisions. Management Science, 15, B-18-B-29.

H Payne, J., Rodney Turner, J., 1999. Company-wide project management: the planning and control of programmes of projects of different type. International Journal of Project Management, 17, 55-59.

Hair, J., Black, W., Babin, B., Anderson, R., 2010. Multivariate Data Analysis: A Global Perspective (7th eds.) Pearson Education Inc. Upper Saddle River, New Jersey.

Hair, J.F., Hult, G.T.M., Christian, M., 2013a. A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM). Thousand Oaks: Sage. http://www. sagepub. com/books/Book237345.

Hair, J.F., Ringle, C.M., Sarstedt, M., 2013b. Partial least squares structural equation modeling: Rigorous applications, better results and higher acceptance.

Halawa, W.S., Abdelalim, A.M.K., Elrashed, I.A., 2013. Financial evaluation program for construction projects at the pre-investment phase in developing countries: A case study. International Journal of Project Management, 31, 912-923.

Hartmann, A., Dorée, A., 2015. Learning between projects: More than sending messages in bottles. International Journal of Project Management, 33, 341-351.

Harvett, C.M., 2013. A Study of Uncertainty and Risk Management Practice Relative to Percieved Project Complexity, Institute of Sustainable Development and Architecture. Bond University, p. 256.

Hashimoto, T., Stedinger, J.R., Loucks, D.P., 1982. Reliability, resiliency, and vulnerability criteria for water resource system performance evaluation. Water resources research, 18, 14-20.

Hayes, A.F., 2013. Introduction to mediation, moderation, and conditional process analysis: A regression-based approach. Guilford Publications.

Hertogh, M., 2014. Opportunity framing Management of engineering projects: people are the key. NAP (The process industry competence network), Nijkerk, The Netherland

Hertogh, M., Baker, S., Staal-Ong, P., Westerveld, E., 2008. Managing large infrastructure projects. Research on Best Practices and Lessons Learnt in Large Infrastructure Projects in Europe: AT Osborne BV.

Hertogh, M., Westerveld, E., 2010. Playing with Complexity - Management and organization of large infrastructure projects.

Highsmith, J., 2009. Agile project management: creating innovative products. Pearson Education.

Highsmith, J.A., 2002. Agile software development ecosystems. Addison-Wesley Professional.

Hillson, D., Simon, P., 2007. Practical project risk management: The ATOM methodology. Management Concepts Inc.

Hillson, D., Simon, P., 2012. Practical project risk management: The ATOM methodology (second edition). Management Concepts Inc.

Hobday, M., 1998. Product complexity, innovation and industrial organisation. Research Policy, 26, 689-710.

Hubbard, D.G., 1990. Successful utility project management from lessons learned. Project Management Institute.

Huchzermeier, A., Loch, C.H., 2001. Project Management Under Risk: Using the Real Options Approach to Evaluate Flexibility in R... D. Management Science, 47, 85-101.

Hutchinson, R., Wabeke, H., 2006. Opportunity and Project Management Guide. Shell International Exploration and Production BV INCOSE.(2004). INCOSE Systems Engineering Handbook. Kunz, J., & Fischer, M.(2012). Virtual design and construction: themes, case studies and implementation suggestions. CIFE, Stanford University, Stanford, CA, CIFE Working Paper, Version, 14, 89-93.

Jalali Sohi, A., bosch-Recveldt, M., Hertogh, M., 2018. Practitioners' perspectives on flexible project management. IEEE Transaction in Engineering Management, ***Under Review***

Jalali Sohi, A., Bosch-Rekveldt, M., Hertogh, M., 2017a. How flexible is project management in practice? An exploratory research into project management of infrastructure projects in construction industry, IPMA, Asatan, Kazakhstan

Jalali Sohi, A., Hertogh, M., Bosch-Rekveldt, M., 2016. Scrum in practice for infrastructure projects EURAM 2016, Paris.

Jalali Sohi, A., Hertogh, M., Bosch-Rekveldt, M., 2017b. What is flexibility in project management in Civil Engineering context? A study into practitioners' perspectives, EURAM (EURopean Academy of Management), Glasgow.

Jamieson, S., 2004. Likert scales: how to (ab) use them. Medical education, 38, 1217-1218.

Jha, K.N., 2011. Construction project management: Theory and practice. Pearson Education India.

Johansson, M.Y., 2012. Agile project management in the construction industry- An inquiry of the opportunities in constrcution projects Department of Real state and Construction Management KTH Royal Institute of Technology Stockholm, Sweden

Jones, R.E., Deckro, R.F., 1993. The social psychology of project management conflict. European Journal of Operational Research, 64, 216-228.

Kalkman, J.P., de Waard, E.J., 2017. Inter-organizational disaster management projects: Finding the middle way between trust and control. International Journal of Project Management, 35, 889-899.

Kaming, P.F., Olomolaiye, P.O., Holt, G.D., Harris, F.C., 1997. Factors influencing construction time and cost overruns on high-rise projects in Indonesia. Construction Management and Economics, 15, 83-94.

Kanwal, N., Zafar, M.S., Bashir, S., 2017. The combined effects of managerial control, resource commitment, and top management support on the successful delivery of information systems projects. International Journal of Project Management, 35, 1459-1465.

Keegan, A., Turner, J.R., 2002. The management of innovation in project-based firms. Long Range Planning, 35, 367-388.

Kellenbrink, C., Helber, S., 2015. Scheduling resource-constrained projects with a flexible project structure. European Journal of Operational Research, 246, 379-391.

Kenny, J., 2003. Effective project management for strategic innovation and change in an organizational context project management journal, 33, 43-53.

Kermanshachi, S., Dao, B., Shane, J., Anderson, S., 2016a. An Empirical Study into Identifying Project Complexity Management Strategies. Procedia Engineering, 145, 603-610.

Kermanshachi, S., Dao, B., Shane, J., Anderson, S., 2016b. Project Complexity Indicators and Management Strategies – A Delphi Study. Procedia Engineering, 145, 587-594.

Khan, K., Turner, J.R., Maqsood, T., Hill, K., 2013. Factors that influence the success of public sector projects in Pakistan, Proceedings of IRNOP 2013 Conference.

Kian Manesh Rad, E., Sun, M., Bosché, F., 2017. Complexity for Megaprojects in the Energy Sector. Journal of Management in Engineering, 33, 04017009.

Kian, M.R.E., Sun, M., Bosché, F., 2016. A Consistency-checking Consensus-building Method to Assess Complexity of Energy Megaprojects. Procedia - Social and Behavioral Sciences, 226, 43-50.

Klein, L., Biesenthal, C., Dehlin, E., 2015. Improvisation in project management: A praxeology. International Journal of Project Management, 33, 267-277.

Kline, P., 1994. An easy guide to factor analysis. Routledge.

Kolltveit, B.J., Grønhaug, K., 2004. The importance of the early phase: the case of construction and building projects. International Journal of Project Management, 22, 545-551.

Koops, L., 2017. Creating public value: Optimizing cooperation Between public and private Partners in infrastructure Projects. Delft University of Technology.

Koops, L., Bosch-Rekveldt, M., Coman, L., Hertogh, M., Bakker, H., 2016. Identifying perspectives of public project managers on project success: Comparing viewpoints of managers from five countries in North-West Europe. International Journal of Project Management, 34, 874-889.

Koppenjan, J., Veeneman, W., van der Voort, H., ten Heuvelhof, E., Leijten, M., 2011. Competing management approaches in large engineering projects: The Dutch RandstadRail project. International Journal of Project Management, 29, 740-750.

Koskela, L., 2000. An exploration towards a production theory and its application to construction, Department of Industrial Engineering and Management VTT Technical Research Centre of Finland, p. 296.

Koskela, L., Ballard, G., Howell, G., Tommelein, I., 2002. The foundations of lean construction. Butterworth Heinemann, Oxford, UK, pp. 211-226.

Koskela, L., Howell, G., 2002. The underlying theory of project management is obsolete, Proceedings of the PMI Research Conference. PMI, pp. 293-302.

Kreiner, K., 1995. In search of relevance: Project management in drifting environments. Scandinavian Journal of Management, 11, 335-346.

Lancaster, G., 2005. Research methods in management. Routledge.

Lane, P.J., Koka, B.R., Pathak, S., 2006. The reification of absorptive capacity: A critical review and rejuvenation of the construct. Academy of management review, 31, 833-863.

Lauras, M., Marques, G., Gourc, D., 2010. Towards a multi-dimensional project Performance Measurement System. Decision Support Systems, 48, 342-353.

Layton, M., 2010. Agile Project Management for Dummies. For Dummies.

Lévárdy, V., Browning, T.R., 2009. An adaptive process model to support product development project management. Engineering Management, IEEE Transactions on, 56, 600-620.

Li, H., Guo, H.L., 2011. International Journal of Project Management special issue on "Complexities in managing mega construction projects". International Journal of Project Management, 29, 795-796.

Lim, C.S., Mohamed, M.Z., 1999. Criteria of project success: an exploratory re-examination. International Journal of Project Management, 17, 243-248.

Lin, H., Zeng, S., Ma, H., Zeng, R., Tam, V.W.Y., 2017. An indicator system for evaluating megaproject social responsibility. International Journal of Project Management, 35, 1415-1426.

Linkov, I., Satterstrom, F.K., Kiker, G., Batchelor, C., Bridges, T., Ferguson, E., 2006. From comparative risk assessment to multi-criteria decision analysis and adaptive management: Recent developments and applications. Environment International, 32, 1072-1093.

Little, R.J., Rubin, D.B., 2014. Statistical analysis with missing data. John Wiley & Sons.

Liu, G.H.W., Wang, E.T.G., Chua, C.E.H., 2015. Persuasion and management support for IT projects. International Journal of Project Management, 33, 1249-1261.

Lu, S., Hao, G., 2013. The influence of owner power in fostering contractor cooperation: Evidence from China. International Journal of Project Management, 31, 522-531.

Lycett, M., Rassau, A., Danson, J., 2004. Programme management: a critical review. International Journal of Project Management, 22, 289-299.

Mansfield, N.R., Ugwu, O.O., Doran, T., 1994. Causes of delay and cost overruns in Nigerian construction projects. International Journal of Project Management, 12, 254-260.

Marhani, M.A., Jaapar, A., Bari, N.A.A., 2012. Lean Construction: Towards Enhancing Sustainable Construction in Malaysia. Procedia - Social and Behavioral Sciences, 68, 87-98.

Marhani, M.A., Jaapar, A., Bari, N.A.A., Zawawi, M., 2013. Sustainability Through Lean Construction Approach: A Literature Review. Procedia - Social and Behavioral Sciences, 101, 90-99.

Marques, G., Gourc, D., Lauras, M., 2011. Multi-criteria performance analysis for decision making in project management. International Journal of Project Management, 29, 1057-1069.

Matinga, M.N., Pinedo-Pascua, I., Vervaeke, J., Monforti-Ferrario, F., Szabo, S., 2014. Do African and European energy stakeholders agree on key energy drivers in Africa? Journal of Energy Policy, 69.

Matinheikki, J., Artto, K., Peltokorpi, A., Rajala, R., 2016. Managing inter-organizational networks for value creation in the front-end of projects. International Journal of Project Management, 34, 1226-1241.

Matos, S., Lopes, E., 2013. Prince2 or PMBOK – A Question of Choice. Procedia Technology, 9, 787-794.

Maylor, H., 2010. Project Management. Financial Times Prentice Hall.

Maylor, H., Blackmon, K.L., 2005. Researching business and management. Palgrave Macmillan.

Maylor, H., Vidgen, R., Carver, S., 2008. Managerial complexity in project-based operations: A grounded model and its implications for practice. project management journal, 39, S15-S26.

McLain, R.J., Lee, R.G., 1996. Adaptive management: promises and pitfalls. Environmental management, 20, 437-448.

Meng, X., 2012. The effect of relationship management on project performance in construction. International Journal of Project Management, 30, 188-198.

Merrow, E.W., 2011. Industrial megaprojects: concepts, strategies, and practices for success. Wiley Online Library.

Mertens, D., 1998. Research methods in education and psycohology. New York.

Militello, M., Benham, M.K., 2010. "Sorting Out" collective leadership: How Q-methodology can be used to evaluate leadership development. The Leadership Quarterly, 21, 620-632.

Mir, F.A., Pinnington, A.H., 2014. Exploring the value of project management: Linking Project Management Performance and Project Success. International Journal of Project Management, 32, 202-217.

Morgan, B.V., 1987. Benefits of project management at the front end. International Journal of Project Management, 5, 102-119.

Morris, P., 2013. Reconstructing project management reprised: A knowledge perspective. project management journal, 44, 6-23.

Morris, P.W., 1983. Managing project interfaces–key points for project success. Project management handbook, 2, 16-55.

Morris, P.W., 1997. The management of projects. Thomas Telford.

Müller, R., Turner, R., 2007. The Influence of Project Managers on Project Success Criteria and Project Success by Type of Project. European Management Journal, 25, 298-309.

Munns, A.K., Bjeirmi, B.F., 1996. The role of project management in achieving project success. International Journal of Project Management, 14, 81-87.

Murino, T., Naviglio, G., Romano, E., 2010. Optimal size of kanban board in a single stage multi product system. WSEAS Transactions on Systems and Control, 5, 464-473.

Nachtigall, C., Kroehne, U., Funke, F., Steyer, R., 2003. Pros and cons of structural equation modeling. Methods Psychological Research Online, 8, 1-22.

Neerlands diep, 2014. Academie voor publieke bouw- en infraprojecten.

Nerur, S., Mahapatra, R., Mangalaraj, G., 2005. Challenges of migrating to agile methodologies. Communications of the ACM, 48, 72-78.

Nguyen, A.T., Nguyen, L.D., Le-Hoai, L., Dang, C.N., 2015. Quantifying the complexity of transportation projects using the fuzzy analytic hierarchy process. International Journal of Project Management, 33, 1364-1376.

Ning, Y., 2017. Combining formal controls and trust to improve dwelling fit-out project performance: A configurational analysis. International Journal of Project Management, 35, 1238-1252.

Nobelius, D., Trygg, L., 2002. Stop chasing the Front End process — management of the early phases in product development projects. International Journal of Project Management, 20, 331-340.

OGC, O.o.G.C., 2009. Managing successful projects with PRINCE2. The Stationery Office.

Olsson, N.O.E., 2006. Management of flexibility in projects. International Journal of Project Management, 24, 66-74.

Oppong, G.D., Chan, A.P.C., Dansoh, A., 2017. A review of stakeholder management performance attributes in construction projects. International Journal of Project Management, 35, 1037-1051.

Osipova, E., Eriksson, P.E., 2013. Balancing control and flexibility in joint risk management: Lessons learned from two construction projects. International Journal of Project Management, 31, 391-399.

Ourdev, I., Xie, H., AbouRizk, S., 2008. An Intelligent Agent Approach to Adaptive Project Management. Tsinghua Science & Technology, 13, Supplement 1, 121-125.

Owen, R., Koskela, L., Henrich, G., Codinhoto, R., 2006. Is agile project management applicable to construction?, Proceedings of the 14th Annual Conference of the International Group for Lean Construction, pp. 51-66.

P2M, 2008. P2M: a guidebook of project & program management. Project Management Association of Japan, Tokyo, Japan

Padalkar, M., Gopinath, S., 2016. Are complexity and uncertainty distinct concepts in project management? A taxonomical examination from literature. International Journal of Project Management, 34, 688-700.

Pahl-Wostl, C., 2007. Transitions towards adaptive management of water facing climate and global change. Water resources management, 21, 49-62.

Perminova, O., Gustafsson, M., Wikström, K., 2008. Defining uncertainty in projects–a new perspective. International Journal of Project Management, 26, 73-79.

Philbin, S.P., 2008. Managing complex technology projects. Research-Technology Management, 51, 32-39.

Pich, M.T., Loch, C.H., Meyer, A.D., 2002. On uncertainty, ambiguity, and complexity in project management. Management Science, 48, 1008-1023.

Ping, L., Xiaoyan, X., Zhaofang, C., Lamei, Q., 2016. Role of Opportunism and Trust in Construction Projects: Empirical Evidence from China.

Pisano, G.P., 2000. In search of dynamic capabilities: the origins of R&D competence in biopharmaceuticals. Oxford University Press, Oxford, New York.

Platje, A., Seidel, H., 1993. Breakthrough in multiproject management: how to escape the vicious circle of planning and control. International Journal of Project Management, 11, 209-213.

PMI, 2001. PROJECT MANAGEMENT BODY OF KNOWLEDGE (PMBOK® GUIDE). PMI

PMI, 2013. A Guide to the Project Management Body of Knowledge (PMBOK® Guide). Project Management Institute, Incorporated.

PMI, 2017. Success rates rise: transforming the high cost of low perfromance PMI's puls of the profession. PMI, Pennsylvania.

Polk, R., 2011. Agile and Kanban in Coordination, 2011 Agile Conference, pp. 263-268.

Preacher, K.J., Hayes, A.F., 2008. Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. Behavior research methods, 40, 879-891.

Priemus, H., van Wee, B., 2013. International Handbook on Mega-projects. Edward Elgar Publishing.

Pryke, S., Smyth, H., 2006. The Management of Complex Projects: a relationship approach. John Wiley & Sons.

Qazi, A., Quigley, J., Dickson, A., Kirytopoulos, K., 2016. Project Complexity and Risk Management (ProCRiM): Towards modelling project complexity driven risk paths in construction projects. International Journal of Project Management, 34, 1183-1198.

Qureshi, S.M., Kang, C., 2015. Analysing the organizational factors of project complexity using structural equation modelling. International Journal of Project Management, 33, 165-176.

R Ireland, L., 1992. Customer satisfaction: the project manager's role. International Journal of Project Management, 10, 123-127.

Radujković, M., Sjekavica, M., 2017a. Development of a project management performance enhancement model by analysing risks, changes, and constraints.

Radujković, M., Sjekavica, M., 2017b. Project Management Success Factors. Procedia Engineering, 196, 607-615.

Ralph, C.G.H., SangHyun, L., Carl, T.H., Samin, S., Seungjun, A., 2016. Exploratory Study on the Effectiveness of Interface-Management Practices in Dealing with Project Complexity in Large-Scale Engineering and Construction Projects.

Rankin, J., Fayek, A.R., Meade, G., Haas, C., Manseau, A., 2008. Initial metrics and pilot program results for measuring the performance of the Canadian construction industry. Canadian Journal of Civil Engineering, 35, 894-907.

Ratcheva, V., 2009. Integrating diverse knowledge through boundary spanning processes – The case of multidisciplinary project teams. International Journal of Project Management, 27, 206-215.

Reid Robert, S., Guillermo, A.-M., John Riker, H., 2013. Relationships between Project Complexity and Communication.

Reilly, J., 2000. The management process for complex underground and tunneling projects. Tunnelling and Underground Space Technology, 15, 31-44.

Rezvani, A., Chang, A., Wiewiora, A., Ashkanasy, N.M., Jordan, P.J., Zolin, R., 2016. Manager emotional intelligence and project success: The mediating role of job satisfaction and trust. International Journal of Project Management, 34, 1112-1122.

Rijke, J., van Herk, S., Zevenbergen, C., Ashley, R., Hertogh, M., ten Heuvelhof, E., 2014. Adaptive programme management through a balanced performance/strategy oriented focus. International Journal of Project Management.

Ringle, C.M., Wende, S., Will, A., 2005. SmartPLS 2.0.M3. Hamburg: SmartPLS, http://www.smartpls.de.

Rising, L., Janoff, N.S., 2000. The Scrum software development process for small teams. IEEE software, 17, 26-32.

Royce, W.W., 1987. Managing the development of large software systems: concepts and techniques, Proceedings of the 9th international conference on Software Engineering. IEEE Computer Society Press, pp. 328-338.

Sager, T., 1990. Notions of flexibility in planning-related literature. Nordic Institute for Studies in Urban and Regional Planning.

Samset, K., Volden, G.H., 2016. Front-end definition of projects: Ten paradoxes and some reflections regarding project management and project governance. International Journal of Project Management, 34, 297-313.

Sanjuan, A.G., Froese, T., 2013. The Application of Project Management Standards and Success Factors to the Development of a Project Management Assessment Tool. Procedia - Social and Behavioral Sciences, 74, 91-100.

Sanvido, V., Grobler, F., Parfitt, K., Guvenis, M., Coyle, M., 1992. Critical success factors for construction projects. Journal of Construction Engineering and Management, 118, 94-111.

Saynisch, M., 2010. Beyond frontiers of traditional project management: An approach to evolutionary, self-organizational principles and the complexity theory—results of the research program. project management journal, 41, 21-37.

Schmolck, P., 2012. PQMethod software. Retrieved from http://schmolck.userweb.mwn.de/qmethod/downpqwin.htm.

Sense, A.J., 2011. The project workplace for organizational learning development. International Journal of Project Management, 29, 986-993.

Serrador, P., Pinto, J.K., 2015. Does Agile work? — A quantitative analysis of agile project success. International Journal of Project Management, 33, 1040-1051.

Sharma, R., Sohl, A.J., Hertogh, M.J., Deketh, J.R., 2017. Controlling the uncontrolled by noticing the unnoticed, Computer Sciences and Information Technologies (CSIT), 2017 12th International Scientific and Technical Conference on. IEEE, pp. 106-114.

Sheard, S.A., 2012. Assessing the impact of complexity attributes on system development project outcomes. Stevens Institute of Technology.

Shenhar, A.J., Dvir, D., Lechler, T., Poli, M., 2002. One size does not fit all—true for projects, true for frameworks, Proceedings of PMI Research Conference, pp. 14-17.

Shenhar, A.J., Dvir, D., Levy, O., Maltz, A.C., 2001. Project Success: A Multidimensional Strategic Concept. Long Range Planning, 34, 699-725.

Shenhar, A.J., Dvir, D., Shulman, Y., 1995. A two-dimensional taxonomy of products and innovations. Journal of Engineering and Technology Management, 12, 175-200.

Shi, Q., 2011. Rethinking the implementation of project management: A Value Adding Path Map approach. International Journal of Project Management, 29, 295-302.

Shrnhur, A.J., Levy, O., Dvir, D., 1997. Mapping the dimensions of project success. project management journal, 28, 5-13.

Simon, H.A., 1962. The architecture of complexity. Proceedings of American Philosophical Society

Skibniewski, M.J., Ghosh, S., 2009. Determination of key performance indicators with enterprise resource planning systems in engineering construction firms. Journal of Construction Engineering and Management, 135, 965-978.

Slack, N., Chambers, S., Johnston, R., 2007. Operations Management, Trans. Atlantic Publications, Inc.

Smith, D., Irwin, A., 2006. Complexity, Risk and Emergence: Elements of a "Management" Dilemma. Risk Management, 8, 221-226.

Smith, R., Mobley, R.K., 2008. Chapter 6 - Key Performance Indicators, in: Smith, R., Mobley, R.K. (Eds.), Rules of Thumb for Maintenance and Reliability Engineers. Butterworth-Heinemann, Burlington, pp. 89-106.

Söderlund, J., 2004. Building theories of project management: past research, questions for the future. International Journal of Project Management, 22, 183-191.

Sohi, A.J., Hertogh, M., Bosch-Rekveldt, M., Blom, R., 2016. Does Lean & Agile Project Management Help Coping with Project Complexity? Procedia - Social and Behavioral Sciences, 226, 252-259.

Stephenson, W., 1953. The study of behavior: Q-technique and its methodology. University of Chicago Press, Chicago, Ill.

Stephenson, W., 1965. Definition of opinion, attitude and belief. Psychological Record, 15, 281-288.

Stoica, R., Brouse, P., 2013. IT Project Failure: A Proposed Four-Phased Adaptive Multi-Method Approach. Procedia Computer Science, 16, 728-736.

Straub, D.W., Welke, R.J., 1998. Coping with systems risk: security planning models for management decision making. MIS quarterly, 441-469.

Suprapto, M., Bakker, H.L.M., Mooi, H.G., 2015a. Relational factors in owner–contractor collaboration: The mediating role of teamworking. International Journal of Project Management, 33, 1347-1363.

Suprapto, M., Bakker, H.L.M., Mooi, H.G., Hertogh, M.J.C.M., 2016. How do contract types and incentives matter to project performance? International Journal of Project Management, 34, 1071-1087.

Suprapto, M., Bakker, H.L.M., Mooi, H.G., Moree, W., 2015b. Sorting out the essence of owner–contractor collaboration in capital project delivery. International Journal of Project Management, 33, 664-683.

Sutherland, J., Schwaber, K., 2013. The scrum guide: the definitive guide to scrum: the rules of the game. Retrieved October, 1, 2013.

Svejvig, P., Andersen, P., 2014. Rethinking project management: A structured literature review with a critical look at the brave new world. International Journal of Project Management.

Tabish, S., Jha, K.N., 2011. Identification and evaluation of success factors for public construction projects. Construction Management and Economics, 29, 809-823.

Takeuchi, H., Nonaka, I., 1986. The new new product development game. Harvard business review, 64, 137-146.

Tashakkori, A., Teddlie, C., 1998. Mixed methodology: Combining qualitative and quantitative approaches. Sage.

Teisman, G., van Buuren, A., Gerrits, L.M., 2009. Managing complex governance systems. Routledge.

Terryn, E., Boelens, L., Pisman, A., 2016. Beyond the divide: evaluation in co-evolutionary spatial planning. European Planning Studies, 24, 1079-1097.

The Standish Group, 2009. CHAOS Summary 2009. The Standish Group International, Boston.

The Standish Group, 2016. Chaos summary 2016. The Standish Group International Boston

Timmermans, S., Tavory, I., 2012. Theory construction in qualitative research: From grounded theory to abductive analysis. Sociological Theory, 30, 167-186.

Tompkins, E., Adger, W.N., 2004. Does adaptive management of natural resources enhance resilience to climate change? Ecology and society, 9.

Toor, S.-u.-R., Ogunlana, S.O., 2008. Critical COMs of success in large-scale construction projects: Evidence from Thailand construction industry. International Journal of Project Management, 26, 420-430.

Toor, S.-u.-R., Ogunlana, S.O., 2010. Beyond the 'iron triangle': Stakeholder perception of key performance indicators (KPIs) for large-scale public sector development projects. International Journal of Project Management, 28, 228-236.

Turner, J.R., 2004. Five necessary conditions for project success. International Journal of Project Management, 22, 349-350.

Turner, J.R., 2014a. Handbook of project-based management. McGraw-hill New York, NY.

Turner, J.R., Cochrane, R.A., 1993. Goals-and-methods matrix: coping with projects with ill defined goals and/or methods of achieving them. International Journal of Project Management, 11, 93-102.

Turner, R., 2014b. The Handbook of Project-Based Management, Fifth ed. McGraw-Hill, Glasgow, United Kingdom

Tzortzopoulos, P., Cooper, R., Chan, P., Kagioglou, M., 2006. Clients' activities at the design front-end. Design Studies, 27, 657-683.

van Exel, J., Baker, R., Mason, H., Donaldson, C., Brouwer, W., Team, E., 2015. Public views on principles for health care priority setting: Findings of a European cross-country study using Q methodology. Social Science & Medicine, 126, 128-137.

Van Exel, J., De Graaf, G., 2005. Q methodology: A sneak preview. Retrieved January, 24, 2009.

Van Marrewijk, A., Clegg, S.R., Pitsis, T.S., Veenswijk, M., 2008. Managing public–private megaprojects: Paradoxes, complexity, and project design. International Journal of Project Management, 26, 591-600.

van Solingen, R., Rustenburg, E., 2010. De kracht van SCRUM.

van Waardenburg, G., van Vliet, H., 2013. When agile meets the enterprise. Information and Software Technology, 55, 2154-2171.

Verweij, S., 2015. Achieving satisfaction when implementing PPP transportation infrastructure projects: a qualitative comparative analysis of the A15 highway DBFM project. International Journal of Project Management, 33, 189-200.

Vidal, L.-A., Marle, F., Bocquet, J.-C., 2011. Measuring project complexity using the Analytic Hierarchy Process. International Journal of Project Management, 29, 718-727.

Walker, D.H.T., Shen, Y.J., 2002. Project understanding, planning, flexibility of management action and construction time performance: two Australian case studies. Construction Management and Economics, 20, 31-44.

Wallace, W.L., 1971. The Logic of Science in Sociology [sound Recording]. Transaction Publishers.

Walters, C.J., 1986. Adaptive management of renewable resources. Macmillan Publishers Ltd.

Wang, C.L., Ahmed, P.K., 2007. Dynamic capabilities: A review and research agenda. International Journal of Management Reviews, 9, 31-51.

Wang, Y., Chen, Y., Fu, Y., Zhang, W., 2017. Do prior interactions breed cooperation in construction projects? The mediating role of contracts. International Journal of Project Management, 35, 633-646.

Ward, C., 1994. What is agility. Industrial Engineering, 26, 14-&.

Webler, T., Danielson, S., Tuler, S., 2009. Using Q method to reveal social perspectives in environmental research. Greenfield MA: Social and Environmental Research Institute, 54, 1-45.

Wei, W., Zongzhong, T., Jiajun, S., 2013. Correlation between Degree of Complexity and Efficiency for Intersections in China.

Westerveld, E., 2003. The Project Excellence Model®: linking success criteria and critical success factors. International Journal of Project Management, 21, 411-418.

Whitty, S.J., Maylor, H., 2009. And then came Complex Project Management (revised). International Journal of Project Management, 27, 304-310.

Whyte, J., Stasis, A., Lindkvist, C., 2016. Managing change in the delivery of complex projects: Configuration management, asset information and 'big data'. International Journal of Project Management, 34, 339-351.

Williams, T., 2005. Assessing and moving on from the dominant project management discourse in the light of project overruns. Engineering Management, IEEE Transactions on, 52, 497-508.

Williams, T.M., 1999. The need for new paradigms for complex projects. International Journal of Project Management, 17, 269-273.

Winter, M., Smith, C., Morris, P., Cicmil, S., 2006. Directions for future research in project management: The main findings of a UK government-funded research network. International Journal of Project Management, 24, 638-649.

Wirkus, M., 2016. Adaptive Management Approach to an Infrastructure Project. Procedia - Social and Behavioral Sciences, 226, 414-422.

Womack, J.P., Jones, D.T., 2010. Lean thinking: banish waste and create wealth in your corporation. Simon and Schuster.

Wysocki, R.K., 2007. Effective Project Management : Traditional, Adaptive, Extreme. Wiley Pub, Indianapolis, IN.

Wysocki, R.K., McGary, R., 2003. Effective project management: traditional, adaptive, extreme. John Wiley & Sons.

Xu, Y., Yeh, C.-H., 2014. A performance-based approach to project assignment and performance evaluation. International Journal of Project Management, 32, 218-228.

Yadav, V.V.V., 2016. A Flexible Management Approach for Globally Distributed Software Projects. Global Journal of Flexible Systems Management, 17, 29-40.

Yap, J.B.H., Abdul-Rahman, H., Chen, W., 2017. Collaborative model: Managing design changes with reusable project experiences through project learning and effective communication. International Journal of Project Management, 35, 1253-1271.

Yescombe, E.R., 2014. Chapter 3 - Project Development and Management, in: Yescombe, E.R. (Ed.), Principles of Project Finance (Second edition). Academic Press, San Diego, pp. 29-60.

Yeung, J.F., Chan, A.P., Chan, D.W., Chiang, Y., Yang, H., 2012. Developing a benchmarking model for construction projects in Hong Kong. Journal of Construction Engineering and Management, 139, 705-716.

Yin, R.K., 2002. Case Study Research: Design and Methods, (Applied Social Research Methods, Vol. 5).

Yin, R.K., 2014. Case study research: Design and methods. Sage publications.

Young, R., Jordan, E., 2008. Top management support: Mantra or necessity? International Journal of Project Management, 26, 713-725.

Young, R., Poon, S., 2013. Top management support—almost always necessary and sometimes sufficient for success: Findings from a fuzzy set analysis. International Journal of Project Management, 31, 943-957.

Yun, S., Choi, J., de Oliveira, D.P., Mulva, S.P., 2016. Development of performance metrics for phase-based capital project benchmarking. International Journal of Project Management, 34, 389-402.

Zhu, J., Mostafavi, A., 2017. Discovering complexity and emergent properties in project systems: A new approach to understanding project performance. International Journal of Project Management, 35, 1-12.

APPENDIX A: SEMI-STRUCTURED INTERVIEW PROTOCOL (EXPLORATION OF RESEARCH TOPIC RELEVANCE)

Main theme of the interview includes the following concepts:

- Project performance
- Programme performance
- Project success vs programme success
- Managerial skills
- Deficiencies in project management skills/abilities/ knowledge

Questions below can investigate the above mentioned factors (very general questions to explore the high-potential areas for further research):

1. How are the project performance and programme performance that you are already involved in? is it successfully delivered phase by phase?
2. As a follow up to the first question, if the project team and stakeholders are not satisfied with the project/programme performance then what could be the main reason(s) of poor performance? (Inadequate managerial skills, inadequate knowledge or information, the external factors like the public effect on the project)
3. What aspects of the project/programme do still remain unmanaged from your point of view? (Like governance, stakeholder management, knowledge management or whatever else)
4. In your opinion, what aspect of the project management knowledge has deficiencies in between managerial skill which is a necessity for successful delivery of the project?
5. What is the most problematic issue in the current project(s)?
6. Do the current project management methodologies or knowledge guides work properly in projects? Or better say do they deliver success for nowadays complex projects?
7. What is going well in the current projects? What aspect of the project is satisfying the stakeholders and parties involved in the project?

In the next part of the interview it is helpful to ask for interviewers' ideas about the following concepts (in order to find out which can be much helpful in projects):

- Project complexity
- Agile project management
- Change management
- Knowledge management
- Governance processes

- Contractual arrangement
- Stakeholder management
- Programme management

APPENDIX B: INTERVIEWEES' PROFILE (CHAPTER 3)

Project ID	Management Approach	Interviewee ID	background studies	Function	Experience: Total	Experience: in current function	Upfront familiarity with Agile PM
Project A	Agile-Managed	AP1R1	Civil engineering	Technical manager	11	2	From the practice
		AP1R2	Land & water management	Scrum master	19	4	Yes
		AP1R3	computing science	Agile (Scrum) coach	21	6	Yes
		AP1R4	Civil engineering +Town planning	Project manager (product owner)	20	3	Yes
Project B	Agile-Managed	AP2R1	civil engineering Geotechnics	Lead engineer/ geotechnical engineer	15	15	Only Scrum
		AP2R2	civil engineering	Project manager	25	15	No
Project C	Agile- Managed	AP2R1	Architecture & Building Sciences	Assistant project manager	5	3	Only Scrum
		AP3R2	civil engineering	Road designer	19	15	Only Scrum
		AP3R3	Civil engineering	Designer	8	4	have heard about it.
project D	Waterfall-managed	CP1R1	civil engineering	Project manager	32	20	No
		CP1R2	civil engineering - Construction management and engineering	Project manager assistant	2	1,5	Yes
		CP1R3	Roads and water management	Technical manager	27	10	A little bit
		CP1R4	Geophysics	Stakeholder manager	14	7	No
Project E	Waterfall-managed	CP2R1	Road and water management	Project leader	38	30	No
		CP2R2	Electrical engineering	Consultant system engineer	28	6	Yes
		CP2R3	Civil engineering	Advisor (Risk)	25	15	Yes
Project F	Waterfall-managed	CP3R1	Technical studies	Project manager	34	12	Only Scrum
		CP3R2	Civil engineering	Technical manager for noise study	37	15	No

APPENDIX C: LIST OF STUDIED LITERATURE DEFINING/IDENTIFYING FLEXIBILITY AND ADAPTABILITY IN PROJECT MANAGEMENT

#	Author(s)	Title	Source	Year	Flexibility/ Adaptability	Summary
1	Sager, Tore	Notion of flexibility in planning-related literature	Nordic Institute for Studies in Urban and Regional Planning	1990	Flexibility	Purpose: providing a key in literature about flexibility in planning activities. Methodology: desk study (literature study). Main findings: definition of flexibility in planning activities and related concepts such as robustness, resilience, and stability (with emphasis on strategic planning).
2	Kreiner, Kristian	In search of relevance: project management in drafting environment	Scandinavian Journal of Management	1995	Adaptability (adaptation)	Purpose: providing insight on the fact that originally relevant outcome of a project might become irrelevant because of external changes such as drifting environments. Methodology: desk study (literature study). Main findings: in uncertain environment, the relevance of original outcome of the project is threatened. *"the concept of drifting environments is intended to capture the essence of the type of uncertainty that can undermine the relevance and ultimate success of a project."*
3	Walker, Derek H. T.; Shen, Yue J.	Project understanding, planning, flexibility of management action and construction time performance: two Australian case studies	Construction Management and Economics	2002	Flexibility	Purpose: to achieve better planning through flexible approaches to overcome unexpected problems. Methodology: two case studies. Main findings: degree of flexibility depends on (1) ability of teams and individuals to be flexible about options and (2) commitment of teams and individuals.
4	Olsson, Nils O. E.	Management of flexibility in projects	International journal of project management	2006	Flexibility	Purpose: to analyse the dynamics related to project flexibility both from theoretical and an empirical perspective. Methodology: multi-case study of 18 projects. Key finding: flexibility is frequently used but rarely prepared for. Flexibility is applicable in front-end but hardly in execution. 5 types of flexibility are late locking, continuous locking, extensions, change, and contingency plans.
5	Linkov, I., Satterstrom, F. K., Kiker, G., Batchelor, C., Bridges, T., & Ferguson, E.	From comparative risk assessment to multi-criteria decision analysis and adaptive management: Recent developments and applications	Environment International	2006	Adaptability	Purpose: Bring comparative risk analysis, multi criteria decision analysis, and adaptive management approach. together to empower decision making with considerations of uncertainty in environment management. Methodology: desk study + case study. Main finding: *"Using adaptive management and multi-criteria decision analysis gives structure to the decision-making process and allows the manager to learn about the system being managed and modify the management strategy based on new knowledge."*

#	Author(s)	Title	Source	Year	Flexibility/ Adaptability	Summary
6	Geraldi Joana G.	The balance between order and chaos in multi-project firms: A conceptual model	International journal of project management	2008	Flexibility	Purpose: Defining the edge of chaos for multi-project firms based on the match between complexity of project portfolio and flexibility of its organisational units. Methodology: literature study . Main finding: five category of flexibility: what, how, who, when, and where. There is a link between flexibility and complexity of organisation.
7	Ourdev, I.; Xie, H.; Abourizk, S.	An intelligent agant approach to adaptive project management	Tsinghua Science & Technology	2008	Adaptability	Purpose: to present a framework to be applied in a real-life monitoring system for a tunnel-boring machine excavation project that helped with forecasting and managing the project timelines in response to the changes in the uncertain excavation environment. Methodology: desk study + test case. Main finding: adaptive project management tool based on the latest available information about the project's progress to calculate the optimal duration of tunnel excavation.
8	Aritua, B., Smith, N. J., & Bower, D.	Construction client multi-projects – A complex adaptive systems perspective	International Journal of Project Management	2009	Adaptability	Purpose: to shed light on the fact that multi-project environments exhibit the characteristics of complex adaptive systems which offer novel approaches for the project manager. Methodology: desk study + case study. Main finding: in portfolio and programme levels understanding of every last detail from individual projects influences multi-project managers to seek a balance between trusting project managers and allowing them flexibility while seeking the necessary level of control and accountability (adaptability). Also increased information-sharing among project teams and organisations impacting on the objectives of a multi-project environment. Project managers must be constantly aware of how their projects fit in the evolving strategy. Trust is required among management levels.
9	Koppenjan, Joop; Veenemen, Wijnand, Van der Voort, Haiko; ten Heuvelhof, Ernest; Leijten Martijn	Competing management approaches in large engineering projects: the Dutch RandstudRail project	International journal of project management	2011	Flexibility	Purpose: combination of Flexibility and control for managing uncertainty and complexity of projects. Methodology: One in-depth case study. Main findings: balance between control and flexibility developing a framework aimed at dealing with the contradictory requirements of control and flexibility.
10	Biedenbach, T., &	Absorptive, innovative	International Journal	2012	Adaptability	Purpose: explore the effect of absorptive, innovative, and adaptive capabilities

#	Author(s)	Title	Source	Year	Flexibility/ Adaptability	Summary
	Müller, R.	and adaptive capabilities and their impact on project and project portfolio performance	of Project Management			within early project phases on project and portfolio performance in pharmaceutical and biotechnology R&D organisations. Methodology: sequential qualitative-quantitative methodology on data gathered from 18 interviews and 80 filled-in online survey. Main findings: Absorptive and adaptive capabilities has primary contribution to the performance outcome.
11	Godinho, P., & Branco, F. G.	Adaptive policies for multi-mode project scheduling under uncertainty	European Journal of Operational Research	2012	Adaptability	Purpose: propose an adaptive model for multi-mode project scheduling under uncertainty. Methodology: desk study. Main finding: proposed an adaptive model for project scheduling in uncertain conditions based on the starting time of the activity and the choice of mode.
12	Osipova, Ekaterina; Eriksson, Per Erik	Balancing control and flexibility in joint risk management: lessons learned from two construction projects	International journal of project management	2013	Adaptability	Purpose: to investigate the degree control and flexibility in joint risk management. Methodology: 2 case studies. Main findings: Joint risk management require both control and flexibility; control in order to managing the risks and flexibility to deal with unforeseen events.
13	Svejvig, P., & Andersen, P.	Rethinking project management: A structured literature review with a critical look at the brave new world	International Journal of Project Management	2014	Adaptability	Purpose: presenting a structured review of the rethinking project management literature (comparison of traditional project management with rethinking project management). Methodology: desk study. Main findings: 6 overarching categories from the literature analysis of the 74 contributions: contextualization, social and political aspects, rethinking practice, complexity and uncertainty, actuality of projects and broader conceptualization. According to Outlining the complexity of projects, their environment, etc. new methods are needed to cope with complexity. Adaptive project management is known as one of the directions of rethinking project management versus classical (traditional project management).
14	Carolin Kellenbrink, Stefan Helber	Schedulingresource-constrainedprojectswi thaflexibleprojectstruc ture	European journal of operational research	2015	Flexibility	Purpose: to propose a model (Genetic algorithm) for resource-constrained project scheduling in flexible project structure. Methodology: desk study + numerical study. Main finding: developed framework (genetic algorithm) for scheduling the project with a flexible structure, based on real-life resource constraints.

Appendix D: Data from interviews to validate flexibility enablers

Category	Definition		Measure	Enabler	NOT applicable	Comments
What	Ability to define and change the scope and goals of the project (contract flexibility)	1	Broad task definition	13	1	R1: It is bounded with time. Broad task definition can be a disabler at the later stages of the project. R3: Broad task definition should explain the functionality of the project. R4: Important for team members to see the final goal of project. R7: At some points for decision making it should be narrowed (for example there is a moment that design should be fixed). R8: If the task is defined too broad then it is destructive and disabler of flexibility. What we have done for Agile transition, is not anymore writing task definition to get maximum flexibility in organic organisation. For differentiating the goal and task it is important to have broad task definition. It should be clear if it is about scope of project or task that people have to do. R9: It should be specific enough to be clear what should be done. But there is a difference between 'what are the tasks' and 'what has to be done?' It should be very specific about what has to be realised.
		2	Embrace Changes	13	1	R1: It depends on time. By nature there are changes happening in the project but due to time restriction not all can be incorporated. R2: Change is good if you can make better use of capital. R3: Embracing change depends on project stages, law, etc. we need entrepreneur mind-set for embracing change. R4: People should look at change with open mind. R5: Every change is possible as long as the parties can negotiate about restrictions (time, cost, ...). R7: When you do a project, there are changes which cannot be neglected. R8: From Agilist point of view, it is very important to embrace change. R9: That is essential. Normally it is not desirable to have change but when it is needed, you have to incorporate with change. R12: In project management change is bad. The impact of change should be clear.
		3	Facilitate change as much as needed (Change is inevitable)	13	1	R4: For facilitating change you have to look at all aspects of the change. You have to investigate the consequences of change. R8: Even in Agile way in which change is desirable, because resources are fixed there is a limit for changes. Within the limits we can be flexible as long as it delivers the maximum value.

						R14: it is the same as 'embracing change'. R12: change needs to be accommodated, not facilitated. R1: If change happens better to facilitate it to minimize its negative impact.
		4	Functional-realisation based contract rather than predefined task execution (functional scope definition)	12	2	R3: It is different with different parties. Because with suppliers it is more clear what they have to deliver but with contractors or other parties, it is more and more going toward defining the function rather than the tasks R4: It gives the opportunity to select the best solution for realising the function. It might negatively influenced by risks like financial risks. R7: not necessary. It seems that there are many options at the beginning, and when one option is chosen, still you have to deal with changes. It helps flexibility but it is not essential. R9: If there is no specification about the project then the development team is not able to take the requirements of the stakeholders into account. (in scrum when the product owner (client) is part of the team then it is possible to have functional-realisation based contract. R1: The extend of flexibility in defining the function or the task is important.
How	Ability to define and change the implementation process (tools and instrumental flexibility)	5	Self-steering of the complete project team (Steering is much more of a horizontal character: in a networks of client, management, contractors, and technology providers)	14	0	R3: Although it is important for flexibility but there should be hierarchy for decision making. In our organisation we introduced project-steering groups comprising members from senior level and board level and every month operational project lead has to report and to them. It is self-steering between boundary. R4: If steering of project team is not being managed properly it becomes a mess. And when it happened it become really long to overcome that. There should be some boundaries and also guidelines for it. R7: hierarchy is required for decision making (Part of bigger scheme high management must force a decision & pull/push people into being more flexible). R8: It is important but for decision making there should be some hierarchy (somebody who makes the decision). R9: Essential. In scrum there are moments that you should look at the work that has been done and see if the desired results have been delivered. And see if it was efficient or not. R2: People can be task-oriented or goal-oriented. For self-steering they should be goal-oriented.
		6	The process of exchanging information is more open	14	0	R3: It is very important R4: Everybody should be transparent in communication. R8: It is very much related to trust. When trust is minimal, the amount of documentation, emails, ... increases. To have a successful agile project the exchange of information should be open. R9: The more close the process of information exchange is, the more effort for steering the team is needed. R14: Transparency is very important. R1: It absolutely helps flexibility but if right information with right person be exchanged.

	7	Unstructured information exchange	8	6	R3: Inform other parties as much as possible but in a structured way. For example there are risks if someone get the information before the decision makers get that piece of information. Especially if it has to do with political information. R4: There is so much information. If you don't structure the information flow, people would drown in information and they cannot pick out what they need. You shouldn't skip the information but structure it in a way that people can handle it. R7: it has negative effect. There is need for structure. R8: It is disabler. Even for open information exchange there should be structure. R9: A system is needed for information exchange. This way people can react to others or put comments. This way there is structure for information exchange by using the system but at the time it is unstructured because the communication lines are not predefined. R1: It is an enabler of flexibility but many people might see it differently (chaos). R2: It is only possible if the relationship between the parties are good. Otherwise there is need for structure. R5: It is not feasible.
	8	Demand-driven information exchange between different groups	12	2	R3: Information is mainly shared based on the regulations and understanding what kind of information each stakeholder needs. R4: Sometime the demand for the information is not understandable by the party who owns the information. The demand could be narrowed when they start working together. To oversee the situation sometimes you should give more information rather than their demand. R7: Difficult to realise. R8: You should always encourage the other parties involved in the project telling what information they require and also what kind of information they generate. R9: There is a pool that all information goes there and team members based on the demand, take what information they need.
	9	Shared interfaces management among the actors involved, rather than a task mainly driven by the formal project manager	14	0	
	10	Contingency planning	11	3	R4: Put it in risk analysis. R8: In agile way, risks should be incorporated in the way the work is being done. R9: When you use scrum to manage the process of developing the project there is no need for contingency planning. For inflexible project environment there should be contingency planning but with using scrum no need for contingency planning. R14: Contingency planning depends on contractual risks. R1: It helps to set up for things that might happen in the future. R2: It depends on the project.

	11	Seize opportunities and coping with threats (resilience)	13	1	R3: It is important especially for big projects. R7: there should be a limit otherwise there are always opportunities and threats. R9: it is essential. R14: If it is about the scoping the project, it should be avoided but if it is about reacting to change, it is helpful.
	12	Trust among parties involved in the project	14	0	R4: One of the basics. It also relates to information exchange. R7: this is essential. R8: Whole contracting is based on trust. R9: If there is no trust better not to use scrum at all. At first or first two sprints there was no production because there was no trust among the people; product owner, scrum master, developer team. when there is no trust, there won't be any production. This is essential to be in place before project starts.
	13	Use standardisation to an extent that fits with the project's context	12	2	R9: The process should be standardised to make it clear what the expectations are from each person. It has also relation to trust.
	14	Visualise project planning and progress	14	0	R4: It is important because it help achieving team commitment. R7: If you know what is the status of the project. then it is possible to absorb changes and it helps. R9: Visualising not project planning but project progress for me as scrum master is needed to have information on velocity of team and the amount of work which is left. It is stimulating the velocity. (burn out charts) it is not essential but an enabler for better performance. R14: Visibility is very important. R1: If you can make it clear for everybody understand the situation, it gives room for flexibility.
	15	Consider all possible alternatives	11	3	R3: In early phases it is definitely important but in later stages it should be limited to a few R4: Trade-off matrixes for procedures as well as design. Sometimes people don't realise but they have a certain preference. R7: That is killing. It add to flexibility but you must dare to decide in time. R8: Pure Agilists believe that it should start with one solution. It is important to have alternatives but they shouldn't analysed thoroughly. Put value to alternatives. R14: only alternatives which deliver value should be considered. R12: For making decisions, there should be options. R1: There are moments in project that the project team thinks of alternatives. But there are moments that the selected alternative should be constructed.
	16	Network structure rather than hierarchical structure	13	1	R4: I agree although it is sometimes difficult. Even as a project manager I join the team as a team member for brainstorming or other tasks. For the team it is difficult to neglect the fact that I am their boss. It makes difficult to get the communication at that point.
	17	Continuous learning	13	1	R4: You have to learn from your failure. You have to leave the organisation more clever than when you came. R9: If there is no room for learning then there is no flexible project management. R2: When you learn you can adjust. This helps flexibility.

Who	Ability to define and change who is carrying out the project tasks (human resource flexibility)	18	Consensus building amongst team members	13	1	R4: It is good to hear other opinions. Consensus is good at the end. R7: It is important that everybody be happy in team. also it is important the team be open to externals. R9: It is not essential but an enabler, because for example one of the team members has the competency to make a decision on a technical aspect.
		19	Stable teams	13	1	R8: It is important for flexibility but my personal opinion is that you should put team for long time together. It might not function well after long time. R9: To be better in agile it is needed. But it is not essential.
		20	Self-assigned individuals to tasks	14	0	R4: It is good when people know what they want and what they do. R7: In this case people are motivated to do the task which they like but they are not necessary always the best people to do the job.
		21	Consider all team member to be skilled in team management	10	4	R4: It is an enablers as long as you know within team management there are different roles. R7: For decision making there should be some hierarchy. R8: It is very important foe self-organising teams. Team member should know how team works toward success. R9: it is important (example in absence of scrum master).
		22	Consider all team member to be valuable stakeholder in team	10	4	R3: It relates to proudness of being in the team. R7: The team must be consist of who is respectful to others (position) this is because of the value someone has. R8: Team member should have the idea that they deliver value. It is about motivation if you are trying to achieve motivated people in your team. R14: Generalizing specialists.
When	Ability to define and change the time constraints for different tasks (schedule flexibility)	23	Make a decision at the last responsible moment or Late locking (redundancy)	11	3	R4: It depends on relation among parties involved (client for example). It is also possible as long as the milestones are not endangered. You should think what is lacked if you make the decision now and what are the consequences. Decisions shouldn't be postponed without thinking about them. R7: Making decision in early stages knowing the fact that they might change later, helps. R8: As long as it is not too late. It is in line with risk-based approach.
		24	Short feedback loops	14	0	R4: It is an enabler because it help understanding what we have done and what can be improved. R9: Where there is no possibility to comment on others task, the hardly there is integration and it is difficult to realise what are the mistakes, problems, faults. Then there should be short feedback loops. Then there won't be shippable product at the end of the sprint.
		25	Continuous locking (iterative)	12	2	R4: Locking does not help flexibility because there is no intention to get back to what was locked. But we should it keep it in mind that there might be good reasons to get back to locked decisions. R8: Hand in over to customer as soon as possible. By doing that the client is responsible for further changes but not the consultant or contractor.
		26	Minimize up-front planning	7	7	R4: Detail planning should be there on time and knowing the fact that even detail planning might change. R7: Still you can make a detail up-front planning but you must allow the project deviate from this plan. If you made the plan and try to stick to it, it is killing. But to have a planning helps a lot.

						R8: My opinion is how to treat planning. There should be planning but not more than it is required. R9: It is essential, because the developers take their responsibility to plan for the sprints R13: Certain level of detail is needed. R2: Always all clients ask for so much detailed plans. R5: You need up-front planning to have a good overview of the project. it should not be ignored.
		27	Iterative planning	14	0	R7: Make a detail planning while you need it.
		28	Iterative delivery	14	0	R3: It is not always possible. R4: Iterative delivery helps learning from client's opinions which is good for next delivery.
Where	Ability to define and change where the tasks are performed (location flexibility)	29	Joint project office for project team	14	0	R4: My preference is to put all people together. Sometimes it is not possible. There are disadvantages when people do not sit together (for example reaching the project end goal). There are many good thing happen during the small chats at coffee machines or lunch times. When people work together understand the problems which are not documented. There are information that will be lost if people do not work together. It help being committed to project. R7: People need to meet, email is killing. R9: By joint project office the mistrust will be minimized. It can be done also through virtual co-location. R14: it help maximizing the amount of communication.
		30	Flexible desks	12	2	R7: Not necessary. I think it is nice to have your own desk. Although it is nice that people meet to discuss. R8: Flexible desks as long as people who work on same project sit together. This helps shortening the communication lines. Deliverable driven system rather than time and location driven.

Appendix E: Demography of respondents per perspective

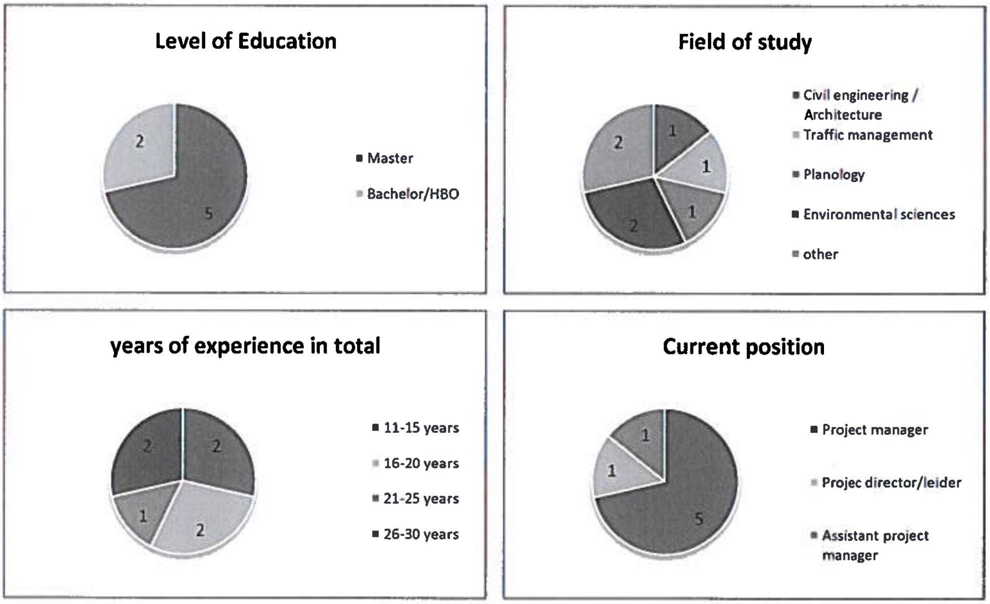


Figure E-1: Demography of respondents in clients' perspective 1

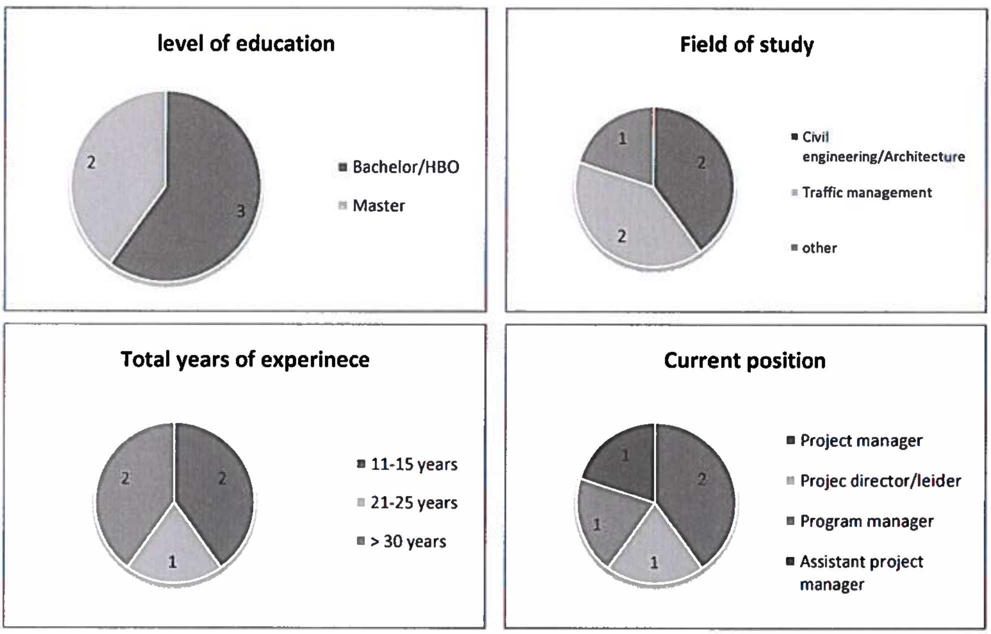


Figure E-2: Demography of respondents in clients' perspective 2

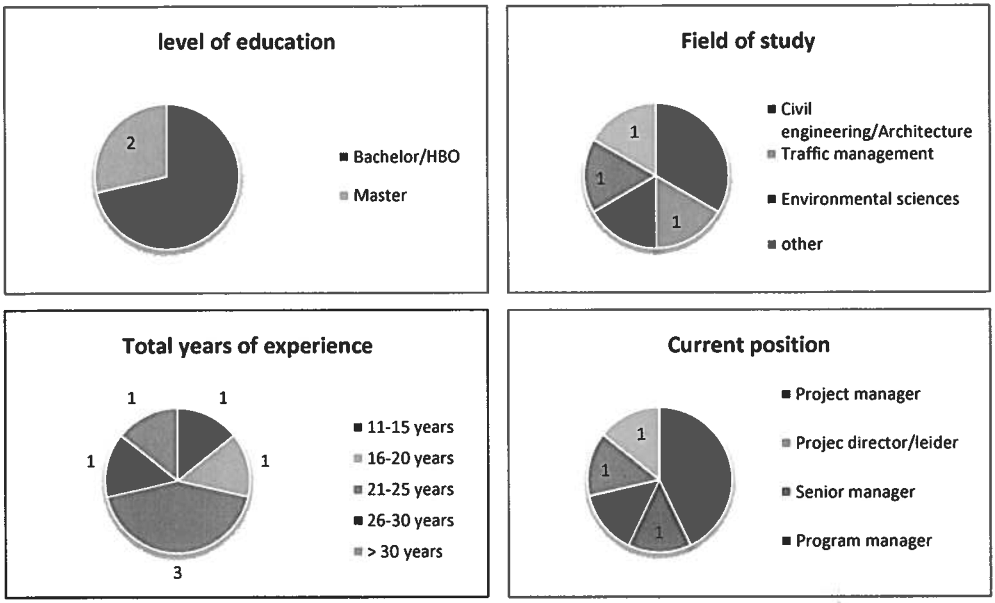


Figure E-3: demography of respondents in clients' perspective 3

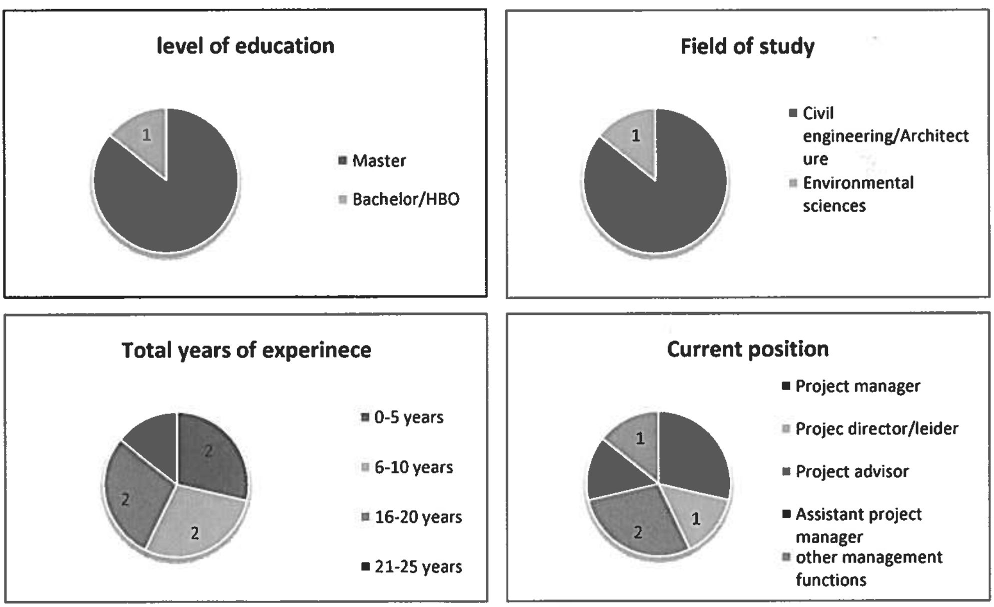


Figure E-4: demography of respondents in consultants' perspective 1

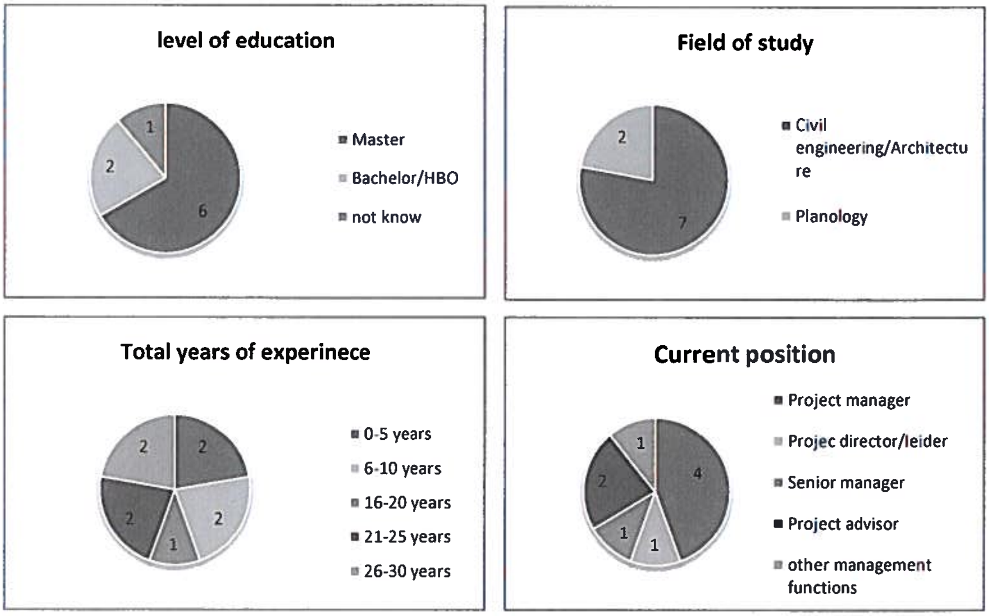


Figure E-5: demography of respondents in consultants' perspective 2

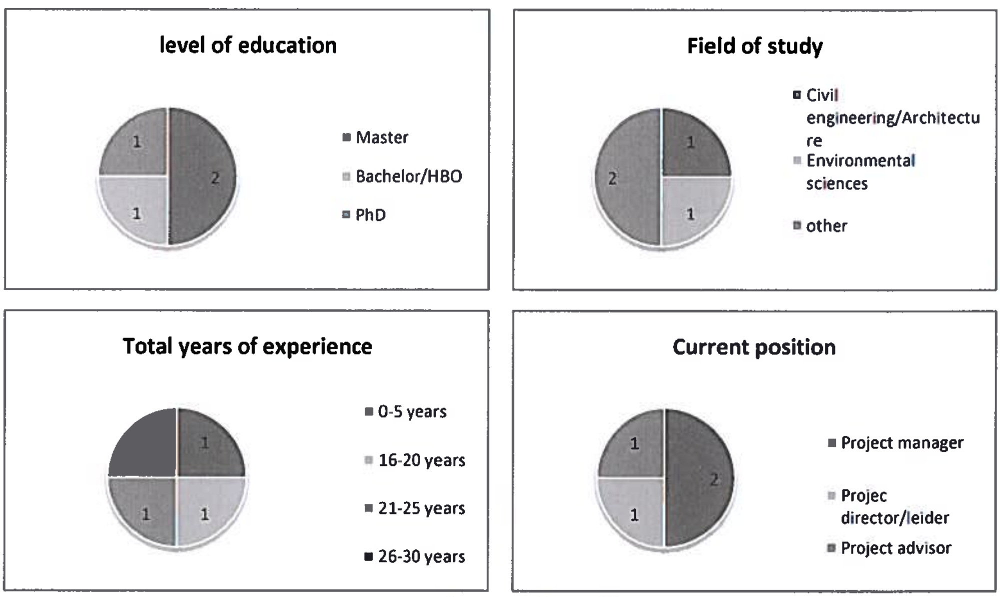


Figure E-6: demography of respondents in consultants' perspective 3

APPENDIX F: LIST OF FLEXIBILITY ENABLERS

	Q-statement
1	Broad task definition
2	Embrace and facilitate change as much as needed
3	Functional-realisation based contract
4	Self-steering of the complete project team
5	Open and demand-driven information exchange
6	Shared interface management
7	Contingency planning
8	Seizing opportunities and coping with threats
9	Trust
10	Standardised process and design
11	Visualised project planning and progress
12	Possible alternatives
13	Network structure rather than hierarchical structure
14	Continuous learning
15	Consensus amongst team members
16	Stable teams
17	Self-assigned individuals to tasks
18	Consider all team member to be skilled in team management
19	Consider all team member to be valuable stakeholder in team
20	Late locking
21	Short feedback loops
22	Continuous locking (iterative)
23	Minimize up-front planning with iterative planning
24	Iterative delivery
25	Joint project office for project team
26	Flexible desks

APPENDIX G: COMPARISON BETWEEN COMPLEXITY MODELS DEVELOPED BY KIAN MANESH RAD ET AL. (2017) AND BOSCH-REKVELDT (2011)

Category	Complexity model by Kian Manesh Rad et al. (2017)	Complexity model by Bosch-Rekveldt (2011)
External competition	External: Market competition	External Complexity: Level of competition
Project environment	External: Market unpredictability and uncertainty	External Complexity: Instability of project environment (exchange rate, oil price, raw material price, etc.)
	External: Stability of project environment	External Complexity: Risks from environment
	External: Changing economy	
	External: Interaction between the technology system and external environment	
Laws/regulations/norms/standards	External: local laws and regulations	Technical Complexity: Conflicting norms and standards
Political influence	External: Political influence	External Complexity: Political influence
Cultural/linguistic diversity	External: Cultural configuration and variety	Organisational Complexity: Number of different languages
	External: Cultural differences	Organisational Complexity: Number of different nationalities
Company support	Organisation/team: Support from permanent organisations	External Complexity: Lack of company internal support
Co-operation with locals		External Complexity: Required local content (forced co-operation with local parties)
Company strategy		External Complexity: Company internal strategic pressure
Capital cost of project & number of financial resources	Organisation/team: Size of capital investment	Technical Complexity: Size in CAPEX
	Organisation/team: Variety of investors and financial resources	Organisational Complexity: Number of financial sources
Contract (number and type)	Organisation/team: Contract types	Organisational Complexity: Number of contracts
Variety of institutional configuration	Organisation/team: Variety of institutional configuration	
Internal communication	Organisation/team: Team cooperation and communication	

Category	Complexity model by Kian Manesh Rad et al. (2017)	Complexity model by Bosch-Rekveldt (2011)
Trust	Organisation/team: Level of trust (inter/intra teams)	Organisational Complexity: Lack of trust in project team
		Organisational Complexity: Lack of trust in contractor
Team	Organisation/team: Diversity of participants	
	Organisation/team: Variety of resources	
	Organisation/team: Dynamic and evolving team structure	Organisational Complexity: Size of project team
	Organisation/team: Experience and capabilities within teams	Organisational Complexity: Lack of experience with parties involved
		Organisational Complexity: Interface between different disciplines
	Organisation/team: Availability of human resources	Organisational Complexity: Lack of resource & skills availability
		External Complexity: Lack of experience in the country
Stakeholders	Organisation/team: Interest and perspectives among stakeholders	External Complexity: Variety of external stakeholders' perspectives
		External Complexity: Number of external stakeholders
		External Complexity: Dependencies on external stakeholders
	External: Significance on public agenda	
Physical resources	Organisation/team: Availability of physical resources	
	Organisation/team: Resource and raw material interdependencies	
HSSE awareness		Organisational Complexity: Lack of HHSE awareness
Presence of JV partner		Organisational Complexity: Presence of JV partner
Organisational risk		Organisational Complexity: Organisational risk
Information availability/platforms	Process of delivery: Availability of information	
	Process of delivery: Reliability of information platforms	
	Process of delivery: Interdependence of information systems	

Category	Complexity model by Kian Manesh Rad et al. (2017)	Complexity model by Bosch-Rekveldt (2011)
	Process of delivery: Level of processing and transferring information	
Location	Process of delivery: Diversity of sites and locations	Technical Complexity: Number of locations
		External Complexity: Remoteness of location
		External Complexity: Interference with existing site
		Organisational Complexity: Involvement of different time zones
Tasks and their interdependencies	Process of delivery: Process interdependencies	
	Process of delivery: Dependencies between tasks	
	Process of delivery: Number of activities	Technical Complexity: Number of tasks
	Process of delivery: Unpredictability of tasks	Technical Complexity: Technical risk
	Process of delivery: Diversity of activities elements	Technical Complexity: variety of tasks
Project duration and diversity of schedules	Process of delivery: Duration of project	Technical Complexity: Project duration
	Process of delivery: Dependencies between Schedules	
	Process of delivery: Intensity of project schedule	Organisational Complexity: High project schedule drive
PM methods and tools	Process of delivery: Applicability of project management methods and tools	Organisational Complexity: Incompatibility between different pm methods/ tools
	Process of delivery: Variety of project management methods and tools	
Projects goals & scope	Project Characteristics: Variety of goals and objectives	Technical Complexity: Number of project goals
	Project Characteristics: Interdependence of objectives	Technical Complexity: Non-alignment of project goals
	Project Characteristics: Transparency of objectives	Technical Complexity: Unclarity of project goals
	Project Characteristics: Scope changing	Technical Complexity: Uncertainties in scope
Technological variety/dependencies	Project Characteristics: Technological experience and capabilities	Technical Complexity: Lack of experience with technology
	Project Characteristics: Repetitiveness of process	
	Project Characteristics: Specifications interdependencies	Technical Complexity: Dependencies between tasks

Category	Complexity model by Kian Manesh Rad et al. (2017)	Complexity model by Bosch-Rekveldt (2011)
	Project Characteristics: Technological varieties	
	Project Characteristics: Variety of system components	Technical Complexity: Involvement of different technical disciplines
	Project Characteristics: Level of innovation	Technical Complexity: Newness of technology (world-wide)
		Technical Complexity: Uncertainty in methods
	Project Characteristics: Changing technology	
Weather conditions		External Complexity: Weather conditions
Quality requirements		Technical Complexity: Strict quality requirements

APPENDIX H: FLEXIBILITY ENABLERS (INDICATORS) ADAPTED FROM JALALI SOHI ET AL. (2017B)

Category	Label	Flexibility enablers	Main Source
What	FlexA	Broad task definition	(Koppenjan et al., 2011)
	FlexB	Embrace change as much as needed	(Olsson, 2006), (Priemus and van Wee, 2013)
	FlexC	Functional-realisation based contract	(Koppenjan et al., 2011)
How	FlexD	Self-steering of the complete project team	(Koppenjan et al., 2011)
	FlexE	Open information exchange among different groups	(Koppenjan et al., 2011)
	FlexF	Shared interface management	(Koppenjan et al., 2011)
	FlexG	Contingency planning	(Olsson, 2006)
	FlexH	Seizing opportunities and coping with threats	(Blom, 2014)
	FlexI	Trust among involved parties	(Atkinson et al., 2006)
	FlexJ	Standardise the process and design	(Giezen, 2012; Perminova et al., 2008)
	FlexK	Visualised project planning and progress	(Beck et al., 2001)
	FlexL	possible alternatives	(Priemus and van Wee, 2013)
	FlexM	Network structure rather than hierarchical structure	(Beck et al., 2001)
	FlexN	Continuous learning	(Giezen, 2012; Perminova et al., 2008)
Who	FlexO	Consensus amongst team members	(Cobb, 2011)
	FlexP	Stable teams	(Beck et al., 2001)
	FlexQ	Self-assigned individuals to tasks	(Cobb, 2011)
	FlexR	Team priority over individual priority	(Beck et al., 2001)
	FlexS	Team members as stakeholders	(Beck et al., 2001)
When	FlexT	Late locking	(Olsson, 2006) (Huchzermeier and Loch, 2001)
	FlexU	Short feedback loops	(Cobb, 2011)
	FlexV	Continuous locking (iterative)	(Olsson, 2006)
	FlexW	Iterative planning	(Cobb, 2011)
	FlexX	Iterative delivery	(Beck et al., 2001)
Where	FlexY	Joint project office	(Osipova and Eriksson, 2013)
	FlexZ	Have flexible desks	(Osipova and Eriksson, 2013)
Added flexibility enablers			
How	FlexAA	Management support	
How	FlexAB	Interactive decision making	
Who	FlexAC	Delegation of responsibilities to team level	
How	FlexAD	Close involvement of stakeholders	

APPENDIX I: SURVEY

TUDelft Delft University of Technology

Welcome to this survey !

In the research group Infrastructure Design and Management of Delft University of Technology, PhD candidate ir. Afshin Jalali Sohi is doing research into flexible project management under supervision of Promotor dr. ir. Marcel Hertogh and Co-promotor dr. ir. Marian Bosch-Rekveldt.

Flexible Project Management in the Front-end phase of Infrastructure projects

Starting in the 1990s and still growing is the awareness of the changing and dynamic project environment. Increasingly it is argued that nowadays a pure (conventional) project management approach is no longer effective. Accordingly there is much attention to the embedding of flexibility in project management, recognizing the complex and changing context of a project. Inherently changes will happen during the project phases. Consequently changes need to be incorporated in the project's outcome, planning, estimates, etc. Hence a certain degree of flexibility needs to be embedded in management of projects.

Purpose
This survey is designed to evaluate if flexible project management helps in delivering successful projects. The results will provide an overview regarding the applicability of flexibility measures that can improve project performance.

What's in it for you as a participant?
By participating in this evaluation, you will get an insight into what extend your management approach is flexible. Moreover, if it proves that flexible project management elements potentially can improve project performance, you could consider to apply these elements in your future projects.
If you are interested in these results please provide us with your e-mail address (you can write it in the last step of the survey).

Instruction
The survey includes 4 main sections. All questions have to be answered for one specific project. Please select the most recent project you were involved in, which at least completed its front-end phase (design and planning phase). Please answer the questions for this specific project. This is not necessary a project that was completely finished; a project with a completed front-end phase would suffice for this research.

The 4 sections of this survey are:
Section 1: to characterize the project.
Section 2: to picture the management approach you/your project team applied for that project.
Section 3: to assess the performance of the specific project you selected.
Section 4: questions regarding your details. The profile of respondents will help us in interpreting the research results.
At the end of the survey there is one open question asking for your comments on this research.

The entire survey will take about 15 minutes. 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).

Confidentiality
This information will be kept confidential and any result will be published anonymous.

Thanks for your time and effort in advance.

This is the first section of the survey . This section aims at making a clear picture of the project you selected.

1. How much was the estimated budget especially for the front-end phase (design and planning) of the project you selected? Please indicate it in K€ (thousand Euro).

2. How long was the estimated duration of the front-end phase of the project you selected?

- ○ 6 months or less
- ○ Between 6 to 12 months
- ○ Between 12 to 18 months
- ○ Between 18 to 24 months
- ○ More than 24 months (please specify)

3. Is the project you selected a private or a public project?

- ○ Public
- ○ Private
- ○ Other (please specify)

4. In which country was the project performed?

5. In which industry was this project performed?

- ○ Construction
- ○ Petrochemical
- ○ IT (information technology)
- ○ Energy
- ○ manufacturing
- ○ Other (please mention)

6. Was the project an infrastructure project?

- ○ Yes
- ○ No
- ○ Not sure! (please specify your answer)

7. Please characterize the project by rating the given statements in this section. Please remember that all answers should be given based on front-end (design and planning) phase of the project.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Not applicable	Do not know
The project's goals were clear and certain to everybody involved.	○	○	○	○	○	○	○
The project's tasks and their dependencies were clear and certain.	○	○	○	○	○	○	○
Project size based on its costs is considered as a relatively big project.	○	○	○	○	○	○	○
The number of contracts within the project was high.	○	○	○	○	○	○	○
The project was technically complex.	○	○	○	○	○	○	○
The project's quality requirements were strict.	○	○	○	○	○	○	○
The project environment was stable.	○	○	○	○	○	○	○
There was trust among parties involved in the project.	○	○	○	○	○	○	○
The size of the project team was relatively big compared to the other projects of my organization.	○	○	○	○	○	○	○
The project was under pressure of politics and conflicting standards/regulations.	○	○	○	○	○	○	○
Required experiences for the project were available in our organization.	○	○	○	○	○	○	○
A high number of external stakeholders were involved.	○	○	○	○	○	○	○

The project was located in multiple or remote areas.	○	○	○	○	○	○	○
The project management tools/methods used by different parties were not compatible.	○	○	○	○	○	○	○
A high number of different disciplines with lots of interfaces was required.	○	○	○	○	○	○	○
There was lack of company internal strategic support.	○	○	○	○	○	○	○
There was high competition in the market.	○	○	○	○	○	○	○
The project duration was relatively long compared to other projects of my organization.	○	○	○	○	○	○	○
The organizational risks were high.	○	○	○	○	○	○	○
The required information was available.	○	○	○	○	○	○	○
Various languages or nationalities were involved in the project.	○	○	○	○	○	○	○
The number of financial resources was relatively high compared to the other projects of my organization	○	○	○	○	○	○	○

Now we are at the second section of the survey.
This section aims at making a clear picture of how the project you selected was managed.

8. Please rate the statements given below. Like in the previous section, all questiones should be answered about the management in the front-end phase (design and planning phase) of the project.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Do not know	Not applicable
We defined the project scope into broad tasks rather than detailed work packages.	○	○	○	○	○	○	○
We had a 'no-change mindset'.	○	○	○	○	○	○	○
The contract for this phase of project was task oriented rather than function oriented.	○	○	○	○	○	○	○
The steering of the project team had a hierarchical character in the network of client, consultant and other involved parties.	○	○	○	○	○	○	○
Information exchange among the parties involved in the project was open.	○	○	○	○	○	○	○
Interface management was a shared task among all involved parties.	○	○	○	○	○	○	○
We considered reservation in either budget/time/resources for unpredictable situations(contingencies).	○	○	○	○	○	○	○
Opportunities were seized and threats were coped with all the time.	○	○	○	○	○	○	○
There was a high level of trust among all involved parties.	○	○	○	○	○	○	○
We followed standardized processes/layouts/etc in this project, like we normally do in other projects.	○	○	○	○	○	○	○
We visualized the project's progress and planning.	○	○	○	○	○	○	○
We considered alternatives (plans/solutions/...) for predicted risks.	○	○	○	○	○	○	○
For project organization we had a network structure rather than a hierarchical structure.	○	○	○	○	○	○	○
We captured the lessons learned from the project.	○	○	○	○	○	○	○
In our team decisions were made according to consensus among project team members.	○	○	○	○	○	○	○
The project team is stable for all our projects rather than being built solely for this project.	○	○	○	○	○	○	○
The project manager assigned tasks to team members rather than team members themselves chose their tasks.	○	○	○	○	○	○	○
All team members were skilled in team management.	○	○	○	○	○	○	○
We looked at the team members as valuable internal stakeholders.	○	○	○	○	○	○	○
We locked the decisions at the last responsible moment (as late as possible).	○	○	○	○	○	○	○
We had short feedback loops on a daily basis within our team.	○	○	○	○	○	○	○
We locked the project continously rather than all at once at the end of the project.	○	○	○	○	○	○	○
We made a detailed planning for the project at the start of the front-end phase.	○	○	○	○	○	○	○

The project was delivered in parts rather than all at the end.	○	○	○	○	○	○	○
The project team had a joint project office (physically or virtually).	○	○	○	○	○	○	○
The project team had freedom to choose the place they work within our organization (flex-desk).	○	○	○	○	○	○	○
We had management support.	○	○	○	○	○	○	○
We made decisions interactively.	○	○	○	○	○	○	○
We delegate responsibilities to team level.	○	○	○	○	○	○	○
We involved stakeholders closely.	○	○	○	○	○	○	○

Now we are in the third section of the survey.
This section aims at evaluating the performance of the project you selected.

9. Please rate the performance of the project based on the given criteria. Take it into account that here the performance of front-end (design and planning) phase should be evaluated regardless of what happend (or will happen) in the execution phase.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Not applicable	Do not know
The project phase was finished within the scheduled time.	○	○	○	○	○	○	○
The project phase was finished within budget.	○	○	○	○	○	○	○
Only a very limited number of agreed scope changes happend during the front-end phase of the project.	○	○	○	○	○	○	○
The activities were carried out as scheduled.	○	○	○	○	○	○	○
The project phase met the planned quality standards.	○	○	○	○	○	○	○
The project complied with environmental regulations.	○	○	○	○	○	○	○
The project phase met safety standards.	○	○	○	○	○	○	○
The project phase was delivered cost effective.	○	○	○	○	○	○	○
Our organization learned from the project.	○	○	○	○	○	○	○
The project phase was performed according to defined procedures.	○	○	○	○	○	○	○
The project's end product was used as planned.	○	○	○	○	○	○	○
The project phase satisfied the needs of users.	○	○	○	○	○	○	○
New understanding/Knowledge was gained from the project.	○	○	○	○	○	○	○
The project's impacts on beneficiaries are visible.	○	○	○	○	○	○	○
The project phase achieved its purpose.	○	○	○	○	○	○	○
The end-user was satisfied.	○	○	○	○	○	○	○
The project phase had good reputation.	○	○	○	○	○	○	○
The project phase enabled us for other project works in future.	○	○	○	○	○	○	○
The project phase results motivated us for future projects.	○	○	○	○	○	○	○
Our organizational capability was improved by this project.	○	○	○	○	○	○	○
Resources were mobilized and used as planned after this phase of project had been finished.	○	○	○	○	○	○	○
The sponsor of the project was satisfied.	○	○	○	○	○	○	○
The steering group was satisfied.	○	○	○	○	○	○	○
The project met the client's requirements.	○	○	○	○	○	○	○
The project met our organizational objectives.	○	○	○	○	○	○	○

10. In your opinion, how flexible was the project management in the front-end phase of the selected project?

	1	2	3	4	5	6	7	8	9	10	
NOT flexible	○	○	○	○	○	○	○	○	○	○	Very flexible

Fourth Section: Personal information

11. What is your background studies?

- ○ Civil engineering/Geoscience
- ○ Business/Management
- ○ Architecture/urban design
- ○ Social science

- Other (please mention)

12. What is the highest level of education you acquired?

- MBO
- Bachelor (HBO/WO)
- Master
- PhD
- Other (please mention)

13. What is your country of origin?

14. What is your current position/role at the company?

- Project manager/leader
- Project director
- Project engineer
- Project consultant/advisor
- Assistant project manager/deputy project manager
- Other (please specify)

15. Do you know what *'Agile Project management'* is?

- Yes
- No
- A little bit

16. Have you ever used Agile project management tools/principals in practice?

- Yes
- No

17. How many years of work experience do you have in total?

- 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

18. How many years of work experience do you have in your current position/role?

- 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

19. For how many years do you work at the current organization/company?

- 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

20. Which sector do you typically work for?

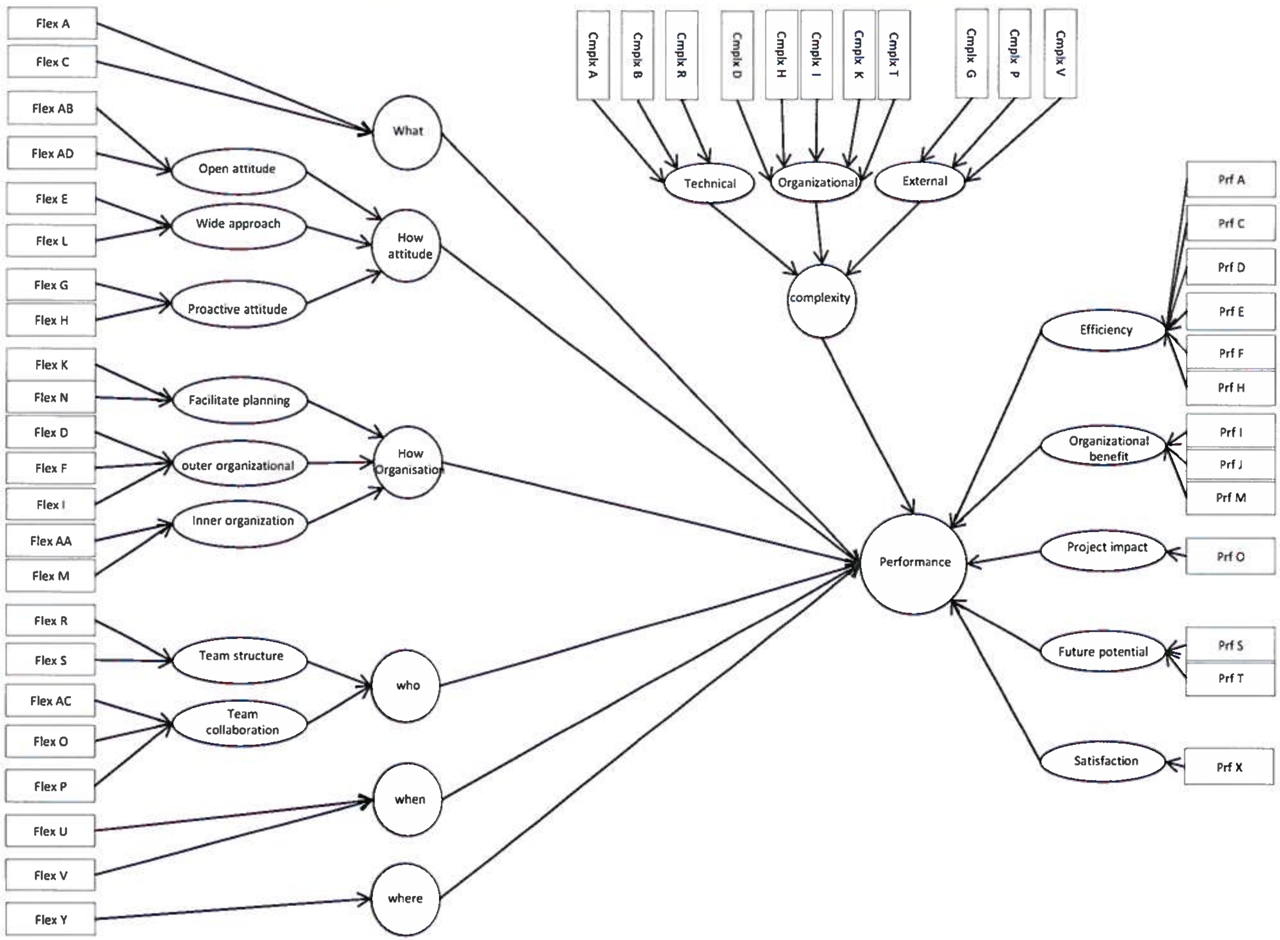
- Public
- Private
- Both

21. What is your company/organization's role?

- Client
- Contractor

For more information please contact Afshin Jalali Sohi via a.jalalisohi@tudelft.nl.

APPENDIX J: STRUCTURAL MODEL AND MEASUREMENT MODEL (EXCLUDING THE UNCONFIRMED INDICATORS)



APPENDIX K: ASSESSMENT FORMATIVE MEASUREMENT MODEL

Variables	Original Sample	Sample Mean	Standard Deviation	Standard Error	T-value
latent variable: project complexity					
Technical complexity	**0.3416**	**0.3384**	**0.0287**	**0.0287**	**11.9159**
ComplexA	0.1832	0.1895	0.0945	0.0945	1.9396
ComplexB	0.7324	0.7094	0.1347	0.1347	5.4382
ComplexC	0.4222	0.4093	0.1965	0.1965	2.149
Organisation complexity	**0.4296**	**0.4269**	**0.0309**	**0.0309**	**13.8823**
ComplexD	0.283	0.2689	0.0865	0.0865	3.2728
ComplexH	0.5521	0.552	0.1046	0.1046	5.2778
ComplexI	0.1625	0.1575	0.1232	0.1232	1.319
ComplexK	0.1968	0.1855	0.0876	0.0876	2.246
ComplexT	0.5119	0.5043	0.0942	0.0942	5.4337
External complexity	**0.3818**	**0.3774**	**0.0285**	**0.0285**	**13.4129**
ComplexG	0.7875	0.766	0.1218	0.1218	6.4655
ComplexP	0.4096	0.4018	0.1185	0.1185	3.4561
ComplexV	0.2245	0.2194	0.172	0.172	1.305
project management Flexibility					
latent variable: Flexibility of What					
FlexA	0.802	0.7264	0.2586	0.2586	3.1006
FlexC	0.4422	0.4446	0.3024	0.3024	1.4623
latent variable: flexibility of How-attitude					
Open attitude	**0.3827**	**0.3817**	**0.0348**	**0.0348**	**11.0064**
FlexAB	0.5685	0.5599	0.1236	0.1236	4.5975
FlexAD	0.5821	0.5848	0.1105	0.1105	5.2665
wide approach	**0.3845**	**0.3838**	**0.0342**	**0.0342**	**11.2579**
FlexE	0.7556	0.753	0.09	0.09	8.3962
FlexL	0.4647	0.4611	0.1204	0.1204	3.8603
proactive attitude	**0.3967**	**0.3945**	**0.0304**	**0.0304**	**13.0568**
FlexG	0.3996	0.398	0.0975	0.0975	4.0962
FlexH	0.7889	0.7864	0.0733	0.0733	10.7669
latent variable: flexibility of How-organisation					
facilitating planning	**0.4616**	**0.4543**	**0.0416**	**0.0416**	**11.1093**
FlexK	0.5521	0.5549	0.1756	0.1756	3.1447
FlexN	0.6704	0.6452	0.1782	0.1782	3.7631
Outer project organisation	**0.446**	**0.4331**	**0.0459**	**0.0459**	**9.7141**
FlexD	0.3445	0.3404	0.1568	0.1568	2.1976
FlexF	0.5452	0.5238	0.1815	0.1815	3.003
FlexI	0.4425	0.433	0.1889	0.1889	2.342
Inner project organisation	**0.3771**	**0.3822**	**0.04**	**0.04**	**9.4295**
FlexAA	0.605	0.6077	0.1288	0.1288	4.6959
FlexM	0.7879	0.7728	0.1033	0.1033	7.6259
Latent variable: flexibility of Who					
Team collaboration	**0.5735**	**0.5675**	**0.0361**	**0.0361**	**15.8707**
FlexR	0.3937	0.3946	0.1515	0.1515	2.5987
FlexS	0.8181	0.807	0.1023	0.1023	7.9971
Team strcuture	**0.566**	**0.5659**	**0.0349**	**0.0349**	**16.2162**
Flex AC	0.6319	0.6254	0.1341	0.1341	4.7115
FlexO	0.4516	0.4542	0.1421	0.1421	3.178
FlexP	0.458	0.4405	0.1298	0.1298	3.5287

Variables	Original Sample	Sample Mean	Standard Deviation	Standard Error	T-value
Latent variable: flexibility of When					
FlexU	0.6732	0.658	0.1836	0.1836	3.6668
FlexV	0.6039	0.5877	0.1872	0.1872	3.226
Latent variable: flexibility of where					
FlexY	1	1	0	0	0
Latent variable: project performance					
Efficiency	**0.349**	**0.3506**	**0.0549**	**0.0549**	**6.3579**
PerformanceA	0.366	0.3485	0.1618	0.1618	2.262
PerformanceC	0.0648	0.0546	0.1556	0.1556	0.4168
PerformanceD	0.048	0.0532	0.1608	0.1608	0.2985
PerformanceE	0.2531	0.2438	0.151	0.151	1.6764
PerformanceF	0.3218	0.3129	0.1369	0.1369	2.3508
PerformanceH	0.4274	0.395	0.1363	0.1363	3.1351
Organisational benefit	**0.3388**	**0.3215**	**0.0556**	**0.0556**	**6.0932**
PerformanceI	0.5525	0.5309	0.1385	0.1385	3.9901
PerformanceJ	0.4218	0.4173	0.1312	0.1312	3.2151
PerformanceM	0.4502	0.4552	0.1303	0.1303	3.4556
Project impact	**0.2365**	**0.2209**	**0.0505**	**0.0505**	**4.6862**
PerformanceO	1	1	0	0	0
Future potential	**0.2507**	**0.2382**	**0.0581**	**0.0581**	**4.3143**
PerformanceS	0.596	0.6035	0.1871	0.1871	3.1861
PerformanceT	0.5285	0.5037	0.2018	0.2018	2.6183
Satisfaction	**0.1513**	**0.1379**	**0.0502**	**0.0502**	**3.0149**
PerformanceX	1	1	0	0	0

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Every chapter of life is a piece of a puzzle, the big puzzle of life. The pieces of this puzzle are shaped and put together by ourselves, so how the puzzle will look at the end depends on the art of its creator. Although we are the artists of our own puzzles of life, there are many others who add colours to each piece while working on those of themselves.

In January 2014 a new chapter began in my life, a chapter starting with a big step: moving from Iran to The Netherlands to pursue a PhD degree. This marked the beginning of creating a new piece in my life's puzzle. Now, in November 2018, that piece is complete and I am proud of the result: this book. This is the right moment to thank those who added their colours to this piece of the puzzle, making it a unique one.

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Afshin Jalali Sohi
Delft, The Netherlands
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Curriculum Vitae

Afshin Jalali Sohi was born in 1986, on March 25th in Tehran, Iran. After obtaining bachelor's degree in Civil Engineering at Vali-e-Asr University in Rafsanjan, Iran, he studied Construction Project Management at University of Tehran to obtain a Master of Science, with the thesis titled 'Study of Maturity of Construction Project Management in Mega Projects'.

Parallel to his master studies, he had worked in private sector in construction industry in Iran. As a project controller, he was involved in a few construction projects in Tehran, varying from an urban development project to construction of multi-functional buildings. In this role he was responsible for tracking the projects schedule and risks, as well as making project progress reports.

In addition to work in the industry, he had worked part-time in different private educational institutes as a teacher and educational consultant in the field of 'Construction Project Management' studies.

In January 2014, he moved to The Netherlands for sake of doing a PhD in Project management at Delft University of Technology. His research interests include, but not limited to, project management methodologies, flexibility in project management, Agile project management, project complexity, and fit-for-purpose project management.

Next to his PhD, he has been involved in different activities. Since 2014, he serves as a teacher assistant in the minor of Project management program for bachelor students. Also he has supervised several master students for their graduation thesis in the field of project management. As part of the team, he was involved in the development of a Massive Online Open Course (MOOC) called 'Project Management of Engineering Projects: Mastering for Success'.

He can be contacted via a.jalalisohi@tudelft.nl or afshin.jalalisohi@gmail.com.

List of publications

J. R. Blom, A. Jalali Sohi, J. W. F. Wamelink, Y. J. Cuperus, 2015, Embarecing change: a road to improvement, 12th IRNOP conference, 22-24 June 2015, London, UK

A. Jalali Sohi, M. J. C. M. Hertogh, M. G. C. Bosch-Rekveldt, 2015, Does lean and agile project management help coping with project complexity?, The 29th IPMA world congress, 28-30 September2015, Panama city, Panama, published in Procedia - Social and Behavioral Sciences, 226, pp. 252-259

A. Jalali Sohi, M. J. C. M. Hertogh, M. G. C. Bosch-Rekveldt, 2016, Scrum in practice in infrastructure projects, The 16th EURAM conference, 1-4 June 2016, Paris, France

A. Jalali Sohi, M. J. C. M. Hertogh, M. G. C. Bosch-Rekveldt, Maurice de Kroon, 2017, Critical success factors for Agile-managed infrastructure projects: A study into practitioners' perspectives, 13th IRNOP conference, 11-14 June 2017, Boston, United States

A. Jalali Sohi, M. J. C. M. Hertogh, M. G. C. Bosch-Rekveldt, 2017, What is flexibility in project management in Civil Engineering context? A study into practitioners' perspectives, The 17th EURAM conference, 21-24 June 2017, Glasgow, Scotland

A. Jalali Sohi, M. G. C. Bosch-Rekveldt, M. J. C. M. Hertogh, 2017, How flexible is project management in practice? An exploratory research into project management of infrastructure projects in construction industry, 4-7 September 2017, 30th IPMA world congress, Asatan, Kazakhstan, published in Computer Sciences and Information Technologies (CSIT), 2017 12th International Scientific and Technical Conference on. IEEE, pp. 44-51

R. Sharma, A. Jalali Sohi, M. J. C. M. Hertogh, J.R Deketh, 2017, Controlling the uncontrolled by noticing the unnoticed, 4-7 September 2017, 30th IPMA world congress, Asatan, Kazakhstan, published in Computer Sciences and Information Technologies (CSIT), 2017 12th International Scientific and Technical Conference on. IEEE, pp. 106-114

A. van Klaringen, A. Jalali Sohi, M. J. C. M. Hertogh, 2018, Does agile project management add value to early project phases of infrastructure projects?, 14th IRNOP conference, 9-12 December 2018, Melbourne, Australia

M. G. C. Bosch-Rekveldt, A. Jalali Sohi, 2018, Manging project complexity, *Projects and People: Mastering success*, NAP Network, editors: H.L.M. Bakker, J. de Kleijn, pp. 163-186

Increasingly it is argued that nowadays a pure project management approach (the conventional project management approach) is no longer effective as it underestimates the influence of the dynamic environment. An approach is needed which recognises the complexities of a project and provides tools to cope with these; an approach that is aimed at increasing flexibility.

Therefore this research investigated the effect of project management flexibility and project complexity on project performance. Using a mix-method approach, the research was divided in different steps including literature study, case studies, Q-study and survey studies.

The main result of this research is a framework called 'Flexible Project Management Framework'. The framework proposes four iterative steps: insight, importance, implementation and improvement. The first step is to create awareness of project complexity and applied project management approaches in practice. The second step is to unravel the practitioners' mind-sets about flexibility. The third step deals with enabling flexibility in project management. A list of 23 enablers was shown to positively contribute to five areas of flexibility (what, how, who, when and where), indeed enabling flexibility in project management. In the fourth step two specific groups of enables are highlighted; flexibility enablers that will help project performance regardless the complexity of the project and flexibility enablers that will help project performance particularly in the case of complex projects.

Practitioners can benefit from this research by recognising the notion of flexibility in project management in their projects. They can learn how to make project management flexible and improving project performance, even in the case of complex projects.