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COLOPHON

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PREFACE

This research represents the last step to conclude my master Construction Management and Engineering at the Technical University of Delft. The subject about dynamic approaches for project management was brought to me more than one year ago in a conversation about the use of Scrum in IT companies. This made me wonder about how the construction industry was adapting to these changes in project management, and it was the reason that motivated me to research in this topic. Today, I conclude my research with an interesting overview of the situation, knowing that there is a long road ahead for agile management in the construction sector; a road that I expect to be an active part of.

Developing this research would not have been possible without the help and collaboration of many individuals. I would like to start by thanking my graduation committee for their constant guidance. Hans Wamelink for the critical reflections that pushed me to continuous improvement. Marian Bosh for the technical input and research mindset. Tim van de Kruijs for the practical advice and encouragement. Maurice de Kroon for the unconditional support and trust. Finally, special thanks to Afshin for all the time and dedication. I sincerely hope this investigation contributes to your own research.

Thanks to the people at Sweco that collaborated me during these last seven months. To the project managers and rest of team members that answered my interviews and questioners. And special thanks to the team projects, for always being willing to answer my doubts and help me even with the minor thinks. I always felt as one more team member, and that was valuable.

Further, thanks to my friends and all the people that were not directly involved in the investigation, but supported me along the process. Finally, profound thanks to my parents and my brother, for their unconditional love and support in this and all my projects. None of this would be possible without you three.

Mary Archila Lamus
Utrecht, July 2017

SUMMARY

Introduction
The implementation of Agile Management in the construction industry is still incipient. Literature in the subject is scarce and further, is yet not conclusive about the performance of these methodologies for managing construction projects.

This thesis aims at developing a framework to implement agile methods for managing the front-end phase of infrastructure projects, with the purpose of enhancing their performance. This framework will be the outcome of solving the main research question: **How can Agile project management improve the performance of infrastructure projects in early phases?**

To obtain the required information for solving this question, a set of sub-questions were formulated, combining a theoretical and practical investigation. The first three sub-questions created a theoretical framework, about performance, early project phases and project management, focusing on agile project management.

- SQ1: Which key performance indicators (KPIs) are used to assess the performance of project management in early project phases?
- SQ2: What are the typical management activities conducted in Front-End Development?
- SQ3: How can the Agility of project management be measured?

Once these questions were solved with the use of literature, the research explored the aforementioned three aspects in practice. A methodology of multiple case studies was used for this phase and the results had obtained provided an answer to the sub-question four.

- SQ4: How are performance indicators, front-end development, and agile management being applied in practice?

These sub-questions lead to the answer of the main research question. By means of qualitative comparative analysis of case studies *a set of guidelines for the application of agile during early project phases to enhance the performance of project management* were proposed.

Theoretical Framework
The first sub-question was answered with a list of 59 indicators that compelled the findings in the literature on how to evaluate the performance of project management. These indicators were divided into four categories: financial, organizational, project and process and customer. The financial indicators related to both the company and the project, the organizational regarding the employees and the project indicators, specifics about the development, such as cost, time, reworks, among others.

For answering sub question two, the front-end phase of projects was researched in literature. Initially, the concept of front-end as the phase was defined, as the phase in which the necessary information to approach a project is developed (Gibson, Wang, Cho, & Pappas, 2006). Further, it was identified, that front-end (FED) is normally developed in a sequential set of sub-phases: initiation, feasibility, and definition. During each phase, the product reaches a higher degree of refinement, until the required material for moving to the design phase is obtained. During each of these phases, a set of activities are commonly completed, and a compilation of various sources resulted in a total, 39 activities. These were distributed as follows; 15 activities during initiation, 9 activities in feasibility and another 15 activities during definition.

According to the literature, most of these activities are common to all industries, thus they could be applicable for different type of projects and not necessarily linked to the construction sector.

At last, sub-question three was answered by compelling a set of principles for the application of agile management. Initially, the ones defined in the Manifesto for Agile Software Development (2001), and further other elements mentioned by different authors, that should be considered for managing a project using agile. A table containing 24 indicators was developed with the objective of assessing the agility of projects. These indicators were classified in eight categories: project definition, communication, customers, control, dynamism, timing, team & personnel, and risks.

Case Studies

For answering the sub-question four, a case study methodology was used with the objective of determining how the three research aspects investigated in literature were applied in practice. Six projects completed by a consultant engineering firm were selected for the study. The parameters for selection were: same organizational department, similar contract cost, same execution period, and especially, the management approached used, taking three projects managed traditionally and three projects managed with agile methods. The six projects were individually assessed using the framework developed from literature to determine: project management performance, front-end activities conducted and level of agility in their management.

The performance of project management in practice is normally measured using two groups of analysis; one regarding the processes that take place inside a company for developing a project, and another one related to the responsiveness of the customers about these processes. For the internal category, the performance of the project is directly associated to cost and time indicators. For the external group, the perception of clients is evaluated once the projects are completed, by asking them about their satisfaction with the final product and with the process. Furthermore, even when literature proposes indicators such as employee satisfaction and motivation for measuring project management performance internally, these measures were not commonly used in practice.

Results

With the information obtained from each project, a cross-case analysis was conducted to compare the results from the three agile managed projects and three traditionally managed projects, in each of the three research subjects.

It was determined, that the activities conducted during front-end phase were common for all projects. There was not a direct link between a specific set of activities and management approach, as all the activities mentioned by literature were conducted during the front-end development (FED) of the projects. Although in general terms the same activities were executed, the development and execution of FED were different for the two groups of projects. It was noticed that the agile projects achieved a higher level of detail, executing the sub-phases of FED completely, from initiation to definition, when the traditional ones were developed until the feasibility sub-phase.

As for the application of agile management, it was found that the agility level was not only related to the Scrum projects but that the six projects used agile practices. It was realized that a set of agile practices are already being currently used in the management of infrastructure projects, without the name of the agile management or any of its application methods, but merged with the traditional approaches.

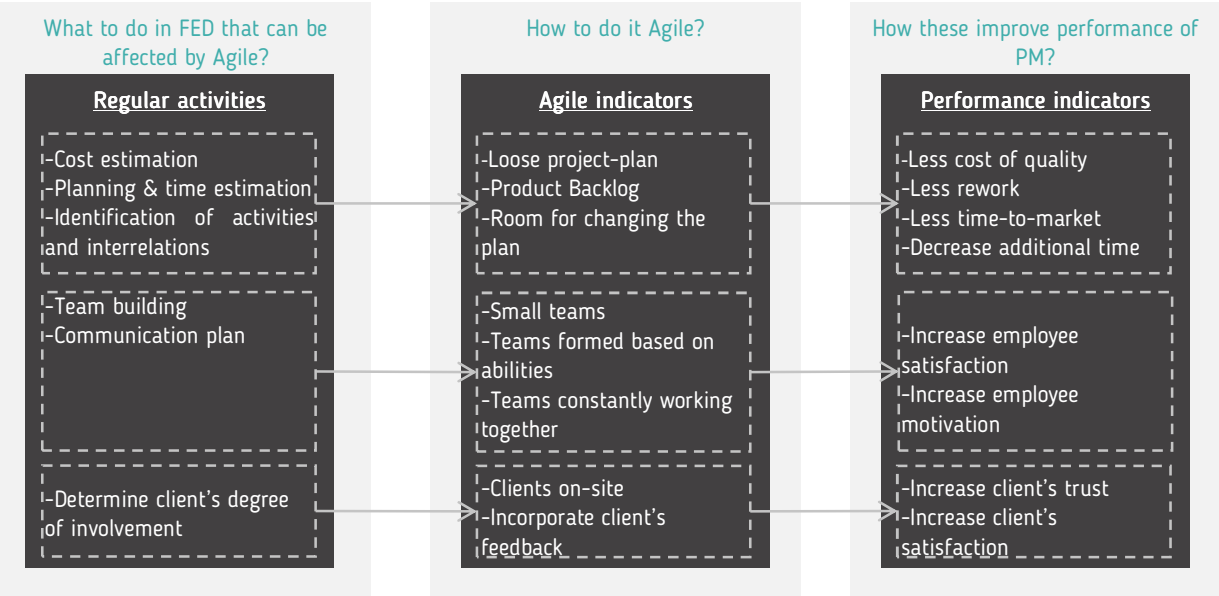
Like the results obtained in agility levels, the general result for project management performance was similar for all projects. Although, some specific indicators showed a considerable difference between the two project groups. The agile projects showed better results in time-related indicators, and the cost associated to rework, what was linked to the thorough planning achieved during the front-end phase. For traditional projects, the client related indicators were more positive, as an outcome of good responsiveness from the client during the development of the project.

Conclusion

This research found that in practice, there is not a distinct difference between agile and traditional management, but more of a hybrid version of the two management approaches. Traditional projects had elements of agile management and the so called 'agile projects' were not as agile as expected. Even when agile projects tried to apply Scrum and execute all the processes suggested by the tool, the development teams were constantly clashing with the different way of working of the rest of the involved actors, which resulted in a hybrid management style.

Even though there was not a clear distinction between management processes, the development of the front-end phase was considerable different for both type of projects. The activities conducted by the agile projects during FED was highly detailed, and the majority of the activities listed from literature were conducted by all projects, but in contrast, the traditional projects barely identified any of these activities. The development of the traditionally managed projects was oriented and based on the experience of the PM, and the process was not formally structured.

The answer of the main research question in how agile can improve the performance of project management, cannot be fully provided by this investigation, as the practice did not allow to make a real differentiation between the agility levels of projects. Furthermore, all the projects had similar performance results. Although, there were some specific agile actions that showed good performance and when applied during FED, could lead to the improvement of PM performance during this phase. The figure below illustrates the answer to research main question by bringing together the answers to all research sub-questions. It shows a set of agile actions to take during the front-end phase, that based on the research, could reflect on improving the performance of project management.



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LIST OF ABBREVIATIONS

APM	Agile Project Management
CII	Construction Industry Institute
CM	Change Management
EVA	Earned Value Analysis
EVM	Earned Value Management
FED	Front-End Development
HoD	Head of Department
IKP	Internal Cost Price
IVP	Internal Sell Price
KPIs	Key Performance Indicators
NPS	Net Promoter Score
PM	Project Manager
PMI	Project Management Institute
PMS	Performance Measurement Systems
ROE	Return on Equity
ROI	Return on Investment
SM	Scrum Master
TL	Team Leader
TPM	Traditional Project Management
WBS	Work Breakdown Structure

CHAPTER 1.
INTRODUCTION

This research investigates the efficiency of the application of Agile Project Management for the management of early project phases of infrastructure projects. In this chapter, first a general introduction to the problem is discussed in section 1.1. In section 1.2 the design of the research is outlined, including the research objective and research questions. In section 1.3 the scope of the research is given, followed by the delimitations in section 1.4. This chapter concludes with the design of the thesis in section 1.5.

1.1 INTRODUCTION

Since the first definition of project management in the early 1950's, the methods used to manage projects have changed considerably. From highly strict to now flexible techniques, the methodologies have evolved responding to the specific needs of the industry they serve. In this search for optimization, agile software management was created in the early nineties, with the idea of simplification of projects by shorter communication channels and time periods in order to deliver more value to the clients Manifesto for Agile Software Development (2001). The core of agile is iteration and constant adaptability, based on constant testing, improvement, and adaptability. With the focus on the client and the development process, agile management strives for an evolution of the traditional management approaches to deliver more value embedded in the product (Dybå & Dingsøyr, 2008).

Agile project management (APM) was originally created in the ICT industry for developing software, and showed to be effective for the processes associated to this sector. Thus, it became attractive to other industries as they strive for optimization. Thus, its implementation transcended ICT, and currently is being used for managing all type of projects, including construction developments. For the construction industry, the application of agile comes as the possible solution to cope with projects' failure due to cost and time of delivery. Researchers have proposed that, by incorporating dynamic practices to manage construction projects, the manager can easily adapt to the constant changes common along this type of ventures (Demir, Bryde, Fearon, & Ochieng, 2012).

The application of APM in the construction industry is fairly new and consequently the guidelines for implementing such a dynamic method in such a traditional industry are still under study. Its use in construction mainly responds to the positive results observed in other sectors. But it should be taken into account that projects executed in the construction industry are highly variable from one to the next which makes the standardization of procedures difficult.

This research aims at determining how the application of Agile PM could enhance the performance of project management for infrastructure projects, and further on, where these set of changes need to be implemented to have the best impact. In order to achieve this goal, it will use a combined approach of literature review and case study research on how agile is being used for managing the front-end phase of infrastructure projects.

1.1.1. PROBLEM DEFINITION

The use of agile methods to manage construction projects is moderately new, and the literature about how is being applied in practice is scarce. Further, it is not known how agile managed projects performed, compared with traditionally managed projects; the usual approach used to manage projects in this industry. These factors lead to the question of how the use of agile could improve the management processes of infrastructure projects in the construction industry. And moreover, where in the life-cycle of a project the application of agile would create a more positive effect. Figure 1-1 schematizes these factors.

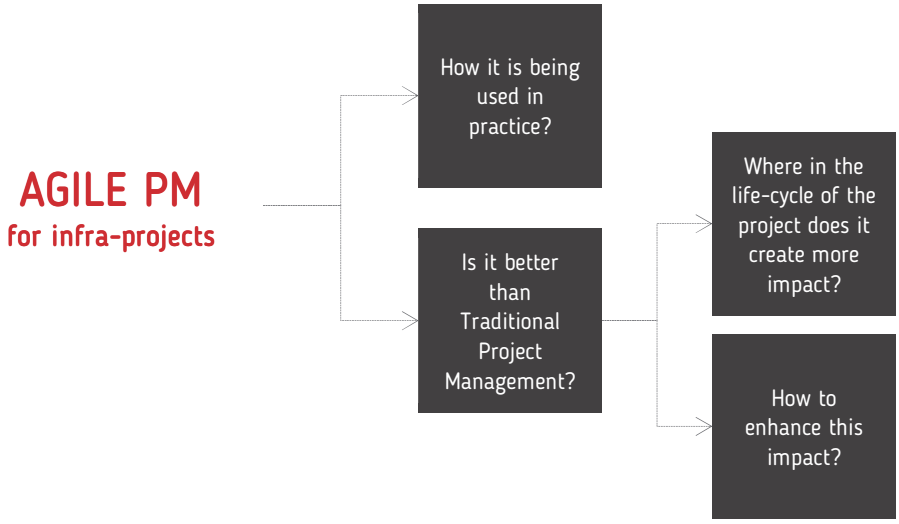


Figure 1-1 Problem definition

The problem for Sweco NL

Looking for alternatives for optimizing project management, Sweco NL (by the time Grontmij) used Scrum, as one of agile management execution tools, for managing three infrastructure projects. For the company, the goal behind this optimization was a significant cost reduction. However, after the completion of the projects the expected result was not achieved. The economical fluctuations and different ways of working used by the third parties involved among other organizational conditions are example of reasons which contributed to this relatively undesirable outcome. As the expected result was not met, the company stopped using this method and went back to their usual way of conducting projects.

Nowadays, Sweco NL is searching for ways to become more efficient, reduce time and costs, to increase financial results, but overall to increase the performance of their management practices for developing projects. Once again, agile principles are being considered as the solution to achieve these goals among some departments. Although, there is not a clear idea about which methods suit better the development processes of the different departments.

As an answer to the problem, this research intent to evaluate the projects conducted using an agile approach and measure their performance. To do the comparison, the performance of projects managed traditionally should be measured as well. By cross analysis of cases it will be studied if there is a link between performance and the management technique used. Moreover, it helps in identifying which elements enhanced the performance of project management.

The focus of this study is on the initial phase of infrastructure projects which is known as front-end phase in literature. By exploring this development phase, the set of activities affected by agile practices can be identified, as well as the specific areas to apply changes.

Having these set of elements clear, the framework required for the company for apply agile practices can be elaborated. This new set of guidelines would take the particularities of the company, their needs and requirements into account, to elaborate on the parameter that contributes to a better performance of project management, particularly suited for them.

1.2 RESEARCH DESIGN

1.2.1 OBJECTIVE OF THE RESEARCH

Based on researches in which the application of dynamic approaches proofs to be suitable for optimizing project management, this research aims to determine the relation between project management performance and project management approach, by comparing traditional and agile managed projects. The scope will be limited to the Front-End Development due to the impact has over the entire project, and the standardization of processes during this phase.

This research will evaluate the performance of two different management approaches during the front-end phase of infrastructure projects being agile and traditional management. The purpose is to determine how agile management practices could help to improve the performance of project management. The scope will be limited to the Front-End Development due to the impact has over the entire project, and the standardization of processes during this phase.

1.2.2 RESEARCH QUESTIONS

Main Research Question:

How can Agile project management improve the performance of infrastructure projects in early phases?

To answer the research question, a set of sub-questions are formulated, as follows:

SQ1: Which key performance indicators (KPIs) are used to assess the performance of project management in early project phases?

SQ2: What are the typical management activities conducted in Front-End Development?

SQ3: How can the Agility of project management be measured?

SQ4: How are performance indicators, front-end development, and agile management being applied in practice?

1.2.3 RESEARCH APPROACH

In this section, the general outline of the research methodology will be explained, complemented with an outline of the expected results.

Research Method

The starting point of this investigation will be a literature review on performance indicators, Front-End Development (FED) activities and Project Management with a focus on agile guidelines. This initial exploration will solve the research sub-questions one, two and three and will create a theoretical framework on these three research dimensions. The outcome of the literature study will be a set of indicators to measure performance and agility of projects. As well, the determination of the management activities conducted during the front-end development of projects.

Subsequently, an analysis on the practical application of the concepts elaborated on the theoretical framework will be conducted. During this second phase, traditionally managed and agile managed infrastructure projects will be studied. Using a 'case study' methodology the project management performance, agility, and front-end activities will be explored in practice. Six cases will be selected, three for each managerial approach, and each of the projects will be studied individually. For studying these cases, a document review and data analysis will be conducted initially. Following by a number of interviews with actors of those projects who played management roles there and questioners to be filled by them. Regardless the role played and the management approach used, all the respondents will be asked to answer the same questions. It is possible, that the interviewees have worked in several projects and have been involved in the use of both managerial practices. With the results obtained from this phase, sub-question four will be answered.

In the third phase, a cross-case analysis will be conducted. The results obtained from the individual projects will be combined and analyzed per research unit. The overall performance, front-end development and agility will be compared between agile and traditionally managed projects. Further, all the results would be combined to determine the set of practices that firstly were developed during the front-end phase, secondly could enhance the performance of project management and thirdly to what extent these practices are associated with agile management. By doing this, the main research question can be answered.

At last, the set of limitations found in the elaboration of the research will be mentioned. The conclusions will solve all the research questions, and lead to the answer to the main research question. Furthermore, two sets of recommendations will be made. One, on how to use the results of this research in practice, and the other, on how this research could be expanded.

1.2.4 EXPECTED RESULTS

The expected outcome of this research is a set of practices that if applied in practice during the front-end phase of infrastructure projects can possibly enhance the management processes of projects. The three intermediate results of this research are 1) project management performance KPIs, 2) front-end development activities and 3) agility measures.

1.3 SCOPE OF THE RESEARCH

This thesis will focus on determining the performance of the managerial techniques used in front-end development (FED) of infrastructure projects. The managerial techniques that will be studied are traditional and agile management. It is important to remark that the subsequent phases of the project's lifecycle, such as construction, delivery and use, are not part of the scope of this research. Figure 1-2 schematizes the scope of this investigation.

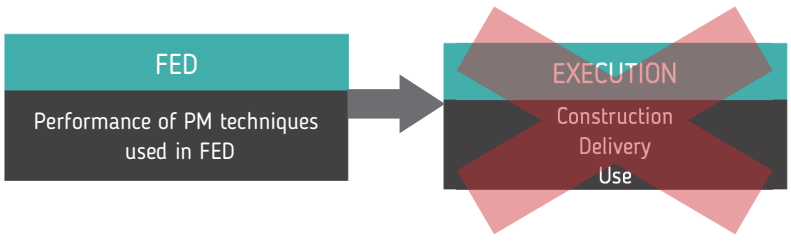


Figure 1-2 Scope of the research

1.4 RESEARCH DELIMITATION

The investigation is limited by two main aspects: the company (1.4.1), the type of projects (1.4.2). This section will elaborate on these aspects.

1.4.1 THE COMPANY

The research will be conducted in only one engineering consultancy company; Sweco Nederland B.V. Sweco NL is part or the Sweco Group, a Swedish-based organization, leading the European consultancy market as the largest consultancy within sustainable urban development with around 14,500 employees in 15 countries. The company has seven business areas over Europe: Sweco Sweden, Sweco Norway, Sweco Finland and Estonia, Sweco Netherlands, Sweco Denmark, Sweco Western Europe (Belgium, Bulgaria, Turkey and the UK.) and Sweco Central Europe (Germany, Poland, Lithuania and the Czech Republic). Sweco focuses on the integral design of cities tackled from the branches of water and energy, mobility and infrastructure, real estate and urban development and industry.

By 2016, Sweco Nederland B.V had 1800 employees, offering consultancy services over; Planning/Landscape, Building Services/Systems, Structural Engineering, Energy, Environment, Water/Flood Protection, Industry, Project Management, Position/GIS, Civils/Roads, Transport Systems, Ports/Harbors and Rail (Sweco Org, 2016).

1.4.2 THE PROJECTS

The investigation will focus on the research of management techniques used over the initial or front-end phase of infrastructure projects. The information will be obtained from the company's database of completed projects. A set of criteria were determined for selecting the projects to study, the first criterion is project phase, as this research aimed to investigate only front-end development. The second criterion is the management approached used, as there was the need of having both traditional and agile managed projects, to create a comparison between the two approaches. Having these initial criteria set, other parameters were established, such as contract value, development team and time. The value of the contract created a linked to other criteria such as project size, internal resources required, among others. For a better comparison, it was decided to select projects which were conducted in same time frame and were performed (almost) by the same development team.

The first criteria, related to the management approach used, limited the selection, as only three infrastructure projects were executed applying an agile management method. Taking these as a base number, it was decided to select an equal number of traditional projects in order to have a comparable sample. The performance of these six projects will be compared with the objective of determining the relation between project management performance and project management approach.

1.5 THESIS DESIGN

This thesis is divided into five chapters. The first chapter will introduce the research overview to the reader by explaining the problem and the objectives of the investigation. In the second chapter, the theoretical framework of key performance indicators (KPIs), front-end development (FED), and project management (PM) will be constructed, giving the theoretical basis for the research. In this chapter, the research sub-questions one, two and three will be solved. In the third chapter, the practical application of the three dimensions which where explored in literature in chapter two will be investigated, using a case study methodology. Six cases will be studied, three cases managed with traditional methods and three cases managed with agile methodologies, solving the research sub-question four. From the results obtained

from the case studies, a cross-case analysis will be conducted in chapter four. The results of this chapter will propose an application scheme for agile management, solving the main research question. At last, chapter five will give the conclusions and recommendations of the overall investigation. Additionally, the limitations found while elaborating the investigation. Figure 1-3 illustrates the design of this thesis.

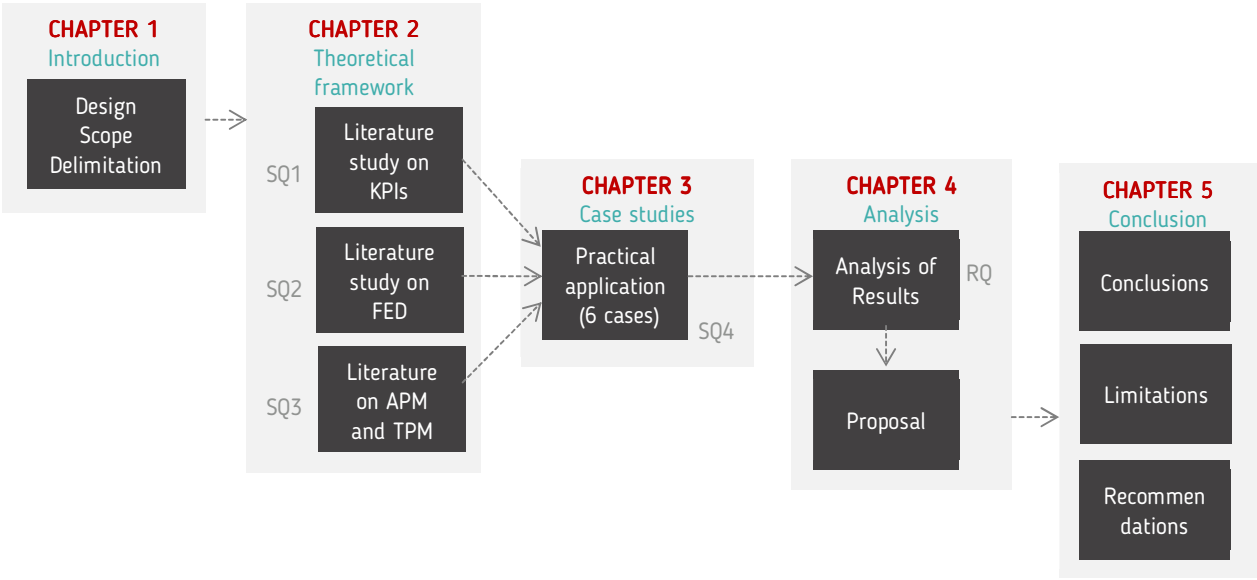
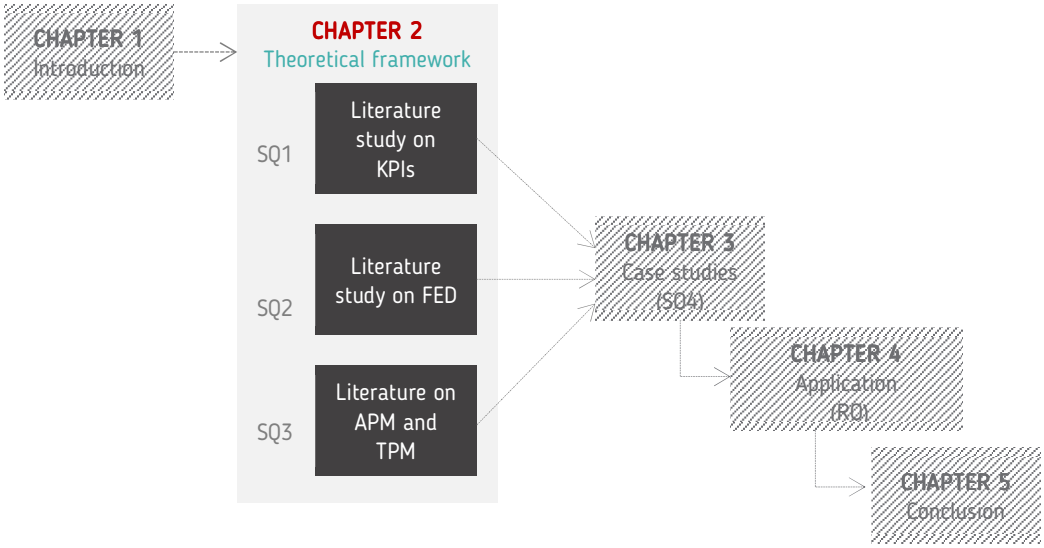


Figure 1-3 Thesis design

CHAPTER 2.
THEORETICAL FRAMEWORK

In this chapter, the literature review for the thesis will be set up. The objective of this chapter is to answer the research sub questions 1, 2 and 3 (defined in CHAPTER 1), thus it will be divided in three main sections. The first section will elaborate on project performance (2.1) and Key Performance Indicators. The second section will discuss Front-End Development (2.2). The third section will review Agile project management (2.3). At last, the analysis of the literature findings will be elaborated in section 2.4.



where is this section in the entire research?

2.1 PROJECT MANAGEMENT PERFORMANCE

The first part of the theoretical framework will discuss performance. First of all, a general overview of the concept is given (2). Next, the common methods for measuring performance are studied (2.1.2). Further (2.1.3), it discusses Key Performance Indicators (KPIs), as tools for performance analysis of project management. With this information, this section contains the input to solve the research sub-question 1 *"Which key performance indicators (KPIs) are used to assess the performance of project management?".*

2.1.1 DEFINITION OF PERFORMANCE

The focus of this study is the analysis of the performance of different project management methods, thus it is necessary to start by defining the meaning of 'performance'. According to the Oxfrod English Dictionary (2017) performance is: *"An act of presenting a play…the capabilities of a machine, product or vehicle…the extent to which an investment is profitable…".* It can be clearly seen that this definition is broad enough to include different areas of development, as artistic, technological and economical. Further research on the terminology has shown that each author customizes the term to its specific field and context, leading to the lack of a uniform definition. For production lines, performance is oriented towards activities and final products, in organizations the term involves the development of internal procedures, for economists performance is linked to the financial value and for change management procedures performance is measured by the impact on the involved actors (Samsonowa, 2012).

To measure and improve performance, organizations have created sets of performance measurement systems and key performance indicators (KPIs) addressed to the measurement over an organizational and project level respectively (Franceschini & Turina, 2013). Al-Jibouri and Haponava (2012) discuss the need to differentiate performance over project and organization levels, proposing to focus over process performance in terms of the level of completion and quality.

2.1.2 PERFORMANCE MEASUREMENT

This section will elaborate on how to measure performance and the common tools applied for this measurement.

Performance measurement systems are tools to track, analyze and improve the activities occurring in an organization. By using performance measurement, a company can analyze the development of the organization, its project and the processes occurring among them (Franceschini & Turina, 2013). Therefore, performance measurement can be analyzed from two perspectives: projects and activities and organization.

- On a project level, understand the functioning of activities, control them and identify possible required improvements.
- On an organizational level, identify the accomplishment of company's goals and evaluate customer and stakeholders' satisfaction (Franceschini, Galetto, & Maisano, 2007).

The core processes of performance measurement are design, implementation, use and refreshing. As performance measurement systems could lose its effectiveness with the changes of organization, it is important that its basic processes are under constant evaluation and redesign (Franceschini & Turina, 2013).

An additional definition by Neely, Gregory, and Platts (1995) associates performance measurement with the quality and usefulness of the process: *'the set of metrics used for of quantifying the efficiency and*

effectiveness of an action'. In order to measure an action, a set of tools need to be established. The most common performance measurement tools are Key Performance Indicators (KPIs).

To comprehend the Neely et al. (1995) definition, it is important to state the difference between efficiency and effectiveness. This last one (effectiveness) evaluates the degree the activities conceived to perform a task are in order with the job; referring to correct resource allocation. Efficiency is a relation input/output and refers to the generation of output with a minimum possible waste. To measure efficiency, it is necessary to evaluate these two concepts. Inputs are required resources to generate a product or execute an activity, such as capital and operational expenditure and people. The output is related to customer, its satisfaction, perceived quality and generated revenue. The measurement of efficiency is directly related to the performance indicators (Coelli, Pradasa Rao, O'Donell, & Battese, 2005). The efficiency of the processes must be monitored constantly and close to real time so that problems can be detected and optimizing measures may be taken as early as possible.

On construction projects, two main categories can define the measurement of performance. On one hand, the performance of the activities executed for the project itself referred as project performance, which are usually related to accomplish cost and time goals. And the other one, the performance of the management techniques used to guide the project, which go beyond time and cost (del-Río-Ortega, Resinas, Cabanillas, & Ruiz-Cortés, 2013).

Figure 2-1 Levels of performance in infrastructure projects

There are many tools proposed for performance measurement in practice. The next section will elaborate on Earned Value Management, as one of the most popular tools for performance measurement.

Earned Value Management (EVM) as a tool for measuring performance

One of the most common used instruments in practice for measuring the performance of systems is Earned Value Management (EVM). This section will elaborate on this tool.

Earned Value Management (EVM) was a method developed in the 1960s, by the department of defense USA to measure projects' performance. It uses scope, schedule and resources to quantify both performance and progress of the project at any point of time, by making a comparison between the planned work and the actual completed work. Its core elements are time, costs and Work Breakdown Structure (WBS). From a continuous track of the executed job, EVM gives the basis for course correction in case of the detection of deviations (Lessard & Lessard, 2007). It is important to mention that even though the method was developed to measure and transmit the physical progress of the project, in practice the attention has shifted mostly to tracking costs (Vanhoucke, 2009).

The initial elements that should be known to conduct earned value management (EVM) are the cost and time baselines of the project (planned value PV and planned duration PD) and a point in time to conduct the analysis (actual time AT in the life of the project). These elements can be used to evaluate the performance of a project at a given point of time and predict its future behavior. But it can also be used to make a retrospective analysis once the project is completed, by comparing the initial estimates (PV and PD) with the real duration (RD) and budget at completion (BAC) (Vanhoucke, 2009). Further explanation about EVM and each of its elements is given in **APPENDIX C**.

2.1.3 KEY PERFORMANCE INDICATORS (KPIs)

The collection of the required information for measuring performance of a system is usually conducted by using Key performance indicators (KPIs). These are tools for data collection and analysis of evolution. These indicators must have a number and unit of measure, so they can be quantifiable, and provides a baseline to be contrasted against (Franceschini et al., 2007).

In the construction industry, as any other industry branch, the indicators to measure performance will vary over the different project phases. This study will make a distinction between the performance indicators for project management and for the construction project itself. After determining this difference, it will focus on project management performance indicators.

Properties of key performance indicators

Literature recommends different characteristics that performance indicators should have in order to fulfill their purpose correctly. This section reviews these set of properties to concludes to a compilation of characteristics of KPIs.

In the early 1980's Doran (1981) introduced the concept of SMART as a way to establish goals and objectives. The main characteristics of the methodology rely on the name itself. According to SMART, indicators should be:

Specific – targets a specific area
Measurable – is quantifiable
Assignable – stipulates on the subject performing the action
Realistic – stipulates what results expect to be achieved
Time-related – stipulates when results will be obtained

Even though SMART is widely used, literature proposes more characteristics for the indicators when it comes to project management. Caplice and Sheffi (1994) compelled a list of the performance indicators mentioned in literature over a period of 20 years. Going further than the SMART methods they mentioned properties such as: reliability, economically and usefulness.

In 2007 Franceschini elaborated on performance indicators for project management suggesting that the previous lists should expand to include organizational and customer features such as companies' goals and stakeholders (Franceschini et al., 2007).

To determine the performance of processes regarding organizations, del-Río-Ortega et al. (2013) propose that indicators should be specific, measurable, achievable, relevant and time bounded. Reaffirming the SMART concept introduced by Doran (1981) decades before.

From the literature review in this section, Table 2-1 was elaborated. It summarizes the properties mentioned by each of the authors above. The base point, was the table of properties elaborated by Caplice and Sheffi (1994). Additionally, the positions of Doran (1981), Franceschini et al. (2007) and del-Río-Ortega et al. (2013) were added. Each of the properties mentioned by the authors were listed on the left column and the authors were organized in the first row, using an historical order. Subsequently, the properties mentioned by each author were cross checked. The objective was to see how these properties have changed or remained during time, but moreover, which ones were had more weight for creating performance indicators.

Table 2-1 Compilation of performance Indicators properties based on Caplice and Sheffi (1994) Doran (1981), Franceschini et al. (2007) and del-Río-Ortega et al. (2013)

Properties \ Authors	Mock and Groves (1979)	Doran (1981)	Edwards (1986)	Juran (1988)	NEVEN (1989) AT Kearney (1991)	Mentzer and Konrad (1991)	Caplice and Sheffi (1994)	Franceschini et al. (2007)	del-Río-Ortega et al. (2013)
Accurate					✓		✓	✓	✓
Assignable		✓							
Available			✓				✓		
Comparable			✓	✓	✓	✓	✓		
Compatible				✓	✓		✓		
Compensation								✓	
Economical	✓		✓	✓	✓		✓	✓	
Impact on stakeholders								✓	
Integrated					✓	✓	✓	✓	✓
Long-term goals								✓	
Meaningful	✓						✓		
Measurable		✓							
Monotony								✓	
Non-counter productive								✓	
Non-redundant								✓	✓
Realistic		✓							
Reliable	✓					✓	✓		
Scale type	✓						✓		
Specific		✓						✓	
Time-bounded		✓							
Understandable				✓				✓	✓
Uniform			✓				✓		
Useful			✓		✓		✓		✓
Valid	✓		✓		✓		✓		

The definition of each of the properties listed in Table 2-1 can be found in **APPENDIX D**.

Classification of key performance indicators

There are many ways to classify performance indicators: based on the type information they measure, by the subject obtaining the information, by their capacity to make a change in the process among others. This section will elaborate on the different ways of classifying KPIs.

Based on the degree of influence they have over the process, indicators can be classified in: leading and lagging. Leading indicators are the drivers or typically input oriented, difficult to measure but easy to influence. They are the goals that want to be achieved and the ones with the ability to indicate future events. Lagging indicators are "output" oriented, easy to measure but hard to influence. Lagging indicators reflect the outcome of the process, telling how the company or project performed compared to initial estimates (del-Rey-Chamorro, Rajkumar, & Steele, 2003).

Focusing on output oriented or lagging indicators, Franceschini et al. (2007) proposed a further classification of performance indicators based on the object and analysis of the information obtained. At first information is classified depending on the degree of involvement of the subject who obtains it. In this level information can be either objective or subjective. The objective information relates to quantitative data, not affected by the perception of the observer. On the other hand, the qualitative information is subjective takes the perception of the observer into account. This last type of information is mainly used in social studies. On a second level, the objective or quantitative information depends solely on the object. Objective information can be either basic which is directly measured by the system, or derived which is calculated by combining information of other indicators.

Figure 2-2 combines the positions of the two sources mentioned in this section for the classification of performance indicators. It was analyzed, that the expected results are the main criteria used for classifying KPIs. Initially, the influence of the result over the development process determines if the indicators have leading or lagging roles. Further, focusing on the output or lagging indicators, authors propose to use the subject obtaining the information as criteria for classification, making KPIs objective and subjective.
This study will focus on lagging indicators, for measuring performance in practice. The definition of these indicators will be made in the last section of this chapter.

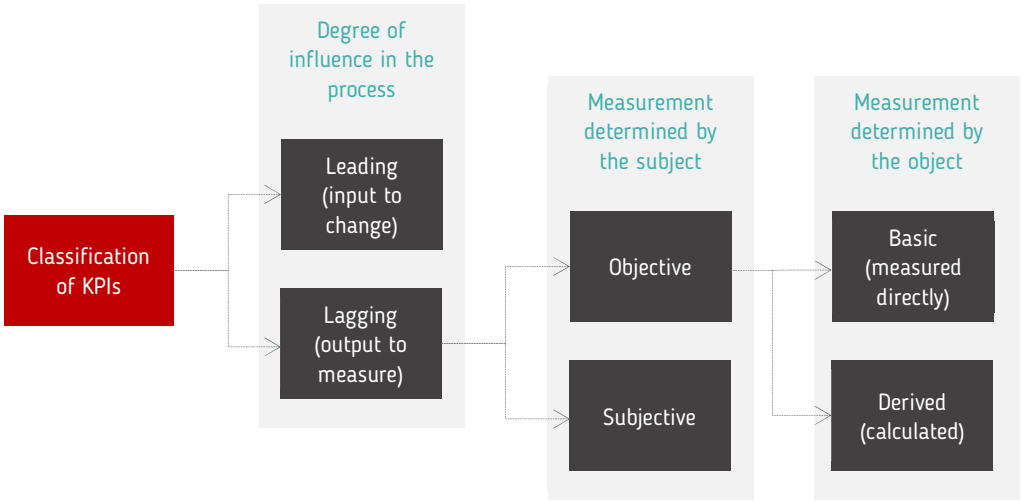


Figure 2-2 Classification of KPIs combining the positions of del-Rey-Chamorro et al. (2003) and Franceschini et al. (2007)

Project management key performance indicators

Performance indicators are measurements directly linked to the organizations. The processes, strategies, and policies of organizations determine how they perceive performance. Further, the indicators to measure the performance of the project management techniques that organizations use are linked to the achievement of those goals and expectations. This section will study the indicators proposed in the literature for measuring the performance of project management practices, on a general level.

For del-Rey-Chamorro et al. (2003) the set of indicators to measure performance over the organization's goals are lagging indicators. They grouped them under four main categories: financial, customer, internal and learning and growth.

Other studies, regrouped the categories mentioned by del-Rey-Chamorro et al. (2003) into two categories of KPIs: internal and external. Internal indicators are the ones linked to the internal processes of the organization and the degree they fulfill stakeholders needs. External indicators are the ones which link the company to its customers ("Measures of Project Management Performance and Value," 2005).

Franceschini et al. (2007) named the internal group 'quality indicators' which are indicators able to 'fulfil different types of requirements − productive, economic, social − with concrete and measurable actions'. In their classification, efficiency and effectives are related to the measurement of the internal processes of the organization and the degree they fulfill stakeholders needs.

For these authors, the performance of project management has elements that are linked to the entire organization, such as financial, customer and employee performance. Further literature such as PRINCE2 and PMBOK, focuses on the performance of the project activities (Project Management Institute Inc. (PMI), 2013); (Axelos, 2015). The performance indicators in this literature are highly influenced by the iron triangle of project management (for further explanation about the PM iron triangle refer to section 2.3.1); dividing indicators into groups of scope, time, and costs.

Compelling the literature mentioned in this section, a complete list of key performance indicators to measure the performance of project management will be elaborated in section 2.4.

2.2 FRONT-END DEVELOPMENT

The second part of the literature study focuses on Front-End Development. This section gives a general introduction on early project phases (2.2.1). Further, it elaborates on the management activities conducted in FED both in traditional and agile managed projects (2.2.3) in order to answer the research sub question 2 *"What are the typical management activities conducted in Front-End Development?".*

2.2.1 FRONT-END DEVELOPMENT: EARLY PROJECT PHASE

The code of practice of project management calls the first phase of the project "inception" (The Chartered Institute of Building, 2014). To Fewings (2013) inception is the process between the owner and its professional team, in which the project is defined starting from the fundamental criteria of time, cost and quality (Lester 2014). This phase starts by the definition of an objective and is completed when consensus is reached between the parties. From the input received from inception, the project advances to feasibility and strategy studies, and further elaboration (Fewings, 2013).

According to PMBOK, the 55% of the processes required to develop the project are in the initiation (2 processes) and planning (24 processes) phases of the project; making them the most complex phases (Project Management Institute Inc. (PMI), 2013). According to the vocabulary, the terms 'Inception' and 'Initiation' are synonyms, as well as the terms 'Strategy studies' and 'Planning'. The phase from now on called "front-end" which covers these two stages of the process.

Front-end development (FED) refers specifically to the phase in which the necessary information to approach a project is developed (Gibson 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 positive impact that correct planning has on the outcome and further success of projects have broad support among experts in the field of project management. They believe that planning efforts conducted

during early stages of a project are crucial for the entire process and have a greater effect on the success of later stages (Dumon et al., 1997; Cho et al., 1999). The improvement on time over project early phases can be finally reflected on the overall performance of operations, as improves the company's capacity to create value in the form of processes which has a direct and immediate effect on the bottom line (Hameri & Heikkilä, 2002).

Following this line of reasoning, Wysocki (2007) emphasizes the importance of planning based on three reasons: uncertainty reduction, the increase of understanding and efficiency improvement. By contemplating of all possible risks that can occur during execution and consequently plan ahead on the actions to mitigate them, uncertainty can be reduced. Moreover, by having clear objectives and allowing understandability and transparency, it helps all actors strive towards the same objective. Finally, by having a clear definition of tasks, processes can strive towards standardization, shortening the projects 'total duration. Knowing the parameters allows a better resource allocation and the creation for a performance measure.

2.2.2 PHASES OF FRONT-END DEVELOPMENT

Front-End development is usually divided into phases, that evolutionary clarify the idea of the project. Through these phases the concept of the project will be shaped and the required information for its execution will be obtained. This section will focus on exploring the phases executed during FED from different sources in literature.

Based on practical research, The Construction Industry Institute (CII) identified five main phases in the FED: Business planning, contracting strategy, project execution planning, facility scope planning and technical planning. George, Bell, and Edward Back (2008) elaborated on these phases and the activities related to each stage. Initially, the business plan is the goal of the organization.The activities in this phase should ensure that the project is in line with these objectives. The contracting strategy is the phase in which the basis for contracting is determined, by revising possible business partners and potential bidders. The project execution plan will create the detailed strategy for completing the project; including initial schedule and safety plans. The facility scope is the determination of the needs for the next project phase (design) and the elements that will be decided on the final FED phase. Thus, the final phase or product technical plan defines all the requirements the project needs, such as licenses, security, testing, in order to have a complete project definition.

Al-Jibouri and Haponava (2009) and Bosch-Rekveldt (2011) studied FED phases in literature over the past forty years and developed a comparison scheme. Al-Jibouri and Haponava (2009) proposes that the three main phases of FED are: initiation, feasibility and project definition. In the first, the client requirements are analyzed and a set of alternatives will be composed. In the second, the set of alternatives will be compared and the preferred option will be chosen. At last, this preferred option is defined and the decision to move to the next phase will be made.

Bosch-Rekveldt (2011) follows the same line as Al-Jibouri and Haponava (2009) and proposes three main steps of Front-End Development: FED1, FED2 and FED3. FED1 is the conception phase, where the main objectives of the project are defined, as well the constraints for the execution; grouping scope, time, budget and risks. Follows by FDE2 which includes feasibility study and the selection of a method to accomplish the objectives. Lastly, in FED3 the required level of detail for initiation is achieved, and the project is defined.

Table 2-2 combines the summarized position of the authors mentioned in this section.

Table 2-2 Classification of early project phases according to George et al. (2008), Al-Jibouri and Haponava (2009) and and Bosch-Rekveldt (2011)

SOURCE	PHASES IN FRONT-END DEVELOPMENT				
George et al. (2008)	Business planning	Contracting strategy	Project execution plan	Facility scope plan	Technical plan
Al-Jibouri and Haponava (2009)	Initiative phase		Feasibility phase		Project Definition phase
Bosch-Rekveldt (2011)	FED1 Conception		FED2 Feasibility		FED3 Project definition

A more detailed compilation of the studies elaborated by Al-Jibouri and Haponava (2009) and Bosch-Rekveldt (2011) can be found in **APPENDIX E.**

2.2.3 FRONT-END ACTIVITIES

Literature suggests that the activities of the front-end phase are in broad terms similar to all projects and industries, as long as the organization applying them using a project management system (Bosch-Rekveldt, 2011). In this section, the common activities performed in Front-End Development will be defined.

Oosterhuis (2008) proposed a standard list of general activities and key deliverables recommended for completing front-end development in the process industry. The author defined a basic set of activities, to be repeated during the front-end phase until achieving the required degree of refinement to move to the next phase.

A previous list had been elaborated in 2007 by Lessard & Lessard mentioning the activities that the project manager should overview on each of the project phases and the relationships among them. The authors define two project phases being the initiation and project plan development. This last one contains the majority of the FE activities. Although this exercise is valuable as includes the role of the project manager in the process, it narrows down the scope of the entire set of activities that should be performed (Lessard & Lessard, 2007).

The Project Management Institute Inc. (PMI) (2013) establishes a set of managerial processes that should be executed on each of the project phases (initiation, plan, execution, monitor, and closure). The majority of the activities of FED for PMI are executed during the 'planning' phase.

More recently, Heagney (2016) defined that the activities of FED are grouped under two phases: initiating and planning. The last one subsequently is divided into plan and definition activities.

Focusing on the activities developed in a construction project, George et al. (2008) identified the typical front-end activities by using CII guidelines, with a focus on engineering procurement and construction (EPC) type of contracts. Using an interview scheme, the authors evaluated 33 activities of FED, in order to establish their criticality. Applying the same methodology, Al-Jibouri and Haponava (2009) validated literature over the main processes covered in the pre-project stage. Years later, Bosch-Rekveldt (2011) uses CII guidelines and the Oosterhuis (2008) list to determine practices to improve value during front-end.

2.3 PROJECT MANAGEMENT: TRADITIONAL AND AGILE

The last part of the literature framework elaborates on project management methods. It starts with a brief historical overview of project management, focusing on traditional management (2.3.1). Next, paragraph (2.3.2) elaborates on agile project management, as a guideline being applied today in managing projects. This section concludes with a set of indicators to measure the agility of a project, as an input to answer the research sub question 3 *"How can the Agility of project management be measured?".*

2.3.1 TRADITIONAL PROJECT MANAGEMENT

Historical review or Project Management

The management of projects, as a discipline was developed in early 1950's in the US Department of defense (DoD) as a coordination solution to cope with the constant technical advances of the time. Its main goal was to manage the harmonization between different phases of weapon production (Morris, 2013).

Following the definition of project management as a technique, in 1969 Dr. Martin Barnes proposed 'the iron triangle' of project management, as the necessary constraints for the development of a project: time, cost and output. The modern triangle has evolved to rename 'output' as 'scope' and include the quality element (Figure 2-3). Additionally, the PMI defines another set of project constraints, such as risk and resources (Project Management Institute Inc. (PMI), 2013). The iron triangle is the main representative of traditional project management.

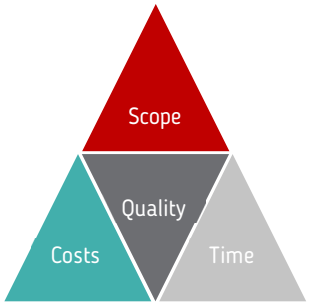


Figure 2-3 Iron Triangle of project management

In 1970, Royce (1970) called this model the "waterfall model" of project management because of the sequential format of phases: Analysis, Design, Coding, and Testing. Today, this approach is usually referred as "traditional project management (TPM)". Its basic points are: fully specifiable systems, thoroughly and heavily planned, formal lines of communication and a command and control management style (Dybå & Dingsøyr, 2008). Command and control management strategies are generally applied in hierarchical organizations. They are sequential and structured decision-making models in which one actor having a leader role sets goals and deadlines for the organization. In this model, changes and adaptability are limited.

Although this method is strict and hence can be criticized, unilateral decision making can help the goal achievement by preventing big deviations. This idea gives the first approximation to the need of hybrid managerial strategies with elements of both command and control and process-based methodologies (Bruijn & Heuvelhof, 2008).

Project Management Today

Over the past 50 years' project management has been under constant evolution and today is defined as "the application of knowledge, skills, tools, and techniques to project activities to meet project requirements" (Project Management Institute Inc. (PMI), 2013). Currently, the most representative standards and guidelines for traditional project management are two: PMBOK and PRINCE2. This section will elaborate on them.

PMBOK established by the Project Management Institute (PMI) defines that projects are composed by 47 processes gathered in 5 project groups: Initiate, Plan, Execute, Monitor and control and Close. Here the Project Manager acts as a change agent and is responsible for the achievement of the project's objectives by linking the strategy and the team in charge to execute it (Project Management Institute Inc. (PMI), 2013). Wysocki (2007) introduced the term of Traditional Project Management (TPM) life cycle in parallel to the one proposed by the PMI.

The two initial phases of the projects' lifecycle generate a big impact over the entire endeavor. The definition phase scopes the project; defining the problem, solution and deliverables. From these, the parties can define the projects' goal and make agreements on how to achieve it. Further on, during this phase the factors that measure the success of the project are determined along with the risks that can affect this success. On the subsequent planning phase, the execution plan for the project is developed. This phase has a big importance and impact to the entire project; a good and effective planning can prevent the increase of project duration, foresee complications, establish mitigation measures, and in general what would reflect on the projects' efficiency. Further, the plan is launched and the project is executed until the entire set of plans is achieved and the project can be concluded and closed. Figure 2-4 shows the project life cycle and the main goals of each phase according to PMBOK.

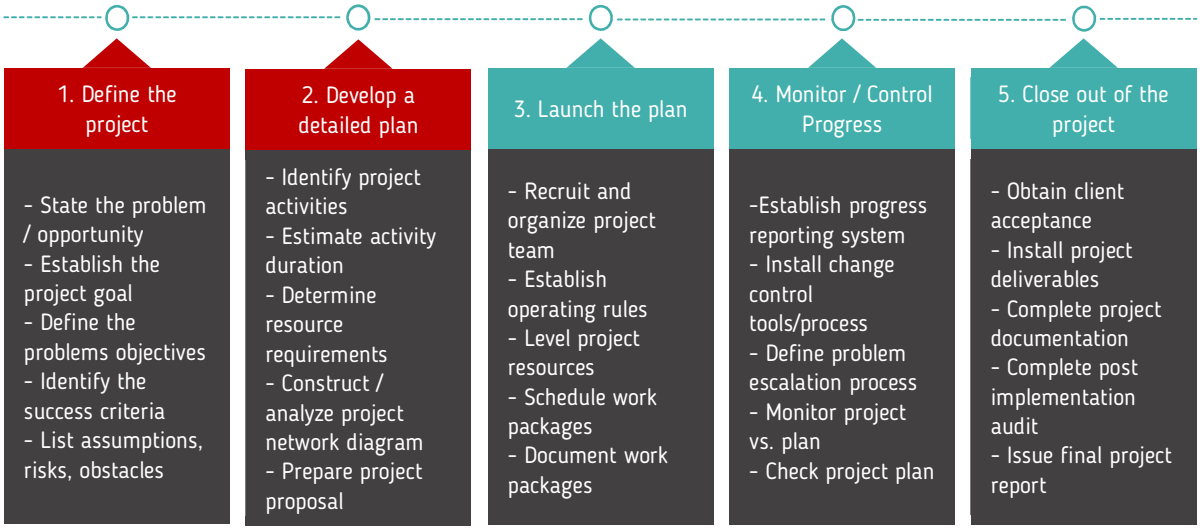


Figure 2-4 TPM Life Cycle according to Wysocki (2007)

The second set of guidelines, developed from the traditional project management, PRojects IN Controlled Environments (PRINCE) is a process-based model, specifically tailored for the type of project to be executed. It consists of a set of seven processes: Starting a project, initiating a project, directing a project, controlling a stage, managing a product delivery, managing stage boundaries and closing the project. For PRINCE the project Manager is in charge of organizing and controlling the process (Roudias, 2015). Even though this approach seems more flexible, it shares the same principles of traditional management, thus is still is classified under this category. PRINCE2 is now evolving towards Agile Management, by creating a new PRINCE2 Agile manual, which includes the frameworks, techniques, and concepts of Agile Management into the PRINCE managerial techniques. The idea is to approach not only the development of projects but as well the execution of routine work, thus expanding its usage degree (Axelos, 2015).

Even though the terminology of both methods might differ, the two methodologies are fully based on the projects life-cycle or the series of phases the project overpasses from initiation to closure. These phases are usually sequential and vary depending on the project's specific characteristics (Project Management

Institute Inc. (PMI), 2013), but can be synthesized in five main categories: Initiating, Planning, Executing, Monitoring and Closing (Roudias, 2015).

Over the past twenty years, management practices have been under transformation, responding more dynamically to the projects changes. Agile management has emerged as one of the results of this transformation. The following section will elaborate on it.

2.3.2 AGILE PROJECT MANAGEMENT

Adaptation to specific needs have pushed traditional management methods to evolve and new techniques of project management have emerged. In the early 1990's the ICT industry developed a more interactive managerial approach called Agile Project Management. This section will elaborate on the principles of agile management and its differences with traditional management. Next, it focused on agile execution methods. Later, the application of agile into the construction industry will be explored and will conclude by reviewing the tools to measure the agility level of enterprises.

Agile is an iterative and incremental method of continuous innovation, based on constant testing, improvement, and adaptability with an informal communication and an evolutionary-delivery model. This style is oriented towards an organic development in which the management focuses on leadership and collaboration, on the basis of constant communication and involvement of the development team (Dybå & Dingsøyr, 2008). The basis of Agile Project Management was stated in the Manifesto for Agile Software Development (2001) with twelve principles contained on four core values: Individuals and interactions, Working Software, Customer collaboration and Response to change.

Basis of Agile Management

The basic values and principles for applying Agile management defined in the Manifesto for Agile Software Development (2001) are;

'Response to change over follow a plan
Individuals and interactions over processes and tools
Customer collaboration over contract negotiation
Working software over heavy documentation'

To do so, the following twelve principles were proposed Manifesto for Agile Software Development (2001):

1. Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.
3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.
4. Business people and developers must work together daily throughout the project.
5. Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.
6. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.
7. Working software is the primary measure of progress.
8. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
9. Continuous attention to technical excellence and good design enhances agility.
10. Simplicity--the art of maximizing the amount of work not done--is essential.

11. The best architectures, requirements, and designs emerge from self-organizing teams.
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly.

It was proposed that these ways should be applied in the development of a project for achieving agility. These practices share some similarities and have differences with traditional project management. These features will be explained in the following section.

Evolution of the Iron Triangle

As management techniques, Agile and Traditional share the same constraints. Thus researchers propose that the triangle for agile management is the result of the adaptation of the traditional iron triangle (explained in section 2.3.1). Highsmith (2010) starts from the original iron triangle (Figure 2-5 left) in which the scope is the main driver and the cost and time can be estimated to satisfy this goal. It proposes that for the initial 'iron' triangle for agile (Figure 2-5 center) the schedule is the main driver; fixed over time boxes, and the scope can change. Although this triangle is already an approximation towards agile it is still based on traditional and not agile principles. Thus, another adaptation was required. The final agile triangle (Figure 2-5 right) includes the customer, which changes the elements into value, quality, and constraints. In this final triangle, the main objective is the maximization of value for the customer. The quality is required for the constant delivery of value. And the constraints are the three elements of the original triangle; time, scope and costs. Within this group, the time can still be fixed (as the initial agile iron triangle) so the scope has to be subjected to changes.

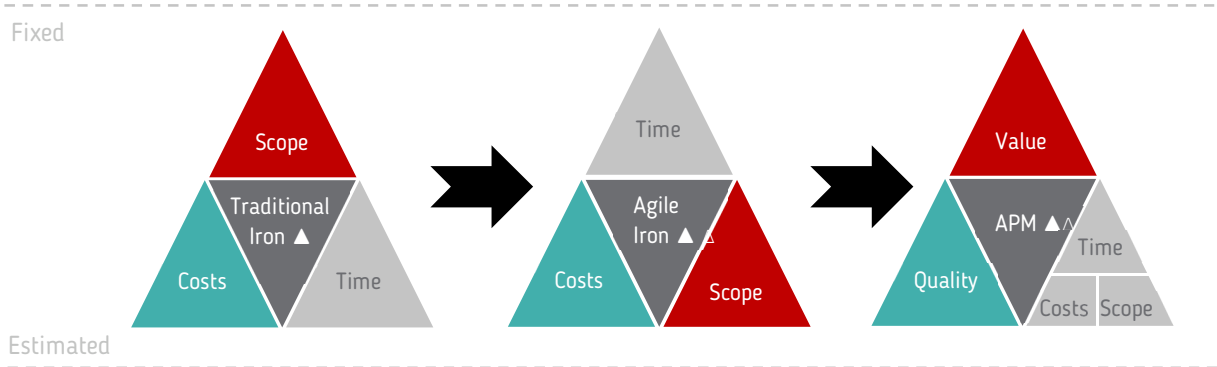


Figure 2-5 Evolution of the iron triangle: Traditional iron triangle (left) and Agile iron triangle (center) and Agile PM triangle (right) based on Highsmith (2010)

The main difference between traditional and agile project management relies on the concept of life-cycle. In a traditional waterfall approach the activities are executed either sequential or overlapping, but always following a strict plan determined from an early project phase. In agile management, the life cycle is adaptive and constantly changing to face emerging requirements.Derived from the life cycle, other features of the project are affected.

Table 2-3 compares the features from agile management with traditional project management practices, by making a classification over project elements (Conforto, Salum, Amaral, da Silva, & de Almeida, 2014).

Table 2-3 Traditional vs Agile project management elements based on (Conforto et al., 2014)

Project elements / Management Style	Traditional	Agile
Definition	Well defined product and project scope.	Product vision. Simple project plan and communication tools.
Planning	Single Plan.	Iterative planning.
Controlling	Continues based on the defined project plan.	Self-managed and self-directed teams for planning and controlling the project.
Revision	After a major milestone, and only to correct deviations.	Update the plan at the end of each development cycle.

Agile Management Execution Methods

The most common agile execution methods are Crystal Methodologies, Dynamic Software Development Method (DSDM), Feature Driven Development (FDD), Lean, Scrum, Extreme Programing (XP, XP2), Adaptive Software Development (ASD). Crystal emphasis is the team that are organized according to the task to develop in size and critically (Dybå & Dingsøyr, 2008). The main principle of DSDM is the initial adjustment of time and resources to further adjust of objectives accordingly. FDD is oriented by a design and plan scheme, what differentiates it from the other methods. Scrum is a framework, rather than a process, based on flexible and iterative development (Schwaber & Sutherland, 2016). The XP method concentrates on iteration and fast development, by enhancing communication and coordination efforts between the customer, the management, and the development team. ADS concentrates on three main phases: speculate, collaborate and learn, in which the team skills are aligned with the development of the project (Ribeiro & Fernandes, 2010).

Scrum is usually referred to when talking about Agile Management. Scrum uses an empirical and incremental framework to tackle problems. Based on small teams and short time frames, focusing on continuous revision and adjustment guided by three main pillars: transparency, inspection, and adaptation (Schwaber & Sutherland, 2016). The dynamicity of these business practices allows organizations make decisions faster and enables rapid optimization tough out all the processes across the lifecycle of a project

Scrum is a framework for developing products, not a management technique itself. It is based on teams and tasks to achieve goals. The first pillar, transparency, refers to the degree of accessibility that all team members share; therefore, impels the use of a common language and equal definition of "goal" terms for all members. Inspection refers to the degree of continuous review that has to be done to achieve the goal. And Adaptation to the adaptability degree when the process is deviating from the acceptable boundaries. Scrum's core is called "the Sprint" and it is a time-box of one-month work in which a specific goal is set. That is why sprints are usually considered as one-month projects. Additionally, four main events that support the Sprint: Sprint planning, Sprint review, Sprint retrospective and Daily Scrum (Schwaber & Sutherland, 2016) (Further information about scrum roles, tools, events and overall process can be found in **APPENDIX B**).

Agile Project Management in the Construction Industry

The application of management techniques developed in the ICT industry to other industry lines has been broadly studied. But the use of agile in the construction industry is still incipient. This section will explore the practice of agile management in the construction context.

In 2006, Owen, Koskela, Henrich, and Codinhoto (2006) studied the applicability of APM on the general phases of construction projects: pre-design, design, and execution. They proposed to focus on four main clusters to differentiate TPM and APM in practice: organizational mindset, planning, execution and control and learning disposition. Within these clusters, they identified a set of general project management indicators that could be the potential areas of improvement if the project is managed using agile guidelines (Table 2-4).[1]

Table 2-4 Areas for potential improvement of APM in construction phases according to Owen et al. (2006)

Application clusters	Management indicators
a. Organizational mindset	Attitude towards change
	Management style
	Organization type
	Work group structure
	Attitude to risk
b. Definition and planning	Nature of planning
	Requirements capture
	Work package structure
c. Execution	Development approach
	Quality approach
	Customer involvement
	Value delivery
d. Control, learn and revision	Project metrics
	Learning attitude

a) The organizational mindset is the main requirement for implementing agile and refers to the disposition of the organization to make this transition. The general ideas are collective decision-making process, empowered teams and risk sharing. Such attitudes could be difficult to find in the execution phase of construction projects due to the diversity of actors who strive for their own goals.
b) Planning is one of the main differences between traditional and agile management. For the authors, this method would result feasible for the design and pre-design phases of a construction project, as they have an iterative nature.
c) Execution (do not confuse with execution phase of construction project or edification) groups quality, value and customer indicators. The core of APM is delivered value constantly, achieved by an iterative and incremental work (Figure 2-6), in which the client is constantly involved. In the construction industry, the TPM are commonly adopted: the customer is seen as an actor that could jeopardize the project. Thus, he is kept apart and value and quality are delivered to him once milestones are achieved.

[1] Note: It is important to emphasize that their study focuses on the areas that could be improved by using agile management. Thus, their list of the indicators shown in Table 2-4 might be already narrowed down using these criteria, excluding some general management indicators.

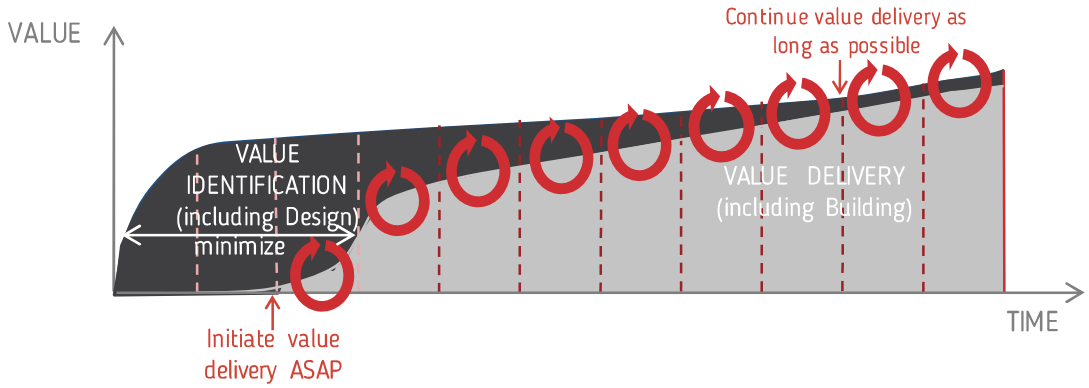


Figure 2-6 APM value delivery (Owen et al., 2006 & Codinhoto, 2006)

d) Control, learn and revision refer to the metrics used to control the project, the lessons learned and corrections applied. Construction projects are normally measured by the accomplishment of milestones and the resources required for its achievement. Further, the high heterogeneity between actors, the division of labor, short-term commitment and de-skill labor, typical characteristics of the construction industry create a barrier for the application of agile.

Owen et al. (2006) conclude that agile is more applicable to the pre-design and design phases of construction projects. Within these phases, the maximization of value could be fully achieved and the application of agile be more effective. This will help the creation of complex products with lower costs. In the execution or construction phase the applicability of APM is more limited due to the disparity of jobs and tasks which are common on this level. The execution phase involves a large set of contractors each having their pole of employees and each developing different activities. The lack of a common organizational culture and the degree of division makes the implementation of agile management difficult. Beyond project phases, the authors emphasize that the applicability of agile would depend on the type and complexity of the project. Projects having more changes along the process, involving a considerable number of clients and trade-off processes could benefit better by the application of APM.

Everts, Pries, and Nijhuis (2011) support the idea that the project management methodology should be chosen according to the type of project to execute. The application of agile management would be more optimal for complex projects with more stakeholders and potential conflicts to be solved. For simple projects, the traditional hierarchical approach works. Nevertheless, complexity is not only related to the overall project but as well affects each of the project's phases. Thus, PM techniques could differ from one phase to the other. For the early phases, where there is major interaction, value added and decision-making processes, agile could have better results. Later phases, as execution, would require a more traditional tactics.

Further, studying the conceptualization of Lean management[2] practices to construction projects, Demir et al. (2012) propose to combine Lean and agile management guidelines. The application of agile management to construction projects would increase their flexibility and ability to cope with uncertainty and changes. As their starting point is Lean construction the authors named the combination of Lean and

[2] *Lean management:* Is the evolution of the Toyota production methodology developed in the late 1970's, with the main idea of eliminating waste among production processes and therefore, reducing costs. The core of Lean relies on the basic concept of efficiency: generate an output by producing the least possible waste (Puvanasvaran, Megat, Tang, Muhamad, & Hamouda, 2008).

Agile 'AgiLean' project management. This approach would eliminate waste and react to changes simultaneously during the entire project lifecycle. Contradicting Owen et al. (2006), Demir et al. (2012) state the applicability of agile management should not be limited to the design phase of the project but should be extended to the execution phase.

Focusing on the construction sector in The Netherlands, Everts et al. (2011) identified that this industry is highly linked to a TPM approach and the idea of mass production developed after the WWII. The most common guidelines for project management applied in The Netherlands are PMBOK and Prince2; both under a TPM umbrella. Projects combine a large number of contractors and specialists, tender procedures, and coordination problems, in a context that has clearly changed. Further on, the cost increases and late deliveries are nowadays common among Dutch infrastructure projects (Cantarelli, Molin, van Wee, & Flyvbjerg, 2012). According to Everts et al. (2011) many of these failures are linked to the strict and sequential management methods used to execute the projects. This emphasizes the need for a change on the traditional mindset towards management approaches more suitable for today's challenges.

Agile Project Management Indicators

As the root of agile management emerged in the ICT industry, its procedures and application requirements are highly associated with this sector. However, the application of APM has extended to different industries and the agile management guidelines have been altered to fit these industries. To rightly determine if a project is or was managed using agile management techniques, it becomes necessary to elaborate a measurement instrument to determine the 'agility level' of projects. This section elaborates on how to determine the level of 'agility' of enterprises, including construction projects.

The initial base point for applying agile are the four values and twelve principles of agile management established in the Manifesto for Agile Software Development (2001) (mentioned at the start of this section). Further, each of the agile execution methods has developed a set of practices and activities. From these initial practices, different authors have explored the application of agile management into industries different than IT.

Tsourveloudis and Valavanis (2002) measured the 'agility' of an enterprise with a focus on manufacturing systems. They propose a division of the assessment areas. On one side, a focus on the process, people, market, and information. On the other side, variables linked to production itself. Since this second category is not directly linked to managerial processes, the variables proposed for this measurement will not be included in this study.

For measuring agility of software development management, Mafakheri, Nasiri, and Mousavi (2008) defined the term as *"the ability of a project to respond to a changing environment effectively"*. This changing environment could include the change on stakeholders' requirements, technological changes, etc. The authors proposed six dimensions to assess agility: dynamism, team size, communication, test, developers' skills and knowledge and culture. For each of these dimensions, a set of parameters that affect agility were projected. The authors tested them using a 'fuzzy approach'[3], and as an outcome, the research concludes a model to determine the agility of projects, that could be extended to other industry lines, such as construction, oil and gas, etc., as long as proper sensitivity analysis is performed to adapt the variations of the specific industry to the agility assessment.

3 Fuzzy logic:" Relating to a form of set theory and logic in which predicates may have degrees of applicability, rather than simply being true or false" (Oxford English Dictionary, 2017).

Using the same study approach, Vinodh and Devadasan (2011) tested a group of criteria for agility assessment on a manufacturing company. Their objective was primarily to determine the level of agility the organization had, and then establish the measures to accelerate their transition to agility. They developed five clusters for enabling agility, two of them related to management practices, and the others to production itself (this study will only contemplate the management associated indicators) and among these clusters a list of agility indicators. After measuring them in practices, the author developed an agility index that could determine the level of agility of the organization.

More recently Conforto et al. (2014) studied literature and developed a set of general practices to adopt APM to businesses different than software development. According to them to apply agile management a company should use: a "product vision", simple plan and communication tools, iterative planning, self-managed and self-directed teams in the project plan and for monitoring and updating activities, and the overall processes should be frequently monitored and updated.

It is important to remember in this section the list of practices elaborated by Owen et al. (2006) on Table 2-4. Even though the indicators proposed by the authors are general for all project management techniques, they are narrowed down to the ones that could improve the management of construction projects by using agile management. For this reason, these indicators will be included in the elaboration of 'agility' measurement indicators.

2.4 BRINGING IT TOGETHER

This second chapter evaluated literature over the three main project dimensions: performance, front-end development, and agile management. This last section will recap the findings of the literature research, to solve the following research sub-questions.

SQ1: *Which key performance indicators (KPIs) are used to assess the performance of project management?*
SQ2: *What are the typical management activities conducted in Front-End Development?*
SQ3: *How can the Agility of project management be measured?*

This literature is the framework for the practical evaluation, to be elaborated in CHAPTER 3.

SQ1: Which key performance indicators (KPIs) are used to assess the performance of project management?

Performance measurement quantifies the resources assigned and consumed by activities, the achievement of goals, waste of resources; and the overall development of a project, giving the information necessary to detect failures and apply corrections. Moreover, the effectiveness and efficiency of a project can be determined by using information obtained from performance indicators. The key factor in creating a good performance measuring system is the determination of the accurate performance indicators; the set of tools that will be in charge of collecting the information. Thus, formulating a good set of performance indicators can determinate the accurate measurement of performance of the system, or, set an incorrect framework.

For this research, the initial approach for the formulation of this framework was the exploration of the required characteristics that indicators should have. Further, different ways to categorize indicators were

studied on a general level. And afterward, the scope was narrowed to the measurement of PM performance in an organization. As a result, Figure 2-7 was elaborated.

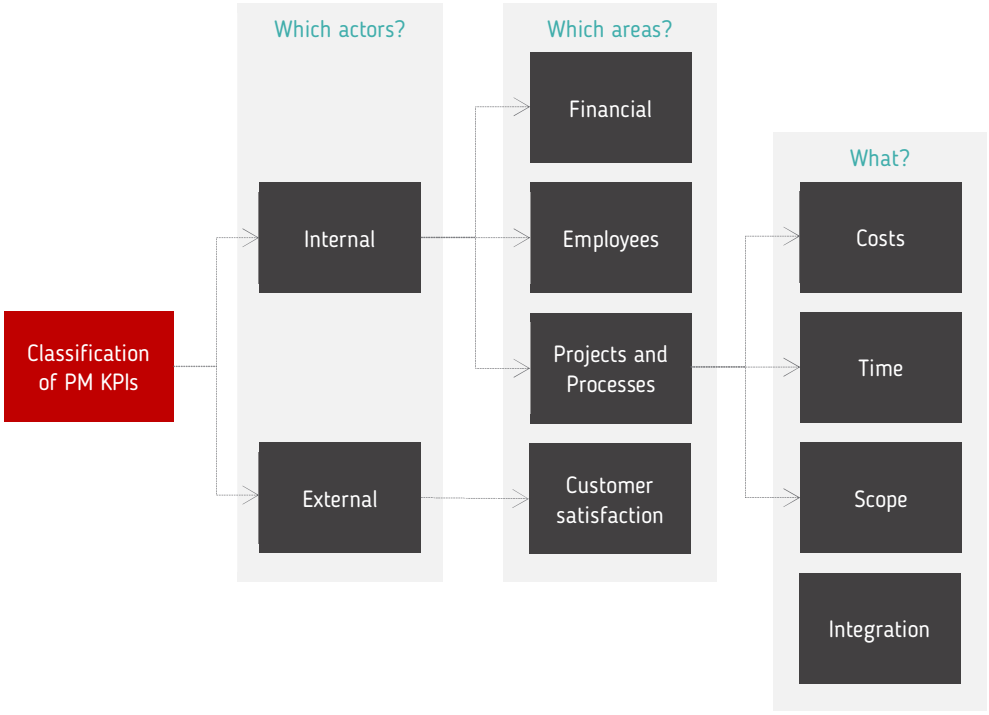


Figure 2-7 Classification of project management KPIs

On the first level, Figure 2-7 shows two categories: internal and external, differentiated by the actors involved in obtaining the information. The external group is the one that requires actors outside of the organization to obtain the information, as are the customers or clients. Thus, customer satisfaction is in this category. The internal category groups all the indicators that can be measured within an organization. In this category, the performance of internal processes and projects can be measured by classifying them subsequently into costs, time, integration and scope indicators. Further, the financial and organizational levels include additional components of the business. Parallel to the KPIs categorization, the actual indicators to measure performance were researched.

The indicators used to assess the performance of project management are associated with the four main areas of Figure 2-7. The first area is the financial results of the project and their input to the entire company's finances. The performance of the employees is measured by their attitude towards their project and the input they generate for achieving the goal. The indicators associated with the project are related to the project's activities and how they are performed within their time and cost constraints, or deviate from them. At last, the customer category, as the employee, is based on perception measures and attitude of the of the client during the development of the project and its satisfaction with the final results.

A total of 59 key performance indicators (KPIs) concluded from literature for assessing the performance of project management. Table 2-5 groups the total set of key performance indicators. This list will be used for evaluating the performance of PM in practice (CHAPTER 3).

Table 2-5 List of KPIs to assess performance of PM

KPIs FINANCIAL CATEGORY	DEFINITION	CBP (2000)	Martz, Shenhar, and Marino (2000)	Phillips, Bothell, and Snead (2002)	del-Rey-Chamorro et al. (2003)	Vanhoucke (2009)	Pennypacker (2012)	CBP (2012)	Project Management Institute Inc. (PMI) (2013)	Axelos (2015)
ROI	Amount of return on an investment relative to the investment's cost	✓	✓	✓			✓		✓	✓
ROE	Relates firm performance to shareholder interest.	✓	✓							
Economic Value-Added (EVA)	Measure of a company's financial performance based on the residual wealth calculated by deducting its cost of capital from its operating profit, adjusted for taxes on a cash basis.	✓	✓					✓		
Sales Growth %	Percentage change of a specific variable within a specific time period, given a certain context	✓	✓							
Sales Growth $		✓	✓							
revenue growth			✓		✓					
Cost Savings	Reduction of expenses	✓			✓					
cash Flow	Total amount of money being transferred into and out of a business		✓							
Earnings Per Share	The profit the company generates for each share of stock over a period of time.	✓	✓							
Cash Flow Per Share	After-tax earnings plus depreciation on a per-share basis that functions as a measure of a firm's financial strength	✓								
Market Share	Percentage of an industry or market's total sales that is earned by a particular company over a specified time period.	✓			✓					
Stock price / Marcap	Total € market value of a company's shares outstanding		✓							
Profit margin	Profit in relation to the sales from which profit is generated.		✓							
Operative profit	Excludes taxes and interest		✓							
Net operating income (NOI)	Analyze real estate investments that generate income.	✓			✓		✓			
Productivity ratio	Measure of output per unit of input: labor efficiency in producing goods and services Inputs: labor and capital. Output: revenues and other gross domestic product (GDP) components such as business inventories.						✓			
Cost of Quality	Money lost due errors on the product/service: cost of: inspection, rework, duplicate work, scrapping rejects, replacements and refunds, complaints, loss of customers, and damage to reputation						✓			
Investment / Business strategy	Set of guidelines of the company for selecting its investment portfolio	✓			✓					

KPIs CUSTOMER CATEGORY	DEFINITION	CBP (2000)	Martz et al. (2000)	Phillips et al. (2002)	del-Rey-Chamorro et al. (2003)	Vanhoucke (2009)	Pennypacker (2012)	CBP (2012)	Project Management Institute Inc. (PMI) (2013)	Axelos (2015)
Customer Satisfaction	Measured / documented primarily from qualitative feedback. The fewer performance issues impacting operations or key stakeholder processes correlates to higher satisfaction and ongoing supplier relationship. Received via survey.	✓	✓	✓	✓		✓			
Customer Retention	Ratio of loyal (retained) customers over total customers per a given time	✓	✓	✓	✓					
Customer Acquisition cost	Key to determine your level of sales and marketing investment. Divide the annualized net gross margin added during the quarter by the sales and marketing costs of the previous quarter.	✓								
Customer Profitability Margin	Ratio of earnings generated by a customer, in comparison with the expenses used	✓								
Customer Use		✓								
Responsiveness	Ratio calculation to quantify and measure the Empathy and Responsiveness dimensions relative to the overall customer satisfaction question.		✓					✓		
Mutual trust	reliability on each other							✓		

KPIs EMPLOYEES CATEGORY	DEFINITION	CBP (2000)	Martz et al. (2000)	Phillips et al. (2002)	del-Rey-Chamorro et al. (2003)	Vanhoucke (2009)	Pennypacker (2012)	CBP (2012)	Project Management Institute Inc. (PMI) (2013)	Axelos (2015)
Employee Satisfaction	General: degree of contentment of the employee with the job specific: satisfaction with job security, pay, social, supervisory, and opportunity for personal growth and development.	✓	✓	✓			✓			
Employee Productivity / Job performance	To reach a goal within a job, role, or organization, but not the actual consequences of the acts performed within a job. Performance in a job is strictly a behavior and a separate entity from the outcomes of a particular job which relate to success and productivity.	✓		✓						
Employee Motivation	the employee experiences positive internal feelings when performing effectively at work	✓						✓		
Employee Turnover	Satisfaction of the employee with his/her turnover	✓	✓	✓			✓			
Training Time	Time spend by employees on training programs	✓		✓						
Employee Empowerment	Amount of power the employee is given Experienced responsibility for work outcomes increases when a job has high autonomy (substantial freedom, independence).	✓	✓							
Alignment to Strategic Business Goals	determine whether or not you're working on the right projects				✓		✓			
Team performance	(same as employee performance, but on a team level)				✓					

KPIs PROJECT AND PROCESS CATEGORY			DEFINITION	CBP (2000)	Martz et al. (2000)	Phillips et al. (2002)	del-Rey-Chamorro et al. (2003)	Vanhoucke (2009)	Pennypacker (2012)	CBP (2012)	Project Management Institute Inc. (PMI) (2013)	Axelos (2015)
Costs	Budget Performance	planned value / BCWS	Budget baseline for every scheduled activity.	✓			✓	✓			✓	✓
		estimate cost at completion (EAC)	Forecast of cost at completion of the project, based on actual costs and the planned duration of the remaining work	✓			✓	✓			✓	✓
		actual cost performed (ACWP)	cumulative actual cost spent at a given point in time	✓			✓				✓	✓
		earned value (EV or BCWP)	amount budgeted for performing the work that was accomplished by a given point in time	✓			✓			✓	✓	✓
		cost performance index (CPI)	Performance measure based on the relation between the earned value and the actual costs	✓			✓	✓			✓	✓
		NPV deviation	Deviation from the planned NPV	✓			✓				✓	✓
		Budget deviation	Deviation from the planned budget	✓		✓	✓				✓	✓
	Schedule performance	schedule variance (SV)	Performance measure based on the difference between the earned value and the planned value	✓			✓		✓	✓	✓	✓
		schedule performance index (SPI)	Performance measure based on the relation between the earned value and the planned value	✓			✓		✓	✓	✓	✓
Time	Schedule performance	time deviation	Difference in time between the planned baseline against the actual schedule.			✓					✓	✓
		extra time/ Overtime	additional time for developing an activity			✓					✓	✓
		assigned time	Time assigned to every activity								✓	✓
		Time variance	Translation of schedule variance (SV) in terms of time	✓			✓		✓	✓	✓	✓
		Time to Market	The time it takes a product or service since it is conceived until it is available for marketing and generating value for the company.	✓								

KPIs PROJECT AND PROCESS CATEGORY			DEFINITION	CBP (2000)	Martz et al. (2000)	Phillips et al. (2002)	del-Rey-Chamorro et al. (2003)	Vanhoucke (2009)	Pennypacker (2012)	CBP (2012)	Project Management Institute Inc. (PMI) (2013)	Axelos (2015)
integration	requirements performance	Process Errors	Number or percentage of errors of the process	✓								
		Defects	Number of defects	✓								
		Rework	Number of hours consumed due rework	✓		✓						
		Resource Utilization	Assets consumed: energy, money, time, IT	✓								
		Task overdue	Percentage of overdue project tasks.								✓	✓
		milestones missed	% of milestones missed								✓	✓
		task interdependencies	Number of interdependencies between tasks								✓	✓
Scope		# milestones	Number of milestones of the project							✓		
		Scope Changes	Amount of times the scope of the project was changed	✓						✓		
		Project Completions	Achievement of milestone, goals or activities	✓								
		Project Risk	Degree of impact of project's activities over the project itself	✓						✓		
		Quality of product	how well the project is delivered to clients and the extent to which clients are satisfied				✓			✓		

SQ2: What are the typical management activities conducted in Front-End Development?

The pre-conception phase is the initial step of the project, where the project is shaped and most of the processes occur. Literature proposes that the activities conducted during this phase are similar to all projects regardless of their nature. Logically each project would have specific activities associated with its particular development.

The necessary information for the execution of the project is usually developed in sub sequential phases within Front-End Development. Starting from the initial idea of the project each of these phases refines the ideas until the refined material for executing the project is obtained. The names that are given in the literature for these phase variate. Thus, for this study, the names of initiation, feasibility, and definition were chosen to use.

During the first phase or initiation the main objectives of the project are defined, as well the constraints for the execution. Subsequently a feasibility study is elaborated and the method to accomplish the objectives is selected. At last, the level of detail for initiation is achieved and the project is defined. These activities reach the refinement throughout each stage from initial phase where these basic features are estimated until definition.

The typical management activities conducted during the Front-End Development are associated mainly to determine the project's goals, components, resources, and risks. In the first group are the activities related to the setting of project's objectives and the requirements for achieving them. Further on, activities to establish the project's components and the interaction between them, which is usually represented in the work breakdown structure (WBS). The activities for establishing the required means usually group cost, human and materials resources. At last, the risk determination activities and the ways to cope with them.

These activities are combined in Table 2-6. This table was elaborated with the literature from section 2.2.3. The first approach for elaborating this table was an extraction of FED activities from literature. Further, a parallel determination of activities and their association with each of the FED phases was made followed by generalization on the names of the FED phases. In this step, the names given to each activity were slightly changed as well. This renaming process was done based on the definition of the activities given by different authors.

In total 39 activities were found which associate to three mentioned phases; 15 activities during Initiation, 9 activities in feasibility and another 15 activities for definition phase.

Table 2-6 Compilation of Front-End activities, categorized per FED phase.

FED phase	FED Activities	Lessard and Lessard (2007)	Oosterhuis (2008)	George et al. (2008)	Al-Jibouri and Haponava (2009)	Bosch-Rekveldt (2011)	Haugan (2011)	Project Management Institute Inc. (PMI) (2013)	Heagney (2016)
Initiation	Define business goals	✓	✓	✓		✓			
	Define project objectives	✓	✓	✓	✓		✓		✓
	Identify project requirements		✓					✓	✓
	Identify and select project alternatives			✓		✓	✓		
	Cost estimate		✓	✓				✓	✓
	WBS Level 1 schedule		✓					✓	✓
	Risk identification and management		✓	✓		✓		✓	
	Contracting strategy		✓	✓				✓	
	Asses stakeholder involvement and feedback		✓		✓	✓		✓	✓
	Establish image and refine public relations			✓					
	Technology review and selection		✓			✓			
	Conduct market research and analysis			✓					
	External benchmarking					✓			
	Address regulatory issues			✓					✓
	Project execution plan (human and materials)		✓	✓	✓			✓	✓

FED phase	FED Activities	Lessard and Lessard (2007)	Oosterhuis (2008)	George et al. (2008)	Al-Jibouri and Haponava (2009)	Bosch-Rekveldt (2011)	Haugan (2011)	Project Management Institute Inc. (PMI) (2013)	Heagney (2016)
Feasibility	Define Scope	✓	✓	✓	✓		✓		✓
	Cost estimate	✓	✓	✓	✓			✓	
	WBS Level 2 schedule	✓	✓	✓			✓	✓	✓
	Analysis of safety and quality issues	✓	✓	✓		✓		✓	
	Risk identification and management	✓	✓			✓		✓	
	Compose the project team		✓	✓		✓			
	Basics of design		✓	✓	✓				
	Prepare specifications								✓
	Project execution plan (human and materials)	✓	✓		✓			✓	✓
Definition	Basic engineering		✓	✓	✓	✓			
	Cost and revenue assessment	✓	✓					✓	
	WBS Level 3 schedule	✓	✓	✓			✓	✓	✓
	Analysis of safety issues		✓	✓		✓			
	Risk identification and management	✓	✓		✓	✓		✓	
	Define funding strategy		✓						
	Prepare contracting plan	✓	✓	✓				✓	
	Define strategic activities, duration and interfaces	✓	✓				✓	✓	
	Project implementation plan	✓	✓	✓	✓	✓	✓	✓	
	Execution schedule	✓	✓				✓		✓
	Control and performance plan			✓	✓	✓			✓
	Communication plan	✓						✓	
	Project management plan	✓					✓	✓	
	Team building / Human resource management		✓			✓		✓	
	Dynamic corrections					✓			

SQ3: How can the Agility of project management be measured?

An initial set of principles for the application of agile software were defined in the Manifesto for Agile Software Development (2001). Moreover, each of agile execution methods established a set of procedures to follow for managing a project in an agile way.

The reviewed literature mentions a group of elements that should be considered for managing a project using agile. Recapping the literature mentioned in section 2.3.2, Table 2-7 was elaborated. This table contains 24 indicators that can be used to assess the agility level of projects.

To elaborate this table, the indicators mentioned in literature were listed. Revising this list, it was found that different authors used different names to refer to the same indicator. Thus, a rename process was conducted with the objective of coordinating different literature (these changes were made based on the definitions given in the literature). As the majority of the indicators were associated with a general parameter (such as communication, team, customer and so on), the indicators were classified using these parameters as well.

Table 2-7 Indicator for measuring 'agility' of projects: compilation according to literature

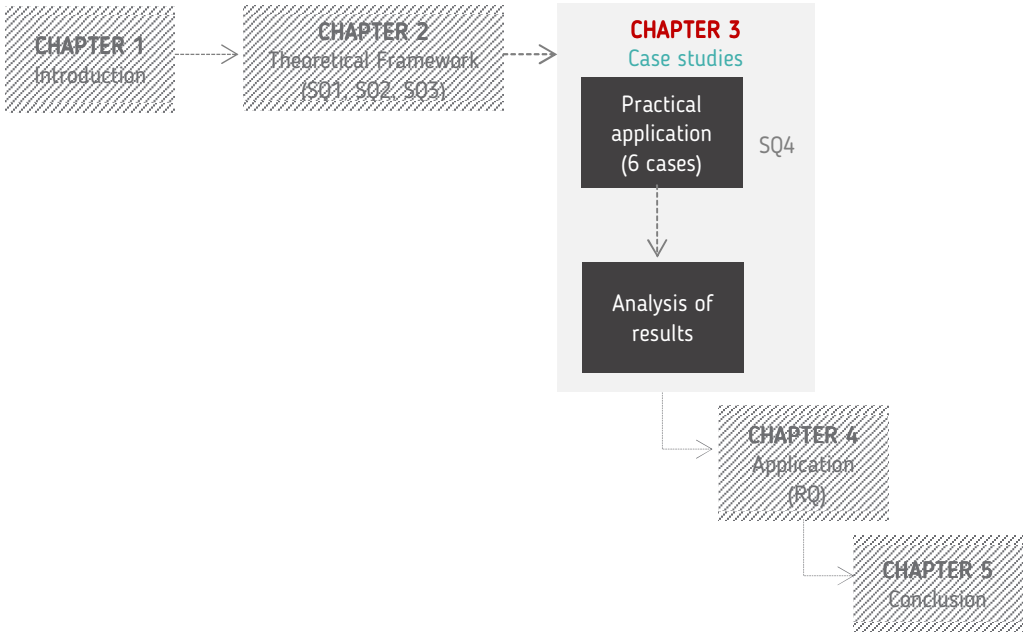
Parameters	Agile indicators	Manifesto for Agile Software Development (2001)	(Tsourveloudis & Valavanis, 2002)	(Owen et al., 2006 & Codinhoto, 2006)	(Mafakheri et al., 2008)	Vinodh and Devadasan (2011)	Conforto et al. (2014)
Project definition	Use of "product vision"	✓					✓
Communication	Simple plan and communication tool	✓	✓			✓	✓
	Minimize documentation	✓			✓		
	Transparency in information sharing		✓			✓	
Customers	Having on-site customers				✓		
	Incorporate customers feedback			✓		✓	
	Satisfied customers	✓					
Control	Frequent monitoring and updating process			✓	✓	✓	✓
	Learning attitude			✓			
Dynamism	Iterative planning			✓			✓
	Ability to change	✓	✓	✓	✓		
	Deliver work constantly	✓		✓	✓		
	Continuous improvement culture	✓				✓	
Timing	Regular meetings processes	✓				✓	
	short term processes	✓				✓	
Team & personnel	Small team				✓		
	Self-managed and self-directed teams	✓		✓	✓	✓	✓
	Working together daily	✓					
	Empowered personnel			✓		✓	
	Multi-skilled personnel		✓			✓	
	Motivated personnel	✓					
	Job rotation		✓			✓	
	Clear definition of responsibilities and authority / roles					✓	
Risk	Shared risks among the involved parties			✓			

The main aspects for measuring the agility level of projects are related to the core values of the management approach: change, clients, employees and deliverables, and the relations that tie them all together. By establishing a set of activities associated to each of these clusters and the degree a project executes them, it's agility could be measured. The first cluster can assemble the activities related to the project plan and its control. The main objective of agile projects is to be adaptable to changes, having a dynamic attitude of working and controlling the project, by establishing short time frames for product development. In the second group represents the involvement of clients during the development process, and specifically their satisfaction during the project and at completion. The employees play a key role when developing an agile project. The way teams are formed and work together influences the degree of agility of a project with emphasis on satisfaction and motivation of the team members about working on the specific project. The relations between the previously mentioned groups completes this measurement criterion. The way the parties communicate and interact, document their process, and share the risks generated by the project are components for measuring project agility.

CHAPTER 3.

CASE STUDIES

In this chapter, the applicability of literature research will be explored. The objective of this chapter is to study the Key Performance Indicators, Front-End Development activities and project management methodologies in practice. This chapter will be divided in three main parts. The first section explains the research method that was used (3.1). In section 3.3 the six case studies will be explained and analyzed. In section 3.4 the application of the three research areas in practice will be discussed.



where is this section in the entire research?

3.1 RESEARCH METHOD

The selected approach to obtain the information on the three aspects of this research (project management performance, FED activities and agility) is the study of real-life cases. This method was chosen since there is no practical evidence of how these aspects work together in real life. Furthermore, the literature about how agile project management is being used in the construction sector is scarce and there is no measurement of performance to compare agile and traditional managed projects. All these reasons emphasis the need to explore these subjects in practice. Additionally, according to Yin (2014) the 'how' structure of the research questions leads to the use of case studies.

The first section of this chapter will explain the research method that will be used for conducting the practical study. It starts with the design of the case studies (3.1.1). Next, paragraph (3.1.2) elaborates on procedure. On paragraph 3.1.3 the procedure used to evaluate the selected cases will be explained.

3.1.1 DESIGN OF THE CASE STUDIES

This research focuses on the evaluation of project management and its performance during the front-end phase of construction projects. These three main aspects set the scope and determine the research strategy of the case studies.

The four different designs for case study research discussed by Yin (2014) were evaluated. Due to the specific characteristics of this research, the multiple-case designs with single unit of analysis was selected. The design elements were established as follows:

- Two contexts would create a fist categorization of the cases, according to the managerial approached used to conduct the projects. These contexts were: traditional management and agile management.
- Further, six cases were selected and categorized under these already mentioned contexts. Three traditionally managed projects and three projects that were managed using agile practices.
- These cases will be evaluated on the performance of project management used to conduct them. To determine this performance, each case will be analyzed using the variables explained in CHAPTER 2 (KPIs, FED activities and PM guidelines).

Figure 3-1 illustrates this design. Once the overall design was decided, each of the elements to study will be explained.

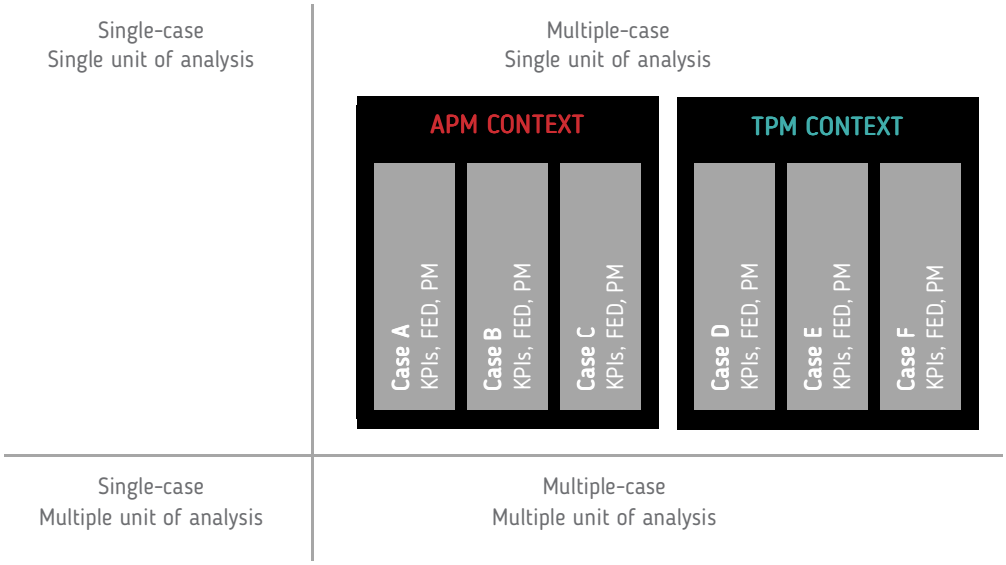


Figure 3-1 2x2 Matrix: Types of designs for case studies (Yin, 2014)

First, it is necessary to define that this research will focus on analyzing completed construction projects. Defining projects as *"temporary endeavors to create products"*, completed projects are the ones that created the product and all the activities and processes associated to it are finished (Project Management Institute Inc. (PMI), 2013). It is important to clarity that for this study the end of the construction project is set with the delivery of the product to the client (other works afterwards would be considered as new projects).

Supplementary to the degree of completion of projects, the management style was used as the context criteria for selection of projects. With the objective of analyzing the practice of different project management guidelines, focusing on TPM and APM, it was needed to evaluate multiple projects that used one or the other (or possibly a hybrid) management approach during the front-end development. It was decided that the research will focus on six completed projects: three projects managed using agile guidelines and another three that were traditionally managed.

These six projects were selected from the database of Sweco Nederland B.V. This company was selected as partner for the investigation as had a set of completed projects that have used either traditional or agile techniques for managing infrastructure projects. Further, the company was interested in evaluating the performance of agile as a managerial approach for developing future endeavors in the infrastructure departments.

In order to study these six projects a combined approach of document analysis and interviews was applied. Initially, a review of the project documentation was conducted to get the basic information about the projects. Once the information was collected and evaluated interviews were conducted with two actors involved in the management of each project; the project managers and assistant project managers. They were asked about key performance indicators, front-end activities and project management guidelines in practice.

3.1.2 SELECTION OF CASE STUDIES

The cases selected for this study were chosen using the following criteria:

Table 3-1 Selection criteria for case studies

Management technique	Half of the sample used Agile management, and the other half, traditional management.
Project phase	Front-End development
Team	Same organizational department and team
Time	2012 to 2016
Contract value	Between €0.5M and €2M
Degree of completion	Completed projects

The main selection criteria were the management technique used and the project phase as the research aimed to investigate on the application of agile management during the front-end phase of infrastructure projects. Regarding this criterion the number of possible cases to study the application or agile management was limited to three projects. The particular characteristics of these projects determined the other selection criteria. All the projects were selected within the boundaries of one organizational team. The main objective behind this decision was that all the teams would have the same goals and would strive towards accomplishing the same expected billing ratio results. Further, time was used as criteria to relate all the projects to the same circumstances of the company.

At the end six projects were selected, which were the only projects that fulfilled all the criteria mentioned above. Table 3-2 shows the projects and their main characteristics. It is important to clarify that the contract values used in this table were rounded, although the exact numbers can be found for each project in section 3.3.

Table 3-2 Projects selected for case studies

	Agile Managed			Traditionally Managed		
Project name	Project A	Project B	Project C	Project D	Project E	Project F
Original contract value	€ 0,4 M	€ 1,2 M	€ 0,5 M	€ 0,1 M	€ 0,06 M	€ 0,3 M
Final contract value	€ 0,6 M	€ 1, 8 M	€ 1 M	€ 0,5 M	€ 1,7 M	€ 0,6 M
Start	2012	2013	2014	2012	2012	2013
Completion	2015	2016	2015	2015	2015	2015

3.1.3 PROCEDURE FOR CASE STUDIES

The procedure for studying the selected cases consisted in a four-phase exercise, as show on the figure below.

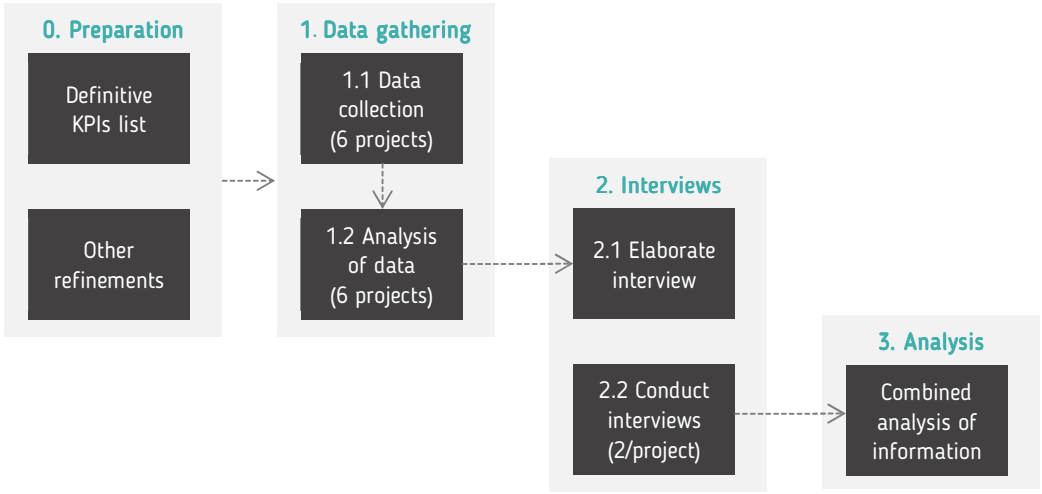


Figure 3-2 Case study procedure

First a preparation phase including projects' documents review was done, covering the projects general data, such as client, duration, costs, development team, etc. Next step was to focus on how to obtain the information listed in the tables of CHAPTER 2. At this point it was determined that the evaluation of the KPIs would involve other areas of the organization such as financial department for the financial KPIs, human resources for the employee satisfaction and communication department for the customer satisfaction KPIs. By organizing separate meetings with these departments and the strategy team of the company, the list of KPIs obtained from literature was refined based on the data availability within the company (the final list of KPIs, and how the information would be obtained, can be found in APPENDIX F). Further, the agility and FED activities were going to be evaluated by the project manager and team members of the project via interviews.

The data collection phase started with the aim of obtaining the information required to measure the KPIs determined in Table 2-5. This exercise and the meeting with each of the already mentioned departments, showed that even when some indicators were listed as management related in literature, they escalated to organization levels and could not be associated with the performance of the management of a specific project. Additionally, some measurement could not be taken directly form databases and have to be obtained from the project members.

Considering these constraints, the number of financial KPIs were considerably reduced to mainly the "operational profit" indicator. From the customer satisfaction category, the communication department manifested that the selected projects did not count with a customer satisfaction report. For the employee satisfaction KPIs, even when the employees' surveys were available, these did not indicate anything about the projects, but about the organization in general.

With the information obtained from this second phase, the financial (profitability), cost and time related indicators in the project level were measured and/or calculated. The rest of indicators would be evaluated in the subsequent interview phase.

Because all the required data was not obtained from the project's documents, it was decided do conduct a set of interviews to deepen into the application of the KPIs (remaining), FED activities and Agility shown in section 2.4. The three subjects were evaluated differently. For the evaluation of the KPIs and Agility, a likelihood scale was developed, in which the interviewee was asked to select between two extremes for

each indicator. This exercise would determine both the applicability of the indicator and the degree of applicability. The evaluation of the FED Activities consisted on a cross-check of activities. The interviewees were asked to check form the list which activities were conducted in their projects. At the end, the table contained a section to add activities that were conducted but were not in the list. Additionally, questions were asked about the project initiation and impact of this phase over the entire project. The interview format and separate questionnaires can be found in APPENDIX F to APPENDIX K.

3.2 STUDY TOPICS IN SWECO

Prior the specific case studies, a general analysis was made inside the company, to determine their position towards the three elements of analysis of this research: performance indicators, front-end development and agile management.

3.2.1 OUTLINE OF KEY PERFORMANCE INDICATORS IN SWECO

For Sweco NL the performance is measured by the satisfaction of three main actors: the client, the employee and the shareholders, which are all linked via the organization (Figure 3-3). For each category, the company stablished a set of leading and lagging indicators (concept explained in section 2.1.3).

Each category is measured differently; the client and employee's satisfaction is measured with a survey, while meeting the shareholder's goals is linked with the economic growth of the company.

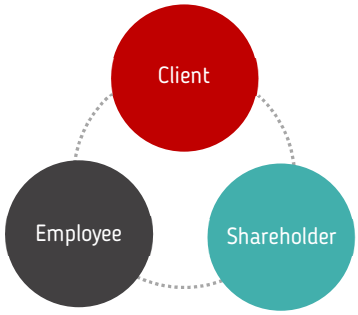


Figure 3-3 Main actors involved in performance measurement at Sweco

For measuring the clients' satisfaction, a survey is sent to clients once the project reaches a degree of completion above 90%. The electronic survey used in the past years contained a total of 10 questions including likelihood scales, Net Promoter Score (NPS) and suggestions section. Based on the results Sweco could address specifically the unsatisfied clients and take ideas for improvement. Currently with the objective of standardizing the client survey for the entire Sweco organization globally, the company reduced this survey to only one question; the one regarding NPS. NPS is a tool to quantify the degree of loyalty of customers to a company in which the interviewee is asked about the likelihood of recommending the company to others and further, the likelihood to hire the company another time.

The satisfaction of the employees is measured by an annual internal survey. As well as with the client survey, the employees give an input for improvement over specific areas or activities inside the company. This survey is not linked to any project directly but to the entire organization.

The performance regarding the shareholders is an economic indicator; directly linked to the revenue and operative profit generated by the company. Internally, the financial division is the one in charge of evaluating the overall economic performance of the company based on the billing ratios of each project. Billing ratios associate the cost of the work conducted by the company for a specific project with the cost charged to the client for the same job. The financial performance of projects will reflect on the overall performance or the organization towards shareholders.

From this analysis, it can be seen that Sweco's performance indicators can be grouped using the criteria of Figure 2-7: The client satisfaction is related to the customer satisfaction cluster, employee satisfaction

is under the employees' cluster and shareholders' satisfaction is associated with the financial development of the company which is the result of the conducted projects.

3.2.2 OUTLINE OF FED IN SWECO

As it was defined in section 2.2, front-end development is part of every project. For each new project, each department develops a set of procedures to define it. The set of activities and procedures of FED will be further explored for each case study in section 3.3.

3.2.3 OUTLINE OF AGILITY IN SWECO

The company uses mainly traditional methods to manage the organization and their projects. The application of agile methods is limited to the GIS ICT department. This department uses Scrum (one of Agile execution tools: section 2.3.2) to manage their projects.

Additionally, the design and contract of three engineering projects were done using Scrum. Their objective was to minimize the planning failures in early project phases and reduce costs. After the completion of these projects, neither Scrum or any other agile guidelines, were used by engineering departments. At the moment of this investigation no engineering project is being managed with agile methods.

3.3 STUDY CASES: 6 PROJECTS

3.3.1 CASE 1: PROJECT A

ANALYSIS

a) Performance

The analysis of project performance had two different perspectives. The financial indicators were analyzed directly from the data covered in the company's financial reports as well as the cost related indicators for the project. The rest of indicators for project, client and employee were evaluated using interviews. Such same procedure was used for all the case studies.

Financial indicators

The financial indicators of project A reflect a negative result. This was mainly attributed to the compromises made by the company when taking the project, and the financial moment they were facing.

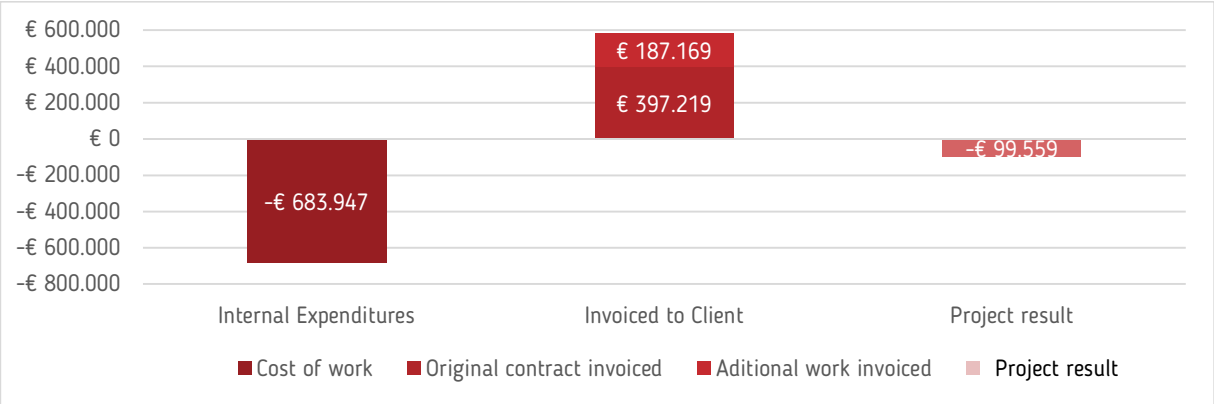


Figure 3-4 Financial result Project A

Client
The relationship with the client was deteriorated during the process. The big amount of changes proposed to the original contract and additional work requested by this actor was the main cause of this deterioration (See Figure. K-2).

Employees
The overall performance of the team was good. Team members were motivated and satisfied with the development process and were empowered to participate. The performance of the team was measured by burned costs in a time phase. The team satisfaction was measured by the scrum master regularly as being part of the scrum process (See Figure. K-3).

Project
The scope of the project suffered from many changes which increased the amount of rework and affected the performance during the development process. Nevertheless, at the end, the delivered product was accepted by the client meeting the quality requirements. The unit of measurement for the performance of the project is cost related. A number of hours spent per unit of time (month), multiplied by the Internal Cost Price IKP of the activities, gives the total amount of hours spent. This calculation determines if the project is within the budgeted costs (See Figure. K-4).

Overall Management Performance
The project overall was evaluated as successful delivering the product within the expected accepted quality standards, even though having financial deviations. The performance of the PM was evaluated every 4 weeks in a meeting with the Team Leader. Their performance is discussed from 2 points of view: performance of the project (cost related) and client satisfaction. In this project, there were a lot of issues with the client. Thus, the client satisfaction factor was highly affected by the raised issues.

b) Agility

This was the first project in which the company used Scrum for the development of an infrastructure project. For scrum process, they hired a Scrum coach that instructed the team at the beginning and accompanied it during the major steps of the process. Each step of the Scrum such as product backlog and sprint progress was documented using post-its and white boards. But this documentation was not saved after project completion.

Planning and Progress
The general progress of the project was controlled using monthly sprints. The initial planning for the project was structured until completion upfront. But during the execution it allowed the occurrence of changes (See Figure. M-1).

Client
Since the tendering process, the client was informed of the intention of the company in using Scrum. During the development process, the client was involved and its feedback incorporated into the product, what allowed faster partial deliveries of the product. Even though its satisfaction was deteriorated during the process as mentioned before (See Figure. M-2).

Team
The main criteria for composing the team was the availability of personnel. The project manager in negotiation with the Head of Department (HoD) and Team Leader (TL) selected available staff from the pool of employees. Besides, the T-Shape employee methodology was used. This model seeks for

individuals that have deep knowledge and skills in a particular area combined with the wish and ability to make connections across fields (See Figure. M-3).

Risks
This aspect was evaluated internally in the company. The different development teams involved in the project assume their responsibilities and shared the risks to their associated tasks, not completely, but to a big extend (See Figure. M-4).

CASE CONCLUSION
This was the first project in which the infrastructure department used APM methodology. It required a big amount of training and commitment from the team to implement this way of working.

The main motivation of the organization to implement Scrum was the evidence of downtime reduction shown in projects from the GIS/ICT department because of using this managerial approach, which resulted in general reduction of costs and increase shareholders' satisfaction at the end. For the project manager (PM), on the other hand, it represented a way of creating added value to the client and increase its satisfaction. During the development process, it was found that there are a lot of problems within the company, not related to Scrum, but regarding employees and teams working together. These problems were not related to the Agile or Traditional management; they will be present when using either of management methods. Overall, managing a project using Scrum in an organization that works traditionally, has colliding points with the organization.

Regarding the performance of the project, the finance aspect did not behave as expected but had a negative result between -10 to -20%. Although, other categories such as the client and employee satisfaction during the development process, started to be considered as indicators to measure performance.

3.3.2 CASE 2: PROJECT B
ANALYSIS
a) Performance
Financial indicators
The profit margin of this project is the lowest of the three Scrum managed projects. It is mainly because the internal amount of work required for conducting this project was considerably more than what it was tendered for. The project was tender 40% lower than the actual internal costs required for executing it for a commercial reason. At completion, the project had a loss similar to the original contract. Even with such loss, an additional phase of the project started subsequently after completion of the phase studied in this research and is currently under execution. This new phase already recovered the initial loss.

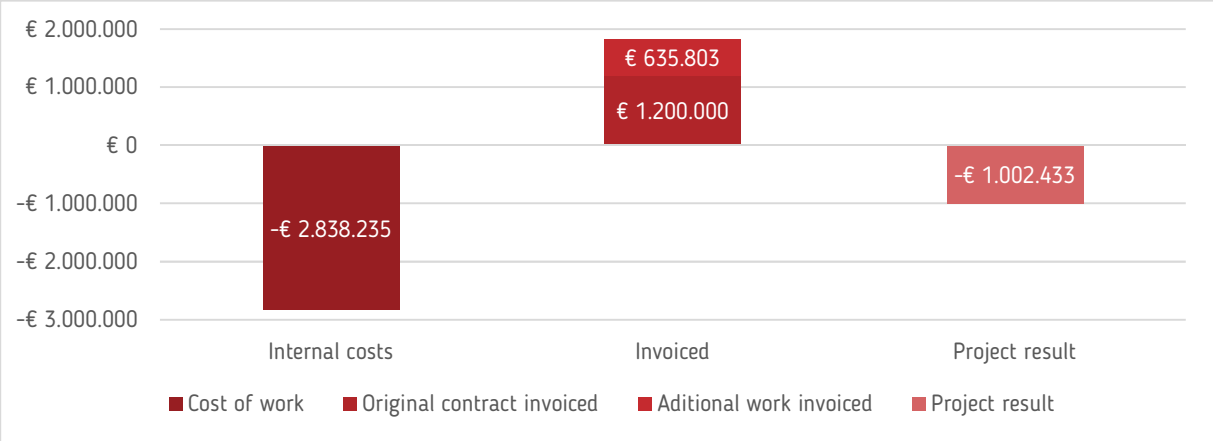


Figure 3-5 Financial result Project B

Client
Even though the mutual trust level with the client was low during the development process, there was a positive responsiveness from its side from beginning to end which overall resulted in a satisfied client (See Figure. K-2).

Employees
The satisfaction and motivation of the team were on a medium level. The main causes were the financial and workload constraints. Regarding the performance of the team, this was measured using cost related indicators. Even when the motivation was not the highest the overall performance of the team was good (See Figure. K-3).

Project
The cost-related indicators for the performance of the project showed the same behavior as the financial indicators, due to the differences between the tendered cost and the cost internal prices (IKP), for what the project had major budget deviations. Adapting to this budget scheme to some degree resulted in redesigning of the process for the team. At the end and even with such differences in costs and reworks, the project was completed without major schedule deviations (See Figure. K-4).

Overall Management Performance
Overall this project was considered as successful project and was delivered with high-quality standards. Further, the performance of the PM was directly associated with the performance of the project, thus it was measured by the achievement of cost and time constraints.

b) Agility

Planning and Progress
The initial phase of the project requires a lot of resources, which was not an exception in this project. A lot of changes occurred within this phase and responsibilities passed from one team to the other one. Moreover, the planning of the Sprints required accurate estimation of the time required to develop of each task (normally in hours). This had to be elaborated by the team which was not a common practice for the teams before.

For this project, the team started to use the virtual tool “Scrumwise” for documentation, development and overall coordination of the process. With this tool, all the information needed for the Scrum process such as project backlog items, tasks, people and roles and overall sprints was reachable for all team members and moreover, all were documented. This was the first time the Scrumwise was used in this department.

The overall plan of the project was structured in a way that allowed changes during the development process. Once the project was being executed it was controlled on regular basis using Sprints with an average duration of 2 weeks to 1 month. At the beginning of the project and for each sprint all the team got together for setting goals. Further regular meetings were established for consultation and progress discussion. This process proof beneficial during the development of the project and once the team had more familiarity with each other showed a decrease in consultation time (See Figure. M-1).

Client
Initially the use of Scum played an important role when making the offer to the client and resulted to be appealing to the client. It gave Grontmij (now Sweco) a distinction over other companies in the market.
Once in use the clients were enthusiastic about the process, what increased the company’s confidence. But client’s methodology of working highly differ from the APM methods. Thus, the information and deliverables expected from the clients usually took longer than expected. This behavior affected the way of working of the teams, jeopardizing the scrum process, as the sprints and standups could not be conducted on the established time-frames. At the end, the client was not fully satisfied with the project (See Figure. M-2).

Team
Team building according to the common practice of the company followed the main criteria of availability of people at technical departments. Within the available people the PM looked for the individuals with the expertise required for developing such a project. The developing teams were divided into smaller teams of approx. 5 individuals, each assigned to a specific subject with defined roles.

According to the managerial actor's interview, the team was motivated and enthusiastic about the project and the use of a new method. But even when the managers and team members responded positively to the questions regarding motivation and satisfaction, the external Scum Master (SM) saw that the constant changes in planning, resulted in extra work and redesign or processes, lead to dissatisfaction within the team. Additionally, the financial and workload constraints made the commitment of the team difficult (See Figure. M-3).

Risks
One indicator of APM is that that the parties involved shared the risks of the project, assigning the tasks to the party most capable of accomplishing it. In this project, the teams were usually trying to avoid this by passing the responsibility to the next team in line (See Figure. M-4).

CASE CONCLUSION

The performance of the project, from a cost point of view was not good due to the differences between the budget approved presented to the client and the actual cost of work, what represented a big amount of additional costs. Nevertheless, the client and employee indicators showed positive results.

This project was the second one in which this department used Scrum. The motivation behind the use of this method was financial, as well as for the first project. In this case many scrum masters participated

during the stages of the process but one remained from start to completion. This person belonged to the ICT/GIS department of the company, who did not have any experience in developing infrastructure projects. The lack of experience of this person in infrastructure development showed to be an obstacle for guiding the team.

At completion, the expected financial benefit for applying Scrum was not visible. But this could be attributed to other organizational motives rather that only the use of Scrum, as occurred in the first case.

3.3.3 CASE 3: PROJECT C

ANALYSIS

a) Performance

Financial indicators

The financial result for this project is negative. The amount invoiced over the original contract summed with additional works generated do not cover the internal cost spent to complete the project.

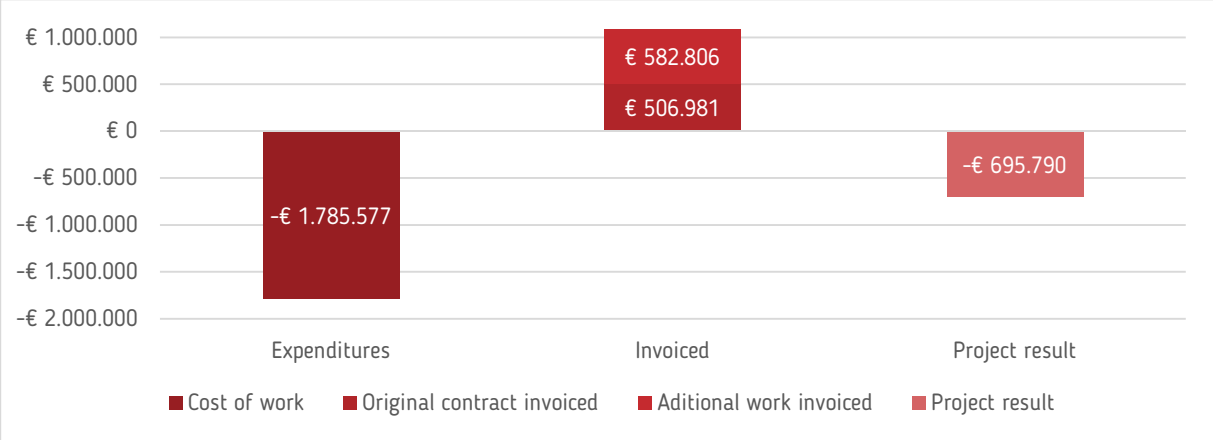


Figure 3-6 Financial result Project C

Client

In this particular case, the performance of both parties was evaluated constantly. The company evaluated the satisfaction of the client with each deliverable and the client was as well evaluating how Sweco was conducting the development process. Using this method, the management and directors of both parties were aware of the status of the project on regular basis. Even though the satisfaction of the parties was under constant evaluation, the satisfaction of the client with the final product and at the end of the project was low (See Figure. K-2).

Employees

The development team was motivated during the process which was influenced by the use of the new management method. Like all other projects the performance of the team was measured with burned costs against time frame (See Figure. K-3).

Project

As it can be understood from the financial KPIs category, the project had budget deviations. Additionally, extra time was required for its completion which results in schedule deviations as well. In this project, the changes in scope were not big which resulted in less amount of rework and less number of errors. The quality of the final product was acceptable but not as same as what was expected (See Figure. K-4).

Overall Management Performance
The performance of this project was evaluated from two aspects; internal and external. Internally the evaluation was financial associated with meeting the budget constraints. Externally the constant evaluation of progress conducted by both parties.

b) Agility

Planning and Progress
The overall plan for conducting the project was flexible and allowed changes to occur along the way. Yet again, the plan did not change very often. As in case 2, the teams have never been requested to elaborate such a detailed plan of their activities (as is required for the Scum methodology) or at least not so early in the process. This request was normally made close to the deadline and when facing budget constraints. The facts that teams were not used to make such a plan, reflected in an inaccurate estimation of sprint duration.

The progress of the project was checked in every sprint. In total, the project had 11 sprints with an average duration of 2 weeks. As in case 2, once the development process was already under way of its progress, the confidence within the development team increased, making the consultation process shorter (See Figure. M-1).

Client
Even though there was the awareness that incorporating the feedback received by the client would improve the product, this feedback was not fully incorporated to the process. Moreover, the parties were not constantly working together, and also the products were not delivered constantly to the client. These factors could be the reasons of client's low satisfaction with the final product (See Figure. M-2).

Team
The team was built based on availability of staff. The PM looked for experience staff in the required fields and social skills. For this project, the T-shape employee model was used. This model seeks for individuals that have deep knowledge and skills in a particular area combined with the wish and ability to make connections across fields. Even though this was not a characteristic of Scrum, it was considered as an option to enhance commitment within the team and help a better team formation, as well, this method was used to cope with the low level of experience of the team members. These set of characteristics made it difficult to define the specific role of team members; people were asked to be involved in different tasks and these tasks changed constantly (See Figure. M-3).

These teams were formed consisting of 5 to 10 individuals working together on daily basis. Moreover, most of the teams working in the project attended the sprints. For these meetings people came from different parts of the organization and quickly built a bond to others in the team which had a positive effect on mood, cooperation and willingness to help each other. This motivation and satisfaction were constantly evaluated and scored high.

Risks
Risks and responsibilities were shared by each the teams, to the extent of their competence (See Figure. M-4).

CASE CONCLUSION

The initial phase of the project was planned for a duration of 6 months in which the management would be conducted using Scrum. The goal of using this method was increasing the speed of the process and an overall reduction of time. Further, Scrum was limited to the initial phase as was the time where more stakeholders needed to be approached and more multidisciplinary teams needed to interact. After this, the project it began to de-scrum and for the pure engineering part of the project the engineering teams conducted their activities traditionally.

Many reasons could have contributed to the fact that APM did not achieved the expected results. First, the high dependency the organization had on the client's requirements and the fact that the clients were not working at the same pace, made both processes collide constantly. Additionally, the multidisciplinary people required to do this type of project was not present. At last, the particularities of an infrastructure project and the impossibility to standardize all the process for all different projects made the adaptation process slow.

3.3.4 CASE 4: PROJECT D

ANALYSIS

a) Performance

Financial indicators

The initial contract value for this project was low and the major part of the work was conducted as additional work. The company usually expects to compensate the discounts given in the original contract with this additional work. In this case even though the additional work was big, the consumed resources internally exceed the amount that was invoiced to client which resulted in loss.

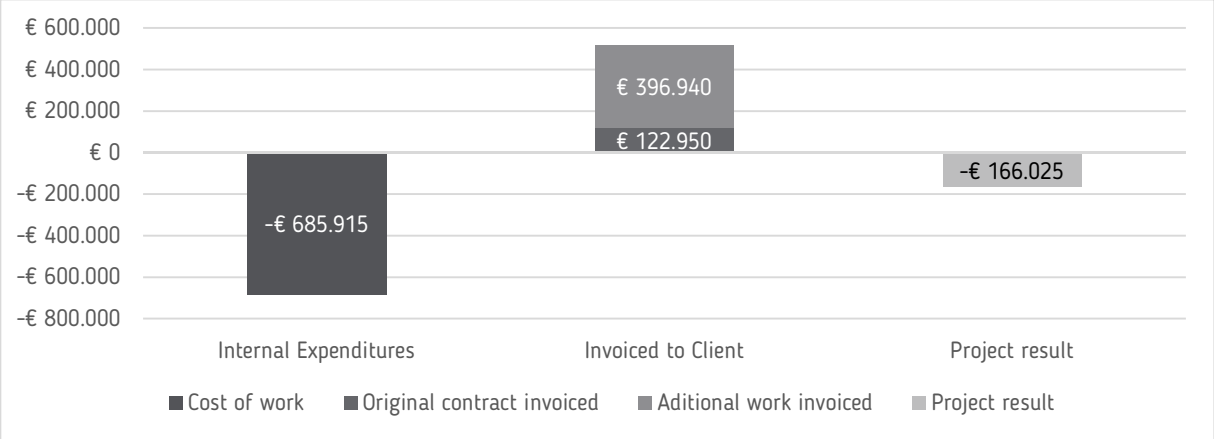


Figure 3-7 Financial result Project D

Client

The level of mutual trust with the client was always good. Even though the responsiveness slightly decreased during the projects, the final level of client satisfaction was high (See Figure. K-2).

Employees

The development team was motivated during the process. The team had autonomy for working, what increased their levels of satisfaction towards the project and aligned their goals. Like all other projects the performance of the team was measured with burned costs (See Figure. K-3).

Project
As it can be understood from the financial KPIs category, the project had budget deviations. Additionally, extra time was required for its completion which results in schedule deviations as well. The time-to-market was considerably long. The scope changed what was reflected in rework and errors. But at the end the quality of the final product was good (See Figure. K-4).

Overall Management Performance
All the categories for measuring the project's performance show average results. The client performance category is the only one that stands out from the others, due to the high trust level between the parties.

b) Agility

Planning and Progress
The complete plan for conducting the project was structured and did not suffer many alterations during the development process (In line with the management idea of not changing the plan constantly). There were monthly meetings to check the overall project progress. According to planning and process category, this project was more on a traditional management extreme (See Figure. M-1).

Client
The project scored high for the majority of indicators in client-related performance measurement. The only indicator that scored lower was the incorporation of client's feedback. Even though there was the awareness that incorporating the feedback would improve the product, some limits were stablished to restrict the feedbacks and they were not fully incorporated to the process (See Figure. M-2).

Team
Like all other projects, the team was built based on availability of staff. Apart from availability of people, the PM looked for required experiences and expertise in the working fields. Working together once a week increased the motivation for small-size teams. Even though the definition of the roles executed by each member was not much clear, the team had a good working rhythm and motivation. This last one was mainly perceived but not formally evaluated during the process (See Figure. M-3).

Risks
The risks were not fully shared, and the culture was more oriented to passing them to the next team. Risk related performance indicators scored on medium level (See Figure. M-4).

CASE CONCLUSION

During this project, there was a good relation with the client, what reflected on higher scores for both performance and agility indicators. Except for client-related indicators, the other clusters for identifying the management approach show that this project is marked by traditional management approach. This was completely in line with the initial classification of project in the category of traditionally managed projects. For this case, traditional management showed a good performance regarding the client and employees, also regarding the general perception of quality and success, even though the project related indicators had low performance scores.

3.3.5 CASE 5: PROJECT E

ANALYSIS

a) Performance

Financial indicators

The initial contract value for this project was low and the major part of the works was conducted as additional. There was a significant scope change at the beginning and a real budget of €1M was agreed between the parties. Consequently an additional amount of work was commissioned or this amount. The internal costs for working on the project were lower than the amount invoiced to the client. These generated a positive project result at the end.

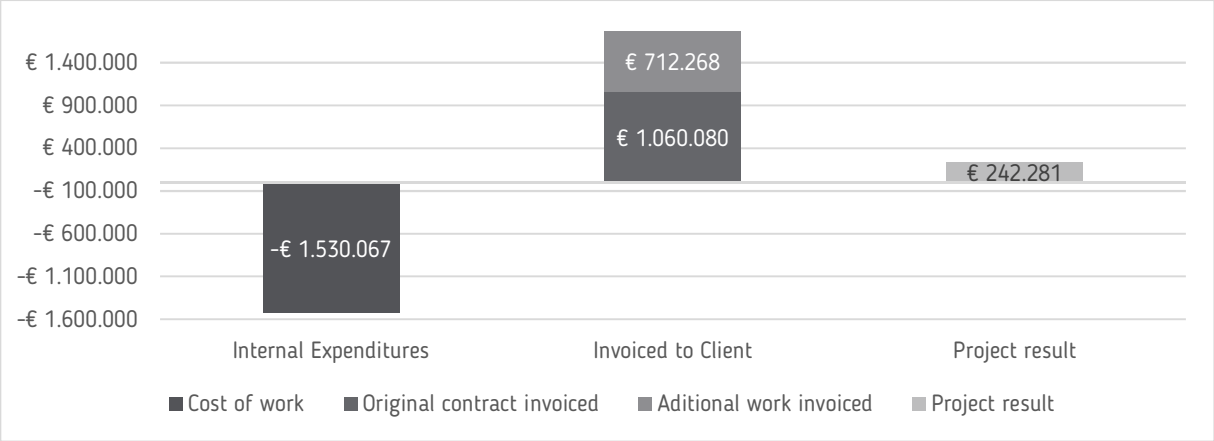


Figure 3-8 Financial result Project E

Client

All the indicators related to this cluster showed high results. The client was completely satisfied with the final product, marked by a good relationship during the development process. In this category, the score obtain is nearly the highest possible (See Figure. K-2).

Employees

The overall performance of the development team and the employees was high except for the indicators related to training. The team did not attend to any training during the development of the project. Further, even though they were satisfied and motivated, the indicator that asses the relation between the employee's goals in correspondence with the project's goal is on a medium level (See Figure. K-3).

Project

As the financial category of indicators reflects the project had budget deviations. But this was positive and generated a good project result. All the indicators related to time scored low. This was because extra time was required for its completion. The time-to-market was considerable long as well. The scope changed considerably at the beginning but not much during the process. There were a considerable amount of errors and reprocesses, but the quality of the final product was high. This category scored the lowest in the entire evaluation of performance (See Figure. K-4).

Overall Management Performance

The performance of this project was average good. The performance related to the client indicators is overall the highest in comparison with all the cases that were studied, even though the cluster for performance of the actual project was lower.

b) Agility

Planning and Progress

Even though the structure for the project plan was loose and allowed room for changes, adaptations to did not happening regularly. The progress was checked every couple of weeks, following a more agile approach (See Figure. M-1).

Client

Even though this project was developed using traditional management methods, it used the majority of processes related to agile management. Clients were involved in the process regularly, products delivered constantly and feedbacks were constantly received and incorporated into the project. Regarding the client related indicators of agility, the project scored high (See Figure. M-2).

Team

Like all other projects the team was built based on availability. The development team size varied between 5 and 15 employees with slightly defined roles. Moreover, during the process the team was spread and did not work together regularly. They only meet for the progress controls and coordination activities. Even with such work environment the team was perceived as motivated to work on this project (See Figure. M-3).

Risks

The risks were not shared and the culture was more oriented to passing them to the next team. This category scores low, which is in line with traditional management approach (See Figure. M-4).

CASE CONCLUSION

From the studied projects, this is the only one showing a positive financial result. In this particular case, a big scope change happened at the beginning of the project and was all invoiced as additional work. Even with such scope change the cost performance was good, generating income. Apart from the financial indicators, all other performance indicators show good results. Regarding agility indicators the client-related ones showed higher score while team-related and risk sharing indicators showed lower scores.

3.3.6 CASE 6: PROJECT F

ANALYSIS

a) Performance

Financial indicators

This project like almost all projects analyzed in this study was tendered for a lower amount than the internal cost price of the company. The additional work for this project costed almost the same as the initial contract value. At completion, these additional costs almost covered the big financial difference, but still the projects had a negative result.

Figure 3-9 Financial result Project F

Client
The relationship with the client was highly deteriorated in the process. The level of trust was minimum and at completion, the client was hardly satisfied with the product and the company (See Figure. K-2).

Employees
Although the team performance was good, the motivation, satisfaction, and autonomy to work were at a medium level (See Figure. K-3).

Project
The project itself was characterized by budget deviations. The constant changes in scope reflected in an increase in rework and errors during the process. These factors lead to an acceptable, but not the ideal quality of the final product (See Figure. K-4).

Overall Management Performance
Project management performance was measured using cost and time indicators. The big deviation of these two indicators negatively affected the overall perception of project success.

b) Agility

It is important to remember that this project was traditionally managed. However, the agility indicators show big similarities with the Scrum-managed projects, as will be explained in the following categories.

Planning and Progress
The project did not have a well-structured planning which to some extent gave room for modifications along the way. Although managers were not keen on making many changes, the slightly loose structure of the plan allowed it (See Figure. M-1).

Client
The project strived to deliver its part constantly to the client, achieved by their partial involvement to the development process. However, even when the feedback was considered important, it was not included at the same importance level.

Another aspect of the agility process is the satisfaction of the client with the process and its constant evaluation. For this project, such factor was not measured during the development of the project and neither at completion due to the deteriorated relationship between the two parties (See Figure. M-2).

Team
In this project like others, the PM selected his team members mainly based on the availability of personnel. The team was formed by members from different departments taking the availability and required skills into account. The size of the development teams was small and their roles were not completely defined, resulting in the fact that one-member being responsible for multiple tasks. With this scheme, the team was participative and motivated. Although this motivation was not strictly measured, it was perceived by the project manager (See Figure. M-3).

Risks
The risk sharing between the teams was at a medium level; each one took partial responsibility of their own duties (See Figure. M-4).

CASE CONCLUSION
The overall results of this project are highly variable. Even with high costs deviations from the original budget and other not completely satisfying indicators such as quality, rework and errors, the project showed good results. In different words, performance from the client's point of view showed negative results mainly because the relationship between the parties suffered from an extreme deterioration. Although this project was managed traditionally, the agility indicators reveal that there was some level of agility applied in the project.

3.4 REFLECTION
This chapter evaluated the practical application of the three main research dimensions explored in literature in the previous chapter: project management performance, front-end activities and agility of projects. Six completed projects were analyzed inside a consultant engineering firm to determine the differences and similarities between agile and traditionally managed projects, and how the management approach used might have influenced the performance of these projects. With this information, this section solves the following research sub-question.

SQ4: How are performance indicators, front-end development, and agile management being applied in practice?

3.4.1 KEY PERFORMANCE INDICATORS (KPIs)
The list for measuring the performance of project management obtained from the literature (Table 2-5) was large since it covered different sources from different authors. When making an initial assessment of the applicability of all these indicators in practice, it was found that not all could be used, as:

- Some of these indicators are related to management in higher levels of the organization and could not be related the specific projects, such as shares information, ROE, business strategy, etc.
- Or, the information required for the assessment was not available in the company.

These considerations reduced the KPI list that was used in practice to a total of 28 indicators (APPENDIX F), dividing into categories of financial, employees, clients and project related indicators. Beyond

literature, this final assessment list included other indicators that were used by the company to evaluate performance.

During the evaluation of the case studies it was found that performance in practice had two moments of measurement: during the project and at completion. Subsequently during each period performance can be evaluated from two perspectives: internal and external. These factors are in line with the classification made from literature (Figure 2-7). Figure 3-10 updates this graphical representation to the one found in practice.

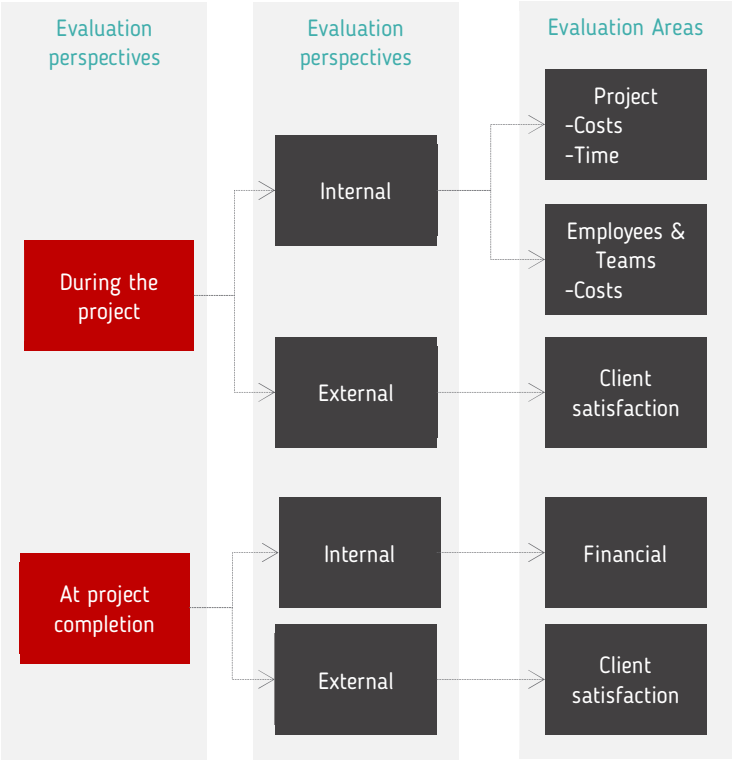


Figure 3-10 Application of KPIs categories in practice

During the project, the internal perspective refers to the performance of the project in terms of time and costs. These two indicators are evaluated constantly using EVM measurements to keep track of the time and money spent in comparison with the original baselines. This indicator is called 'burned costs' and is used as well to measure the performance of the team.

Further, the organizational teams are assessed using a 'billing ratio' indicator. This indicator refers to the relation between a number of hours internally spent in executing a job and the amount hours that can be actually charged to the client. Each organizational team has a billing ratio objective that applies for all the projects developed by this unit. Further, the management of the company uses a billing ratio baseline to determine the project's feasibility at the start. For the top management, an increase in this billing ratio indicator is the reflection of good performance of the team.

This study initially considered to include this variation of the billing ratio as a measurement of performance (as is for the management of the company). But after a thorough analysis, it was discarded. The reason behind this decision is that the billing ratio is a goal established for an entire organizational team and not directly associated with one project. A variation in this rate would not represent the behavior of the team

assigned to one project, but the behavior of the entire department or so called organizational team. To use this indicator to measure performance of project management would give accurate results.

For the external perspective during the project the responsiveness of the client towards the company is evaluated constantly in an informal way. In this aspect the project manager (PM), who is the link between the client and the company is always striving to have a satisfied client and maintain a good relationship.

Once the project is completed, two main aspects are evaluated; financial and client satisfaction. Internally, the financial performance is represented by the operative profit generated by the project. This value is the result of the difference between the internal expenses and the final amount invoiced to the clients which includes additional works (AW). Using this same information, a comparison can be made between the expected result at the beginning of the project and the actual result obtained at the end. As well for the comparison between the amount of AW that the project generated over the original contract and the profits obtained from this AW. This category has a big importance for the company. Because it represents the project's results to the shareholders.

The client satisfaction would represent the external perspective of evaluation once the project is completed. For evaluating client's satisfaction, the company had an electronic survey which according to the protocol, should be sent to the clients once the project had achieved a degree of completion higher than 90%. In this survey, the client was asked to determine, using linear scales, the relation with the company during the process and its satisfaction with the final product. Further, one question using a Net Promoted Score (NPS) scheme, was included to ask the client if they would recommend the company to others. Today, this survey had changed and the client is only asked one question; the NPS.
Even tough when this should be a requirement for all projects, the available information to assess this indicator was not there for the studied projects and the degree of client satisfaction had to be asked from the project managers.

Moreover, literature mentions the consideration of employee satisfaction as an indicator to measure the performance of the project management. In practice, the satisfaction of employees is measured once a year using an electronic survey. In this survey, the employees are asked general questions about their attitude, motivation, and satisfaction towards the organization and the department they work at. This survey is anonymous and does not give any information to evaluate the satisfaction of employees to a specific project, as suggested in the literature. However, it was noticed that for the agile managed projects due to the nature of the Scrum methodology used, the satisfaction of the employees was evaluated during the development process. But, regardless of the employee satisfaction level, this indicator showed not to have a major influence on the measurement of project management performance.

3.4.2 FRONT-END DEVELOPMENT

The studied projects focused on the development of the two initial phases of the project's lifecycle defined earlier in this research as pre-design (or front-end) and design. The front-end phase started internally, once the project was awarded, as a result of a previous tendering process. Once the company wins a tender a project manager (PM) is designated and this person is in charge of organizing a team and coordinating the works.

The initial step to take in a project is to read the contract documents and as a result of a document analysis, define milestones, activities and connections between them, and with this information make WBS and fill it as far as possible. For the WBS, the main milestones are established by the contract document. Moreover, by analyzing these milestones, the human resources that will be required to achieve the goal

can be defined, and also the activities to conduct within the company to achieve the milestones. By having the WBS as complete as possible, the workload to execute the project is defined. Then the composition of the team starts. For this, the PM should start a 'negotiation process' with the team manager and head of the department in order to search for the required people with the right skills, that are available to work in the project. Once these initial elements are defined the developing process starts.

According to literature the front-end phase is composed of three stages of development: initiation, feasibility, and definition (Table 2-6). For evaluating the application of these activities, the interviewees were asked to make a cross-check of the entire list defined from literature. The general results show that all the activities from this list were checked meaning that they were conducted during the Front-end phase of projects. But when evaluating each project separately, it can be seen that the agile managed projects were the ones marking the majority of the activities while the respondents from the traditionally managed projects marked less items from the list. For these last ones, the development is linked to PM and its expertise and is not very formal. For the agile projects due to the nature of the Scrum methodology which required detail product backlog, the process was more detailed.

Deepen into the specific activities, the ones that have a "commercial" nature, such as market research and external benchmarking, were not conducted for the majority of projects. The model of the contract did not require the company to research about the final customer or possible buyers, as the clients were already defined and the contracts were awarded. As well for finding the fund sources, since the projects were tendered, the funds for the project would be covered with the tender amount defined by the client.

3.4.3 PROJECT AGILITY

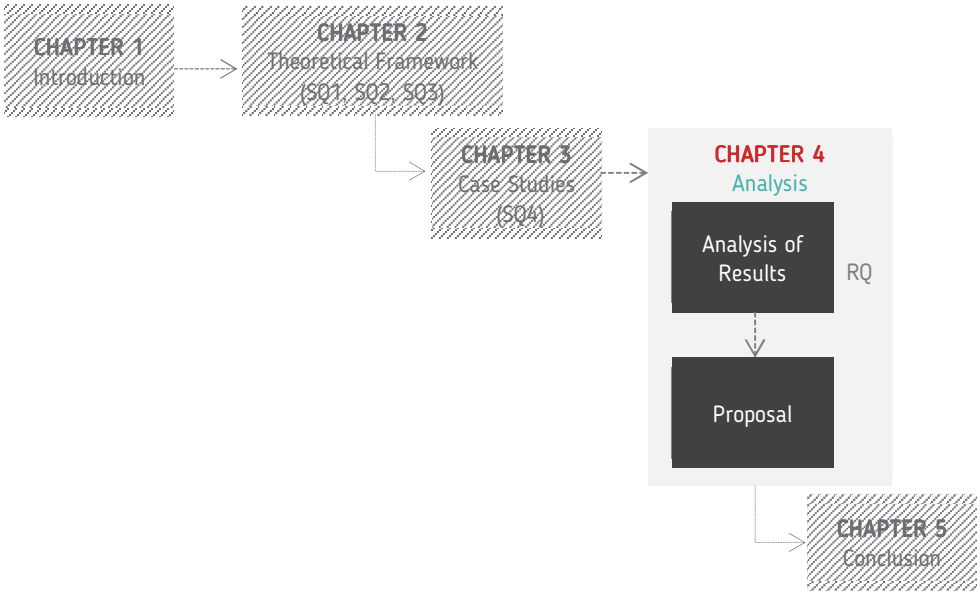
By using the indicators defined in Table 2-7, the level of agility of the projects was evaluated. Each of the questions asked was framed in a way that could be applicable for both agile and traditional projects without changing the 'agility' core of the indicator. The respondents were asked to choose between five options, in which the lowest extreme represented a more traditional approach and the higher extreme, more agility.

From the results in this section, is it evident that in practice, the application of agile management in infrastructure projects is usually combined with elements of traditional management. The projects conducted using agile project management do not score considerably high in "agility level" in comparison to the traditionally managed projects. The majority of the agility indicators, instead of being on an agile extreme scored lower, which could lead to classifying them as "hybrid projects". In this same line of reasoning, could be concluded that the traditionally managed projects apply elements of agile management to conduct their activities.

CHAPTER 4.

CROSS-CASE ANALYSIS

In this chapter, a cross-case analysis (4.1) will combine the results obtained in the six case studies, based on the management approach used. As a result of this analysis, section 4.2.1 associates the three study areas, with the management techniques used. Lastly, in section 4.2.2, a set actions on how the application of agile management can improve the performance of projects in early phases.



where is this section in the entire research?

4.1 CROSS CASE ANALYSIS

Using the information obtained in CHAPTER 3, this section will elaborate a cross-case analysis over the three main research dimensions: project management performance (4.1.1), front-end activities (4.1.2) and agility of projects (4.1.3).

4.1.1 PROJECT MANAGEMENT PERFORMANCE: KEY PERFORMANCE INDICATORS (KPIs)

The evaluation of performance had two approaches: one quantitative and one qualitative. The quantitative one includes the measurement of available quantitate data at company. This data mainly combined financial reports and project plans. With such information, the financial, cost and time indicators could be measured. The qualitative analysis was used for measuring the client, employee and project performance indicators that could not be obtained from the available documentations, as well as the general perception of the projects. For evaluating these three categories, the interviewees were asked about each indicator, by selecting in a scale from 1 to 5; 1 being the lowest or least likely, and 5 being the highest.

General perception of the projects

The qualitative data obtained from the questionnaire starts with a question regarding the general perception of the project's success (overall success, budget, time and quality). The results show that the traditionally managed projects were perceived as more successful than the agile managed ones. For both types of projects, the budget constraints were exceeded, resulting in low scores for this indicator. Regarding the time category, the agile projects show a better performance, exceeding by almost one point from the traditionally managed projects. For the last category, all projects delivered good quality products. Figure 4-1 shows the results for these four performance categories.

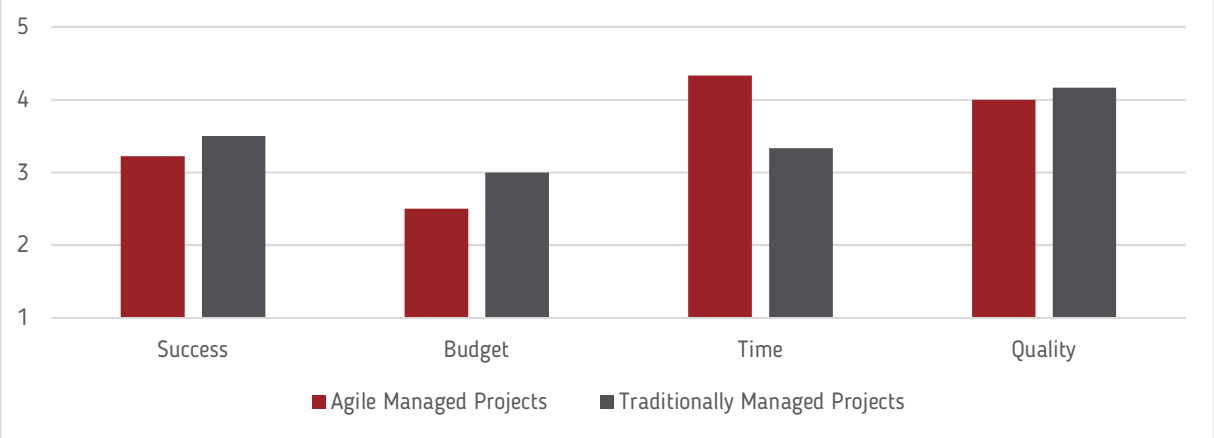


Figure 4-1 General perception of the projects' success

Financial Performance

The final financial results of the projects were analyzed using two of the indicators defined in literature: operative profit which is associated with the result of the project and cost of quality, that the represents the cost of rework.

Before deepen into the financial performance of the projects, it is important to remark that the financial structure of the company is complex and some of the project's results were not visible in the data used for this analysis. This mainly is because the company normally gives big commercial discounts during the

initial phase of the projects (the ones which were analyzed in this study). Such discount would be expected to recover during the subsequent phases or as additional work. For this reason, the numbers shown in the following analysis are negative regardless the fact that the projects generated a certain amount of profit to the company.
Having mentioned these facts, Table 4-1 shows the expected results of the projects at the start and the percentage of this results variation by completion. These negative results at the beginning of the project are internally defined as "discounts", calculated over the internal cost to execute a job. In the first row, the percentage of expected gain (or loss) over the original contract is elaborated. For all six studied projects (agile and traditionally managed projects) this expectation was negative. On the second row, the result at the end of the project is presented which is calculated over the total cost invoiced to the client including additional work. On the last row, the variation between the expected and the final result is calculated.

As it can be seen from the table the final results for all the projects was better than what was expected at the beginning. Although it is evident that for the agile managed projects the company gave bigger discounts than for the traditionally managed ones. Agile projects at the end showed better results compared to initial expected results for them but still their improvement in total was not as significant as it was for the traditionally managed projects.

Table 4-1 Results of Financial related KPIs

		Agile Managed			Traditionally Managed		
	Project name	Project A	Project B	Project C	Project D	Project E	Project F
1	Expected project result % at the start	-22%	-57%	-67%	-25%	-7%	-24%
2	Project result % at the end	-17%	-55%	-64%	-32%	14%	-10%
3	Variation in project result	5%	2%	4%	-7%	21%	16%

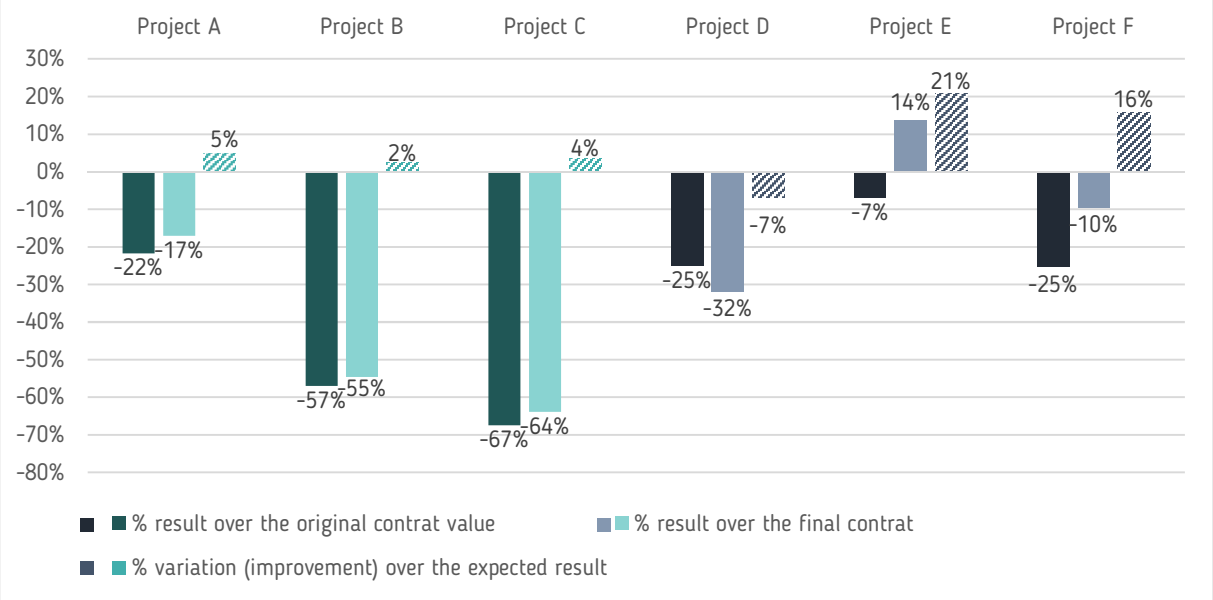


Figure 4-2 Financial KPI Expected and final project result

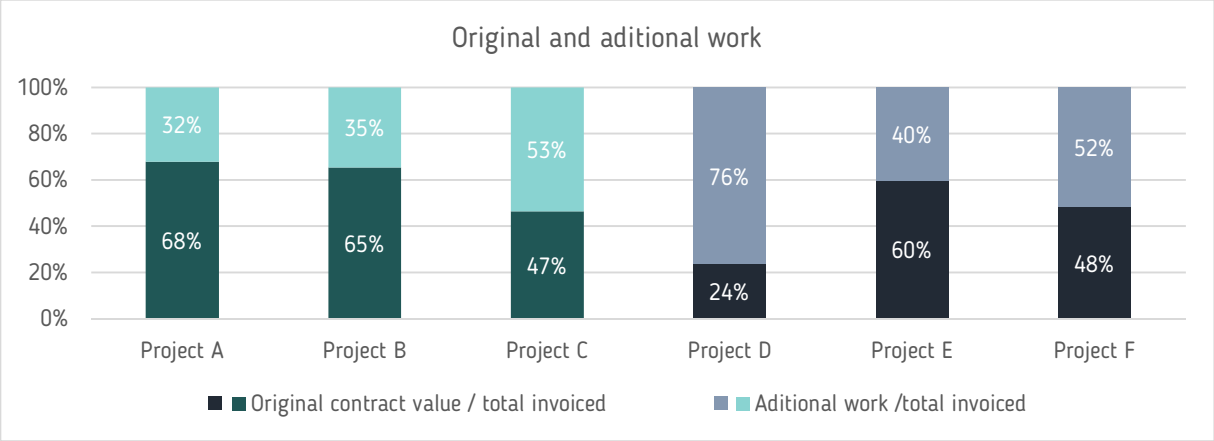


Figure 4-3 Relation between original contract and additional work (per project)

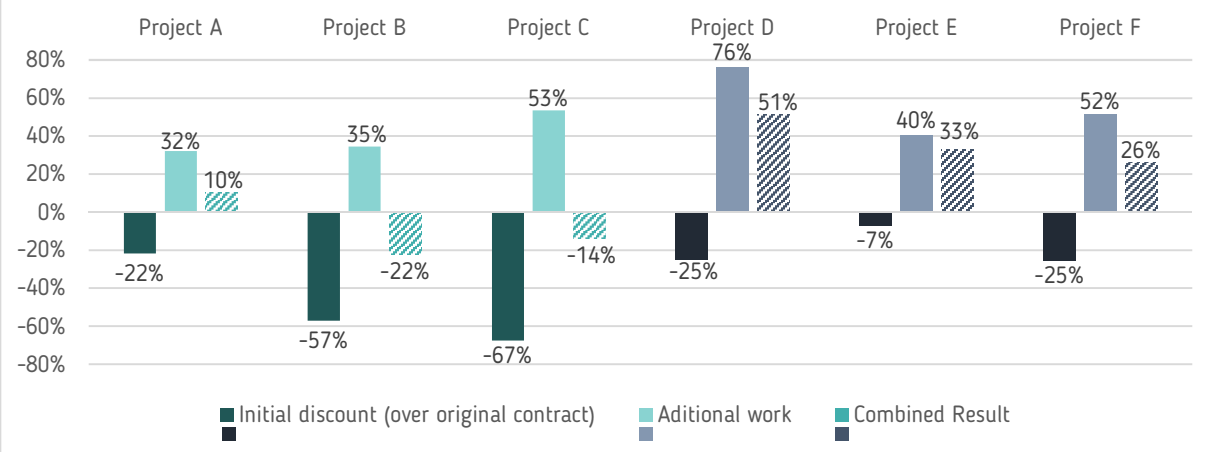


Figure 4-4 Relation between initial discount and additional work, affecting the result

Client Performance

In general, the clients accepted the final products with a medium/high level of satisfaction. But, even though they were satisfied with the results, the relationship among the parties usually suffered from deterioration during the development process, which resulted in the low scores of the responsiveness indicator. Although the performance regarding the satisfaction and responsiveness of the client scored almost the same for both agile managed projects and traditionally managed ones, there is a big difference regarding mutual trust for the two types of projects. Traditional projects scored considerable high in this last indicator compared to the agile projects. Figure 4-5 shows these results.

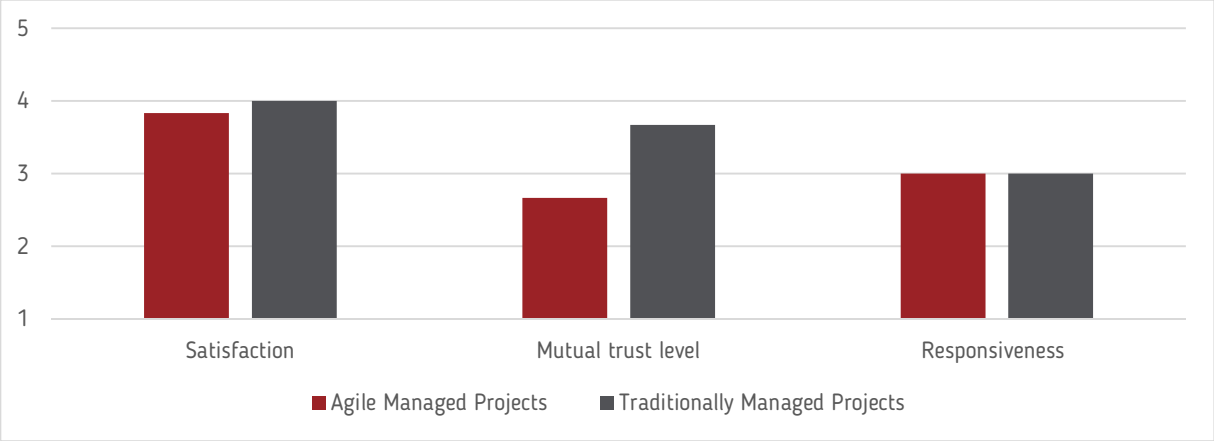


Figure 4-5 Results of Client related KPIs

Employees Performance

Figure 4-6 shows the results for employee related performance measurement including empowerment, motivation, satisfaction, training, overall performance and aligned goals with the project. As can be seen from the figure for all projects the levels of motivation and satisfaction of the employees were similar. The training programs were mostly associated with the use of the Scrum tool. Thus, these projects show higher results in the training indicator although the overall score is relatively low. The overall performance of both agile and traditionally managed teams was similar in all the categories.

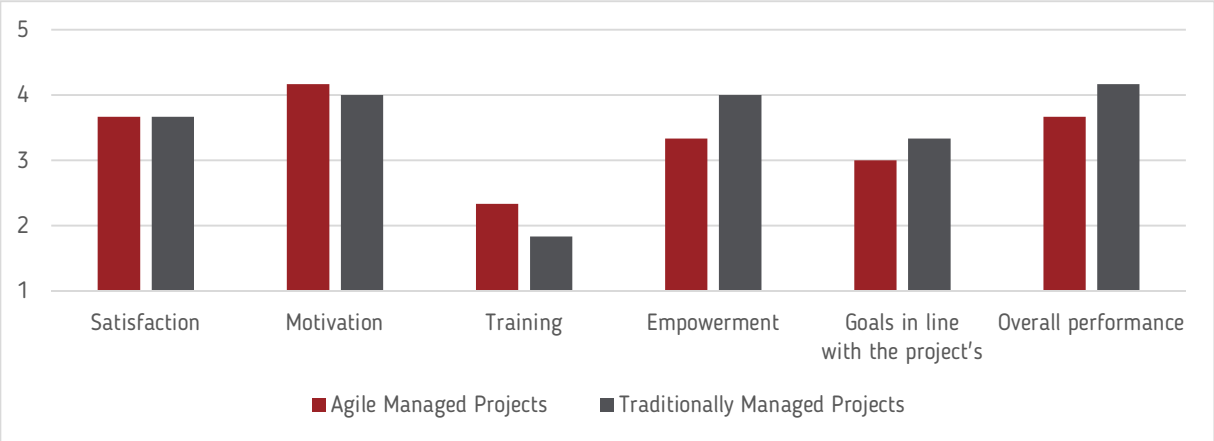


Figure 4-6 Results of Employee related KPIs

Project Performance

The project related KPIs were analyzed using two components: cost and time data for calculating the budget and schedule performance and the interviews for complementing these results. It is necessary to remind that in the financial category of indicators (presented in previous section) the majority of the cost indicators show negative results due to the financial structure used by the company. Regardless these negative results, it can be seen from the analysis that the traditionally managed projects performed better in this aspect.

The data for the rest of indicators gathered from the interviews. The project related KPIs show many differences from one project to the other. Some general remarks about these results are:

- Both the agile and traditionally managed projects had major budget deviations; a reason for the low scores of the budget related indicators.
- In the scrum managed projects, the scope did not change considerably, but the number of errors was lower. As well, the better scores of the time-related indicators (schedule variations) were obtained by these projects.
- The quality of the final product delivered by the agile managed projects was higher in comparison with the traditionally managed projects.
- The majority of the scores of the traditionally managed project variate in the low ranges, indicating relatively average performance.

Figure 4-7 shows the results for project qualitative performance.

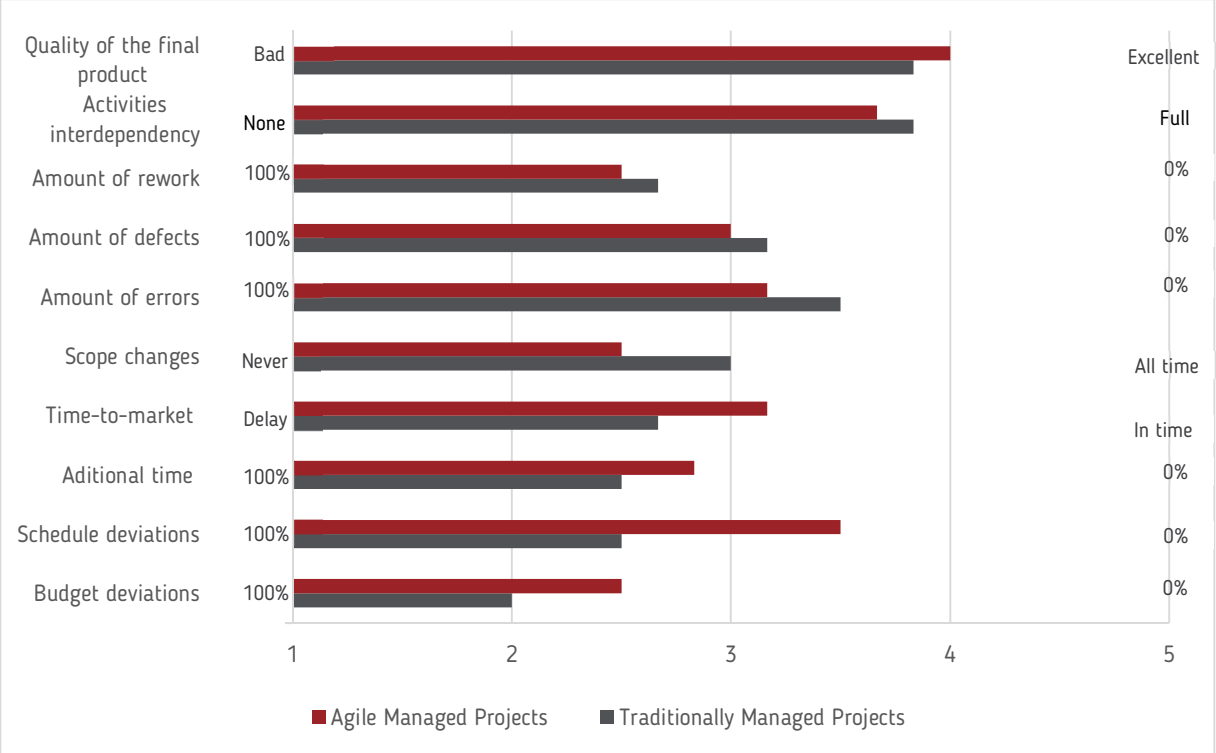


Figure 4-7 Results of Project related KPIs

Importance of each performance category, according to respondents

At last, the respondents were asked if all four categories of indicators have same weight (importance) or not. In order to do so, the interviewees asked to give a percentage of importance to each category summed up to 100% for all four categories. In general, the score (percentage) given to each category did not show a pattern for the agile projects but were in a similar range for the traditionally managed projects. For these last projects, it was observed that only the employee and project related indicators share similar scores. Figure 4-8 shows, on the left, in the green, the percentage given to each category of indicators for agile managed projects, and on the right, in blue, for the traditionally managed projects.

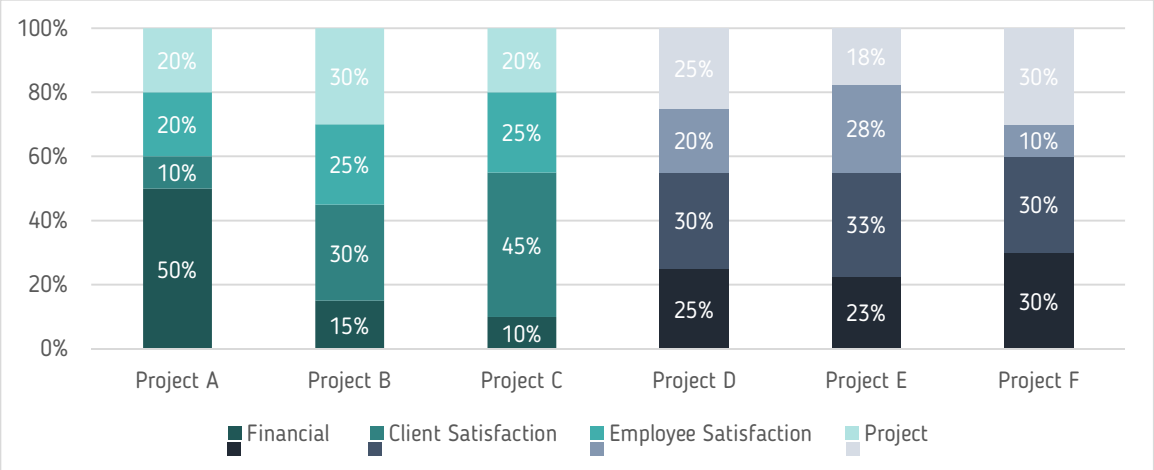


Figure 4-8 Weight of Performance Indicator's Categories

Overall performance

Figure 4-9 combines the overall result of the categories considered for evaluating project management performance, showing that results are almost similar for all the categories. The most significant difference is seen in the financial category, where the traditionally managed projects had a better performance.

Figure 4-9 General performance of Agile vs Traditionally managed projects, in each of the categories studied

4.1.2 FRONT-END DEVELOPMENT

The first step in front-end development is the understanding the project's goal by considering the required conditions established by the client. Definition of milestones, activities, and connections between them are other tasks to do in FED phase.

With defined milestones, the PM starts building the development team by analyzing what the required disciplines, skills and experiences are to execute the project within the given time. From this point, starts a "negotiation" process with the team manager (TM) and head of the department (HoD) to search for the people that have the availability to work in the project. This process requires compromise for both parties, as the PM and the HoD have different KPIs. PM will look for quality and ability of the staff in doing the job while HoD wants to increase the billing ratio of his area, trying to allocate personnel in the different

projects. At the end, the usual criterion for the selection of the team was the availability of the staff, determined by the HoD.

Moreover, the interviewees were asked to cross-check the activities that were conducted during the front-end phase of the project, based on the general list obtained from the literature. The following figure (Figure 4-10) shows the results.

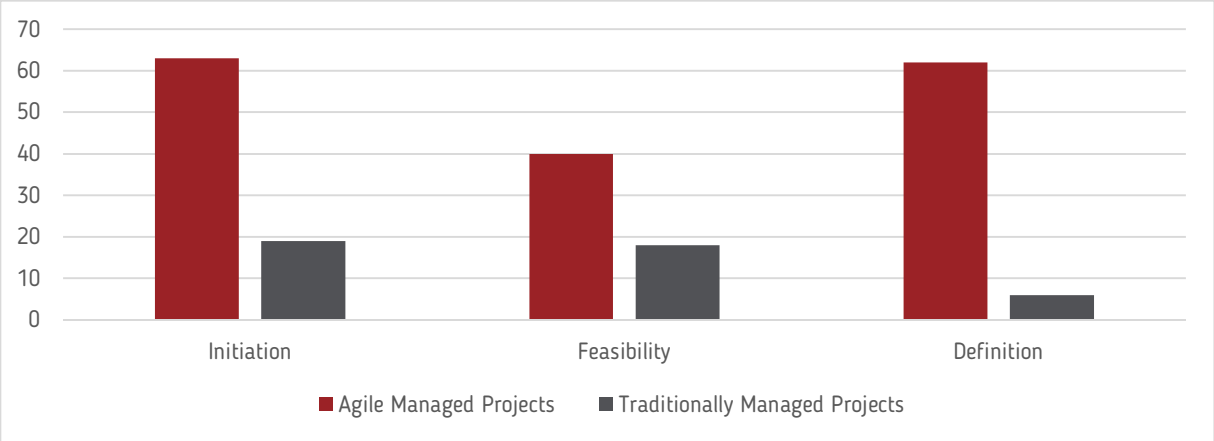


Figure 4-10 Front-End Activities per phase

The results indicate that:

- The majority of the activities found in the literature are conducted in the Front-end phase of projects.
- The vision of projects managers is broader on the activities which were carried out in the project compared to other involved individuals such as Scrum Masters and Assistant Project Managers. Thus, the list of activities cross-checked by other roles than project manager, is narrower compare to the ones filled by project managers themselves.
- The agile managed projects put more attention to the activities executed since the Scrum process required such attention on the process.
- The traditionally managed projects executed the least number of activities from all the FED activity list specially the activities in the initiation and feasibility phases.

4.1.3 PROJECT AGILITY

Regarding the evaluation of agility level of the projects, the interviewees were asked to select a value between 1 and 5; 1 being the lowest leaning on more traditional extreme, and 5 being the highest and agile extreme. The agility of the projects was checked using the four categories established from the literature study: planning and progress, client, team, and risk. In this section, the agility assessment results are presented.

Planning and Progress

In the planning and progress category, the only indicator in which agile projects have a considerable advantage over traditional ones is the 'attitude towards change'. In the APM projects, the progress was checked mainly at the end of sprints, every 2 weeks, similar frequency as traditional projects. Additionally, the team worked together on daily basis, shortening lines of communication and making the control easier.

Although the loose structure of the plan is one of agile's guidelines, this indicator scored considerably higher for traditional projects. The following figure (Figure 4-11) shows these results.

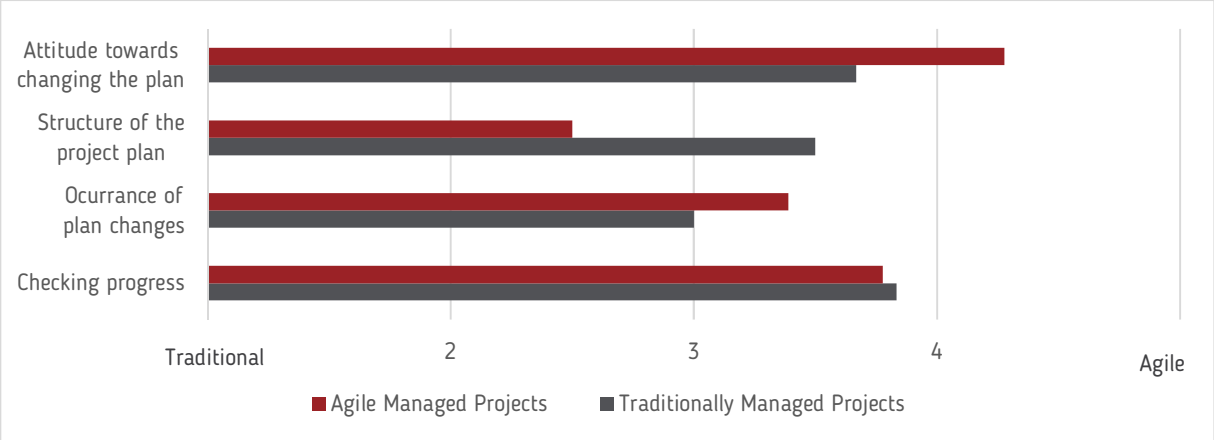


Figure 4-11 Results on Agility level regarding Planning and Progress indicators

Client

It is interesting to see that even when the client is an important aspect of agile management methodology, the agile projects did not score high regarding the indicators in client-related category of indicators. Moreover, that traditional projects show better results in all the indicators. These results could be aligned with lower scores the client category had in the evaluation of performance for agile managed projects. Figure 4-12 illustrates this outcome.

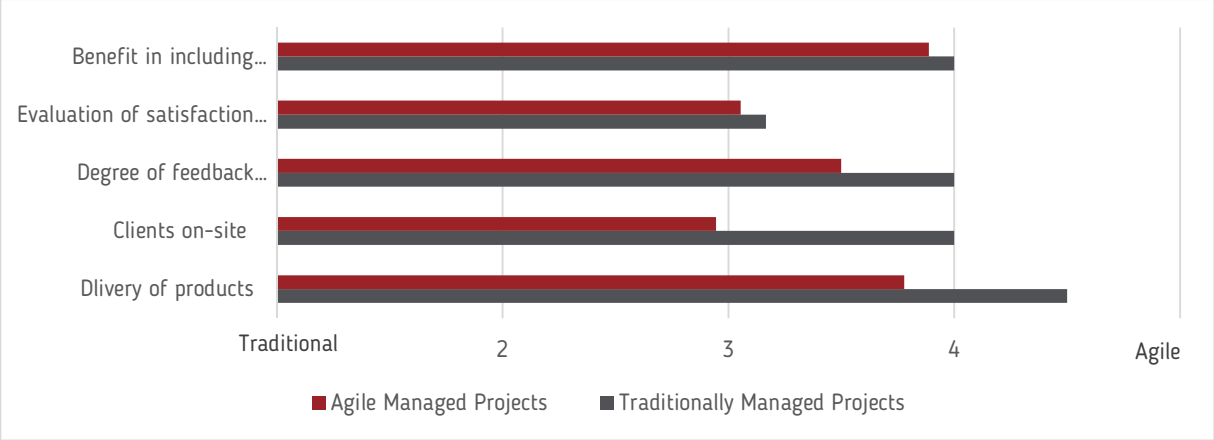


Figure 4-12 Results on Agility level regarding Client related indicators

Teams

The results in the category of team related indicators are highly homogenous for the majority of indicators, although two specific ones show a considerable difference. The 'frequency of working together' scores the highest possible for the agile projects, as these teams were under constant interaction. In contrast, the 'size of the development teams' of the traditional projects was more aligned to agile principles (small team size).

The team empowerment was incentivized in the agile projects, but in the traditionally managed projects the hierarchical structure of the decision making prevailed. Further, in all the projects the input from the

teams was valuable and incorporated into the development regularly. As a consequence, the teams were highly motivated with the process.

As an additional remark it is important to mention that even when the projects were selected in the same organizational team, the development teams for each project were different. Focusing on the agile projects, due to the training required to work with the Scrum tool, this is a pitfall as for each project new staff had to be trained.

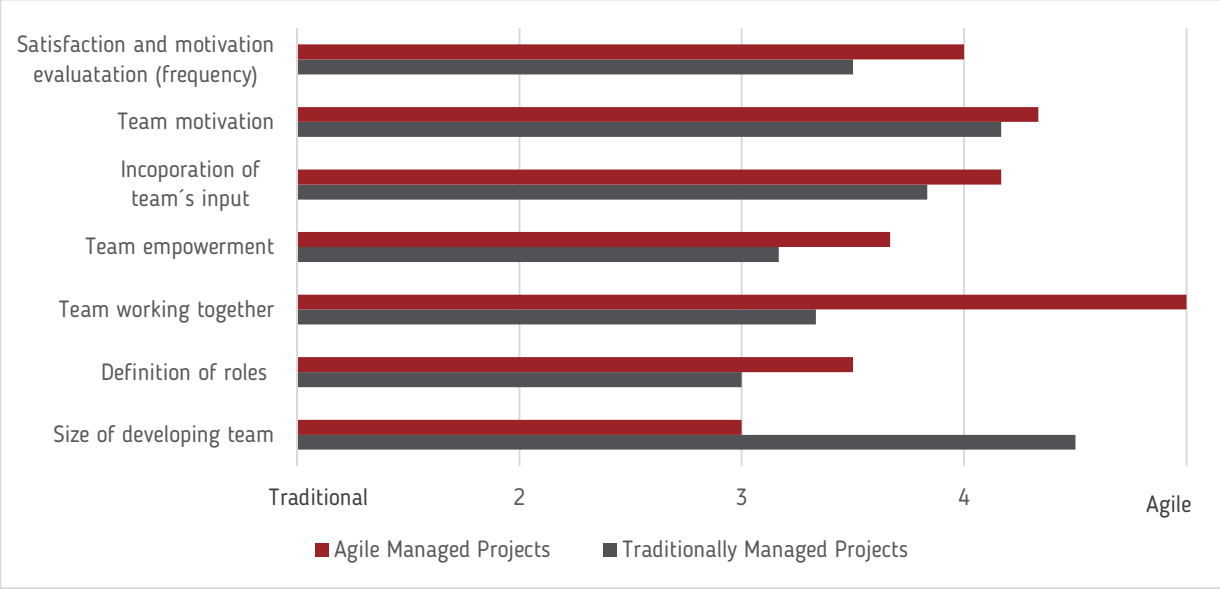


Figure 4-13 Results on Agility level form regarding Team related indicators

Risks

In the category of risk related indicators regarding agility assessment, the interviewees responded to this question if there is a culture to share risks among the different multidisciplinary teams involved in project. The agile managed projects were keener to sharing risks. In this case, each team strived to take their own responsibilities, avoiding passing them to others.

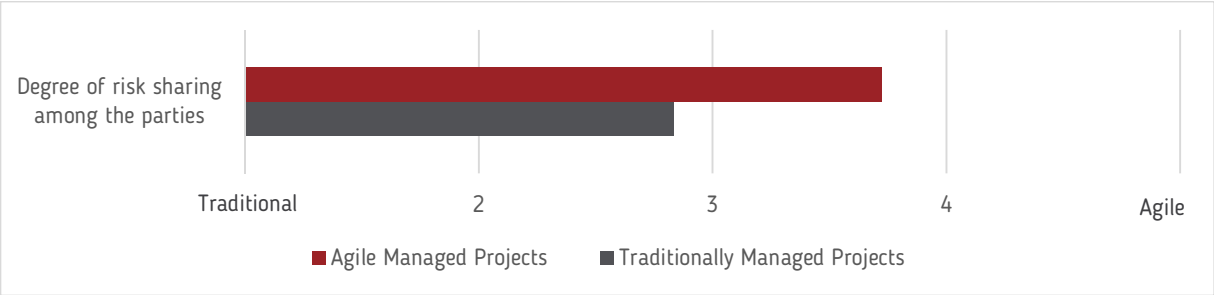


Figure 4-14 Results on Agility level regarding Risk related indicator

Agility analysis

From the results of agility assesment is it evident that the projects conducted using Scrum do not score high regarding agility levels in comparison to the traditionally managed projects. The majority of the agility indicators instead of being on an agile extreme (what would be represented by a score of 5), scored average numbers (around 3), what could lead to classifying them as “hybrid projects”. Especially focusing

on the categories of planning and client related indicators, the agility levels of the projects generally remains in the average. For the remaining two categories, the team and the risks, the agility level of the Scrum projects scored higher (around 4). Using this same criterion, it was found that the traditionally managed projects apply elements of agile management to conduct their activities.

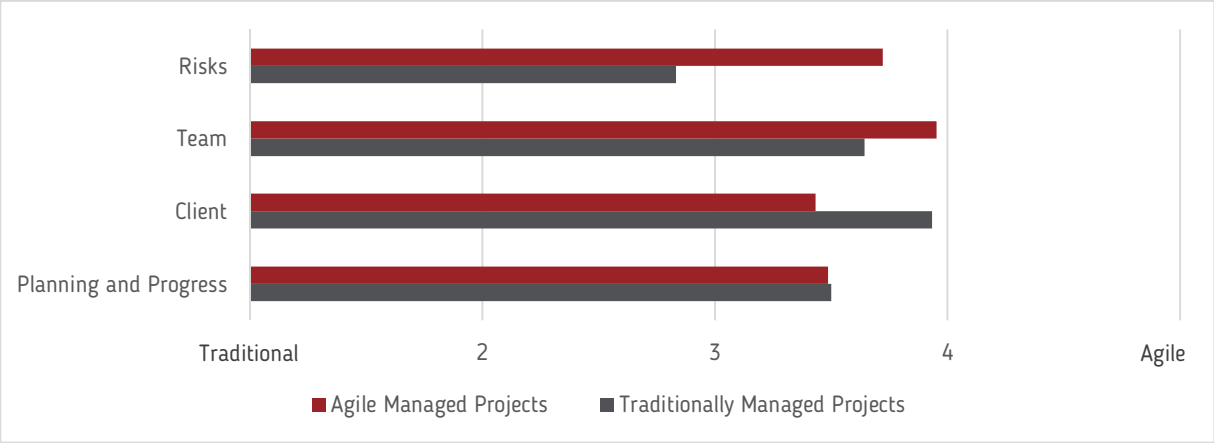


Figure 4-15 General Agility results

Besides the agility indicators, some general questions were asked about the project outcome and the application of Agile Management (Scrum) in those projects. It was noticed that the organization expected to reduce costs by implementing Scum, but this goal was not achieved. Additionally, once these projects were finished, there was a rejection from some layers of the organization regarding the use of Scrum, justifying that these projects had a large amount of reprocesses, extra work, big amount of meetings, which increased the costs of the project. Therefore, because the projects did not show the expected cost reduction, the company did not implement this method in the infrastructure department anymore.

In general the process of managing a project using APM tools requires big compromise and effort from both managers and teams. It was evidenced that the implementation of these methods and overall application of changes is highly dependent on the leader figure; the team adopts the change, as long as the leader acts as a modaretor. This behavior is what is highly associated with a traditional management approach, and can be directly linked to the traditional organizational structure of the company.

4.2 RESULTS

4.2.1 COMBINING THE RESULTS

In this section, the results obtained from the cross-case analysis were be combined, using the three following steps.

First the activities conducted in FED were evaluated. It was noticed that FED activities were the same for all projects, regardless the management approach used. They were no significant or different activities related to one or other management method. However, the amount of detail reached by the agile projects was higher by executing all activities listed in Table 2-5. By evaluating each sub-phase of FED, it was noticed that agile managed projects executed all the activities of each of the sub-phases, while traditional projects focused on developing the initiation and feasibility phases, and barely conducted the activities associated to the definition sub-phase.

Figure 4-16 associates a number of activities listed in literature, with the amount executed by the projects. It establishes percentage degrees of phase completion, as a ratio of a number of activities executed over the total number of activities per phase. In the first phase or initiation, all the 15 activities were executed by the agile projects, resulting in a 100% score, while only 11 were conducted in the traditional projects, what gives a result of 73% over the total. A similar situation occurs in the feasibility phase, where agile projects execute the total 15 activities, scoring a 100%, when traditional projects did 8 out of 9 activities, resulting in an 89% from the total. On the last sub phase, agile projects again conducted the total 15 activities, highly contrasting with the 4 activities conducted by the traditional projects, represented in a 27% of completion during this phase.

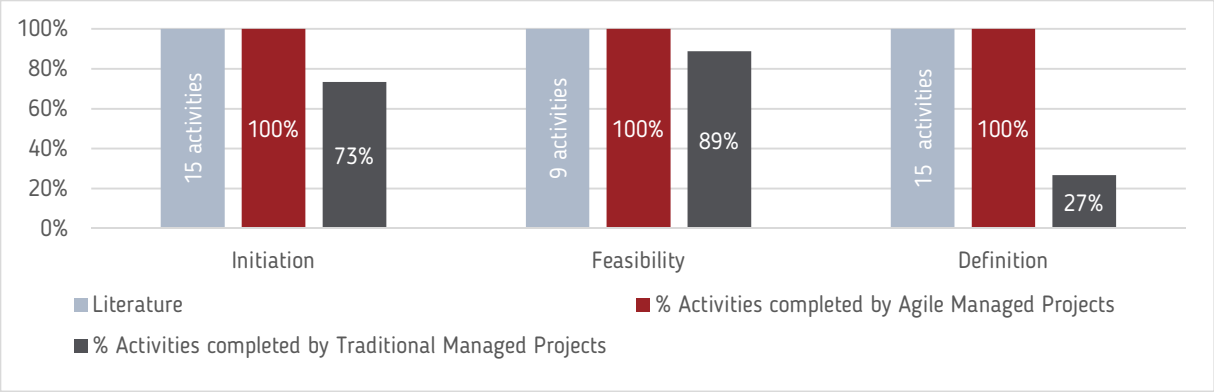


Figure 4-16 Percentage of completion of FED phases: comparison between literature and management technique used

Further, the level of agility of the projects was calculated by using the Table 2-7 developed during the theoretical phase (section 2.4). This table contained a set of indicators that according to the literature should be present in the management of projects to call them "agile". By determining that, by the application of this guidelines would classify the project as agile if certain agile characteristics are in place and in opposite extreme would classify the management of the project as traditional while no or less agile practices are evident in the project. These results are elaborated in section 4.1.3 and the general results combined in Figure 4-1. Further, by converting the numerical indicators of Figure 4-1 into percentage scale, the agility ratio of the agile and traditionally managed projects was obtained (Figure 4-17).

In this aspect, all the evaluated projects shown high agility levels. The scores obtained from these indicators were high for the both management approaches, with an approximate 70% agility level.
For the agile managed projects (Figure 4-17 left), the average level of agility was 73% and for the traditionally managed projects (Figure 4-17 right), was 70%.

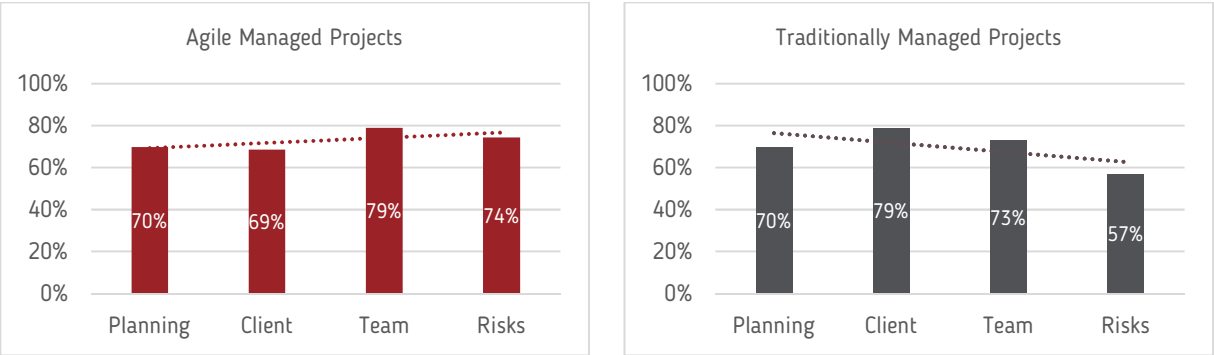


Figure 4-17 Percentage of agility level per management technique used (left agile managed projects, right traditionally managed projects)

At last, the performance assessment results were associated with the two previous analyses. It was observed, that majority of performance indicators had nearly equal results, regardless the management approach. Thus, a distinction was made in the range of >10% and <10%, to be able to make a comparison. Any difference in these ranges would be considered as "significant", and all the indications below these percentages would be associated with both managerial approaches equally. Important to mention that using the range of 10% is only for some indications and is not a recommended percentage by any literature. Figure 4-18 is the outcome of associating these results together

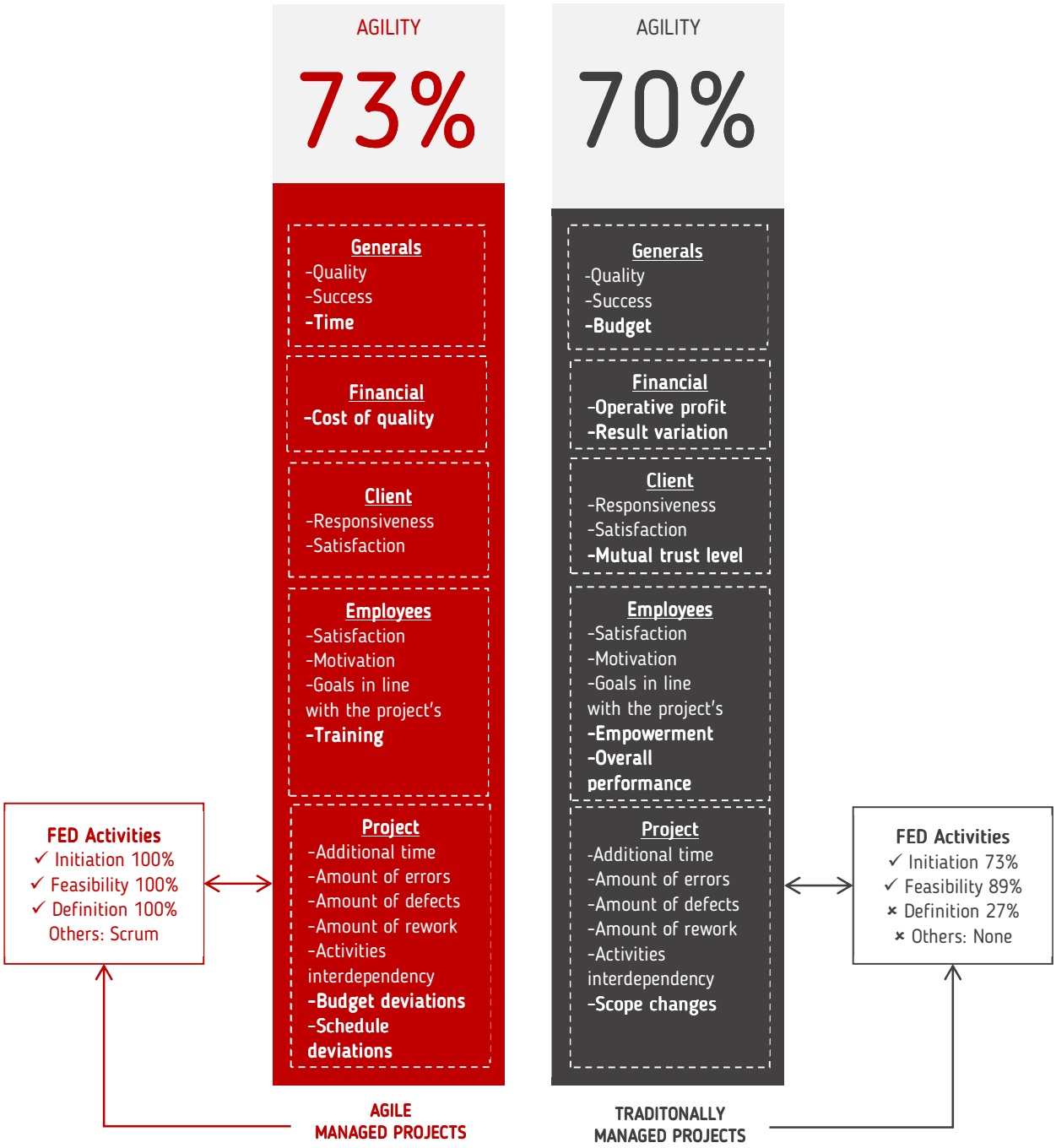


Figure 4-18 Combining the results of agility, performance and FED

4.2.2 DISCUSSING THE RESULTS

Based on these findings, this section will make a connection between the three research dimensions to solve the main research question of this study.

How can Agile project management improve the performance of infrastructure projects in early phases?

A definitive answer to this question cannot be fully provided by this investigation, as the practice did not allow to make a real differentiation between the agility levels of projects. Furthermore, all the projects had relatively similar performance results. However, there were some specific agile actions that showed good performance and if applied to activities during FED could lead to the improvement of PM performance during this phase.

Figure 4-19 shows a scheme on how agile management practices, associated with front-end activities, positively affect the performance of project management, during this initial phase of the project. Initially, in the left box, a set of FED activities was reduced to the specific ones that could be directly linked to agile actions affecting the project management performance. In a separate box, a set of activities specific to the application of agile methods, particularly Scrum is presented. Following, in the middle box, a set of guides to do the previously defined activities in an agile way, in a project and its planning, the teams and the clients are presented. The box on the right presents the link on how doing FED activities in an agility way affects the performance.

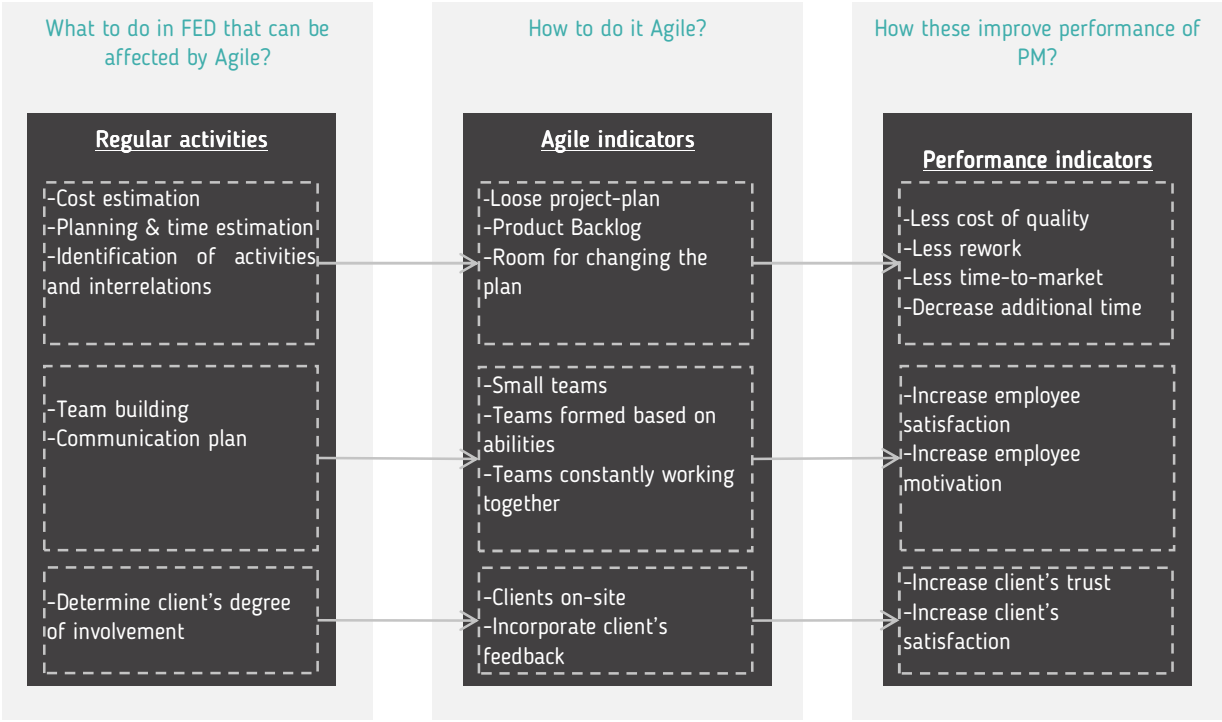


Figure 4-19 Solving the main research question

Each box in Figure 4-19 is subdivided in three main action groups, (showed by the dotted lines in the figure). These groups are related to the performance categories defined previously in this study: financial,

project, employees, and client. For this proposal, the actions regarding these first two categories (financial and project) were combined.

a) Project and Finances

In the project category, the indicators related to schedule and planning had better results in the projects that used agile management. Specifically, the schedule variations, additional time and time to market showed better results. Associating them with agile practices, the following actions can be taken for enhancing schedule performance.

First, working together constantly helps the development team to shorten communication lines and create a faster development process. The team members have the possibility to discuss the process on regular basis and adjust the product accordingly, instead of waiting for long-periods for answers.

Combining this continuous work with a regular check of progress, enhances traceability and allows corrective actions to be taken accordingly. But, for these corrections to happen, the structure of the project plan should allow changes. Changes during the project are inevitable and by recognizing this dynamicity, a flexible plan can prevent that these natural adaptations to affect negatively the overall schedule.

The financial results of the studied projects made it difficult to make an analysis in this category, as the majority of the projects had a negative outcome. However, some specific characteristics affecting all the projects were identified that could overcome this matter. The main reason is the big gap between the amount the company offers their contracts to clients and the internal costs required to fulfill them. This gap is represented in initial discount for work and is being overcome during the project by the generating additional work. Additionally, a certain profit is included among this internal cost. For this reason, the negative results of a project at completion do not necessary represent big losses for the company. For some projects, the expected results from FED phase are compromised for future results to be obtained in the subsequent project phases. For these set of reasons, even tough when projects show a negative profit, the company's results are feasible for working.

In the financial category, the projects managed using agile methods shown fewer errors and rework, what was associated with the cost of quality indicator. The application of agile helped in the reduction of rework, what finally reduced some costs in this category. Even though this was observed in specific activities, it cannot be generalized for the overall project result, as these were generally negative.

b) Employees and development team

The employee satisfaction and motivation indicators play a key role during the development process. When an employee is motivated and its goals are aligned with the project's, its performance could increase. To achieve this degree of motivation, the autonomy to work and inclusion of the employee's feedback in the process are important.

Further, performance is affected by the degree of training of the employees, and this was the main lack observed during the practical part of the research. The training programs were limited to the use of Scrum, and the learning curve was not developed as trained employees did not worked in more than one Scrum project. The employees that received training in a particular subject, should develop their knowledge and be able to use it in practice. New projects should strive to make a team selection including these criteria. If not, each time the new development team would have to be trained increasing costs and time of the project.

This specific category is usually underestimated in practice while it has a high impact on the project, as teams are the ones in charge of developing the projects. More consideration should be put into this group.

c) Client

As the project develops the performance measured by the attitude of the client towards the company is changing constantly. This is related to the performance indicator of 'responsiveness' and according to agile management, to maintain a satisfied client from beginning to end, its satisfaction should be regularly evaluated. Although the time frames for this evaluation are embedded in the particular method used for managing the project, agile establishes short time frames.

During the development process, satisfaction and mutual trusts levels could be enhanced by having the clients on site and receiving their feedback constantly. Further, the received feedbacks should be taken into account for future stages of the project. The constant delivery of products helps as well in increasing client satisfaction, allowing the client to see progress and results.

The overall satisfaction of client at the end of the project is associated with the quality of the final product and the relationship with the company during the development process.

4.3 LIMITATIONS OF THE CROSS-CASE ANALYSIS

To conduct this research, it was necessary to analyze different data of the projects and the company. It was found that even with a big amount of information, its quality was not optimal for the analysis as could not be directly measured using the indicators established in the literature. Following a set of limitations found during the case studies and cross-case analysis.

a) Project information: Costs and Time

The initial budget of the project is calculated by the project manager, by estimating the composition of the team, a number of hours that will be spent per employee and cost of each team member per hour in addition to the costs that need to be paid to external parties for a specific labor. Combining these elements, the company can calculate the Internal Cost Price (IKP) for executing a project, and further, the internal sell price (IVP). Having these two values determined, the company can establish a value that the commercial department can use for giving discounts to the client. All this information of initial costs is contained in a form named RATO at the company.

Once the project starts, the resources spent on the project vs the labor executed the project is being traced. These reports are Excel sheets executed by the project controller, who keeps track of resources spent vs resources available.

Additionally, it is usual that during the project, additional labor is requested by the client. This is different work that the ones agreed in the original contract and is referred as Additional Work (AW). For this additional work new cost estimations should be conducted, and new RATO forms for additional work should be elaborated.

Regarding these aspects of the information about cost estimates, it was found that:

- Not all these information is contained in the companies' archive.
- Not all projects used a standard excel RATO form.

Once the project starts, the accountability for spent hours in a project is done in an Oracle database. Each project has a different code, and all the hours spent working on it should be filled in detail by each employee. The project controller is in charge of verifying and supervising that this accountability is being done properly and keep track of other costs, such as the ones payable to external parties.
For correctly filling this database, two main type of hours should de distinguished; the hours spent over the original contract (initially agreed with the client) and the hours spent on additional work. These two types should have different codes to differentiate them and moreover, bill the client on the specific labor work. It was found in the database that not all projects used different codes for activities linked to the original contract and additional work.

Further, when linking the two sources of information explained above, regarding the cost of the project, many differences were found in the data.

- The values contained in the RATO and the Oracle were different for some projects.
- During the projects, additional discounts are given to the client, over the additional work (AW). These amounts are usually recorded in the financial reports of the project, but were not equally traceable in the Oracle database.

Overall, they are many formats in use and ways of storing information that are not common for all the projects. This leads to differences in the data sources. There were a lot of discrepancies between the follow-up reports of the project and the final information contained in the financial database. Since the amount and quality of information is different for all projects, it is difficult to make any analysis of data from different projects.

a) Client information

The link between the company and the client is the project manager (PM), and all the communication and processes between the two parties are steered by this person. As a standard procedure for all projects, the satisfaction of clients is evaluated at project completion. Thus, once the projects have achieved a degree of completion over the 90%, the project manager (PM) should authorize the communication department of the company to send the satisfaction survey to the client.

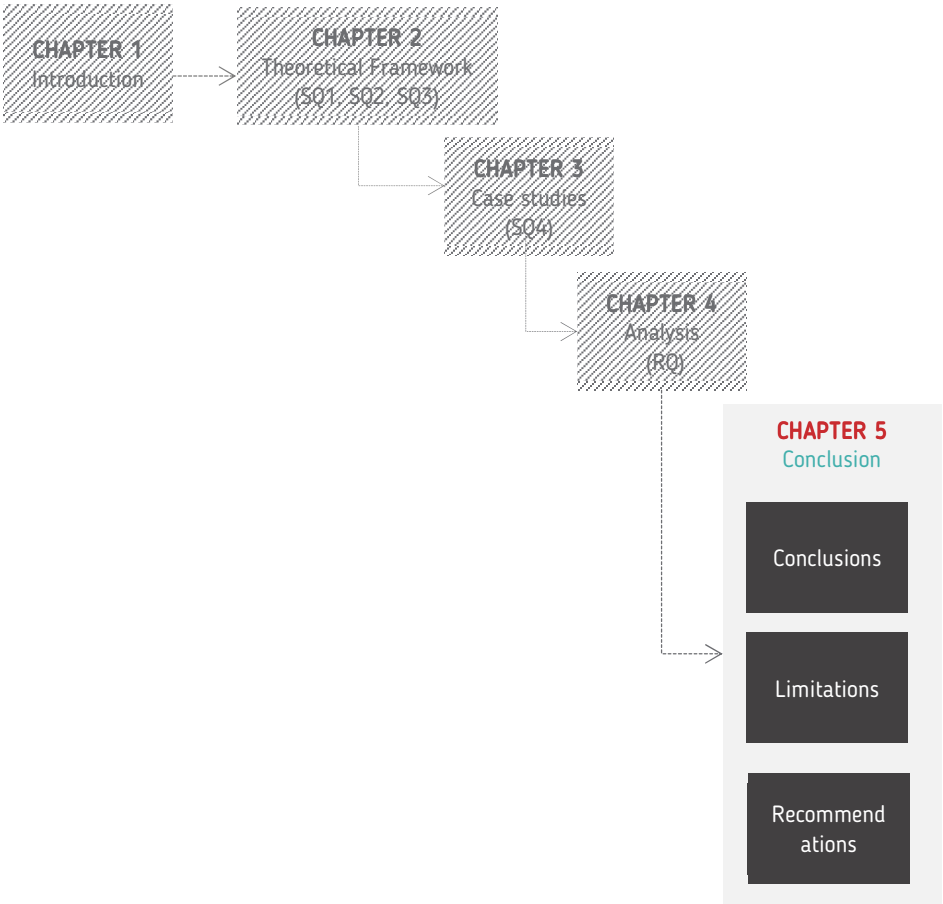
From this survey, the company had only one answer out of the six projects studied, which was insufficient for the analysis. Due to lack of information in this regard, the indicator related to the client had to be asked from managers, and their perception of this party. In some way, such data can be considered as manipulated data. But this was the only possible way of collecting such information for this study.

According to the communication department the reasons behind this lack were, due to three main reasons. First, the arbitrary decision the PM has over sending the survey to the clients. Second, a commercial moment in which the parties might be involved in future projects, and the fact that sending the survey could generate “disturbance” of this negotiation process. And at last, external reasons for which the client decides not to fill or send back the survey to the company.

CHAPTER 5.

CONCLUSIONS AND RECOMMENDATIONS

This last chapter starts with the discussion of the research, in section 5.1. Followed by the limitations encountered during the research (5.2) regarding literature and during the analysis. In section 5.3 the overall conclusion of the research will be presented. At last, a set of recommendations will be made in section 5.4.



where is this section in the entire research?

5.1 DISCUSSION

In this study project management of infrastructure projects in front-end development phase was researched by conduction extensive literature review and in-depth case studies. The objective was to establish the connections between the management techniques used during the front-end development of infrastructure projects and the performance of this phase from project management point of view. Further on the research focused on how the application of agile management could influence the management performance. The scope of the study was limited to early project phases or front-end development due to the high impact FED has over the entire project. Also, because the processes conducted during this phase are highly common for an extensive range of projects. For this last reason, the interventions in this stage could cover a broader range of projects.

A combined approach of a literature study and practical analysis (case study) was applied. At first, the areas of study were defined as project management approach, front-end development, and project management performance. These three areas were reviewed in literature to create a base framework for analysis. For the first dimension, the common practices conducted in traditional management and agile management were identified. For the second study dimension, the focus was the identification of a general set of activities conducted during this phase. For the last one, a set of indicators were established to measure the performance of project management.

Once a framework was established, the investigation moved to analyze the three aforementioned areas in practice. To fulfill this objective, six completed projects executed by a consultant engineering firm were selected and the application of each of the indicators derived from literature was evaluated correspondingly. The first available source to obtain the majority of the required data for the analysis was hard data and reports. Such data were subjected to quantitative analysis. Although once the practical phase started, it was noticed that the available data is not enough for answering the research question. Hence another way of collecting the required data had to be chosen. The complementary source of data was people at the company and data collection was done by conducting interviews with the key players at the selected projects. The drawback of collecting data through interviews is the subjectivity of such data which would affect the outcomes of many indicators, such as client and employee satisfaction. Because the answer would be influenced by the perception of the interviewees.

The results of case study analyses showed that there was not a big difference between the application of agile and traditional management in the studied projects. Also, the performance of all projects was very similar. Due to these blurry lines, a real analysis could not be done linking agility with performance. Although when focusing on the results of FED, the relation between the development of this phase with the management approach is clearer. Agile projects had a thorough FED which is been reflected in a better performance concerning reprocesses and the associated time to it.

Although this research can make some connections between agile practices and performance, there was not a major differentiation between agile and traditional management in the studied projects, making the answer to the research question unclear. Analyzing these results, this research cannot give a full answer on how the performance of projects during the front-end phase could be improved by using agile management. Further, the analyzed sample is too small and the information too scarce to give a definitive answer. But, when comparing the initial state of the art and the results obtained, this research could become the initial step in the measurement of the relation between agility and performance of project management. Moreover, it is considered that by expanding the sample and the quality of data, the results could be more accurate and the research question could be answered.

5.2 LIMITATIONS

This section discusses the limitations found while doing this research, diving in the limitations regarding the theoretical framework (5.2.1) and the real-life case studies (5.2.2).

5.2.1 LIMITATIONS REGARDING THE THEORETICAL FRAMEWORK

The theoretical framework elaborated for this research combined an extensive number of sources on the subjects of the performance of project management, front-end development, and project management methods, focusing on traditional and agile management. Although the number of sources contributes to establishing this framework was large, not all the literature available about these aspects were covered in this study. Therefore, the guidelines for measuring project management performance, agility and front-end activities could be broader. Moreover, all the referred literature covered different industry lines and was not specific to the construction industry, meaning that some additional indicators might be left out, and as well some indicators might not be applicable to construction projects.

The main limitation in literature was the lack of information regarding the application of agile management in the construction industry. The literature found in this topic was scarce and many sources were academic papers, in which the application and guidelines proposed were limited to case studies samples.

5.2.2 LIMITATIONS REGARDING THE CASE STUDIES

Information

a) Financial performance indicators

The financial reports elaborated for the projects were thorough and detailed although the overall financial scheme of the company was complex and hard to understand. The main reason was the differences between the feasibility baseline and the tracking progress baseline. The feasibility of projects was elaborated using internal cost prices (IKP) which associate the number of hours expected to spend and the cost of each hour. These IKP costs include operating expenses of the company besides the actual cost of labor. During the execution of the project, the costs spend were traced using actuals cost of labor, what creates a difficulty when connecting the two values. For this study, these two reports (initial and during elaboration) came from two different sources, and the information contained in the two was different. Besides the traceability, there were many differences between the project reports, elaborated by the PM and the team, and the final data contained in the company's system. These incompatibilities made the numerical analysis challenging.

b) Customer performance indicators

The customer satisfaction survey for the projects evaluated in this research was not available. There are several reasons for this lack. The first is that the project managers (PMs) are the ones in charge of deciding whether the survey should be sent to the client or not. Normally, the PM decides not to send the survey when the relationship whit the client is deteriorated, or when there are more offers being presented to the client at the time, or due to other commercial reasons. Once the PM decides to send the survey, the client will answer it and send it back to the communication department. Not always the clients answer the survey and/or send it back to Sweco.

In this matter, it was interesting to observe that even in the case that customer satisfaction is one of Sweco's core KPIs, the real information about it, is scarce. Nevertheless, the PMs of the agile projects mentioned that the customer satisfaction was evaluated during the execution of the project. However, this information was not stored and the client related indicators had to be asked to the interviewees, what affects the results to somehow.

c) Employee indicators

The surveys for employee satisfaction are conducted by the company once a year. In the survey, the employees are asked about motivation, satisfaction, goals, performance and about their direct leader. The survey is the same for the organization in the Netherlands and is completely anonymous, thus cannot be used for measuring performance at a project level. Like as the client indicators because there was no recorded information on employee indicators per project the questions regarding employee satisfaction, motivation, training programs, etc. had to be asked to the PMs. As it was mentioned before, this might affect the results.

Case Studies

In the case studies, the complete lists elaborated from literature for measuring the performance of project management, the level of agility and the activities conducted during the front-end development phase were evaluated. At the beginning, the lists used for this evaluation were the same ones obtained from literature and were not subjected to any alteration, validation or refinement process.

When evaluating them in practice, it was noticed that many of the indicators to measure performance were not applicable or traceable at the project level. Especially the indicators in the financial category reached higher organization layers and could not be measured in the project's level. Thus, the performance measurement list objected an initial refinement. Further, when comparing the available information and the information required, an additional refinement process occurred, as many indicators could not be measured with the available data. Thus, the case studies covered both validation of the KPIs' lists and also the measurement of KPIs in projects.

Subjectivity of gathered data

The main limitation of the analysis was the subjectivity of the results. The research aimed to obtain most of the information from objective sources, such as financial reports, customer, and employee satisfaction surveys, etc. But the rest of required data was obtained from subjective sources by doing interviews with project managers and assistant project managers, that would give an overview of the project in the aspects of performance, agility and front-end development. Therefore, the results obtained from them are subjected to their perception of the process and not from the direct source of information, such as customers or employees.

5.3 CONCLUSIONS

The objective of this research was to determine how agile management practices could help to improve the performance of project management during the Front-End Development of infrastructure projects. To accomplish this goal, three main research topics were established: project management techniques, project management performance and front-end development processes. To associate these three topics together, a combined approach of theoretical research and a practical application was used.

The investigation was guided by four research sub questions, the first three, aimed to establish a framework from literature about the already mentioned research topics and a fourth one to evaluate their application in the practice of infrastructure projects. By solving these sub questions, it was expected to have the required information to answer to the main research question.

SQ1: Which key performance indicators (KPIs) are used to assess the performance of project management in early project phases?
The first research sub question aimed to establish an assessment method to measure the performance of project management. At first, the concept of performance was defined and the different ways to measure it explored. It was determined that performance measurement is linked to the establishment of Key Performance Indicators (KPIs) and that these indicators should have a set of properties in order to fulfill their purpose correctly, such as accuracy, compatibility, measurability, etc.

Focusing on the KPIs to measure the performance of project management, literature proposes different categorizations and classifications; according to the type of information they are measuring, the subject obtaining the information, their capacity to make a change in the process, inter alia. For this study, a classification was made based on the second criteria, the actors involved in obtaining the information.
Four categories were decided upon: financial, organizational, project and client. The first three categories are indicators which are measurable inside the organization and the last one is related to external parties, who are the clients in this research.

For the internal categories, in the first group, are the indicators related to the financial results of the project and their input to the entire company's finances. The performance of the employees is measured by the staff's attitude towards the project and the input they generate for achieving the goal. The indicators associated with the project are related to its activities, and how the project behaves within its time and cost constraints. At last the customer category relates to the attitude of the of the client during the development process and its satisfaction with the final results.

SQ2: What are the typical management activities conducted in Front-End Development?
Front-end is the phase in which the project is defined guided by the fundamental criteria of time, cost, and quality (Lester 2014). This phase starts by the definition of an objective and is completed when the necessary information to approach a project is obtained (Gibson et al., 2006).

The process for obtaining this information is gradual, and literature defines a set of sub phases for developing front-end. An initial phase, in which the initial idea of the project is established and the business case is defined. Followed by a feasibility phase, where the evaluation of the project is made and outline of the case created. And finally, a definition phase wherein a conceptual design is reached and the basic requirements are defined, for moving to the next phase of the project's lifecycle.

The typical management activities conducted during the Front-End Development are associated mainly to determine the project's goals, components, resources, and risks. In the first group, the activities related to the setting the project's objectives and the requirements for achieving them are covered. Further on it includes activities to establish the project's components and the interaction between them, what is usually represented in the work breakdown structure (WBS). The resource activities usually include cost, human, and materials needed for the project. At last, it includes the risk determination activities and the ways to cope with it.

SQ3: How can the Agility of project management be measured?
Agile project management is an iterative and incremental method of continuous innovation, based on constant testing, improvement, and adaptability with an informal communication and an evolutionary-delivery model. This style is oriented towards an organic development, in which the management focuses on leadership and collaboration, on the basis of constant communication and involvement of the development team (Dybå & Dingsøyr, 2008). The basis of Agile Project Management were established in

the Manifesto for Agile Software Development (2001) with twelve principles contained and four core values: Individuals and interactions, Working Software, Customer collaboration and Response to change. The main aspects for measuring the agility of projects are related to the core values of the management approach: change, clients, employees and deliverables, and the relations that tie them all together. By establishing a set of activities associated to each of these clusters, and the degree a project applies them, its agility could be measured. The first cluster can assemble the activities related to the project plan and its control. The main objective of agile projects is to be adaptable to changes, having a dynamic attitude of working and controlling the project, by establishing short time frames for product development. The second group is about the involvement of clients during the development process, and moreover, their satisfaction during the project and at completion. The employees play a key role when developing an agile project. The way teams are built and work together influences the degree of agility of the project. Moreover, the satisfaction and motivation of the team members regarding the project is important for agile management. The relations between the previously mentioned groups complete these criteria. The way the parties communicate and interact, document their process, and moreover, share the risks generated by the project are components for measuring project's agility.

SQ4: How are performance indicators, front-end development, and agile management being applied in practice?

To answer this question, the research focused on studying six projects completed by a consulting engineering company. In this company, the development of a project usually starts when the company decides to participate in an open tendering procedure offered by public entities. At this moment, an initial scheme is drafted and the company proposes it for the open tender. The next step follows once the company is awarded the project, and this is the front-end development phase that was analyzed in this study.

The performance of project management in practice was associated with the performance of the project and the satisfaction of the clients. For the first one, the performance of the projects is related mainly to time and cost indicators. During the project, the development teams are constantly evaluated using 'burned cost' indicators. 'Burned cost' indicators show how the resources budgeted for developing a project are being consumed vs the activities conducted and the progress achieved, in a determined unit of time. At completion, the project expected and obtained financials results are compared and an evaluation is made on the basis of operative profit. Also at completion, the perception the clients towards the company is assessed, by using satisfaction surveys.

Front-end development is the processes of obtaining the required information and resources for designing a project. FED starts with the assigning a PM to the project, who is the one in charge of organizing the team, determining main activities and overall, making sure the client requirements are being fulfilled with the product. The activities conducted during this phase, reach mostly the competence of this actor as this person has a complete overview of all the processes that need to be executed to achieve the goal. According to the literature, many of the activities conducted in FED are common for all projects regardless nature or industry line they are associated to, what was reflected in practice. All the studied projects started FED following these activities, but the way the phase was developed was different for the agile and traditional projects. The first ones followed a more organized and thorough development from the start, while the last ones were defining the activities along with the development process.

The application of agile management was fixed to the use of the Scrum tool. These projects tried to change the way the processes are normally conducted in the department, by adapting all the activities to fit the parameters and requirements of Scum; such as daily stand-ups, monthly sprints, process backlogs, etc. At

the beginning of the projects, this abrupt change created a disturbance for the Scrum teams that needed to adapt to a new working style. Further on, during the development process, the scrum teams encountered many glitches the teams that were managed traditionally. The two ways of working, and the specific goals and processes were constantly colliding, making the development of the project challenging.

How can Agile project management improve the performance of infrastructure projects in early phases?

This research found that in practice there is not a defined line between agile and traditional management, but more of a hybrid version of combining the two management approaches. Traditional projects had elements of agile management and the so-called 'agile projects' were not as agile as expected. Even when these last ones tried to apply Scrum and execute all the processes that this method suggests, the development teams were constantly clashing with the different ways of working with the rest of the involved actors, what created a mix of management methods.

Even though there was not a clear distinction between management processes, the development of the front-end phase was considerably different for both types of projects. The activities conducted by the agile projects during FED was highly detailed, and the majority of the activities listed from the literature were conducted by all projects, in contrast, the traditional projects barely identified any of these activities. The development of the traditionally managed projects was oriented and based on the experience of the PM, and the process was not formally structured. Further, the majority of the activities of the total front-end were mainly conducted during the initiation phase, and the majority did not reach the definition sub-phase. On the other hand, the agile projects executed the majority of the activities, constantly over the three sub-phases.

The answer to the main research question in how agile can improve the performance of project management, cannot be fully provided by this investigation, as the practice did not allow to make a real differentiation between the agility levels of projects. Furthermore, all the projects had similar performance results. Although, there were some specific agile actions that showed good performance and if applied to activities during FED, could lead to the improvement of PM performance during this phase.

First, working together constantly helps the development team to shorten communication lines and create a faster development process. The team members have the possibility to discuss the process on regular basis and adjust the product accordingly, instead of waiting long periods for answers. Combining this continuous work with a regular check of progress enhances traceability and allows corrective actions to be taken accordingly. But, for these corrections to happen, the structure of the project plan should allow changes. Changes during the project are inevitable and by recognizing this dynamicity, a flexible plan can prevent that these natural adaptations affect negatively the overall schedule. As well, the projects managed using agile methods shown fewer errors and rework, what was associated with the cost of quality financial indicator. The application of agile helped in the reduction of rework, what finally reduced some costs in the financial category.

The employee satisfaction and motivation indicators play a key role during the development process. The degree the employee is motivated and his/her goals are aligned with the project's, his/her performance is most likely to increase. This specific category is usually underestimated in practice, and it has a high impact on the project, as the teams are the ones in charge of developing the projects. More consideration should be put into this group.

Al last, the performance measured by the attitude of the client towards the company. During the process, satisfaction and mutual trust levels could be enhanced by having the clients on site and receiving their feedback constantly. Further, this feedback received should be taken into account for future stages of the project. The constant delivery of products helps as well in increasing client satisfaction, as allows the client to see progress and results. The overall satisfaction of client at the end of the project is associated with the quality of the final product and the relationship with the company during the development process. A satisfied client during the process can be achieved with the actions mentioned above.

5.4 RECOMMENDATIONS

5.4.1 RECOMMENDATIONS FOR SWECO

The application of agile management methods in the infra-department of Sweco was limited to three projects during the years 2012-2016. This study evaluated the performance of these projects in comparison with another three projects managed traditionally during the same time span and the same organizational team. This was aimed at determining if there was a relation between elements of agile management and project management performance, during the front-end development phase. Further on, to recommend the company on how to tailor their management processes in order to improve the performance of project management and consequently the performance of projects.

The set of recommendations proposed in this section are divided into two categories: recommendation about current situation and recommendations for application of agile methodologies in the management of projects.

Recommendations About Current Situation

As mentioned in section 4.3, many data limitations were found while conducting this research. This section gives a recommendation on how to tackle them.

a) Project information: Costs and Time

It is recommended to standardize the procedures and forms for handling and storing information during the projects. All the projects and teams should use the same formats for controlling the project and these formats should be filled out in the same way. The information should be entered into to the database, differentiating always between the cost associated with the original contract and additional costs. Further, it is recommended to conduct regular audits to verify that these procedure is being followed.

In general, there are many formats, procedures, and ways of storing information. Every project applies a different form or stores information differently, making the data available non-uniform for all the projects. The main recommendation is to create standard procedures for all the activities, within all the company's departments, in order to create a good traceability.

b) Client information

In this moment, the company is changing the survey scheme to only one question, the NPS. They aim to standardize this survey over the entire Sweco group. It would be expected as well that by reducing the number of questions, the response rate would increase.
It is recommended that:

- The client satisfaction survey, or now NPS, is sent to clients always at the completion of the project, without exception.

- The management studies both positive and negative results, with the objective of taking corrective measures for improving future relations with the client.
- All the information received form the NPS is verified and stored at the completion of the project.

Recommendations about the Application of Agile Management

According to Sweco, the application of agile management was limited to three projects that used the Scrum tool. These three strived to apply Scrum "by the book" and encountered any difficulties during the process. Bellow, the main ones.

- Commitment: there were contradictive positions inside the organization towards the use of Scrum in this department. Some actors were keen in its application and some others opposing it.
- Expected results: the financial improvement expected from these projects was considerably high, especially for being a pilot project.
- Relationships: the interaction moments between parties working with Scrum and the ones working traditionally generated clashing moments that jeopardized the normality of the Scrum process. As an example, teams found impossible to Sprint as planned (every couple of weeks) since the information was not received from other parties.
- Multiplicity of projects: The development teams work on different projects simultaneously, not focusing completely on one goal.

But even when Sweco considers that only three agile projects were conducted, in practice it was found that many agile principles were used as regular management practices. The reason behind this is that agile management is not limited to one tool, such as Scrum. Agile guidelines are broader and embedded in the regular guidelines of project management. The following list mentions some of the agile principles already being used in Sweco:

- Client involvement.
- Client satisfaction evaluation.
- Constant delivery of products to the client.
- Small development teams.
- Teams working together regularly.
- Loose structure of the project plan.

It is perhaps not feasible for the organization to make a full change to complete agile models for managing their projects, but the occurrence of the previously listed principles indicates that there is already a certain level of agility embedded in their management processes and the migration towards agile could be feasible. Following, a set of recommendations for increasing the agility level in project management is recommended.

In an organization level, probably the most important point when applying a change is the commitment. This was already a crucial reason for ceasing the use of agile tools one time in the company. A change of attitude and major commitment from all the parties involved makes the transition easier as all parties are striving for the same goal. Commitment should be reached in all layers of the organization, form the employees, till top management actors. But perhaps due to the traditional structure of the company, reaching this commitment is highly dependent on a leader. There is the need for an actor or set of actors in top management position to propel change and constantly motivate individuals towards the goal of becoming agile (Owen et al., 2006 & Codinhoto, 2006)

At a team level is important to focus on employees; increase their motivation and commitment towards the project. A regular evaluation of these aspects could help the manager orient their goals with the teams

and in this way, increase their performance. Further, training programs combined with a practical application of this knowledge. In this way, employees become experts and can transmit their knowledge to others. Additionally, if the PM requires for some particular expertise, he should strive for building a team with staff that already has this knowledge, decreasing the need for additional training every time (Owen et al., 2006 & Codinhoto, 2006).

For the regular development of projects, having teams working together regularly, shorten communication lines helps in achieving goals rapidly. Additionally, constant interaction with the client, receiving feedback and delivering products, but moreover, keeping a constant evaluation of the attitude of the client, and taking these feedbacks for developing the project.

Some of these practices are already being applied in Sweco, but slightly changing their occurrence and enhancing the application of some new ones, would be the way for the company to become agiler. The recommendations listed in this section were combined as a set of procedures to apply in different layers of the organization. Figure 5-1 shows this final application model. In the scheme, the activities highlighted with a line below, are the ones proposed as new, and the others, the ones already in practice that need to be revised.

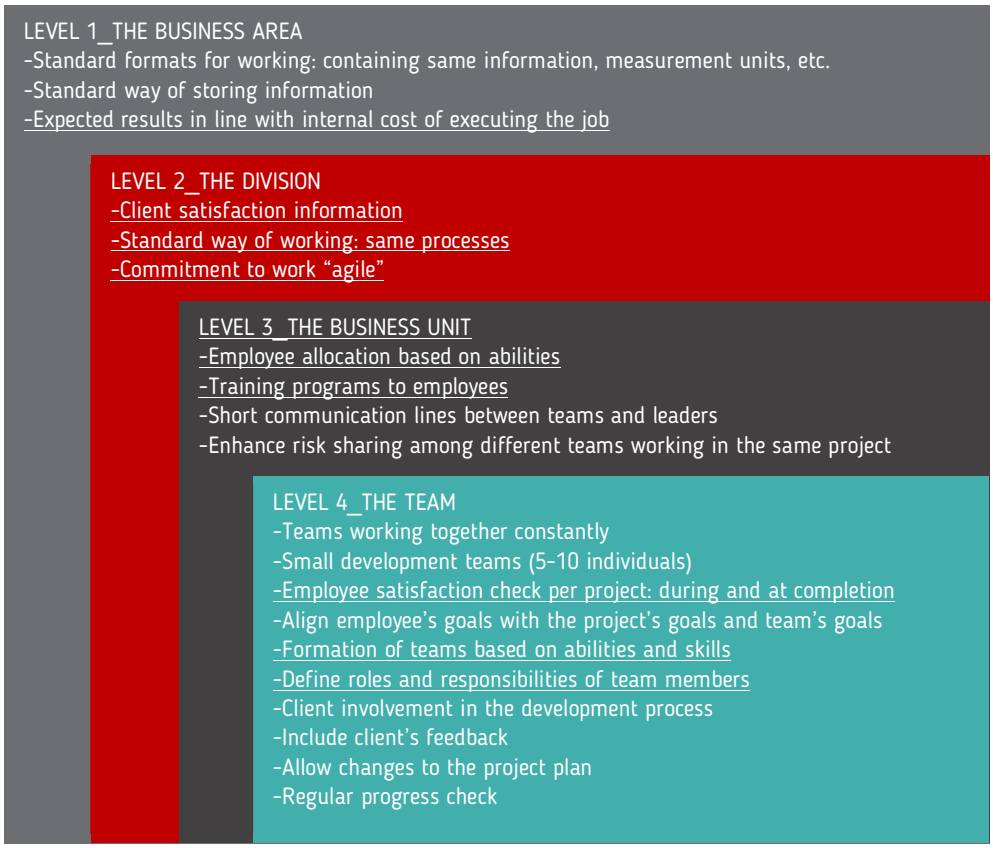


Figure 5-1 Guidelines for the application of agile management in Sweco NL, per organizational layer

5.4.2 RECOMMENDATIONS FOR FURTHER RESEARCH

The results found in this investigation show that agile is being applied in the construction industry, although still has many constraints. Based on these results and the limitations explained previously in this chapter, the following list elaborates on point to focus for further research.

- This research proposed a list of indicators to measure the performance of project management from the combination of different literature. However, it was found that in practice, many of these indicators were not applicable to a project level. Further research could be done to expand the list to measure the performance of project management, focusing on project level.
- In the same subject of performance, the list for performance measurement combined indicators from the literature and the ones used in practice by one consultant engineering company. These last indicators found in practice were linked directly to the objectives and procedures conducted by this company, and the application in other companies could be limited. Expanding the research on different organizations, could generalize in the indicators to measure performance in practice, and could help to cope with this limitation.
- The majority of the performance measurement conducted in this study was qualitative and subjective due to the lack of data and/or quality of the information. For a future study, it is recommended to focus on quantitative data, to be able to triangulate the results obtain more as objective outcome.
- Due to the combined approaches found in practice between agile and traditional management, it is recommended that prior following further research about the applicability of agile in construction projects, an ex-ante evaluation of the agility levels of the project is elaborated.
- For establishing these agility levels of projects, this research elaborated a set of indicators to measure agility on broad terms. A further research could focus on just one agile tool, and elaborate indicators to measure its applicability. Thus, establish the agility of the project by focusing on indicators associated with one tool, the accuracy of agility levels could increase.
- The projects analyzed for this study were completed around two to three years. It would be valuable to expand the research to study the application of agile management over more recent projects.
- The guidelines recommended by this investigation were assumptions made from the case studies and were not used in practice. Further research could evaluate the performance of projects that have applied these recommendations, to evaluate their validity.
- There is still not definitive literature or parameter of how agile management enhances the performance of project management. Thus, following further research about the agile in the construction industry is a feasible subject for future research.

Additionally, different research alternatives could be used. Two different scenarios could be proposed for handling the data obtained from the projects: one, about evaluating the quality of the data, and the other, a change in the data analysis.

The first scenario is an ex-ante data evaluation. This scenario proposes a deeper inquiry about the data that could be obtained from the company, in order to shape and design the research accordingly. Doing this in the research early phases could give a complete picture of the information available and the quality of the data. By having an overall data quality assessment form an initial phase, the study can focus on how to maximize the results with scarce information, or change investigation procedures to fit better.

The second scenario is a change in the evaluation procedure if having the same data available. A different procedure could be the expansion of the respondents of the interview and survey, by having three

different answer groups, one for each of the analysis units. For the first category, front-end activities would be asked only to project managers, as these actors shown to have a broader view of the process, making their answers more valuable. The second category, performance, would be divided into three focus groups. The indicators related to the client should be answered by this party, avoiding involving the perception of thirds parties into the process. As should happen for the indicators related to the employees, where these actors answer for these indicators. For the project related indicators, the focus group would be the PM and its entire development team, as all these actors were involved in the process and are aware of the results. The last category, agility, should be answered as well by this last group of PM and team, for the same reasons as the project related KPIs.

As a general remark, additional to the recommendations mentioned above, it is important to mention that the initial objective of this research was to develop a decision-making model by which a company could decide on the managerial approach to using during the Front-End phase of a project. This model would take the project's particular features such as costs, construction time, constructed area, stakeholder involved, inter alia, to establish if an agile management approach suited better the development, or the company should use traditional methods. During the elaboration of this study, especially during the case study phase, this objective was changed, due to the limitations of information. For proposing such a model, it was realized the need to study the application of agile management over more cases and, moreover, expand the amount of information about them. This research could be used as an initial step in the elaboration of such a scheme.

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APPENDICES

APPENDIX A. GLOSSARY

Agile project management (APM)	Iterative and incremental method of continuous innovation, based on constant testing, improvement, and adaptability with an informal communication and an evolutionary-delivery model. This style is oriented towards an organic development, in which the management focuses on leadership and collaboration, on the basis of constant communication and involvement of the development team (Dybå & Dingsøyr, 2008).
Agility	Set of capabilities that an organization/project needs to thrive and complete in a continuous changing and unpredictable business environment. (Mafakheri et al., 2008).
Efficiency	Are we doing the things right? Franceschini et al. (2007).
Effectiveness	Are we doing the right things? Franceschini et al. (2007).
Font-End Development (FED)	Initial phase of the project, in which the necessary information to approach a project is developed (Gibson et al., 2006).
Lean management	Evolution of the Toyota production methodology developed in the late 1970's, with the main idea of eliminating waste among production processes and therefore, reducing costs. The core of Lean relies on the basic concept of efficiency: generate an output by producing the least possible waste (Puvanasvaran et al., 2008).
Productivity	Maximum possible output that can be obtained by a determined input (Coelli et al., 2005).
Work Breakdown Structure (WBS)	Subdivision of the project deliverables and project work into smaller, more manageable components. A WBS provides a structured vision of what has to be delivered (Project Management Institute Inc. (PMI), 2013).

APPENDIX B. SCRUM

Scrum roles

The actors involved in the projects can be grouped in three categories: Product owner(s), Stakeholders and Development Team. The Product Owner is responsible for maximization of value and work of the Development Team. Subsequently the Development Team is the generator of increments over the project (Schwaber & Sutherland, 2016).

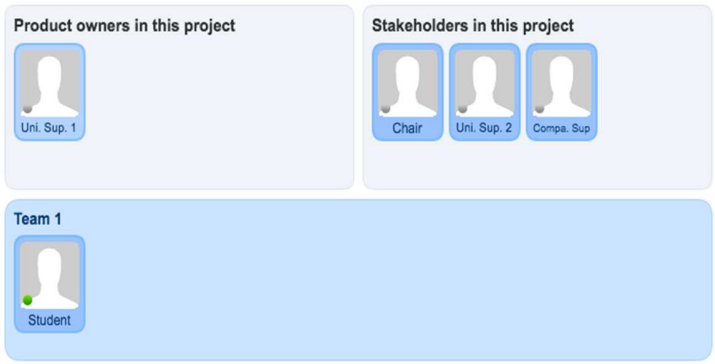


Figure B-1 Scrum Roles

Scrum tools

a) Product Backlog

The Product Backlog is the complete set of elements that are needed to achieve the goal of the Sprint. It contains a set of tasks with attributes, as description, order, value. The evolution of the Backlog products determines the percentage of completion towards the Sprint, therefore is dynamic and can be subjected to constant changes to comply with the product's needs. The responsibility for the Products Backlog relies on the Product Owner (Schwaber & Sutherland, 2016).

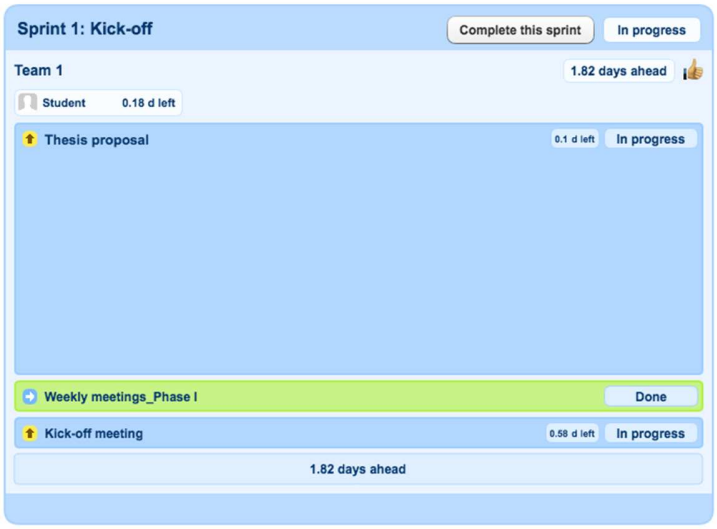


Figure B-2 Product Backlog Scrum

b) Task Board

Each of the Backlog Products is subsequently composed by a set of individual tasks. The percentage of completion of each task need to be filled up constantly, what groups them as to do, in progress, to test and done. Figure B-3 shows an example of the board of tasks. On the left column, each of the Backlog products that compose the Sprint and four additional columns that classify the task according to their degree of completion.

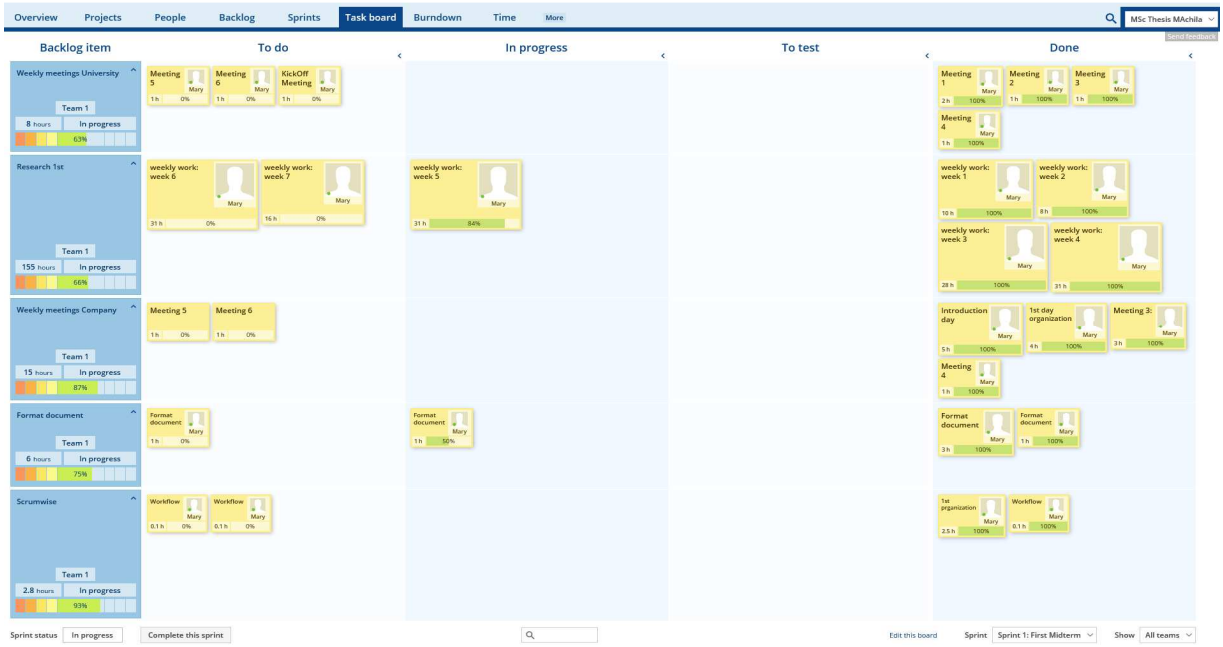


Figure B-3 Task Board Scrum

Scrum events

Scrum's core is called 'the Sprint', and it is a time-box of one-month work in which a specific goal is set, that is why sprints are usually considered as one-month projects. Additionally, four main events that support the Sprint: Sprint planning, Sprint review, Sprint retrospective and Daily Scrum (Schwaber & Sutherland, 2016).

For inspection and adaptation, four formal events are prescribed: Sprint Planning, Daily Scrum, Sprint Review and Sprint retrospective. The first three events have directly connected the Sprint and their frequency is linked to the occurrence of the Sprints.

Table B-1 Scrum Events (Schwaber & Sutherland, 2016)

Event	Duration	When?	People involved	Goal
Sprint Planning	5 hours/ 1-month Sprint	Initiation/ After completion of the Sprint	Product Owner Development Team	Set Goal for next Sprint How to achieve the Goal?
Sprint Review	4 hours/ 1-month Sprint	After completion of the Sprint	Product Owner Stakeholders Development Team	Revise the outcome of the Sprint and propose the necessary adaptations.
Sprint Retrospective	3 hours/ 1-month Sprint	After Sprint Review	Development Team	Inspection of the team and necessary improvements
Daily Scrum	15 minutes	Every day	Development Team	Create a 24-hr. team plan revise what was executed

Scrum Process

Figure B-4 combines the Scrum elements mentioned over the previous sections, giving a general overview of the entire process.

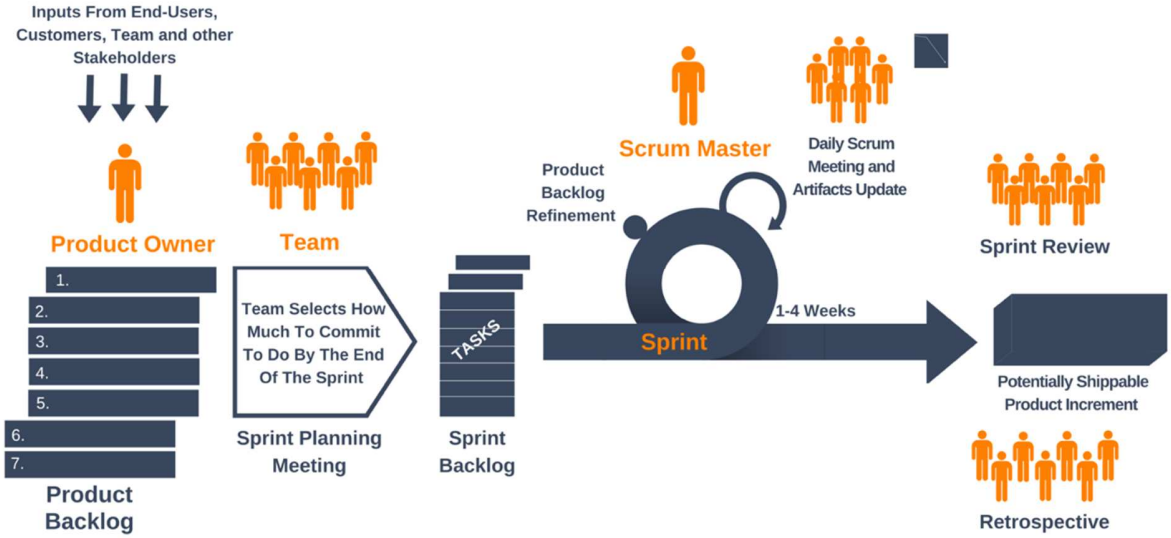


Figure B-4 Scrum process and elements (Yanado)

The initial step is the definition of the roles that will be played by each member. To start, the product backlog is settled by the product owner, as is the one knowing the purpose of the project as is the one that received the input from external actors. Then, the sprint planning meeting takes place, where the development team sets the goal of the sprint and the methodology for its development, and the specific set of tasks for the sprint are set. By this point, the sprint is ready to start. The sprint can have a duration of one to four weeks, with a daily scrum meeting occurring every day, where the development team creates a plan to execute for the upcoming 24 hr. The sprint finishes with the generation of a product or partial product. After completion of the sprint, the sprint review meeting takes place where the team, owner, and stakeholders revise the outcome of the sprint and discuss the possible adaptations for the next phase. Lastly, a sprint retrospective meeting is held by the development team, to do an internal review. The process is repeated until the project is completed.

APPENDIX C. EARNED VALUE MANAGEMENT (EVA)

The three initial parameters are:

- Planned Value (PV); also known as Budgeted Cost of Work Scheduled (BCWS), and is the budgeted baseline for every scheduled activity.
- Actual Costs (Owen et al., 2006), or Actual Cost of Work Performed (ACWP), is the cumulative actual cost spent at a given point in time (Jugdev & Müller, 2005).
- Earned Value (EV), or Budgeted Cost of Work Performed (BCWP), refers to the amount budgeted for performing the work that was accomplished by a given point in time, or the percentage of completion (PC) times the budget at completion (BAC) (Jugdev & Müller, 2005).

Earned Value	$EV = PC - BAC$	(1)

Vanhoucke (2009) defines groups the indicators in steps to measure EV. Initially the key parameters. Derived from this the indicators that measure performance. And lastly, the indicators to forecast behavior, based on the previous category (See figure above).

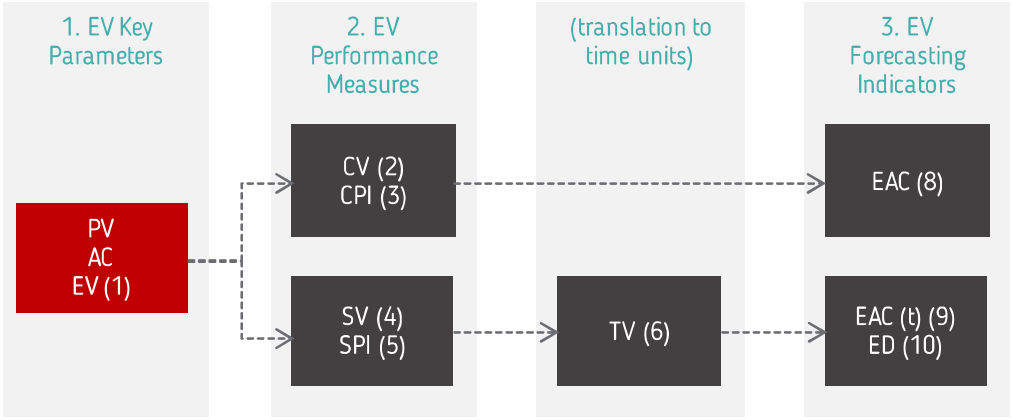


Figure C-1EVM: key parameters, performance measures and forecasting indicators based on (Vanhoucke, 2009)

From these parameters, the performance of the project can be quantified by calculating the variances with relation from respective baseline (Vanhoucke, 2009).

Cost variance	$CV = EV - AC$	(2)
Cost performance index	$CPI = EV/AC$	(3)
Schedule variance	$SV = EV - PV$	(4)
Schedule performance index	$SPI = EV/PV$	(5)

All the previously mentioned performance measures are monetary units, including the SV and SPI. To keep track of the performance of the project in terms of schedule, these measures should be expressed in time units. This can be done using Time Variance (TV) for the SV and Earned Duration (ED) for the SPI. Time variance is the relation between the schedule variance SV and a planned value rate (PVrate). PVrate is at the same time, are the relation between the budget at completion and the planned duration PD (See equations (6) and (7)).

Time Variance	$TV = SV/PVrate$	(6)
Planned Value Rate	$PVrate = BAC/PD$	(7)

The forecast the future behavior of the project results from adding the actual state to the planned remaining work. As an additional tool, the earned duration (ED) can calculate the project's final duration, based on the SPI and the actual duration AD (Vanhoucke, 2009).

Estimated Costs at Completion	$EAC = AC + PCWR$	(8)
Estimated Duration at Completion	$EAC(t) = AD + PDWR$	(9)
Earned Duration	$ED = AD * SPI$	(10)

APPENDIX D. PERFORMANCE INDICATOR PROPERTIES AND DEFINITIONS

Table D-1 Definition of properties of performance indicators according to (Caplice & Sheffi, 1994; Doran, 1981); Franceschini et al. (2007); (del-Río-Ortega et al., 2013)

Characteristic	Definition
Accurate	Sufficient level of detail Not provide more than the required information
Assignable	Stipulates on the subject that is performing the action
Available	Uses available data
Comparable	Can be compared across time, location and organizations Broad application
Compatible	Compatible with the exiting information
Compensation	Any change in an aggregate of indicators should compensate each other, without making changes on the specific indicator (s).
Economical	The benefits compensate the cost of using the indicator
Impact on stakeholders	Analyze the impact on the process for the stakeholders
Integrated	Include all important aspects of the system, not omitting anything
Long-term goals	Incentivize the achievement of long-term goals
Meaningful	Accurate when transforming the type of scale
Measurable	Quantifiable
Monotonous	Any change in an aggregate of indicators should be directly linked to the change of specific indicator (s).
Non-counter productive	Non-incentive counterproductive acts
Non-redundant	Does not include extra / unnecessary indicators
Realistic	Stipulates on the results that expect to be obtained
Reliable	Control for errors in data collection / repeatable
Scale Type	Uses a correct type of numerical scale
Specific	Target a specific area Represents the representation target
Time-bounded	Stipulates when the results expect to be obtained
Understandable	Easy to understand and use
Uniform	Viewed and interpreted similarly by all the parties
Useful	Provide a guide to take actions
Valid	Capture events and activities accurately

APPENDIX E. CLASSIFICATION OF EARLY PROJECT PHASES

Table E-1 Table 5 3 Early project phases classification, according to Al-Jibouri and Haponava (2009); Bosch-Rekveldt (2011) and George et al. (2008)

SOURCE	PHASES IN FRONT-END DEVELOPMENT					
RIBA, 1973	Conception		Feasibility	Outline proposal	Scheme design	
(Morris & Hough, 1987)	Pre-feasibility		Feasibility		Design	
(Kagioglou et al., 1998)	Demonstration of need	Conception of need	Outline feasibility	Substantive feasibility and financial authority	Outline conceptual design	Full conceptual design
(Best & De Valence, 1999)	Project idea sources	Concept development	Evaluation stage		Definition stage	
(Cho, Furman, & Gibson, 1999)	Perform business planning		Perform pre-project planning			
(Smith & Jackson, 2000)	Idea	Conception phase	Client development brief	Evaluation phase	Commitment to proceed	
(Woodhead, 2000)	Initial idea	Capital proposal	Outline case		Full case	Decision approval
(Hutchinson & Wabeke, 2006)	Identify and assess		Select		Define	
(George et al., 2008)	Business planning	Contracting strategy	Project execution plan		Site development	Technical plan
(Oosterhuis, 2008)	Define business case		Do conceptual design		Do basis engineering	
Al-Jibouri and Haponava (2009)	Initiative phase		Feasibility phase		Project Definition phase	
(IPA, 2009)	Appraise		Select		Define	
Bosch-Rekveldt (2011)	FED1		FED2		FED3	

APPENDIX F. DEFINITIVE LIST OF KPIS FOR CASE STUDIES

Table F-1 List of KPIs for evaluation during case studies

Category		KPI	Obtainment	
			Data / calculation	Interview
Financial		Operative profit	✓	
		Cost of Quality	✓	
		Project result variation	✓	
Customer		Customer Satisfaction		✓
		Responsiveness		✓
		Mutual trust		✓
Employees		Employee Satisfaction		✓
		Employee Motivation		✓
		Training Time		✓
		Employee Empowerment		✓
		Alignment to Strategic Business Goals		✓
		Team performance		✓
Project	**Costs and Time**	planned value / BCWS	✓	
		actual cost performed (ACWP)	✓	
		earned value (EV or BCWP)	✓	
		cost performance index (CPI)	✓	
		Budget deviation	✓	
		schedule variance (SV)	✓	
		schedule performance index (SPI)	✓	
		assigned time	✓	
		Time variance	✓	
		Time to Market		✓
	integration	Process Errors		✓
		Defects		✓
		Rework	✓	✓
		task interdependencies		✓
		Scope Changes		✓
		Quality of product		✓

+

APPENDIX G. INTERVIEW FORMAT

INTERVIEW DETAILS				
INTERVIEWER	Name	Mary Archila Lamus	Interview code	[Case number] – [Interview number]
	Date			
INTERVIEWEE	Name		Department	
	Background		Project	
	Years Exp.		Role in the project	

Interview Part 1: Introduction (5 min)

- Thank them for participating in interview
- Introduce myself
- Explanation about the research and its progress
- Explanation why the interview helps the research
- Ask permission to record interview

Goals of the interview

- Evaluate the performance of project management of infrastructure projects.
- Determine the activities of the front-end phase of infrastructure projects.
- Establish the relation between the management approach used and the performance of the project, focusing on agile project management.

Interview Part 2: Questionnaire (55 min)

Front-End Activities

1. From the online file "Front-End Activities", could you cross-check the activities conducted in the project? At the end of this table, there in this a space, you can add activities that were performed and are not on this list.
2. How did you plan your project at the beginning?
3. How did you estimate the duration of the tasks the team has done?
4. How did you build your team?
5. Do you consider that a good planning of this phase is important/not for the development of the rest of the project?
6. What degree of influence would you give to this phase over the entire project? (%)
7. How long (approx.) did this project lasted? (the part from start to delivery to client)

Performance of the Project and Project Management

8. How is the performance of the project usually measured? Are there any KPIs established?
9. Do you consider the management of the project influences its performance?
10. Is there any performance measurement for the management of the project? Which?
11. What about the performance of the team involved, it is measured? How?
12. In order to validate a series of indicators to measure the performance of project management., I will ask you now to fill the online questionnaire called "KPIs".

Project Agility

13. In order to determine the level of agility of the project, a series of indicators were developed. In this moment, could you please fill the online questionnaire "Agility".

Project Outcome

14. For which part of the project was Scrum (APM) used? For how long?
15. What was the objective of using Scrum (APM)? Was this objective meet?
16. If you compare this project, with the other projects you have been involved in, do you consider that the use of Scrum (APM) increased or decreased its efficiency? In how much would you quantify this change? (approx. +/- %)
17. Why do you think Scrum (APM) was no longer used for conducting infrastructure projects?

Interview Part 3: Closure (3 min)

- Ask the interviewee if he/she has any questions or comments
- Agreements
- Anonymity
- Use information from interview for academic purposes
- Informing interview of research results
- Thank interviewee

APPENDIX H. SURVEY FED ACTIVITIES

Front-End Activities

This questionnaire intends to determine the activities conducted during the front-end development (FED) of an infrastructure project, the phase in which the necessary information to approach a project is developed (once is awarded to the company). FED can be divided into sequential phases to achieve its goal: initiation, feasibility, and definition.

You will be given a list of activities that are normally conducted during each of these phases of FED. The objective is to check the activity (by clicking on the box "yes"), if you did it for the project of study (if you did not do it, do not mark it).
You might find the same activity in all the sub-phases, as the product generated from the activity is refined on each step.

At the last section, you can add other activities that you did, but were not listed

* Required

Name *

Your answer

Role in the project *

Your answer

Initiation Phase

Define business goals

☐ Yes

Define project objectives

☐ Yes

Identify project requirements

☐ Yes

Identify and select project alternatives

☐ Yes

Cost estimate

☐ Yes

WBS Level 1 schedule

☐ Yes

Risk identification and management

☐ Yes

Contracting strategy

☐ Yes

Asses stakeholder involvement and feedback

☐ Yes

Establish image and refine public relations

☐ Yes

Technology review and selection

☐ Yes

Conduct market research and analysis

☐ Yes

External benchmarking

☐ Yes

Address regulatory issues

☐ Yes

Project execution plan (human and materials)

☐ Yes

Feasibility Phase

Define Scope

☐ Yes

Cost estimate

☐ Yes

WBS Level 2 schedule

☐ Yes

Analysis of safety and quality issues

☐ Yes

Risk identification and management

☐ Yes

Compose the project team

☐ Yes

Basics of design

☐ Yes

Prepare specifications

☐ Yes

Project execution plan (human and materials)

☐ Yes

Definition Phase

Basic engineering

☐ Yes

Cost and revenue assessment

☐ Yes

WBS Level 3 schedule

☐ Yes

Analysis of safety issues

☐ Yes

Risk identification and management

☐ Yes

Define funding strategy

☐ Yes

Prepare contracting plan

☐ Yes

Define strategic activities, duration and interfaces

☐ Yes

Project implementation plan

☐ Yes

Execution schedule

☐ Yes

Control and performance plan

☐ Yes

Communication plan

☐ Yes

Project management plan

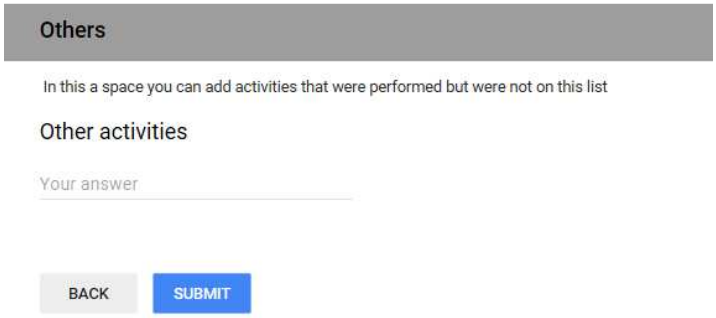
☐ Yes

Team building / Human resource management

☐ Yes

Dynamic corrections

☐ Yes

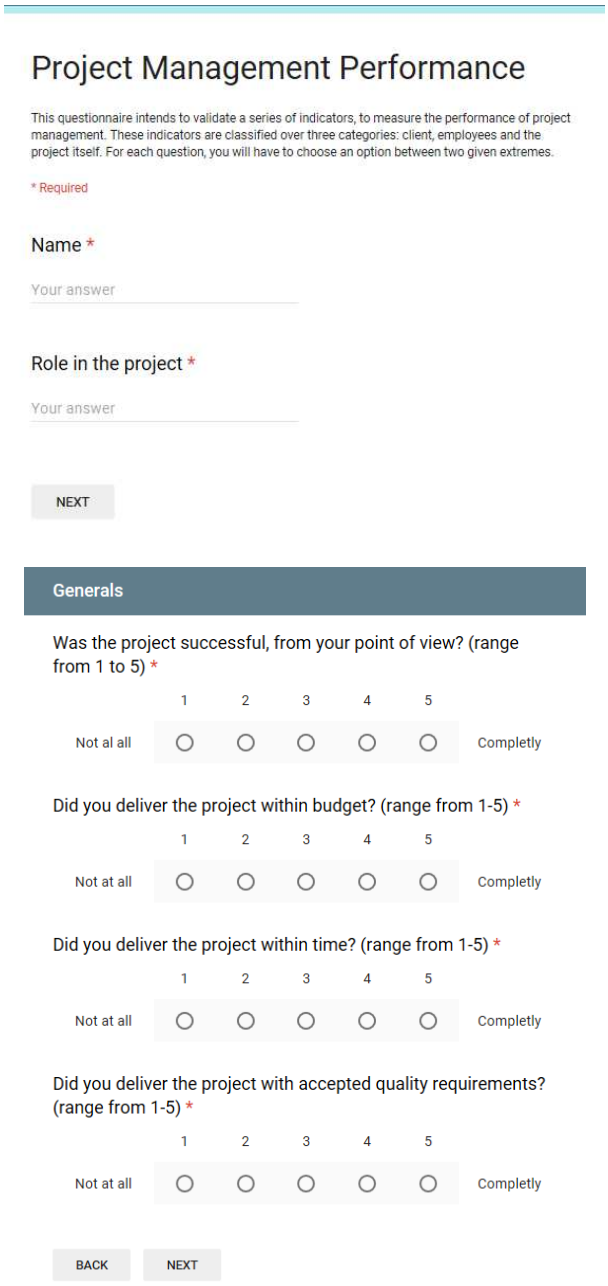

Others
In this a space you can add activities that were performed but were not on this list
Other activities
Your answer
BACK
SUBMIT

APPENDIX I. RESULTS ON FED ACTIVITIES

Table I-1Results of FED activities per management approach

FED Phase and Activity / Project	Agile Managed Projects	Traditionally Managed Projects	Total
Initiation			
Define business goals	3	1	4
Define project objectives	5	2	7
Identify project requirements	6	2	8
Identify and select project alternatives	5	1	6
Cost estimate	5	3	8
WBS Level 1 schedule	5	1	6
Risk identification and management	6	1	7
Contracting strategy	4	0	4
Asses stakeholder involvement and feedback	4	1	5
Establish image and refine public relations	2	0	2
Technology review and selection	5	1	6
Conduct market research and analysis	2	0	2
External benchmarking	1	0	1
Address regulatory issues	4	1	5
Project execution plan (human and materials)	6	1	7
Feasibility			
Define Scope	5	3	8
Cost estimate	4	3	7
WBS Level 2 schedule	5	0	5
Analysis of safety and quality issues	3	1	4
Risk identification and management	6	1	7
Compose the project team	6	2	8
Basics of design	3	2	5
Prepare specifications	3	1	4
Project execution plan (human and materials)	5	2	7
Definition			
Basic engineering	5	2	7
Cost and revenue assessment	4	0	4
WBS Level 3 schedule	3	0	3
Analysis of safety issues	2	0	2
Risk identification and management	5	0	5
Define funding strategy	1	0	1
Prepare contracting plan	5	1	6
Define strategic activities, duration and interfaces	5	0	5
Project implementation plan	3	0	3
Execution schedule	6	1	7
Control and performance plan	5	0	5
Communication plan	2	0	2
Project management plan	5	0	5
Team building / Human resource management	5	0	5
Dynamic corrections	6	0	6
Others			
Structuring teams for working with scrum	2	0	2
Review documents with regards to process/product	1	0	1

APPENDIX J. PROJECT PERFORMANCE SURVEY



Project Management Performance

This questionnaire intends to validate a series of indicators, to measure the performance of project management. These indicators are classified over three categories: client, employees and the project itself. For each question, you will have to choose an option between two given extremes.

* Required

Name *

Your answer

Role in the project *

Your answer

NEXT

Generals

Was the project successful, from your point of view? (range from 1 to 5) *

	1	2	3	4	5	
Not al all	○	○	○	○	○	Completly

Did you deliver the project within budget? (range from 1-5) *

	1	2	3	4	5	
Not at all	○	○	○	○	○	Completly

Did you deliver the project within time? (range from 1-5) *

	1	2	3	4	5	
Not at all	○	○	○	○	○	Completly

Did you deliver the project with accepted quality requirements? (range from 1-5) *

	1	2	3	4	5	
Not at all	○	○	○	○	○	Completly

BACK NEXT

Client

Was the client satisfied with the final result? *

	1	2	3	4	5	
Not at all	○	○	○	○	○	Completely satisfied

How was the mutual trust level with the client? *

	1	2	3	4	5	
No trust	○	○	○	○	○	Complete trust

How was the responsiveness of the client, from beginning to end? *

	1	2	3	4	5	
The client was as unsatisfied at the end, contrary to its attitude at the beginning	○	○	○	○	○	The client was as positive at the end, as it was at the beginning

Employees

Were the employees satisfied? *

	1	2	3	4	5	
Unsatistied	○	○	○	○	○	Completely satisfied

Were the employees motivated? *

	1	2	3	4	5	
Not at all	○	○	○	○	○	Completely motivated

Did the employees attended training programs on subjects related to the project? *

	1	2	3	4	5	
No	○	○	○	○	○	Constantly

Where the employees empowered? *

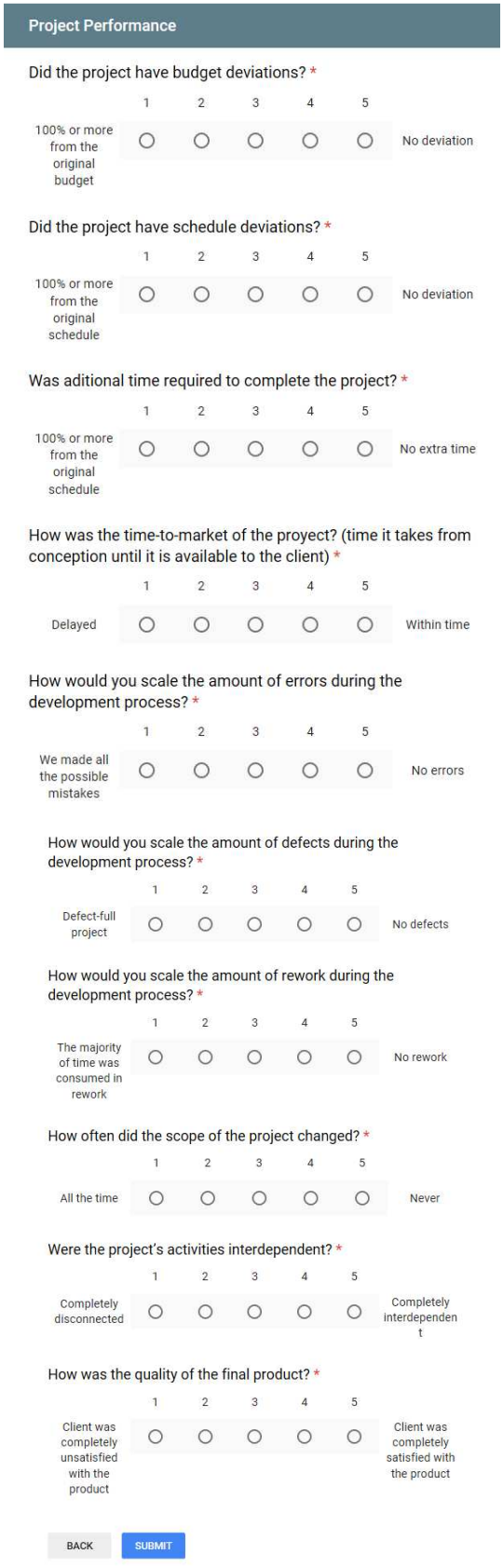
	1	2	3	4	5	
Not at all	○	○	○	○	○	Complete autonomy

Where the employee's goals in line with the project's goals? *

	1	2	3	4	5	
Not in line	○	○	○	○	○	Completely synchronized

How would you grade the performance of the team? *

	1	2	3	4	5	
Bad	○	○	○	○	○	Excellent



Project Performance

Did the project have budget deviations? *

	1	2	3	4	5	
100% or more from the original budget	○	○	○	○	○	No deviation

Did the project have schedule deviations? *

	1	2	3	4	5	
100% or more from the original schedule	○	○	○	○	○	No deviation

Was aditional time required to complete the project? *

	1	2	3	4	5	
100% or more from the original schedule	○	○	○	○	○	No extra time

How was the time-to-market of the proyect? (time it takes from conception until it is available to the client) *

	1	2	3	4	5	
Delayed	○	○	○	○	○	Within time

How would you scale the amount of errors during the development process? *

	1	2	3	4	5	
We made all the possible mistakes	○	○	○	○	○	No errors

How would you scale the amount of defects during the development process? *

	1	2	3	4	5	
Defect-full project	○	○	○	○	○	No defects

How would you scale the amount of rework during the development process? *

	1	2	3	4	5	
The majority of time was consumed in rework	○	○	○	○	○	No rework

How often did the scope of the project changed? *

	1	2	3	4	5	
All the time	○	○	○	○	○	Never

Were the project's activities interdependent? *

	1	2	3	4	5	
Completely disconnected	○	○	○	○	○	Completely interdependent

How was the quality of the final product? *

	1	2	3	4	5	
Client was completely unsatisfied with the product	○	○	○	○	○	Client was completely satisfied with the product

BACK SUBMIT

APPENDIX K. RESULTS ON PROJECT PERFORMANCE SURVEY PER PROJECT

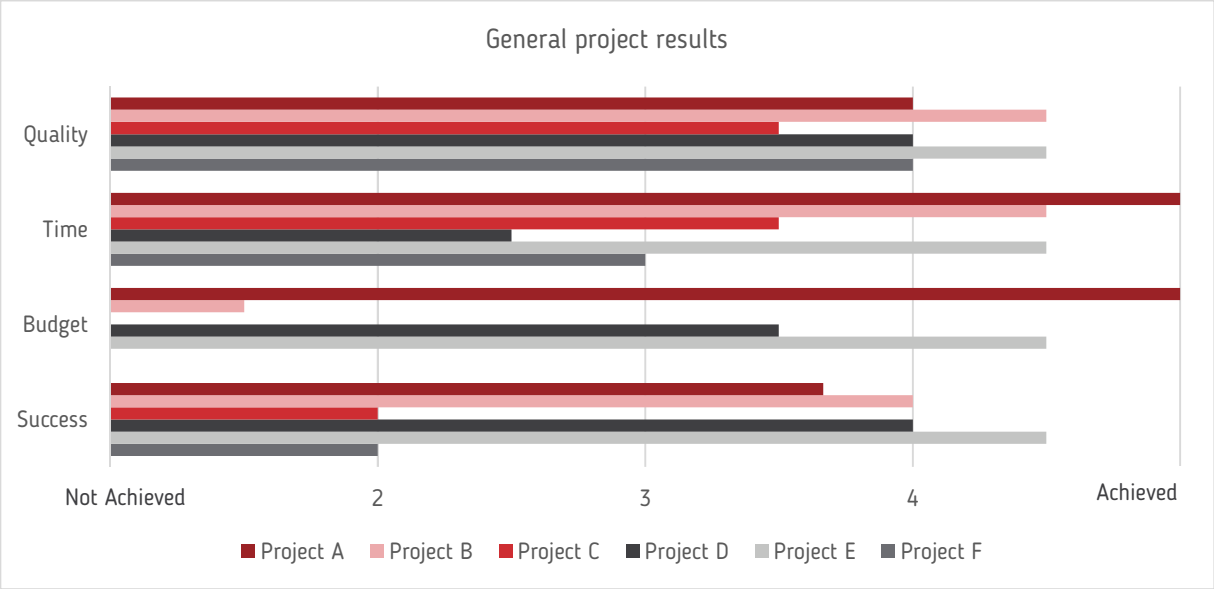


Figure. K-1 General perception of performance per project

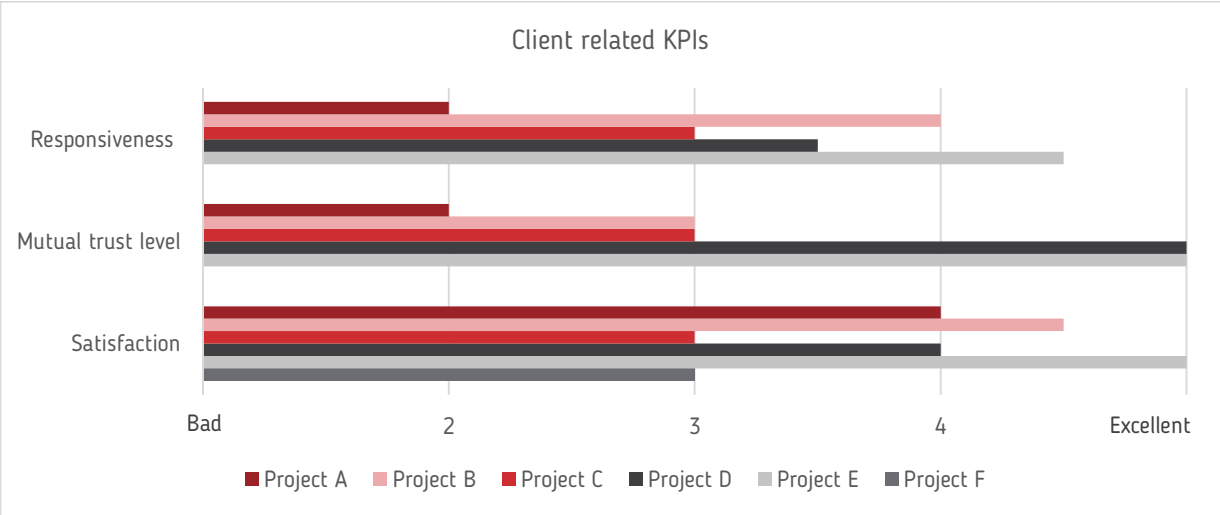


Figure. K-2 Performance based on client indicators (per project)

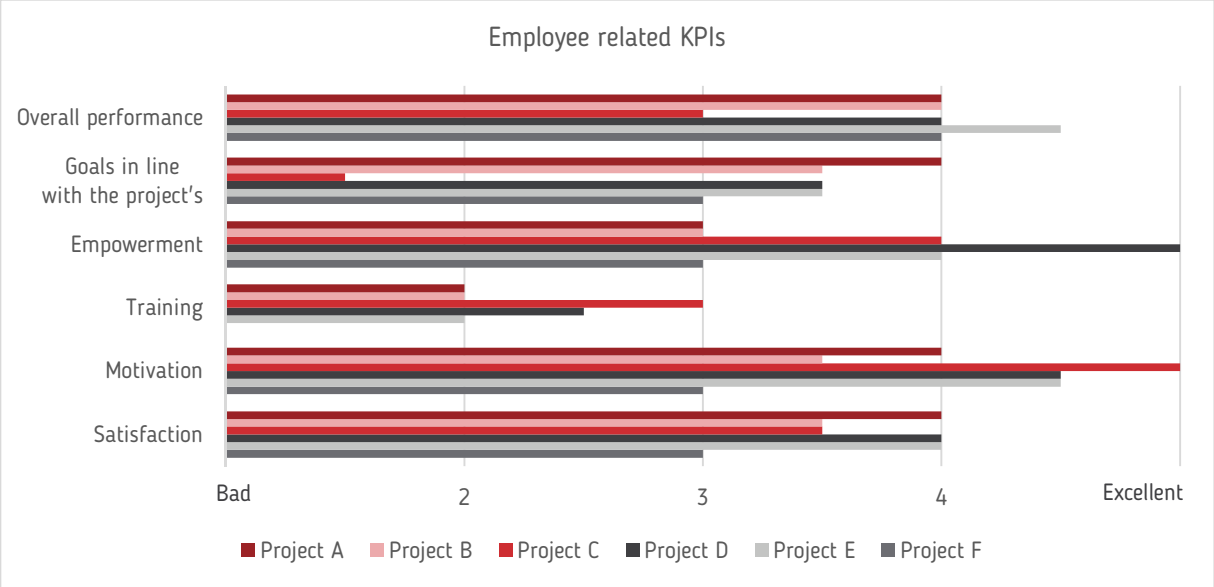


Figure. K-3 Performance based on employee indicators (per project)

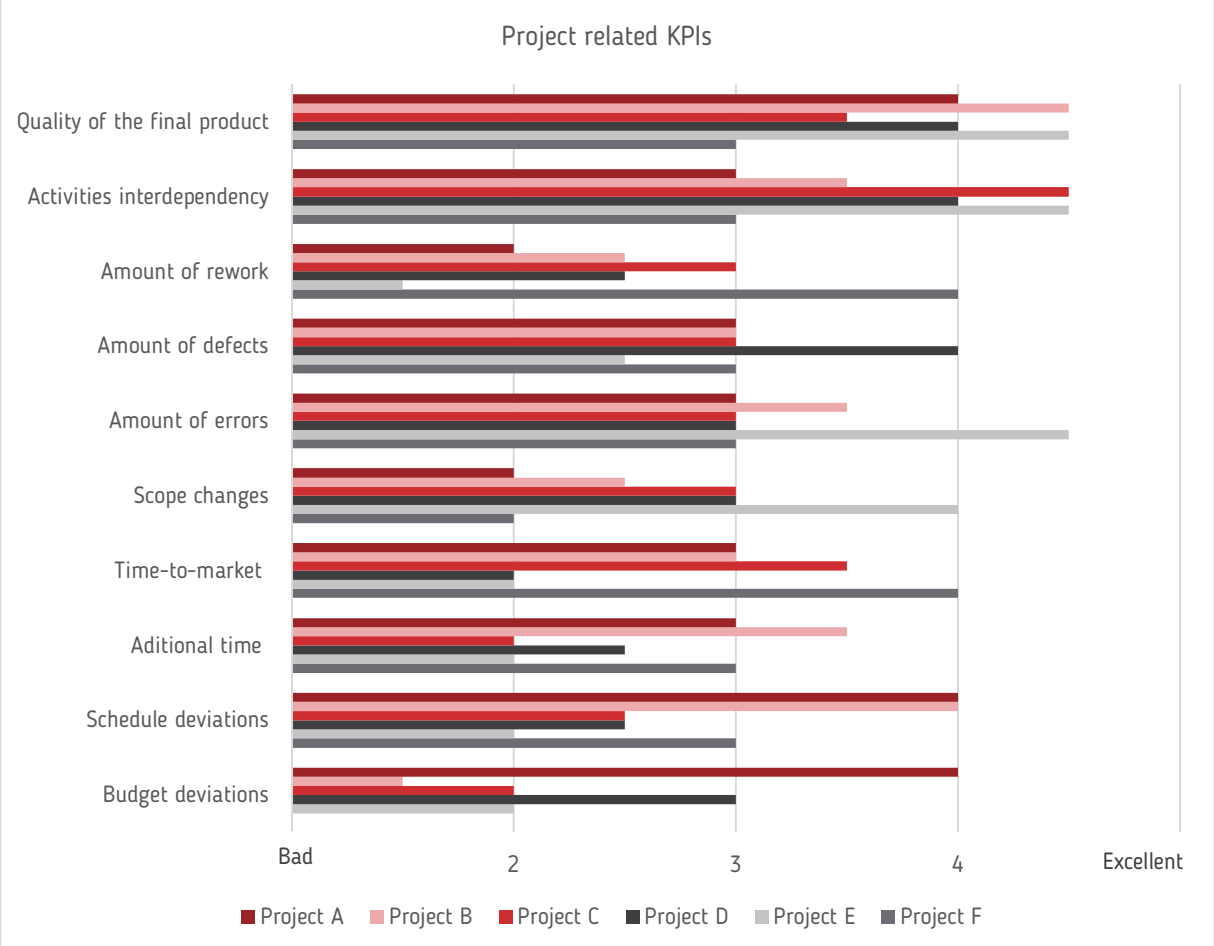


Figure. K-4 Performance based on project indicators (per project)

APPENDIX L. PROJECT AGILITY SURVEY

Agility of the Project

This questionnaire intends to evaluate the agility, related to the type of management techinque used for the project. You will be asked about the client, the planning, the development team, and the risks. For the majority of questions, you will have to choose an option between two given extremes.

* Required

Name *

Your answer

Role in the project *

Your answer

NEXT

Planning and Progress

How often was the progress of the project checked? *

- ◯ Once a year
- ◯ Once every six months
- ◯ Once a month
- ◯ Once a week
- ◯ Once a day

How often did the plan changed? *

	1	2	3	4	5	
Never	◯	◯	◯	◯	◯	Constantly

How was the structure of the project plan? *

	1	2	3	4	5	
Well-structured until completion	◯	◯	◯	◯	◯	Constructed on-the-way

Was what the attitude towards changing the project plan? *

	1	2	3	4	5	
Taking measures to get back to the original plan	◯	◯	◯	◯	◯	Room for changes

Client

How often where products delivered to the client? *

	1	2	3	4	5	
Just at completion	○	○	○	○	○	Constantly during the development process

Where there clients on-site while developing the project? *

	1	2	3	4	5	
Never	○	○	○	○	○	All the time

To what extend do you consider benefitial to include the client's feedback during the development process? *

	1	2	3	4	5	
Jeopardizes the process	○	○	○	○	○	Improves the process

Was the feedback from the client incorporated in the project? *

	1	2	3	4	5	
Not feedback was taken into account	○	○	○	○	○	All the feedback received was included

Was the client´s satisfaction evaluated during the project? *

	1	2	3	4	5	
Never	○	○	○	○	○	Constantly

Team

How was the process for composing the team? Was it based on skills, background, experience, others? *

Your answer

How big was the developing team? *

- ○ Between 1 and 5 people
- ○ Between 5 to 10 people
- ○ Between 10 to 15 people
- ○ More than 15 members

Where the roles of each member of the team specifically defined? *

	1	2	3	4	5	
Not defined at all	○	○	○	○	○	Specifically defined

How often was the team working together? *

- ○ Never
- ○ Once every six months
- ○ Once a month
- ○ Once a week
- ○ Daily

Was the team empowered? *

	1	2	3	4	5	
Not at all	○	○	○	○	○	Complete autonomy

To what extent was the input from the team incorporated to the project? *

	1	2	3	4	5	
Not at all	○	○	○	○	○	Completely

Was the team motivated? *

	1	2	3	4	5	
Not at all	○	○	○	○	○	Completely

Were the satisfaction and motivation of the team evaluated during the development of the project? *

	1	2	3	4	5	
Never	○	○	○	○	○	Constantly

Risks

Where the risks of the project shared among the parties? (client-company-other companies involved) *

	1	2	3	4	5	
Risks transferred to one party	○	○	○	○	○	Risks shared among different parties

APPENDIX M. RESULTS ON PROJECT AGILITY SURVEY PER PROJECT

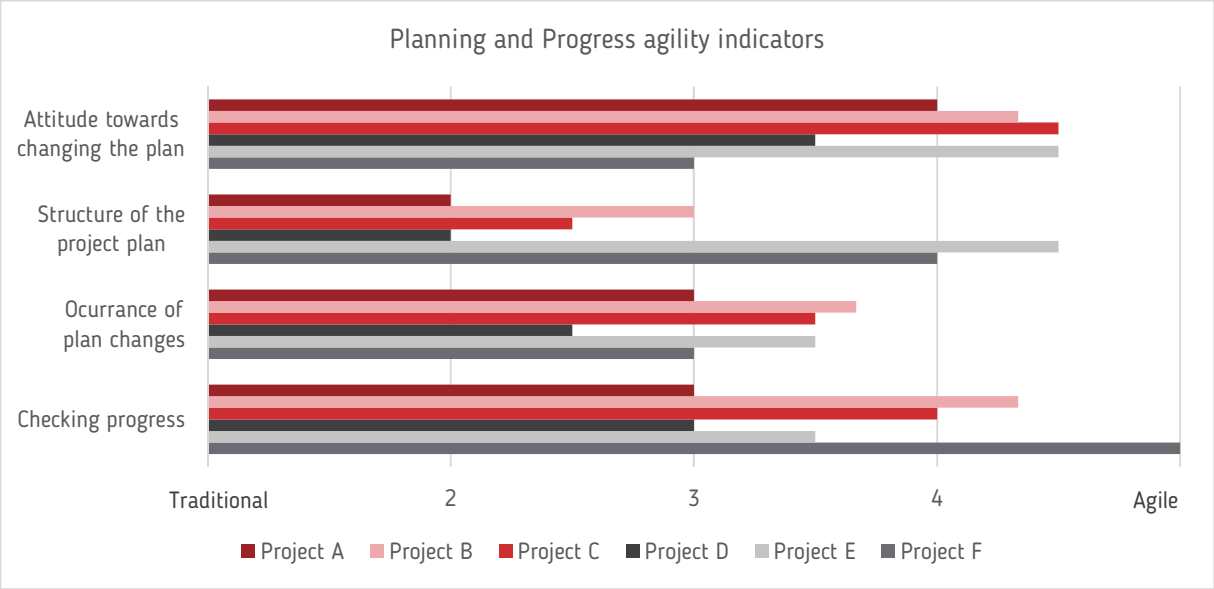


Figure. M-1 Agility based on planning and progress indicators (per project)

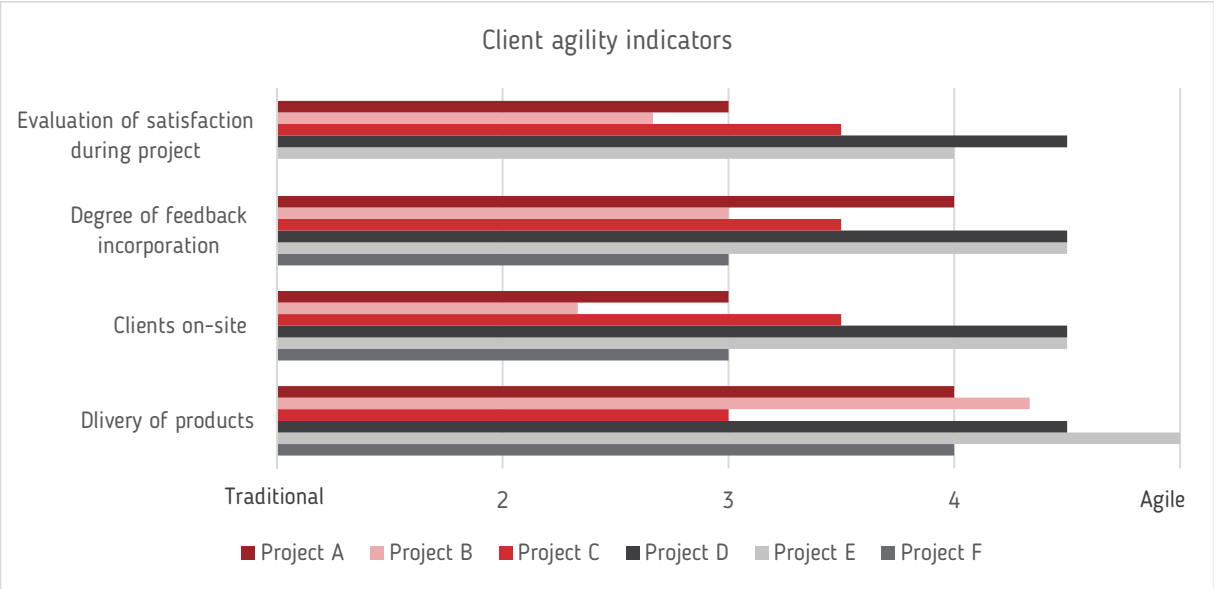


Figure. M-2 Agility based on client indicators (per project)

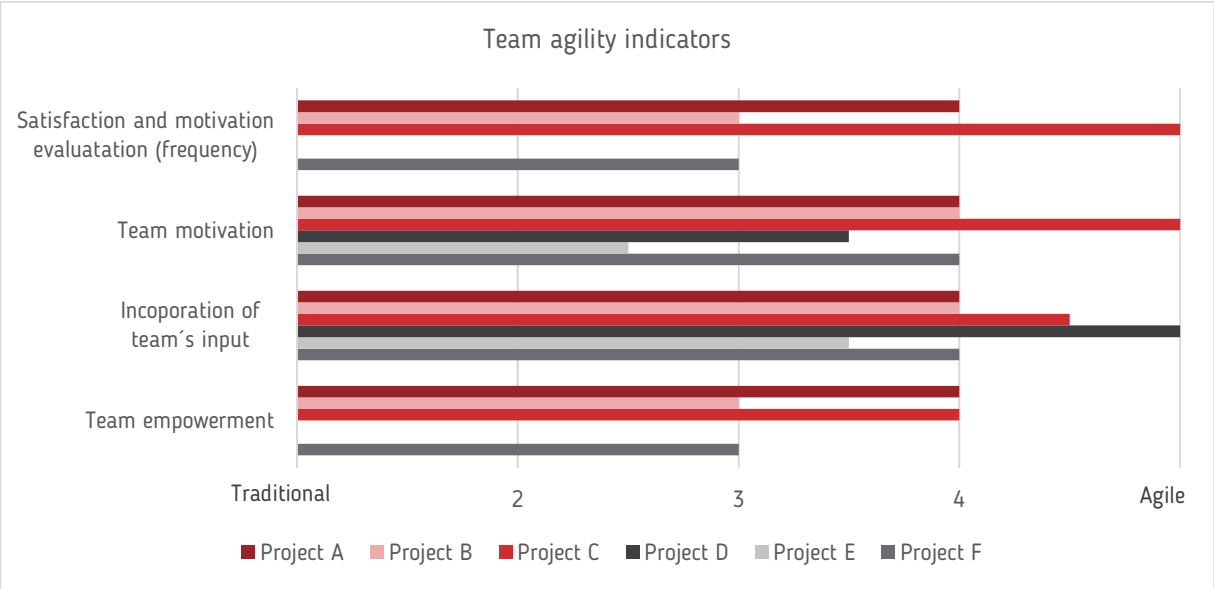


Figure. M-3 Agility based on team indicators (per project)

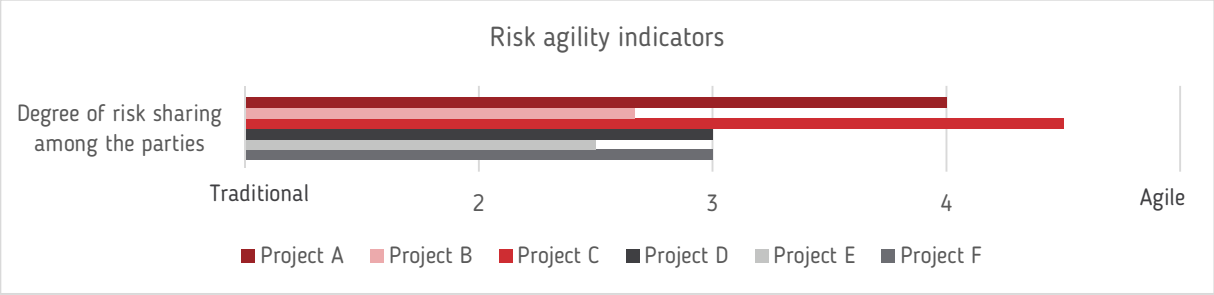


Figure. M-4 Agility based on risk indicators (per project)