AGILE PROJECT MANAGEMENT IN THE TURKISH CONSTRUCTION INDUSTRY

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AGILE PROJECT MANAGEMENT IN THE TURKISH CONSTRUCTION INDUSTRY

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ABSTRACT

AGILE PROJECT MANAGEMENT IN THE TURKISH CONSTRUCTION INDUSTRY

In today's business world, companies need to be more agile and seek to adapt to new conditions faster than before due to rapidly developing technologies, fast evolving business needs and increasing competition. Within the context of construction industry, the common problems of construction projects, which are low productivity, poor performance, insufficient quality, delays in project schedule, and cost overruns, are often associated with complexity of projects and uncertain project environment. As a response to the need for a new management methodology to overcome these problems, Agile Project Management, which is originally developed by software developers, and its adoption has recently become quite popular in construction industry. It is an project management approach based on delivering project requirements incrementally through short iterations by a small, self-organized, cross-functional team. In order to explore factors affecting Agile PM implementation in the Turkish construction industry, an integrated framework composed of 6 constructs and corresponding 42 indicators is established based on in-depth literature review and expert opinions. The data collected through questionnaire survey is analyzed statistically and findings are evaluated accordingly. As a result, It is found to be promising and have a great potential especially in detailed design and construction stages to meet the needs of construction industry for performance improvement. However, the clear benefits is yet to be demonstrated in construction industry. Effective leadership of top management and professionals' awareness of Agile PM is very critical at the beginning of implementation process. Besides, its recommended to combine Agile PM techniques with other management methods like lean, BIM, traditional PM etc. It is also found that that Agile PM doesn't have direct impact on reduction of time and cost but focuses to prevent delays and cost overruns and to increase perceived quality and client satisfaction through improvements in responsiveness to change, transparency and visibility of the project, communication and organization learning within the project team, and finally reduction of the risk.

ÖZET

TÜRK İNŞAAT SEKTÖRÜNDE ÇEVİK PROJE YÖNETİMİ

Günümüzün iş dünyasında, hızla gelişen teknolojiler, hızla değişen iş ihtiyaçları ve artan rekabet nedeniyle şirketlerin daha çevik olmaları ve yeni koşullara daha hızlı adapte olmaları gerekmektedir. İnşaat sektörü kapsamında, inşaat projelerinin ortak sorunları olan düşük verimlilik, yetersiz kalite, proje zaman gecikmeleri ve maliyet aşımları genellikle proje karmaşıklığı ve dinamik proje ortamıyla ilişkilendirilmektedir. Bu sorunların üstesinden gelmek için yeni bir proje yönetim metoduna duyulan ihtiyaca karşılık olarak önerilen "Çevik Proje Yönetimi" [PY] aslen yazılımcılar tarafından geliştirilmiş olup son zamanlarda inşaat sektöründe oldukça popüler hale gelmiştir. Küçük, kendi kendini organize eden, çok fonksiyonlu bir ekip tarafından kısa aralıklarla proje gereksinimlerinin aşamalı ve iteratif olarak teslim edilmesi prenisibine dayanan bir proje yönetimi yaklaşımıdır. Türk inşaat sektöründe Çevik PY uygulamasını etkileyen faktörleri araştırmak için, derinlemesine literatür taraması ve uzman görüşlerine dayanarak 6 ana faktör ve 42 alt faktörden oluşan entegre bir kavramsal çerçeve oluşturulmuştur. Anket yoluyla toplanan veriler istatistiksel olarak analiz edilip bulgular buna göre değerlendirilmiştir. Sonuç olarak, Çevik PY'nin inşaat sektöründe performansı iyileştirme gereksinimini karşılamak amacıyla özellikle detaylı tasarım ve yapım aşamalarında umut verici olduğu belirlenmiştir. Ancak, inşaat sektöründeki faydaları henüz belirgin bir şekilde ortaya çıkmamıştır. Üst yönetimin etkin liderliği ile inşaat profesyonellerinin Çevik PY hakkındaki farkındalığı ve bilgisi gibi faktörler bu yönetim biçiminin uygulama sürecinin başlangıcında çok önemlidir. Ayrıca, Çevik PY tekniklerinin yalın, BIM vb. gibi diğer yönetim biçimleriyle birleştirilmesi önerilmektedir. Son olarak, Çevik PY'in zaman ve maliyetin azaltılması üzerinde doğrudan bir etkiye sahip olmadığı, ancak gecikmeleri ve maliyet aşımlarını önlemeye ve kalite ve müşteri memnuniyetini artırmaya odaklandığı tespit edilmiştir. Proje değişiklik taleplerine cevap verilebilme, projenin şeffaflığını ve görünürlüğünü arttırma, proje ekibindeki iletişim ve organizasyonel öğrenme kabiliyetini geliştirme ve son olarak da riskin azaltılması gibi süreç iyileştirmeleri yoluyla proje sonucuna önemli katkı sağlamaktadır.

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LIST OF ACRONYMS / ABBREVIATIONS

AEC	Architectural, Engineering, Construction
AGFI	Adjusted Goodness of Fit Index
AMOS	Analysis of Moment Structure
ANOVA	Analysis of Variance
BIM	Building Information Modelling
CAD	Computer-Aided Design
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
dof	Degree of Freedom
DSDM	Dynamic Systems Development Method
ECI	Early Contractor Involvement
EQS	Equations
EU	Europe Union
GFI	Goodness of Fit Index
GLM	General Linear Model
GLS	Generalized Least Squares
ICT	Information and Communication Technologies
IFI	Incremental Fit Indexes
IT	Information Technology
ITC	Information Technology in Construction
KN	Knowledge Management
LISREL	Linear Structural Relationships
LSD	Least Significant Difference
ML	Maximum Likelihood
MMC	Modern Methods of Construction
NFI	Normed Fit Index
NNFI	Non-Normed Fit Index
OECD	Organization for Economic Co-Operation and Development
PM	Project Management

PMBOK	Project Management Body of Knowledge
PMI	Project Management Institute
R&D	Research and Development
RFI	Request for Information
RMSEA	Root Mean Square Error of Approximation
SEM	Structural Equation Model
SME	Small – Medium Enterprise
SPSS	Statistical Package for the Social Sciences
TCA	Turkish Contractors Association
TCEA	Turkish Construction Employers Association
TSLS	Two Stage Least Squares
UK	United Kingdom
USA	United States of America
USD	United Stated Dollar
WLS	Weighted Least-Squares

1. INTRODUCTION

In recent decades, due to rapidly developing technologies, fast evolving business needs and increasing competition, companies need to be more agile than before and seek to adapt to new conditions faster in their projects. For this reason, "Agile Project Management" [PM], its use and benefits in most of the business sectors as well as construction sector are widely investigated for ways of implementation by many researchers and companies. The origin of Agile PM methodologies in construction can be linked to the agile developments in both manufacturing and IT (Owen and Koskela, 2006). The purpose of this study is to investigate the perception and opinion of construction professionals for status and factors affecting agile PM implementation in construction projects. The background of the research, problem definition and statement, purpose and objectives of the study, related studies, research methodology, scope and limitations, and organization of the thesis will be presented in the following parts of introduction chapter.

1.1. Background of the Research

In today's world, projects are getting more complex, uncertain, and rapid since projects have more tendency to evolve during all stages due to new requirements arisen from dynamic project environment or changes requested by clients. In addition, the construction industry has got chronic problems of low productivity, poor performance, insufficient quality, delays in project schedule, and cost overruns which are often referred and studied by construction professionals and researchers. Those problems are usually attributed to factors like project complexity, dynamic and uncertain project environment, and scattered nature of construction projects with many stakeholders and poor communication among them. As a response to these difficulties listed above, Agile PM, which is originally created and used by software developers, is an approach based on delivering requirements iteratively and incrementally throughout the project life cycle by a small, self-organized, multidisciplinary team. There is vast amount of research about Agile PM in IT industry and its benefits make huge impact on success of IT projects. However, the literature is very limited for non-IT sectors especially for construction industry and methods of Agile PM in construction industry is yet to be defined and applicable.

1.2. Problem Definition and Statement

Due to the project based nature of construction industry, all projects are unique and its constraints and requirements are specific to itself in a dynamic and uncertain environment. This feature of construction industry presents one of the most complicated challenges to the management and organization of the construction firms. It is clear that construction industry needs a more transparent and respondent way of managing projects. There has been a number of solutions or ways to relieve these problems in construction or adopted from other industries. One of the most popular candidate to be adopted from IT industry is Agile PM since it takes advantage of collaborative, integrated and productive teams composed of key project participants guided by principles of trust, transparent processes, effective collaboration, open information sharing, organizational learning, shared risk and reward, and decision making based on prioritized value. Therefore, successful implementation of Agile PM in construction projects depends on various factors which needs to be investigated in detail to shed light on difficulties and critical considerations for future researchers and companies.

The major part of the current literature on Agile PM concentrates on IT and manufacturing industries, while Agile PM theories and practices have not been investigated empirically in the construction industry. This study is conducted on the basis of the definition and terms of agile PM and investigation of factors affecting its implementation in construction industry according to opinion of construction professionals. According to in-depth literature review and expert opinions, Agile PM has got multi-dimensions that needs to be investigated for a better understanding of the links between these components and its various dimensions of implementation. As a result, a comprehensive and logical framework is required to investigate direct and indirect effects of factors on Agile PM implementation in construction.

1.3. Related Studies

Agile PM in IT and manufacturing industries is well established and researched which helps success of projects significantly. However, the literature is limited for construction

industry. Koskela and Howell (2002a; 2002b) as well as Owen and Koskela (2006) first started to investigate the applicability of Agile PM in construction projects. Owen *et al.* (2006) claims that agile is immature for construction and further discussed the fundamentals of agile theory and its applicability to construction. It is argued that agile seems to be more applicable to the pre-design, design and the planning of the execution while agile principles and methods may present great potential for performance improvement. Chen *et al.* (2007) studied the relationship between agile and interface management. Ribeiro and Fernandes (2010) argued that agile methods has got high potential for managing the whole project with medium. Daneshgari (2010) discussed tangible principles and methods, through implementing those for several case studies in the form of electrical contractors. Demir *et al.* (2014) combined agile and lean concepts to present a potentially new framework, called "AgiLean PM". Suresh Kumar and McArthur (2015) discussed the application of Agile PM to BIM for an optimized process of collaboration, documentation, and life-cycle data management. On the other hand, Tomek and Kalinichuk (2015) introduced a hybrid scheduling approach by combining Agile PM and BIM in pursue of exploring its practical application. In recent years, there have been many academic studies which investigated applicability of agile methods in construction and non-software industries and drivers, barriers and other factors of its implementation (Nowotarski and Paslawski, 2015; Kashikar *et al.*, 2016; Gustavsson, 2016; 16-Streule *et al.*, 2016; Adut 2016; Ekström and Pettersson, 2016; Totten, 2017; Sakikhales and Stravoravdis, 2017; Sonneveld, 2018, Qaravi, 2018). In addition, Project Management Institute (2017) issued a comprehensive guide for agile practice guide which provides detailed information regarding agile methods and principles. However, there is still lack of research about Agile PM in the Turkish construction industry and there is still need for a comprehensive investigation of factors affecting Agile PM implementation in construction as well as relationships among them.

1.4. Aims and Objectives of the Study

The main purpose of this research is to investigate the perception and opinion of construction professionals for current status and factors affecting implementation of Agile Project Management [PM] in the Turkish AEC (Architectural, Engineering, Construction) industry. In order to do so, an integrated framework composed of factors and indicators of

Agile PM in the Turkish construction sector will be constructed based on extensive literature review. The validity of the framework and the relationships between factors and indicators will be explored and tested by statistical analyses using structural equation modelling (SEM) based on data collected through a questionnaire survey. Since the construction research on Agile PM is very limited and its implementation in construction projects is still not clear, this study will contribute significantly to construction literature and help companies to understand factors of Agile PM implementation and decide on long and short term strategies accordingly. The objectives of this research are determination of the determinants and indicators of Agile PM implementation, development of an integrated framework for Agile PM implementation in construction projects with special focus on Turkish construction industry, and investigating the interrelations among factors affecting Agile PM implementation in construction projects.

1.5. Research Methodology

As a result of an extensive literature review, a conceptual framework for the factors affecting Agile PM implementation in the Turkish construction industry is proposed in a structured and logical framework. In order to measure and identify the importance of this framework and its components, a questionnaire survey is designed and addressed to construction professionals to reveal their perception and awareness of Agile PM. The collected data is analyzed by using statistical methods liker descriptive statistics and ANOVA. Furthermore, structural equation modelling (SEM) technique is utilized as a research tool with the help of SPSS AMOS V25.0 software to test the validity of the proposed conceptual model and to test the hypotheses proposed based on relations among factors of Agile PM implementation. Based on statistical findings, results have been discussed and recommendations have been given for the future academic work.

1.6. Scope and Limitations

The scope of this research is mainly about developing a conceptual framework of Agile PM implementation and identifying the components and principles along with their importance. The questionnaire developed in the scope of this study reflects the opinions and

perceptions of Turkish construction professionals regarding factors and components of Agile PM implementation. However, this research is limited to Turkish construction industry since questionnaire survey is only administered to Turkish construction companies and professionals. In addition, rating levels of some of the factors and results of hypnotized relations between components might not be the similar if the questionnaire was addressed to construction professionals in another country. Another limitation is that the hypotheses among the components of Agile PM implementation are constructed based on literature review and expert opinions, which are subjected to the personal judgment.

1.7. Organization of Study

This research consists of six chapters. In the first chapter, the background of the research, problem definition and statement, purpose and objectives of the study, related studies, research methodology, scope and limitations, and organization of the thesis are presented. In the second chapter, an extensive literature review about Agile PM and its applications in other sectors and construction industry, overview of traditional management methods and comparison with Agile PM is provided. In the third chapter, proposed conceptual framework of Agile PM implementation along with its components, administrated questionnaire survey, brief information about statistical analysis methods as well as hypothesized relations among components are presented under title of research methodology. In the fourth chapter, statistical analysis results are presented that are obtained from descriptive statistics, Analysis of Variances (ANOVA) and structural equation modelling (SEM) analysis of the data collected through questionnaire survey. In the fifth chapter, statistical analysis results obtained in previous chapter is discussed in detail and summary of findings is presented. In the sixth and last chapter, conclusion of the research composed of major findings, contributions to literature, limitation of the research, recommendation for future studies is presented. In Appendix section of this study, sample questionnaire survey, descriptive statistics and correlation matrices are provided.

2. AGILE PROJECT MANAGEMENT IN CONSTRUCTION

Agile Project Management, which has been very popular in recent years, has emerged as a result of the failure of IT projects in the 1990s. The main reason for those failures is to be unable to see the results of the project beforehand, to be unable to test and change the targets according to the situation before the end of the project, and to be unable to find solutions to some bottlenecks in the classical project management. To overcome those problems, a different technique is needed to be applied than conventional project management approaches. Cervone (2011) indicated that experts in the software development industry realized the importance of iterative project process can facilitate collaboration that leads to increase the quality of end product compared to traditional methods. Jim Highsmith, who is a renowned software engineer and author of many books in the area of software development and Agile PM defines agility as the ability to respond to change reactively or proactively while viewing it an opportunity.

The engineering industry has realized the benefits of iterations in design process in order to analyze and investigate alternative design options at initial stages of the project particularly during collection of requirements and specification (Ulrich and Eppinger, 2012; Sakikhales and Stravoravdis, 2017). In the projects where traditional methods are used, there is a long time for analysis and design process. Within this period, all the requirements of the project are foreseen. Since the communication with the customer is very little during the process, the product cannot meet customer needs. Changes to be made during the execution of the project are recognized later. For all these reasons, conventional methods may fail. Agile PM has been developed in order to avoid such situations. As a result of success of Agile PM in IT industry, its application and benefits in other sectors like marketing, banking as well as construction industry are investigated in more detail by scholars and professionals.

2.1. Traditional Project Management

According to the Project Management Institute (PMI) (PMBOK, 6th ed., 2017, p.4), project is defined as “a temporary endeavor undertaken to create a unique product, service,

or result". Whereas, project management is defined as "the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements". The core attributes of project management is to plan, organize, monitor and control measures to meet the project requirements (Wysocki, 2011); it relates to all aspects of projects and, helps companies to run an effective and efficient project through proper implementation and integration of project management. On the other hand, many scholars argued that operational planning is the main concentration of traditional PM methods. As a traditional approach, the management of construction projects is usually undertaken by dividing the project in to activities, estimating the duration and budget for each activity, identifying a logical order through various planning methods, and then either subcontracting its execution or assigning it to internal teams.

The Project Management Triangle (also called as the Triple Constraint or Iron Triangle) is a model of the constraints where each activity and the total project progress are monitored to be at desired quality. The quality of work is constrained by time, cost and scope as also seen in below Figure 2.1 And these three variables are in direct correlation with each other as well; i.e. adding scope is to increase cost or extend time or, delivering in less time is to increase the cost or to reduce scope, etc.

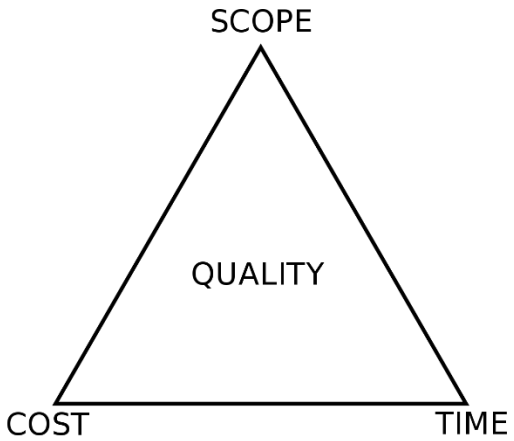

Figure 2.1. The traditional iron triangle (Atkinson, 1999)

Traditional project methods would be successful in case of having up-to-date and stable technology along with having very well-known and predictable information about customer requirements. However, these methods are not able to succeed in real life since,

initial requirements of projects vary greatly as well as technology changes rapidly and, individuals can have differentiations in unpredictable ways. Traditional project management also known as waterfall method is a common technique based on a sequential process of activities developed by Royce in 1970 as shown in Figure 2.2 below. The main drawback pf this method is sequential execution of phases slowly and monolithically without any feedback mechanism (Aoyama, 1998; Wysocki, 2006).

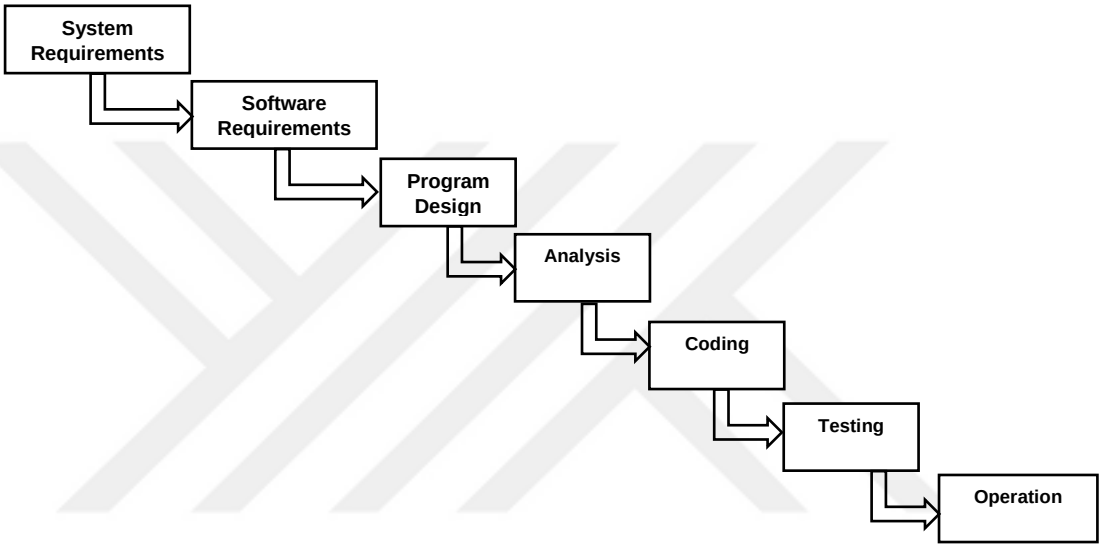

Figure 2.2. The waterfall software development stages (Royce, 1999)

Traditional project management provides a generic framework applicable to most of the project types. The framework consists of stages defined by PMI as initiating, planning, executing, monitoring and, controlling and closing as typical interaction/distribution of each phase can be seen in below Figure 2.3 along with level of effort in each stage where there is no real separation between phases in terms of project work. In this framework, it is always targeted to deliver the project with desired quality on time and within budget. Working with this approach in construction projects is considered to be not flexible and take longer in duration especially in dynamic project environment (Karrbom and Gobary, 2012).

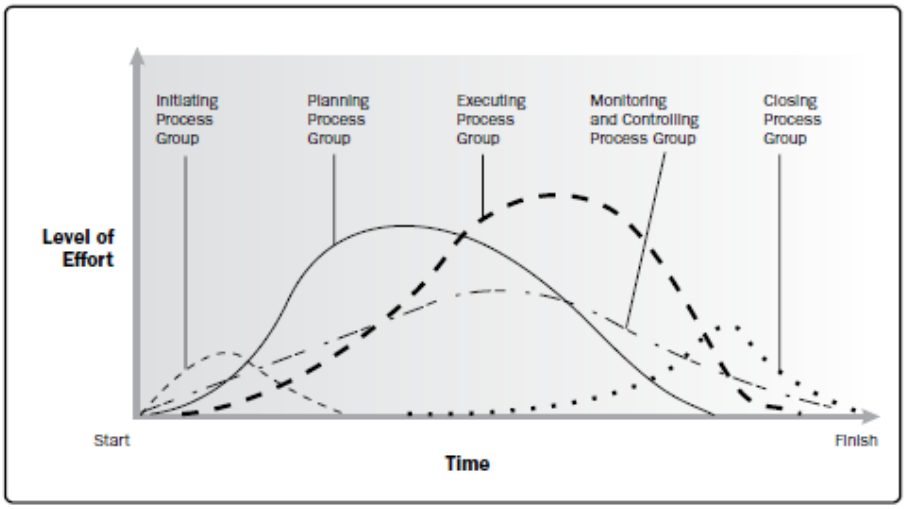

Figure 2.3. The phases of typical project with level of effort (PMBOK, 2017)

Project management of today is mainly about systematically incorporating customer needs, working concurrently on all aspects of the project in cross-functional teams by implementing a comprehensive project management process in order to deal with uncertainties, sudden changes, trade-offs, etc. which can be succeeded with Agile PM in construction industry.

As stated by Koskela (2014), the organization of a project has effectively two layers which are planning and monitoring as one and execution of the project as the other. However, this fragmented nature of construction projects usually leads to many issues and areas of improvement such as poor project performance and poor communication between project execution team and management team as well as client and other stakeholders. Many scholars argue that poor performance of construction projects like delays and cost overruns is common. Furthermore, PMI (2017) indicated that the degree of impact of change on the project duration and cost increase towards the completion of a project while the risk of the project decreases due to reduction of variability and unknowns towards the end of project. It is also noted that the ability to influence the final product, with lower impact on schedule and cost, is highest at the beginning of the project. Thus, client involvement especially at the stage of collection of requirements and project development is very critical.

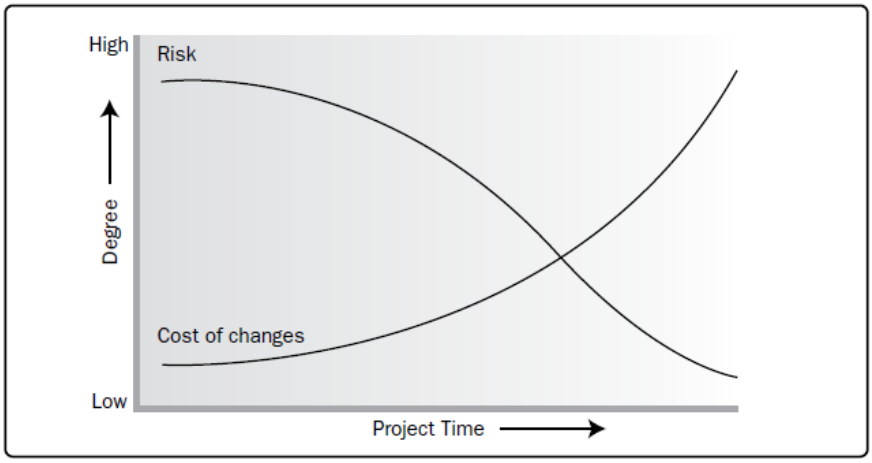

Figure 2.4. The impact of change over time (PMBOK, 2017).

Considering agile project management as a direct replacement to traditional project management methodologies is not always correct. Agile approach is generally preferred at the beginning of the project due to lack of information about the end product and customer requirements. In accordance with company's culture and requirements of projects, it can be preferred to use agile approach without ignoring classic project methodologies. Agile is a modern approach that can be implemented in addition to traditional methods to increase agility in projects.

2.2. Agile Project Management

Agile Project Management is defined as a management approach based on delivering requirements incrementally through iterations as project phases from beginning till end of the project by Association for Project Management in the UK. In Agile PM approach, the project is divided into project phases called iterations and at the end of each phase, a working product is aimed to be created. In the first iteration phase, it is aimed to produce a product with minimum features but ensuring the key requirements of client. First of all, it focuses on the most important requirements of the customer. By adding other necessary features in each iteration, it is aimed to reach the final product as a result of the project. Therefore, it is a flexible process through iterations that mainly concentrates on frequent interaction with client for increased customer value and adapting to today's dynamic business environment rather than following a uniformly constructed plan.

2.2.1. History and Principles of Agile Project Management

The idea of Agile PM was first introduced in a paper in the Harvard Business Review by Takeuchi and Nonaka in 1986. However, according to Cervone (2011), the concept of Agile PM did not draw much attention until the use of agile methods in software development is firstly discussed in 1995. Afterwards, in order to establish a common values and principles for Agile PM methodologies, 17 software developers gathered together in 2001, Agile Manifesto was created under the name of Agile Software Development Alliance movement. Agile Software Development Alliance (2001) declared a manifesto with four values as following:

"We are uncovering better ways of developing software by doing it and helping others do it. Through this work we have come to value:"

- "individuals and interactions over processes and tools"
- "working software over comprehensive documentation"
- "customer collaboration over contract negotiation"
- "responding to change over following a plan"

Along with Agile manifesto, 12 principles have also been produced and listed below:

- "Our highest priority is to satisfy the customer through early and continuous delivery of valuable software."
- "Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage."
- "Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale."
- "Business people and developers must work together daily throughout the project."
- "Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done."
- "The most efficient and effective method of conveying information to and within a development team is face-to-face conversation."
- "Working software is the primary measure of progress."

- “Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.”
- “Continuous attention to technical excellence and good design enhances agility.”
- “Simplicity--the art of maximizing the amount of work not done--is essential.”
- “The best architectures, requirements, and designs emerge from self-organizing teams.”
- “At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly.”

One of the main principles of Agile PM method is to break down the project in to smaller parts that are more valuable to customer and other stakeholders (Highsmith and Cockburn, 2001) and, is to deliver customer needs incrementally through iterations. Agile PM consider that it is impossible to reduce or avoid the dynamic project environment (Moe *et al.*, 2010). The core feature of Agile PM is autonomous, self-organized teams that are responsible for technical level of the project and this responsibility can lead to increase team motivation and satisfaction through self-identification and increased self-confidence.

The five phases of Agile PM are identified by Highsmith (2009) as shown in Fig. 2.5 where envision refers to determination of project objectives, constraints and stakeholders and speculate corresponds to planning the delivery of the product incrementally. Moreover, explore refers to running and testing features of the product iteratively within short intervals in order to decrease the risk. Finally, adapt is reviewing the results and adapt accordingly while close is the closure of the project as well as reviewing the key learnings of the project.

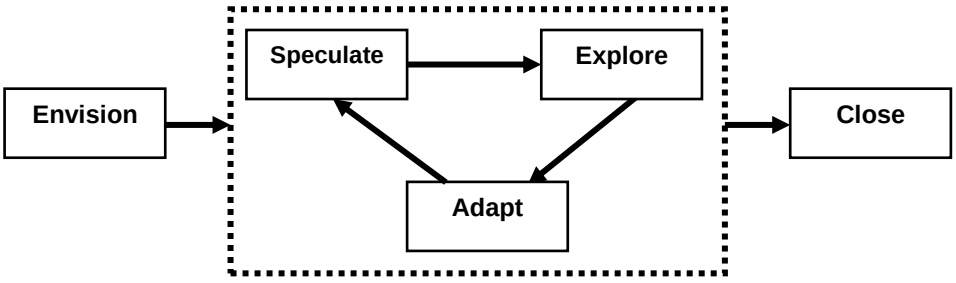

Figure 2.5. Agile workflow reproduced from Highsmith (2009)

2.2.2. Methods and Benefits of Agile Project Management

Agile PM considers that variability can't be decreased. As a result, instead of minimize or eliminate change, feedback loops are constructed in this method in order to achieve the agility by means of responsiveness and flexibility so that the ability to respond to change systematically (Hunt, 2006). Agile PM has many different methods such as scrum, Crystal, Kanban, extreme Programming, Dynamic Systems Development Method (DSDM) etc. as identified in PMI Agile Practice Guide (2017). There are few common components of these methodologies like backlogs, user stories, daily meetings, and iteration planning (Weyrauch, 2006). In this study, the emphasis will be given on Scrum method as it is more applicable to construction projects according to researchers and practitioners.

Scrum is the most common Agile PM method developed by Schwaber in 2004 based on idea of short-cycle output generation and feedback. It aims to manage and deliver the projects incrementally through short iterations (Hu *et al.*, 2009). The method prioritizes important requirements and can easily apply necessary changes during project time. One of innovations brought by Scrum is, entire project team can see status of project comprehensively since it is able to show continuous project progress, its responsibilities and objectiveness in a single board, transparent, and clear which allows all team members to prevent any possible delays from growth. The components and steps of Scrum is explained and illustrated in Figure 2.6.

- All the requirements of a project are identified by the participation of the employer and other stakeholders and it starts with creating a project/product backlog which is Product Owner's responsibility.
- Sprint meetings are being held in order to identify prioritized tasks (Backlogs)
- Prioritized requirements are carried out by a self-organizing, multi-disciplinary team (a.k.a. Scrum Team) in sprints of 2 or 4 weeks and this team is led by Scrum Master for coaching and teaching the Scrum Process.
- Sprint is an iteration in Scrum process which has function of execution during these sprints, a short 15-minute daily stand-up meeting including the employer's representative will be

held and everyone in the scrum team is aimed to be informed about the work completed, to be done and if there are any problems.

- The performance of the work done during the sprint stage is followed by burndown chart
- At the end of each sprint, a retrospective meeting is held to assess the performance of the team and project completed so far, and to decide on regulatory and remedial actions for following sprints.
- This cycle continues until the end of the project.
- The goal is to improve communication, teamwork and speed of development.

The process described above is applied continuously until the project is completed and customer satisfaction is ensured by delivery of quality products at the end of each process in which, the customer also takes an active role and follows project development.

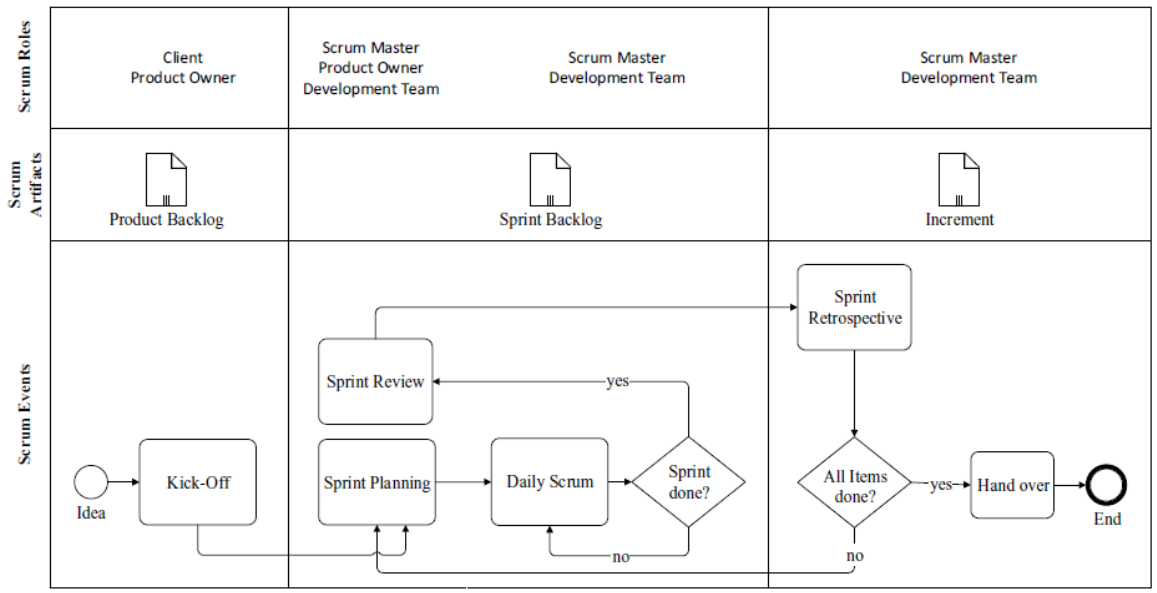

Figure 2.6. The typical scrum framework (Streule *et al.*, 2016)

In conclusion, Agile PM methods are mainly implemented in IT industry but it can be applied in other industries due to its flexibility. In IT projects, its success is demonstrated in many projects and is reported higher than traditional methods. Finally, projects undertaken by using Agile PM methods are also more responsive to changes and dynamic environment while minimizing risks and offering better quality products.

In the IT industry, many surveys and studies have been conducted to show benefits of Agile PM. Those studies undertaken by Vijayasarathy and Turk (2008) and Highsmith (2009) reported increase productivity, cost reduction, as well as improved quality and client satisfaction based on the surveys addressed to project participants used Agile PM. Moreover, the product obtained at the end of each iteration is tested so that errors can be detected early and rectification measures can be taken accordingly. The earlier the error is detected, the lesser this error will cost to the project. Moreover, after each iteration, feedback from the customers can be get and these improvements can be implement in the next iteration according to these customer needs. Finally, Measey and Radtac (2015) reported the benefits of Agile PM in IT industry from 2002 to 2010 by comparing its results with traditional PM which resulted in three times more successful.

On the other hand, benefits reported other than IT industry are limited. Gustavsson (2016) has conducted a research by systematical review of non-software development literature to identify the main benefits referred in the case studies. According to this study, the main benefits are mainly related to team work, customer interaction, productivity and flexibility as well as the impediment removal process or better focus. Besides, Struele *et al.* (2016) indicated the benefits of scrum as improved transparency, better collaboration, communication, and flow of information so faster project development.

2.3. Comparison of Traditional and Agile Project Management

The main difference between traditional PM and Agile PM is the delivery process of project's product while one is linear and final outcome at the end, on the other hand, the other is incremental outcome at the end of each iteration as shown in Figure 2.7 below. The study of Wysocki (2006) paid attention to linear, iterative and incremental projects. Linear projects were employed for a defined goal and a solution, iterative projects were employed for a defined solution without a defined goal, and incremental projects were employed for a defined goal without a defined solution. Linear projects are the center of the attention of Construction PM (ibid). Illustration showing the comparison between them is shown below,

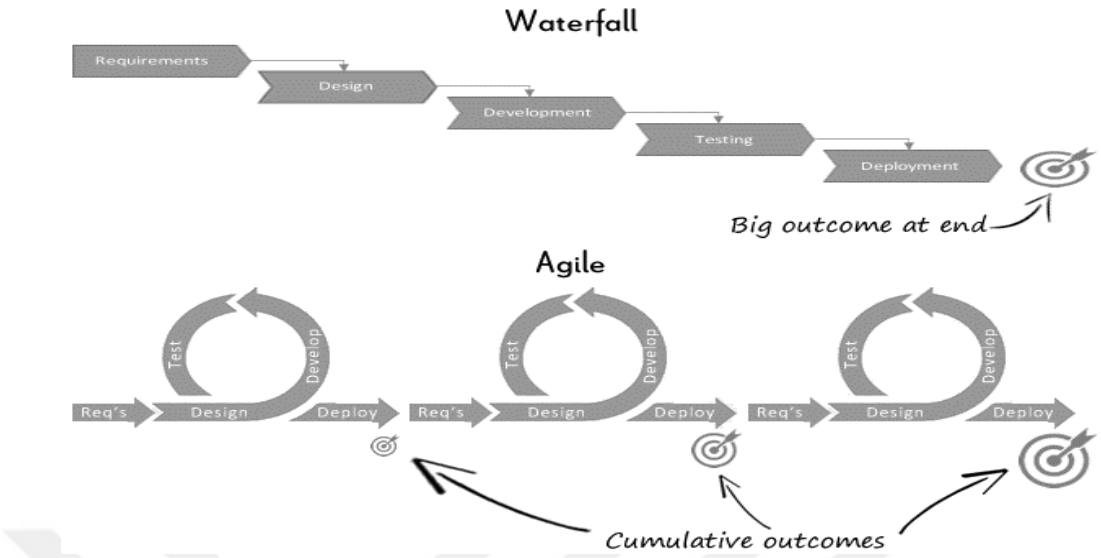

Figure 2.7. The comparison between Agile PM and Traditional PM (Sliger, 2011)

Although traditional methods have no tolerance on change in the scope, the Agile PM provides flexibility on scope change to some extent. Thus, the Agile PM needs different applications to enable incremental delivery of the project through short iterations. (Hass, 2007). Traditional PM based on setting up a project plan and applying the plan strictly that the coordination is enhanced, and the variability is reduced (Lindstrom and Jeffries, 2004). Agile methods use goal of flexibility and responsiveness as different from traditional methods, which use goal of optimization.

Owen and Koskela (2006) claimed that the 'iron triangle' of traditional project management took the form shown in Figure 2.8, since Agile PM explicitly depends on incremental and iterative development taking time and cost into account for evaluation of the optimal value. The principle of iron triangle of Agile PM is the contrary of traditional PM where traditional PM manage time and cost by fixing requirements while Agile PM consider time and cost as fixed in order to manage requirements. Teams are leaded by scrum, which is one of the significant element of the agile methodologies for the sake of iterative and incremental delivery of the project. Time and cost control are provided by establishing requirement, while scrum executes the other way around by fixing time and cost in order to control the requirements.

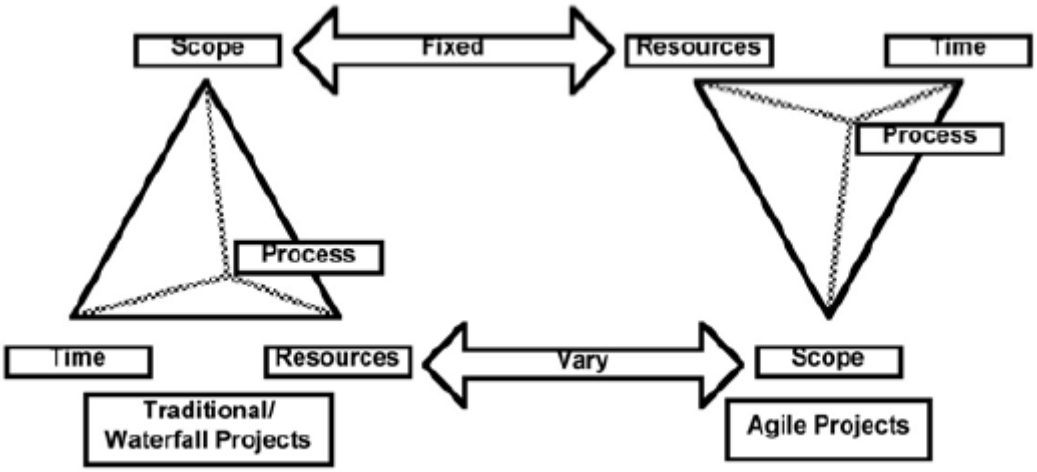

Figure 2.8. The illustration of traditional versus Agile PM (Owen *et al.*, 2006)

2.4. Agile Project Management in Construction Industry

In construction projects, the main concern of the owner is not only increasing efficiency and maximizing functionality but also reducing costs and risks. Similarly, the designers consider efficiency and functionality by providing better solutions. However, better solutions might increase the expenses. The costs are at the center of attention of the contractors rather than other features of the work.

According to Demir (2014), the elements that significantly affect the construction environment are identified as increasing customer expectations, globalization, competition, external influences, low profit, increase of interfaces, increase of stakeholders, market influences, and fragmentation. Construction companies are required to comply their transformation with the dynamic environment. On the other hand, Bennett (2003) categorized the construction projects as general building projects and engineered projects. The first category is the residential, commercial, and industrial buildings, while the second includes more complicated structures, such as, highways, pipelines, marine structures etc.

2.4.1. Application and Potential Benefits of Agile PM in Construction Industry

The literature does not have a comprehensive study that clearly defines the Agile construction and a descriptive framework that depicts broad strokes of the process. The researcher indicated also, the main interests of Agile construction are time, cost, and quality. Koskela and Howell (2002a) as well as Owen *et al.* (2006) compared the traditional project management with contemporary approaches. Daneshgari (2010) emphasized that Agile construction is a crucial method to increase efficiency, profit, standards, and quality. Demir *et al.* (2014) combined agile and lean concepts, namely "AgiLean PM". Besides, the application of Agile PM to BIM for collaboration, documentation, and life-cycle data management is discussed by Kumar and McArthur (2015). On the other hand, Tomek and Kalinichuk (2015) introduced a planning approach by combining Agile PM and BIM in pursue of exploring its practical application. In recent years, there have been many academic studies which investigated applicability of agile methods in construction and non-software industries and drivers, barriers and other factors of its implementation (Nowotarski and Paslawski, (2015); Kashikar *et al.*, (2016); Gustavsson, (2016); 16-Streule *et al.*, (2016); Adut (2016); Ekström and Pettersson, (2016); Totten, (2017); Sakikhales and Stravoravdis, (2017); Sonneveld, (2018), Qaravi, (2018)). In addition, Project Management Institute (2017) issued a comprehensive guide for agile practice guide which provides detailed information regarding agile methods and principles.

However, it should be indicated that there is not enough completed research in the literature in terms of empirical approaches in Agile PM that can be used in practice. Stracusser (2015) reported a collaborative work on a nuclear plant project utilized some agile management principles in terms of pre-delivery tests which leads to on time, under budget and safe delivery of the project. Although Sakikhales and Stavroravdis (2017) revealed that the construction industry often adopts the methods and techniques from the other industries. However, there are not many demonstrations of Agile PM implementation in construction sector.

Since there are significant similarities between the design phase in construction and software development, agile can be an appropriate implementation. Owen *et al.* (2006)

examined the Agile PM techniques for the steps of pre-design, design, and construction phases considering various criterion. The agile management may be efficient in pre-design of constructions, since the agile deals with risk properly and provide effective solutions. The agile fits perfectly the design phase because it increases the quality and reduces the cost. Since the changes might cause severe effects on ongoing projects, agile might not be the best management practice for construction phase.

Ribeiro and Fernandes (2010) discovered that Agile PM methods are effective tools to manage projects when smaller scaled projects are considered. The researchers emphasized the agile cultural collaboration between the stakeholders and formalization of the structure. According to Demir (2014), IT and construction projects shows variety considering scenario building and testing in IT applications. This approach is unfortunately not an applicable procedure for construction. Thus, construction projects are more distinctive than IT applications, since the construction projects focus on the consequences directly. Stracusser (2015) revealed that iterative process is not a practical application for construction projects since the dynamics are changing rapidly and consequences of those become more expensive through the construction process.

The status of the research and implementation of Agile PM in Turkey is quite similar to global status as mentioned above. Agile PM has been broadly studied by researchers from both software development and manufacturing industries. It has also been discussed in the conferences organized by project management institutions. Besides, IT companies often utilize Agile PM in software development projects especially the ones specialized in banking industry as per literature. On the other hand, the effort of construction industry is very limited. There is only one study about Agile PM in the Turkish construction industry. Ezcan *et al.* (2015) has presented their study about the critical factors affecting companies' agility in diffusing and using emerging technologies in the Turkish AEC sector. However, this study is not about Agile PM methodologies, but mainly discusses about being agile and it principles. Finally, there is a group of professionals and companies, namely Agile Construction Turkey, are searching for ways to adopt Agile PM in construction industry through pilot studies and meetings to share their experience.

3. RESEARCH METHODOLOGY

The main objective of this research is to construct a framework to investigate the factors affecting implementation of Agile PM in the Turkish construction industry. The research methodology followed in this study consists of 3 main steps as listed below.

- An extensive literature review was carried out to determine the full set of factors which are structured and consolidated under main components of a proposed conceptual model.

- An online questionnaire survey is conducted in order to investigate the perception and awareness of construction professionals about implementation of Agile PM in the Turkish construction sector as well as their opinions regarding factors and components of its implementation.

- Both statistical analysis (descriptive statistics and ANOVA) and the structural equation modelling (SEM) were undertaken to identify interrelations between variables and to test the validity of the proposed conceptual model along with importance weight of factors.

3.1. Measurement Framework for Factors of Agile PM Implementation

In order to construct an integrated framework to identify and measure the factors and indicators of Agile PM in the Turkish construction sector, a conceptual model is proposed by considering the implementation of Agile PM in a construction project as an innovation process along with its components of inputs and outputs similar to innovation framework proposed by Ozorhon (2013). The proposed framework conceptualizes the implementation of Agile PM as an innovation process in a construction project and identifies its components comprising the drivers, barriers, enablers, inputs, process improvements, and benefits.

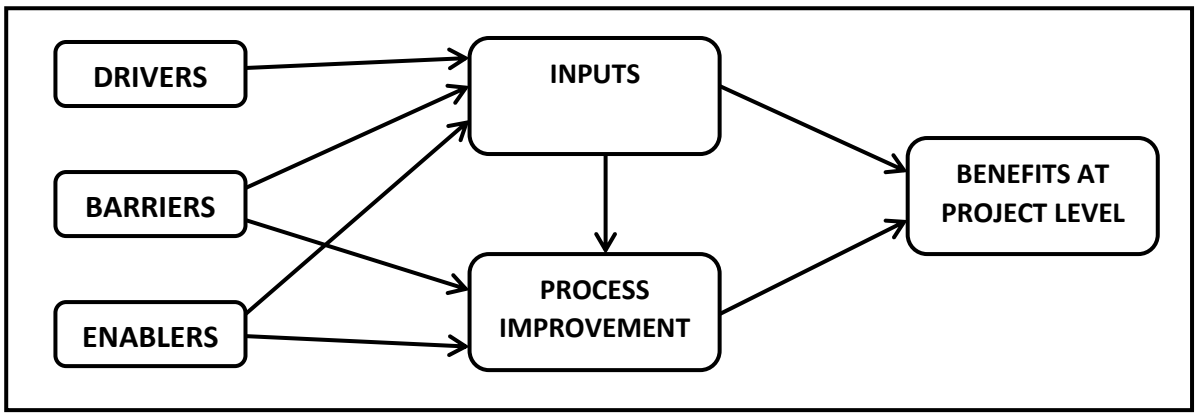

Figure 3.1. Measurement framework for components of Agile PM implementation.

The main components of the proposed framework are the drivers, enablers, barriers, inputs, process improvements, and benefits at project level. The drivers represent the main motivations for initiation of Agile PM implementation in a construction project. The barriers are considered to impede the uptake of Agile PM in Construction Industry. The enablers act to overcome the barriers and help to promote Agile PM implementation in construction industry. The inputs are the resources employed to facilitate Agile PM in construction projects. The process improvements as its name suggests are kind of interim benefit of Agile PM during execution of construction project. Benefits can be defined as the outcome at the end of the project. The experience and knowledge obtained in a project can be utilized in the future projects.

3.2. Hypotheses of the Research

With reference to proposed conceptual framework shown in section 3.1 of this study, several hypotheses are built about the interrelationships among components of Agile PM implementation in the Turkish construction sector. The hypotheses are constructed with the help of expert opinions and review of past studies which are listed below;

- H1: Drivers have a positive effect on the inputs.
- H2: Barriers have a negative effect on the inputs.
- H3: Barriers have a negative effect on the process improvements.

- H4: Enablers have a positive effect on the inputs.
- H5: Enablers have a positive effect on the process improvements.
- H6: Inputs have a positive effect on the process improvements.
- H7: Inputs have a positive effect on the benefits.
- H8: Process improvements have a positive effect on the benefits.

The links and hypothesis between constructs of Agile PM implementation are established logically based on considering simple stages of an innovation process similar to innovation framework proposed by Ozorhon (2013). In the nature of an innovation process, there are inputs affecting the process itself and it yields outputs according to initial set up and purpose of the process. In the proposed conceptual framework described in section 3.1, “drivers”, “barriers” and “enablers” are the casual inputs of a process where “drivers” refer to the main motivations for initiation of a process, “barriers” are the obstructions working against a process so affecting it negatively and “enablers” are acting against barriers and promoting the implementation of Agile PM. Those inputs of the process have direct effects on the process itself which is indicated with the name of “inputs”. The “inputs” representing the process itself as a construct are the resources or components utilized to enable Agile PM implementation. As a result of process itself, namely Agile PM implementation or “inputs” in the framework, there are outputs of “process improvements” and “benefits” which are affected directly from Agile implementation. Both process improvements and benefits are the project-level outputs.

3.3. Questionnaire Survey

The questionnaire survey is a quantitative research method that enables to collect information from large numbers of individuals or targeted respondents with the help of internet technologies. Clarke and Dawson (1999) argued that the data collection through questionnaire survey is a very common practice to explore and asses a research topic. According to Denzin and Lincoln (1998), quantitative research focuses on the measurement and analysis of fundamental relationships between variables.

Once the questionnaire survey is prepared to test the hypothesized relations between the variables according to an in-depth literature review, a pilot study is undertaken to ensure that the questionnaire is clear and right to the research objective. To do so, few engineers and architects was requested to participate in the survey for their comments and understanding about the design of questionnaire. Based on their feedback through face to face interviews, background reading part at the beginning was clarified by adding explanatory charts and figures. There are also revisions in some questions to make the wording simpler and more easily understandable.

Afterwards, the questionnaire was addressed to construction professionals working for AEC companies in Turkey. Since the Agile PM mainly emphasizes on multidisciplinary team work and horizontal hierarchy in a project, it is targeted to reach out people from all disciplines and levels of an organization. The list of targeted respondents are clients, project management and design consultants, contractors, sub-contractors, vendors and suppliers,. The questionnaire survey was administered through an internet link via email or online messages through professional online platforms like Linkedin and employees of the large-scale AEC firms who are among members of Turkish Contractors Association (TCA) and Institution of Civil Engineers (IMO). However, main source of participation in the survey comes from members of Institution of Civil Engineers in Istanbul, Turkey. As a result, a total of 203 questionnaires were returned out of around 1300 sent out, which resulted in approximately 16% response rate. Face-to-face interviews were also conducted with 14 professionals. The sample questionnaire can be seen at Appendix A of this study.

3.3.1. Content of Questionnaire

In the beginning of survey, a brief information about the purpose of the study, privacy of the collected data, definition of Agile PM along with contact details of researcher are provided to increase confidence and engagement of participants in the survey. In addition, a short background reading about implementation and techniques of Agile PM with explanatory flowcharts and figures are presented for construction professionals who are not aware of Agile PM before.

The questionnaire survey is designed to collect general information about participants, their company, project type and their awareness and knowledge of Agile PM as well as data to test the hypothesized relationships among components and factors in proposed conceptual framework. The main objective of questions regarding the information company and project information is to generate a profile of the respondent in order to draw meaningful conclusions and determine differences between respondent groups during statistical analysis. The general information requested from respondents is listed below;

- Personal experience of respondents in the construction sector
- Position of respondents in their current company
- Company experience
- Business type of their company
- Project type executed by their company
- Turnover of their company (total)
- The number of total employee of their company
- Awareness of agile pm and opinion about its usefulness (yes or no) and project stages
- Previous experience with Agile PM and intention to implement Agile PM (Yes or No)
- Opinion about benefits and techniques of Agile PM based on previous experience

In the last part of the questionnaire survey, the respondents were requested to assess the components of Agile PM implementation through the pre-defined indicators based on a 1–5 point Likert scale. The following questions were asked to measure the components of Agile PM implementation according to experience and perception of respondents.

- For “Drivers” - To what extent do you think the following factors create the need for Agile PM in Construction Industry?
- For “Barriers” - To what extent do you think the following factors hinder the implementation of Agile PM in Construction Industry?
- For “Enablers” - To what extent do you think the following factors help promote Agile PM in Construction Industry?
- For “Inputs” - To what extent do you think the following factors facilitate Agile PM

in Construction Industry?

- For “Process Improvements” - To what extent do you think the Agile PM in Construction Industry improves processes of the project?
- For “Benefits” - To what extent do you think the Agile PM in Construction benefits your project?

3.4. Components of Agile Project Management Implementation

In this section of this study, the definitions of the determinants and indicators that are affecting Agile PM implementation in construction projects are provided along with the reference given to prior literature. As a result of the extensive review of factors in the literature, there were 63 number of factors determined initially which were reduced to 42 factors grouped under 6 components at the end of the process. The evaluation and refinement of the list of factors were carried out through interviews with two university professors, two experienced construction professionals as well as one agile consultant by deleting, renaming or merging the factor with another one. It was aimed to avoid overlapping of the meanings of factors for a better content validity and reduction of intercorrelation among factors. For instance, factors of “ability to react to change” and “requirement for proactive organization and quick adaption to change” in the initial table are merged under name of “responsiveness to changes and client requirements”. As explained in previous section, the purpose of this part of questionnaire survey is to measure and quantify the factors of Agile PM implementation using a Likert Scale (1-5) based on experience and opinion of professionals in the Turkish construction industry.

3.4.1. Drivers of Agile Project Management Implementation

The construction and Agile PM literature is extensively searched to find out the factors creating the need and motivation for Agile PM implementation in construction projects. Many articles and research studies have been examined and reviewed. As a result, 30 number of them are selected as main source of factors mentioned in this study. These drivers and their corresponding literature source are tabulated and shown in Table 3.1.

3.4.1.1. DR1-Responsiveness to changes and client requirements. This factor was identified as an ability to react change in a systematic and structured way in literature. Owen *et al.* (2006) states that recognizing change as an opportunity will enhance delivered value of the project. In a traditional application of project management, changes to the project and new requirements from client are usually considered to be a distraction and setback from original project plan as it may impact on scope, time and cost of the project. Therefore, changes are usually tried to be pushed back or ignored to respond in construction projects. Furthermore, Demir *et al.* (2014) claims that changes are not welcomed in each project phase of a construction project, because in the execution phase particularly the impacts and consequences of those changes are high. During the initiation and design phase it is easier to react to changes and therefore agile methodologies fit better in that phase (Owen and Koskela, 2006).

3.4.1.2. DR2 - Need for Project Performance Improvement. According to many scholars, poor performance is a common problem in construction projects such as low productivity, delays in schedule and cost overruns etc. Therefore, Pan *et al.* (2007), Demir (2013), Sohi *et al.* (2016) states that there is an inevitable necessity of tailored management methods to overcome poor performance and delays in projects and need for future project management challenges and requirements of modern practices. Many scholars, which are listed in Table 3.1 and marked for this factor, mentions about an urgent need for increase in productivity, quality and reduction in cost, duration and risk in construction projects. Besides, some studies suggest that reason of poor performance can be divided into external and internal causes (Meng, 2012). External causes may be attributed to adverse weather and site conditions, market fluctuation, and regularly changes. On the other hand, the internal causes may be originated by the client, the designer, the contractor, the consultant and various suppliers who provide labor, materials and equipment (Assaf & Al-Hejji, 2006). Thus, it is clear that internal causes of poor performance can be eliminated or minimized by employing more efficient management practices and techniques.

3.4.1.3. DR3 - Poor communication with client and stakeholders. Due to large, scattered and temporary nature of construction projects, proper communication, coordination and interoperability between various stakeholders of the project is always one of the most

challenging problems during management and execution a project. Therefore, the proper collaboration between project stakeholders is utmost importance for a successful completion of the projects. Communication and knowledge sharing are both aspects of collaboration that often lack in teams in the engineering industry (Humpfrey, Ma, Qi, & Wang, 2008). The diversity of stakeholders with their different interests and goals from the project leads to hindered communications in different levels of the people involved in a certain project.

3.4.1.4. DR4 - Dynamic and uncertain project environment. The dynamic project environment in construction projects can be associated with uncertainty. The uncertainty is defined by Pender (2001) as the variability of future outcomes where probability distributions cannot be predicted. The state having no prior knowledge of future occurrence and replicability leads to uncertainty. According to Atkinson *et al.* (2006), uncertainties causes changes in the project and creates a dynamic project environment. Therefore, it can be concluded that increase in number of changes due to uncertainties will make project environment more dynamic. The changes originated from uncertainties are identified as project uniqueness, changing designer teams, awarding of unknown contractors, ground conditions, changing material cost, and weather conditions (Rosel, 1987). However, Hertogh and Westerveld (2010) claims that the influence of dynamic project environment seems to be underestimated by the latest project management methodologies. The uncertainties of a project get reduced towards to the end of the project since the more knowledge is available and there is less unknown information.

3.4.1.5. DR5 - Projects with high complexity and risk. The complexity of construction projects are often associated with uncertain project environment, technical challenges, temporary, large and scattered nature of construction projects, and occurrence of many activities simultaneously in construction literature. Gidado (1996) stated that the complexity of construction projects can be divided in two categories as managerial perspective and the operative and technological perspective. The derivation of complexity from managerial point of view can be related to unfamiliarity of management with local resources and environment, lack of complete specification for the activities at the construction site, and lack of uniformity of materials, work and teams with regard to place and time due to uniqueness of the project (ibid). On the other hand, the complexity of the operative and technological point

of view is linked to the number of technologies involved in a task, the rigidity of sequence and overlapping stages between the various main operations (ibid). In addition, there is high complexity in procurement of construction projects due to variety of materials in each project (Koskela, 2000; Dubois and Gadde, 2002). Therefore, increasing complexity of construction projects has resulted in search for a new and tailored project management methodology to deliver complex projects successfully (Demir, 2013; Sohi *et al.*, 2016).

3.4.1.6. DR6 - Competition level in market. There is an increasing attention on the importance of competitiveness stems not only from its ability to enable sustainable growth, but also from dynamic competition in today's world. According to Buckley *et al.* (1988), the concept of competitiveness reflects both past performance and also the perception of potential and the improvement of managerial processes. Few researchers indicated that Agile PM implementation can create a competitive advantage for construction companies through achievement client's objectives with high client satisfaction and quality.

Table 3.1. Literature review on drivers of Agile PM implementation.

No	**Literature Source**																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
DR1	●	●		●		●	●		●		●					●			●	●	●						●		●	●
DR2	●									●	●	●			●	●		●	●					●						●
DR3										●				●		●		●						●					●	●
DR4		●		●					●	●			●			●	●							●						
DR5				●						●		●		●		●											●			
DR6																									●					●

Drivers: DR1: Responsiveness to changes and client requirements, DR2: Need for Project Performance Improvement, DR3: Poor communication with client and stakeholders, DR4: Dynamic and uncertain project environment, DR5: Projects with high complexity and risk, DR6: Competition Level in market

Literature Sources: 1-Owen *et al.,* (2006); 2-Vázquez-Bustelo *et al.,* (2007); 3-Vijayasarathy and Turk, (2008); 4- Ribeiro and Fernandes, (2010); 5-Misra *et al.*, (2009); 6-Daneshgari, (2010); 7-Han, (2013); 8-Demir *et al.*, (2014); 9-Conforto *et al.*, (2014); 10-Tomek and Kalinichuk, (2015); 11-Sohi *et al.*, (2016); 12-Sonneveld, (2018); 13-Kumar and McArthur, (2015); 14-Kashikar *et al.*, (2016); 15-Gustavsson, (2016); 16-Streule *et al.*, (2016); 17-Adut (2016); 18-Ekström and Pettersson, (2016); 19-Owen and Koskela, (2006); 20-Chen *et al.*, (2007); 21-Totten, (2017); 22-PMI Report, (2017); 23-Sakikhales and Stravoravdis, (2017); 24-Arya and Sahay, (2017); 25-Pikas *et al.*, (2015); 26-Nowotarski and Paslawski, (2015); 27-Straçusser, (2015); 28-PMI Guide, (2017); 29-Oyegoke *et al.*, (2008); 30-Qaravi, (2018).

3.4.2. Barriers to Agile Project Management Implementation

There are some difficulties to implement Agile PM in construction projects. Research shows that organizational resistance, management apathy, and inadequate training are the most important barriers towards implementing Agile PM (Vijayasarathy and Turk 2008). The construction and Agile PM literature is extensively searched to find out the factors impede the uptake of Agile PM implementation in construction projects. Many articles and research studies have been reviewed and 30 number of them are selected as main source of factors mentioned in this study. These barriers and their corresponding literature source are tabulated and shown in Table 3.2. The definition of each factor along with its citation in related article is provided in the following paragraphs.

3.4.2.1. BA1 - Resistance to Organizational and Cultural Change. Changing old work habits and mind set to allow flexibility is usually difficult for people accustomed to work with conventional methods. Researchers and practitioners argued that agile method is relatively difficult for people who used to work with traditional methods (Bowes, 2014; Agile delivery Community, 2016). The construction industry has been generally criticized as slow to adopt both new management practices and new technologies (Latham, 1994; Egan, 1998; Fairclough, 2002). This can be attributed to industry leaders' unwillingness to acknowledge the long-term advantages of structural and cultural change and accepting a short-term profit instead (Cole, 2003).

3.4.2.2. BA2 - Lack of top management support and commitment. The support and commitment from top management is critical to convey the idea of change within organization and break the employees' resistance to change. In order to break the resistance to change in the construction firm, the managing director has to act as an innovation champion (Ozorhon, 2013). However, it should be noted that decision makers lacked full understanding of the approach may impede full commitment of top management. Besides, top management support help considerably to create an agile culture within the firm which promotes the mentality of being proactive for a better response to the changes and uncertainties.

3.4.2.3. BA3 - Lack of commitment and engagement of customer/client. Commitment and engagement of client especially at the stage of collection of requirements and project development are very critical to ensure that the project progress is aligned with client's expectations. Adut (2016) argued that the client or customer of the project should be willing to engage in decision making, constant feedback-loops and tight follow-ups. If a client is involved in decision making process throughout the project and provide regular feedback, it becomes an enabler for Agile PM and project success, otherwise, it becomes a barrier.

3.4.2.4. BA4 - Lack of commitment and engagement of team members and other stakeholders. One of the unique features of Agile PM that creates difference is its ability to facilitate a better employee engagement and encourage team work. Sheng *et al.* (2010) indicated that the basis of good team work begins with commitment to the project goal and trust within team. When team members have a common target to achieve, communication and flexibility within the team will improve significantly through rise of team spirit. Otherwise, without an adequate knowledge sharing and open communication between team members and stakeholders, team members will lose motivation to work together and focus on their individual work which may lead to failure of the project.

3.4.2.5. BA5 - Team members working on multiple projects and in different locations. In order to implement Agile PM in construction projects, it is essential to keep team members motivated and focused fully during project execution. Working on multiple projects in different locations will create distractions to team members and lead to project interruptions so unsuccessful projects. The uniform and consistent progress of team members should be maintained from initial phase to closure of project as well as during transition to a new project. It is claimed by researchers if an agile method is implemented inappropriately, it can introduce extra inefficiencies (Bowes, 2014).

3.4.2.6. BA6 - Unclear benefits and methods of implementation of Agile PM in Construction industry. IT industry has developed the theory of Agile PM based on the experience gained during execution of IT projects as opposed to other management methods where theoretical framework is firstly developed, then it is implemented in projects. Agile PM has shown proof of a successful implementation only in the IT sector so far. However, it is not clear to what

an agile approach would imply in the construction environment and technique, practice to follow.

3.4.2.7. BA7 - Lack of awareness of Agile PM methods and practices. The knowledge and awareness of top management in construction industry is very limited and they are in great need of education about Agile PM methodologies in order to realize their benefits. Since senior management lacks proof of concept of adapting agile approaches onto traditional project management, it results in reluctance to change working ways and old habits.

3.4.2.8. BA8 - Lack of contractual aspects of using Agile PM between stakeholders. The construction projects are usually large, scattered and has many stakeholders including client, project management consultancies, designers, contractors, subcontractors, vendors and other specialists. All these stakeholders have their own contractual agreement with one another stakeholder and work accordingly for completion of their scope. The extensive use of subcontracting has brought contractual relations to the fore and prevented the continuity of teams which is essential to efficient working (Egan, 1998).

3.4.2.9. BA9 - Bureaucratic project environment with multiple stages of project acceptance. Construction projects are subject to multiple acceptance stages due to tight requirements of laws and regulations in construction industry. This highly bureaucratic project environment of construction industry contradicts with iterative and incremental delivery principle of Agile PM. Moreover, it should be noted that the decision making mechanism of construction projects sometimes gets quite complicated due to inflexibility of regulations and laws.

3.4.2.10. BA10 - Fractured nature of construction projects with large number of stakeholders. The fractured and temporary nature of the construction organization brings many challenges to construction professionals especially for coordination and collaboration between variety of stakeholders. The extended use of subcontracting allowed on the one hand to transfer risks and achieve more flexibility, but on the other it made the project coordination more complex (Raiden *et al.*, 2004). The high degree of fragmentation leads to complex communication structure along with cultural diversity among the different teams involved in the project.

Table 3.2. Literature review on barriers to Agile PM implementation.

No	Literature Source																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
BA1	●		●	●	●				●				●	●		●					●	●			●	●	●	●		●
BA2				●		●						●		●		●		●			●				●	●		●	●	●
BA3	●			●		●													●						●				●	
BA4									●			●		●					●						●			●		
BA5									●					●		●				●	●					●			●	
BA6	●			●									●	●		●		●												
BA7	●												●			●		●												
BA8									●							●						●				●				
BA9				●			●						●			●										●			●	
BA10		●		●						●		●				●				●										●

Barriers: BA1: Resistance to Organizational and Cultural Change, BA2: Lack of top management support and commitment, BA3: Lack of commitment and engagement of customer/client, BA4: Lack of commitment and engagement of team members and other stakeholders, BA5: Team members working on multiple projects and in different locations, BA6: Unclear benefits and methods of implementation of Agile PM in Construction industry, BA7: Lack of awareness of Agile PM methods and practices, BA8: Lack of contractual aspects of using Agile PM between stakeholders, BA9: Bureaucratic project environment with multiple stages of projects acceptance, BA10: Fractured nature of Construction projects with large number of stakeholders

Literature Sources: 1-Owen *et al.,* (2006); 2-Vázquez-Bustelo *et al.,* (2007); 3-Vijayasarathy and Turk, (2008); 4- Ribeiro and Fernandes, (2010); 5-Misra *et al.,* (2009); 6-Daneshgari, (2010); 7-Han, (2013); 8-Demir *et al.,* (2014); 9-Conforto *et al.,* (2014); 10-Tomek and Kalinichuk, (2015); 11-Sohi *et al.,* (2016); 12-Sonneveld, (2018); 13-Kumar and McArthur, (2015); 14-Kashikar *et al.,* (2016); 15-Gustavsson, (2016); 16-Streule *et al.,* (2016); 17-Adut (2016); 18-Ekström and Pettersson, (2016); 19-Owen and Koskela, (2006); 20-Chen *et al.,* (2007); 21-Totten, (2017); 22-PMI Report, (2017); 23-Sakikhales and Stravoravdis, (2017); 24-Arya and Sahay, (2017); 25-Pikas *et al.*, (2015); 26-Nowotarski and Paslawski, (2015); 27-Straçusser, (2015); 28-PMI Guide, (2017); 29-Oyegoke *et al.*, (2008); 30-Qaravi, (2018).

3.4.3. Enablers of Agile Project Management

An in-depth review of construction and Agile PM literature is carried out to determine the factors promoting Agile PM implementation in construction projects. Many articles and research studies have been reviewed and these enablers and their corresponding literature source are tabulated and shown in Table 3.3.

3.4.3.1. EN1 - Short-term visualized planning for iteration and incremental delivery. Iteration and incremental delivery of a project enables to plan the work in small manageable sizes while delaying the decisions until the last responsible moment. In order to react to change and uncertainty, many scholars suggested to use short-term visual planning to evaluate progress in project along with concurrent execution of activities as per shown in the Table 3.3. Owen *et al.* (2006) defined Agile PM as an incremental and iterative development with continuous learning being essential to the evolution of the optimal value (to the customer) within the constraints of time and cost. Successful managers have to use iterations between their management methods in order to be able to respond to changing project circumstances (Lewis *et al.*, 2002).

3.4.3.2. EN2 - Timely and continuous involvement of client. Client satisfaction is one of the most essential and desired output of successful projects. This can be only achieved if all expectations and requirements of client is met based on continuous communication with client. Thus, timely and continuous involvement of client especially at the stage of collection of requirements and project development are very critical to ensure that the project progress is aligned with client's expectations. Getting regular feedback from client through client input periodically will enable to understand requirements of client and their priority correctly as well as the line for no further changes. Adut (2016) argued that the client or customer of the project should be willing to engage in decision making, constant feedback-loops and tight follow-ups.

3.4.3.3. EN3 - Collaborative partnering of contractor and other stakeholders. Construction projects are executed by the collaborative effort of multiple organizations through the integration of design and construction. Many researchers argue that successful project performance often requires effective collaboration, coordination and working relationships between the different stakeholders in construction projects such as the contractors, subcontractors, suppliers, architects, engineers, clients, the government, universities, etc. Besides promoting collaboration between stakeholders tied to each other through contracts may also enable to transfer risk to the most capable actor regardless of initial contract. Demir (2013) argued that a collaborative environment will encourage the elimination of interfaces between the designers and contractors and create trust for a better project performance.

3.4.3.4. EN4 - Commitment and organizational learning via short feedback loops. Being agile can be achieved through short feedback loops (Wysocki, 2006) since it promotes organizational learning and commitment of project teams. These feedback loops are called "iterations" (Chin, 2004; Hunt, 2006; Wysocki, 2006; Fernandez and Fernandez, 2008; Moe *et al.*, 2010; Saleh, 2011; Dingsoyr *et al.*, 2012). For a proper and organic organizational learning, it is essential to employ a highly trained team along with bi-directional loyalty and mutual long-term commitment. The feedback loop allows flexibility and responsiveness, consequently the ability to react to change in a systematic and structured way (Hunt, 2006). Besides, continuous organizational learning by receiving early and recurrent feedback from client and other team members enables continuous improvement of team performance and frequent adaptation process for change. According to Sohi *et al.* (2016), the awareness of who is doing what increases the level and amount of communication and availability of resources.

3.4.3.5. EN5 - Organizational trust among employees. Organizational trust among employees and a culture of teamwork has a very positive effect on knowledge sharing and collaborative project environment. Organizational trust as a key construct interacting with agile methods to supply shared intent, and ensuring sustained high project performance at substantially reduced managerial overheads. Organizational trust which can be defined as trust in the leadership and among employees is essential for employee engagement and motivation.

3.4.3.6. EN6 - Effective Leadership. Considering Agile PM as an innovative process, leadership has been stated as one of the main enablers of innovation in the construction literature (Tatum, 1987; Ozorhon *et al.*, 2010). Effective leadership lead to increase in motivation and commitment of the project team to the project objectives (Aronson *et al.*, 2006). According to PMI (2017), servant leadership is the practice of leading through service to the team, by focusing on understanding and addressing the needs and removing organizational impediments in order to enable the highest possible team performance. PMI (2017) also suggests that the characteristics of servant leadership like promoting self-awareness, safety, respect, and trust, coaching vs. controlling enable project leaders to become more agile and facilitate the team's success.

3.4.3.7. EN7 - Face to face communication. It is one of the main principles of Agile PM as mentioned before that the most efficient and effective method of conveying information to and within a development team is face-to-face conversation. Agile PM encourages face to face communication instead of written communication. Moreover, it enables extensive, close, transparent and informal communication between stakeholders involved in the project which results in better knowledge sharing and increased motivation and trust among employees.

3.4.3.8. EN8 - Promoting minimal documentation and simple solutions: With reference to Agile manifesto, emphasis should be given on working software over comprehensive documentation. Since traditional document-driven reporting is time consuming and costly, Agile PM suggests to focus on value added activities and more effective ways of communication. Demir (2013) argued that documentation effort shall be kept as low as possible, because the aim of documentation is to make the project reproducible, which "of course contradicts the project character in principle".

Table 3.3. Literature review on enablers of Agile PM implementation.

No	Literature Source																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
EN1	●	●		●	●	●				●	●	●		●		●			●	●	●	●					●		●	
EN2	●	●		●	●			●		●		●		●		●				●		●				●			●	●
EN3	●	●			●	●		●				●		●	●	●	●				●		●							
EN4										●				●		●		●									●			●
EN5	●			●						●						●		●											●	
EN6				●																●	●						●		●	
EN7												●																		●
EN8				●												●														

Enablers: EN1: Short-term visualized planning for iteration and incremental delivery, EN2: Timely and continuous involvement of Client, EN3: Collaborative Partnering of contractor and other stakeholders, EN4: Commitment and organizational learning via short feedback loops, EN5: Organizational Trust among employees, EN6: Effective Leadership, EN7: Face to face Communication, EN8: Promoting minimal documentation and simple solutions

Literature Sources: 1-Owen *et al.*, (2006); 2-Vázquez-Bustelo *et al.*, (2007); 3-Vijayasarathy and Turk, (2008); 4-Ribeiro and Fernandes, (2010); 5-Misra *et al.*, (2009); 6-Daneshgari, (2010); 7-Han, (2013); 8-Demir *et al.*, (2014); 9-Conforto *et al.*, (2014); 10-Tomek and Kalinichuk, (2015); 11-Sohi *et al.*, (2016); 12-Sonneveld, (2018); 13-Kumar and McArthur, (2015); 14-Kashikar *et al.*, (2016); 15-Gustavsson, (2016); 16-Streule *et al.*, (2016); 17-Adut (2016); 18-Ekström and Pettersson, (2016); 19-Owen and Koskela, (2006); 20-Chen *et al.*, (2007); 21-Totten, (2017); 22-PMI Report, (2017); 23-Sakikhales and Stravoravdis, (2017); 24-Arya and Sahay, (2017); 25-Pikas *et al.*, (2015); 26-Nowotarski and Paslawski, (2015); 27-Straçusser, (2015); 28-PMI Guide, (2017); 29-Oyegoke *et al.*, (2008); 30-Qaravi, (2018).

3.4.4. Inputs of Agile Project Management Implementation

The construction and Agile PM literature is extensively searched to find out the factors facilitating Agile PM implementation in construction projects. Many articles and research studies have been reviewed and these inputs and their corresponding literature source are tabulated and shown in Table 3.4.

3.4.4.1. IN1 - Autonomous, self-organised, multi-disciplinary team: According to in-depth literature review, autonomous, self-organized, and multi-disciplinary teams are one the most a crucial enabler and input of Agile PM methods (e.g. Agile Manifesto, 2001; Hunt, 2006; Moe *et al.*, 2010). Schwaber (2004) stated that teams should be self-managing, self-organizing, and cross-functional in order to iterative and incremental delivery of the project. The main advantage of autonomous teams is the change of traditional hierarchical management with unidirectional flow of communication and decentralized decision making which helps to cope with changes and dynamic environment in more agile and responsive way. Demir (2013) also claimed that the responsibility coming from being member of autonomous and self-organized teams results in higher team motivation and team satisfaction, since the project team members have a platform where they can identify themselves with the project.

3.4.4.2. IN2 - Daily stand-up meeting: Since the organization structure of construction projects are set up based on the project requirements, managing the teams and tracking the progress day to day become the main effort project teams instead of focusing on long term objectives. PMI (2017) asserts that daily stand-up meetings enables teams to commit each other, uncover problems, improve organization learning and work flows smoothly through the team. The duration of daily meetings is meant to be short and rules should be followed strictly. In these meetings, each member of the team provides information regarding the work completed since last meeting, the work being planned between now and next meeting, and finally impediments, problems encountered. It should be noted that daily stand-up meetings is only for realizing the problems not for solving them. The problems should be resolved with most appropriate people in another meeting.

3.4.4.3. IN3 - Size of project team: Agile PM methods are suitable for smaller teams since communication is getting very difficult with larger teams. As a result of the small size of project team, enhanced communication and collaboration will promote working together as a team. Besides, it is reasonable to say that small teams can be highly responsive to change and has high ability to adapt quickly to dynamic environments. Owen *et al.* (2006) and Bonabeau and Meyer (2001)claimed that the use of small, self-organized, multi-skilled teams in Agile PM encourages the tacit knowledge sharing and dense communications among team members to enable creation of innovative solutions through swarm intelligence. The main differences between agile teams and traditional project teams are the self-organising capability and cross-functionality of the agile team members with small sizes and no differences in ranking (Cockburn & Highsmith, 2001).

3.4.4.4. IN4 - Location of project team: Collaboration and communication within project team improves significantly when the project team works in the same place at the same time. PMI (2017) argues that colocation of the project team enables better communication, improved team dynamics, knowledge sharing, reduced cost of learning, and commitment to working with each other. Besides, It is also mentioned in PMI Agile Practice Guide (2017) that colocation and frequent business conversations allow for lightweight requirements since gaps in understanding can be filled quickly. However, colocation is quite difficult since employing remote engineering teams are financially more feasible and preferable by companies. Yet, this problem can be handled through communication tools of today's new technologies that can bring together all communication channels to a single interface such as instant messaging, email, teleconferences, video conferencing.

3.4.4.5. IN5 - Experience of project team: In order project team to be self-managed, self-organized and be capable of decision making for multidisciplinary issues, team members should be highly experienced and knowledgeable in their profession and area of expertise. Furthermore, experience of each team members in their area of expertise will also affect significantly on collaboration and trust between them. PMI (2017) suggests that the team members of agile teams should be selected from "T-shaped people", who have developed good skills in their areas along with knowledge and interest in other areas as well as have

good collaboration skills, rather than “I-shaped people” who have deep specializations in one domain, but rarely contribute outside of that domain.

3.4.4.6. IN6 - Consultancy and training of team members: It is obvious that experience and knowledge of agile team in implementation of Agile PM has considerable influence on project performance especially from the beginning of the project till team gets fully functional. The training and coaching for Agile PM implementation from a consultancy company helps employees to have a smooth transition who used to work with traditional ways of project management. These services will bring extra cost to company or project but it will definitely pay off and bring extra benefits to company and employees in the long run. Research shows that inadequate training are the most important barriers towards implementing Agile PM (Vijayasarathy and Turk 2008).

3.4.4.7. IN7 - Information technology integration and support: Information technology (IT) integration plays a vital role in the business practices and strategies of entire industries in today’s world. Knowledge management with the help of IT integration and support can address key business challenges of companies by revealing the value hidden deep in their data. IT integration and support not only helps to get the right information to the right people at the right time through merits of BIM and cloud technologies which helps to centralize the project database generated by all stakeholders but also enables team members and stakeholders to communicate more effectively through teleconferences, video conferencing.

3.4.4.8. IN8 - Internal Knowledge Resources: All companies and professionals involved in a construction project has got their own unique skills and resources as well as knowledge and data. Organizational learning and sharing of the knowledge with the organization is one of the most vital keys of maintaining long term competitiveness. Knowledge management is a method of exploiting, or transforming knowledge as an asset for organizational use to facilitate continuous improvement (Robinson *et al.*, 2005).

Table 3.4. Literature review on inputs of Agile PM implementation.

No	Literature Source																												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
IN1	●	●	●	●		●		●				●		●	●	●				●	●				●	●	●		●	
IN2	●									●		●				●				●	●									
IN3				●				●										●				●							●	●
IN4								●				●																		
IN5	●			●				●				●																	●	●
IN6	●																				●									
IN7				●										●				●												●
IN8				●														●			●								●	

Inputs: IN1: Autonomous, self-organized, multi-disciplinary team, IN2: Daily stand-up meeting, IN3: Size of project team, IN4: Location of project team, IN5: Experience of project team, IN6: Consultancy and training of team members, IN7: Information technology integration and support, IN8: Internal Knowledge Resources

Literature Sources: 1-Owen *et al.*, (2006); 2-Vázquez-Bustelo *et al.*, (2007); 3-Vijayasarathy and Turk, (2008); 4- Ribeiro and Fernandes, (2010); 5-Misra *et al.*, (2009); 6-Daneshgari, (2010); 7-Han, (2013); 8-Demir *et al.*, (2014); 9-Conforto *et al.*, (2014); 10-Tomek and Kalinichuk, (2015); 11-Sohi *et al.*, (2016); 12-Sonneveld, (2018); 13-Kumar and McArthur, (2015); 14-Kashikar *et al.*, (2016); 15-Gustavsson, (2016); 16-Streule *et al.*, (2016); 17-Adut (2016); 18-Ekström and Pettersson, (2016); 19-Owen and Koskela, (2006); 20-Chen *et al.*, (2007); 21-Totten, (2017); 22-PMI Report, (2017); 23-Sakikhales and Stravoravdis, (2017); 24-Arya and Sahay, (2017); 25-Pikas *et al.*, (2015); 26-Nowotarski and Paslawski, (2015); 27-Straçusser, (2015); 28-PMI Guide, (2017); 29-Oyegoke *et al.*, (2008); 30-Qaravi, (2018).

3.4.5. Process Improvements of Agile Project Management Implementation

The construction and Agile PM literature is extensively searched to find out the factors that Agile PM implementation improves their process in construction projects. Many articles and research studies have been reviewed and these process impovements and their corresponding literature source are tabulated and shown in Table 3.5.

3.4.5.1. PI1 - Improvement of communication and collaboration: Due to large and scattered nature of construction projects, there are many stakeholders or parties who can affect or can be affected by outputs of construction projects (Gann, 1996; Chinyio and Olomolaiye, 2010). This feature construction projects makes the management and coordination a very complex task. Therefore, enhanced collaboration among team members on an on-going basis and better flow of information between project stakeholders are key process improvements

which lead to increased cross-organizational collaboration and knowledge sharing as well as improved employee engagement, so the successful completion of projects. Process improvement due to agile methods can be listed as a higher transparency, better communication and collaboration, better flow of information and faster project development (Streule *et al.*, 2016). According to the results of the study carried out by Kumar and McArthur (2015), the benefits of Agile PM to project process is particularly emphasized such as improving communication within the team and with external parties, improving efficiency by minimizing re-work, and reducing client-driven design changes late in the process.

3.4.5.2. PI2 - Increase in transparency and visibility of the project: Higher transparency and visibility of a project is a key process improvement as a result of Agile PM implementation which is mentioned by many researchers and practitioners. Visibility, transparency and reporting are key to factors to managing a team and keeping them on track for projects, team meetings, daily tasks. Increased transparency and consistent visibility enables to reduce the risk of the project with progress and improves motivation of team members along with self-satisfaction and confidence.

3.4.5.3. PI3 - Improvement of organizational learning and practices: The area of organizational learning offers great potential, both during the project and in the medium and long term (Owen *et al.*, 2006) since organizational learning is such a large part of the project and impacts on the performance of the project. For a proper and organic organizational learning, it is essential to employ a highly trained team along with bi-directional loyalty and mutual long-term commitment. Agile PM promotes a culture where employees can contribute to organizational learning which result in successful projects and profitability.

3.4.5.4. PI4 - Better Response to Changes: In a traditional application of project management, changes to the project and new requirements from client are usually considered to be a distraction and setback from original project plan as it may impact on scope, time and cost of the project. However, Raiden *et al.* (2004) and Gareis (2010) argued that only those projects will not fail if the project team is able to increase the speed of learning and matching the changing project requirements on time. With the help of Agile PM features

like autonomous and multidisciplinary teams along with short-term planning, companies have quicker and more responsive approach to changes. Han (2013) indicatesthat the Agile PM can help to handle changes in a three-step process: stay responsive, keep proactive, and adapt to changes.

3.4.5.5. PI5 - Decrease in Project Risk: The risk in construction projects are derived from uncertainties and unknowns due to dynamic project environment. In order to mitigate and control these risks, Agile PM makes use of frequent reviews of incremental and iterative work approach with cross-functional project teams to accelerate knowledge sharing by understanding the dimensions of risk. Owen *et al.* (2006) claimed that the agile approach of tackling with risk is to pass it whichever stakeholder is most capable of resolving it, irrespective of initial contractual relationships. It is also stated that there is a good possibility of better results in terms of productivity and risk mitigation for pre-design and design phases respectively for a construction project with Agile PM approach.

Table 3.5. Literature review on process improvements of Agile PM implementation.

No	Literature Source																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
PI1	●	●		●		●						●		●	●			●	●		●								●	
PI2	●										●			●	●				●	●	●								●	●
PI3		●												●		●														
PI4	●					●										●										●			●	●
PI5		●		●															●		●									

Process Improvements: PI1: Improvement of communication and collaboration, PI2: Increase in transparency and visibility of the project, PI3: Improvement of organizational learning and practices, PI4: Better Response to Changes, PI5: Decrease in Project Risk

Literature Sources: 1-Owen *et al.*, (2006); 2-Vázquez-Bustelo *et al.*, (2007); 3-Vijayasarathy and Turk, (2008); 4- Ribeiro and Fernandes, (2010); 5-Misra *et al.*, (2009); 6-Daneshgari, (2010); 7-Han, (2013); 8-Demir *et al.*, (2014); 9-Conforto *et al.*, (2014); 10-Tomek and Kalinichuk, (2015); 11-Sohi *et al.*, (2016); 12-Sonneveld, (2018); 13-Kumar and McArthur, (2015); 14-Kashikar *et al.*, (2016); 15-Gustavsson, (2016); 16-Streule *et al.*, (2016); 17-Adut (2016); 18-Ekström and Pettersson, (2016); 19-Owen and Koskela, (2006); 20-Chen *et al.*, (2007); 21-Totten, (2017); 22-PMI Report, (2017); 23-Sakikhales and Stravoravdis, (2017); 24-Arya and Sahay, (2017); 25-Pikas *et al.*, (2015); 26-Nowotarski and Paslawski, (2015); 27-Straçusser, (2015); 28-PMI Guide, (2017); 29-Oyegoke *et al.*, (2008); 30-Qaravi, (2018).

3.4.6. Project Level Benefits of Agile Project Management Implementation

IT industry has benefitted from Agile PM methods in their projects in the last decade. Thus, its use and benefits in other sectors as well as construction sector are investigated in detail by many scholars and practitioners. The construction and Agile PM literature is extensively searched to find out the factors that Agile PM implementation provide benefits to construction projects. Many articles and research studies have been reviewed and 30 number of them are selected as main source of factors mentioned in this study. These inputs and their corresponding literature source are tabulated and shown in Table 3.6.

3.4.6.1. PB1 - Improvement of client satisfaction: Client satisfaction is one of the key success factors of all projects. A project may not be regarded as successful, even if it is completed on time and within the planned cost and scope, if the customer or key stakeholders are not satisfied (Bourne and Walker, 2005). Agile PM enables projects to be executed through iterative and incremental approach with a high responsiveness to change and better understanding of client requirements which results in high degree of customer satisfaction and project success (Wysocki, 2006).

3.4.6.2. PB2 - Increase in project performance: One of the chronicle problems of construction industry is low productivity and poor performance. Those problems are usually attributed to factors like project complexity, dynamic and poor communication among stakeholders. As a response to these difficulties listed above, Agile PM is an approach based on delivering requirements iteratively and incrementally throughout the project life cycle by a small, self-organized, multidisciplinary team. It has been stated by many scholars that Agile PM will increase project performance by increasing working efficiency of team members (Owen *et al.*, 2006; Daneshgari, 2010; Han, 2013; Sohi *et al.*, 2016; Sonneveld, 2018).

3.4.6.3. PB3 - Increase in project quality: As it indicated by many scholars, projects executed by using Agile PM methods are more likely to have better quality than the projects using traditional project management methods (Owen *et al.*, 2006; Vázquez-Bustelo *et al.*, 2007; Oyegoke *et al.*, 2008; Sonneveld, 2018; Qaravi, 2018). Owen *et al.* (2006) explained the

reasons for improvement in both defect rates and perceived quality as defects are determined and corrected much earlier because of the feedback mechanisms of Agile PM and improved collaboration. It is also noted by Owen *et al.* (2006) that Agile PM also concentrates on evolving customer perceptions, rather than conformance to an early plan.

3.4.6.4. PB4 - Decrease in project cost & PB5 - Decrease in Project Duration: Since the project performance is usually managed through use of principles of Iron Triangle which focuses on meeting the cost, time and quality objectives, the literature usually refers to both of the benefits together. As of today, Agile PM fails to demonstrate a successful application other than the IT sector and the success stories are still quite few (Conforto *et al.*, 2014). Therefore, the reference given in the construction literature can be considered as the expectation of researchers. Due to increased productivity, speed and quality as main benefits of Agile PM, researchers indicated that Agile PM will help to decrease project cost and duration. (Owen *et al.*, 2006; Owen and Koskela, 2006; Conforto *et al.*, 2014; Kashikar *et al.*, 2016; Gustavsson, 2016; Totten, 2017; Qaravi, 2018)

Table 3.6. Literature review on benefits of Agile PM implementation.

No	Literature Source																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
PB1		●		●			●					●		●		●		●		●	●	●							●	
PB2	●	●				●					●	●		●					●							●			●	●
PB3		●										●		●						●	●								●	●
PB4	●			●					●						●				●		●									●
PB5	●								●					●	●						●									●

Benefits: PB1: Improvement of Client Satisfaction, PB2: Increase in Project Performance, PB3: Increase in Project Quality, PB4: Decrease in Project Cost, PB5: Decrease in Project Duration

Literature Sources: 1-Owen *et al.*, (2006); 2-Vázquez-Bustelo *et al.*, (2007); 3-Vijayasarathy and Turk, (2008); 4- Ribeiro and Fernandes, (2010); 5-Misra *et al.*, (2009); 6-Daneshgari, (2010); 7-Han, (2013); 8-Demir *et al.*, (2014); 9-Conforto *et al.*, (2014); 10-Tomek and Kalinichuk, (2015); 11-Sohi *et al.*, (2016); 12-Sonneveld, (2018); 13-Kumar and McArthur, (2015); 14-Kashikar *et al.*, (2016); 15-Gustavsson, (2016); 16-Streule *et al.*, (2016); 17-Adut (2016); 18-Ekström and Pettersson, (2016); 19-Owen and Koskela, (2006); 20-Chen *et al.*, (2007); 21-Totten, (2017); 22-PMI Report, (2017); 23-Sakikhales and Stravoravdis, (2017); 24-Arya and Sahay, (2017); 25-Pikas *et al.*, (2015); 26-Nowotarski and Paslawski, (2015); 27-Straçusser, (2015); 28-PMI Guide, (2017); 29-Oyegoke *et al.*, (2008); 30-Qaravi, (2018).

3.5. Statistical Analysis Methods

According to Merriam Webster's dictionary, statistics is classified as a branch of mathematics in order to deal with the collection of the data as well as its analysis and interpretation. In order to assess the relations and variance between variables investigated in online questionnaire, various statistical analysis methods are utilized in this study with the help of Statistical software package SPSS version 25.0 such as descriptive statistics, Analysis of various (ANOVA), and Structural Equation Modeling (SEM). The description of these statistical analysis methods is provided as following.

3.5.1 Descriptive Statistics

Descriptive statistics is basically to simplify large amounts of data in meaningful way where the data is summarized to describe the basic features of the samples as an approximation of the population in a study. In other words, the data is transformed and presented in simple graphics clearly, concisely, and enables to grasp the essential characteristics of data to draw appropriate conclusions for statistical analysis. The descriptive statistics such as percentage of population, mean, median, standard deviation, variance, mean ranking, Cronbach's alpha for reliability, kurtosis and skewness for normality is provided as a result of statistical analysis undertaken by SPSS. Definition of some of the critical statistics is given below.

Skewness of a data is checked to measure the symmetry of it. The symmetry of the data can be seen when it is plotted. When the data is skewed or unsymmetrical, the tail of the data plot looks extended to one side rather than a bell shape of symmetrical normal distribution. Shapes of plotted data can be seen in Figure 3.2 below.

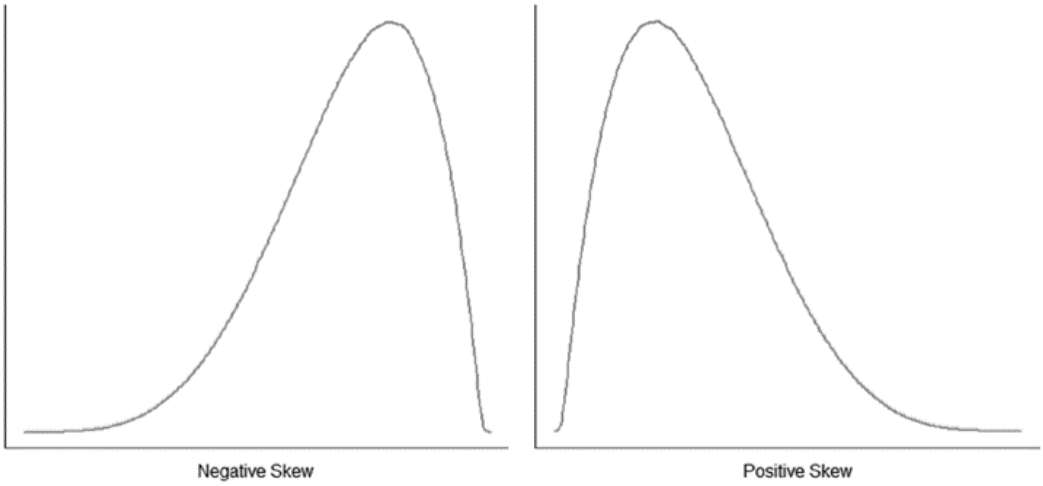

Figure 3.2. Example of negative and positive skewed data plot.

Another helpful way of understanding the distribution of data is kurtosis which is used less often compared to skewness due to its difficulty of interpretation. In order to understand kurtosis of a data set, the peak of the sample data can be checked in a way of being sharper or flatter and it can be described as higher level of kurtosis or positive kurtosis and lower level of kurtosis or negative kurtosis respectively as shown in Figure 3.3. Nevertheless, the way of calculation is not related to peak of the data and it is calculated by using the tails of the data. Thus, outliers are more effective on this calculation compared to skewness.

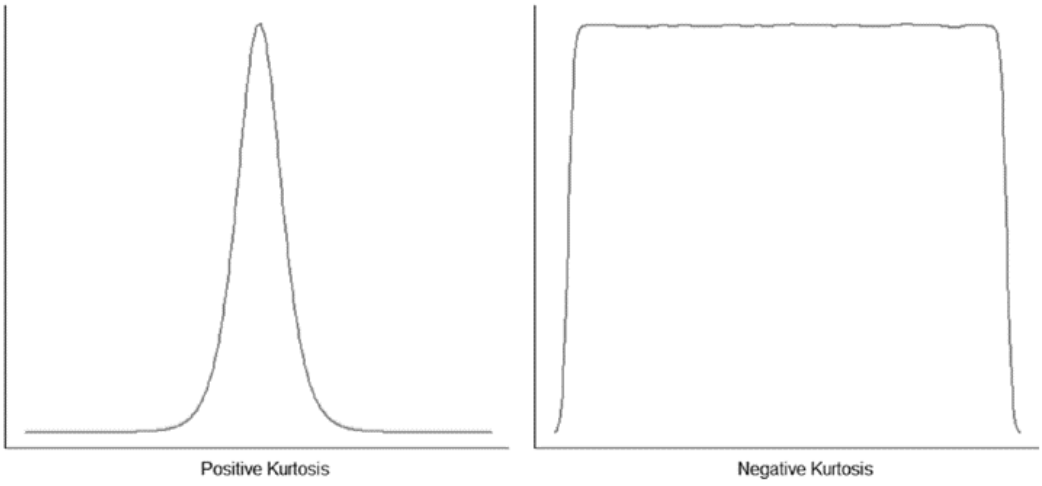

Figure 3.3. An example of positive kurtosis and negative kurtosis.

The skewness and kurtosis of a data set is usually compared with plot of a normal distribution. It has been argued by many scholars in recent decades that a data set can be classified as normally distributed based on their skewness and kurtosis values. Values of skewness within the range of -1 to +1 indicate a normal distribution the data. (Hair *et al.*, 2006). In addition to that, Sposito and Skarpness (1983) claims that skewness and kurtosis values within range of +2.2 and -2.2 can be considered as normal distribution.

Mean ranking enables to determine the significance of each factor based on ratings by the respondents. Kululanga *et al.* (2001) used similar approaches to assess the survey results and realize the importance of the surveyed factors. The formula for calculation of mean ranking is given below:

$$\text{Mean} = \frac{\sum_{i=1}^{5} iN_i}{\sum_{i=1}^{5} N_i} \tag{3.1}$$

Cronbach (1951) introduced a reliability coefficient for a data set to test the internal consistecy, which is named as Cronbach's alpha Alpha. The coefficient is calculatedby averaging the correlation of elements within a test. The correlation value can be ranged from 0 to 1 which refers to implication of results from unreliable to reliable (Graham and Lilly, 1984). Cronbach’s alpha values greater than 0.70 are found to be satisfactory as per Nunally’s recommendation (1978).

In SPSS, the formulation of Cronbach’s Alpha is as the following:

$$\alpha = \frac{k\overline{\text{cov}} / \overline{\text{var}}}{1 + (k-1)\overline{\text{cov}} / \overline{\text{var}}} \tag{3.2}$$

where k refers to the number of items, var refers to the average variance while kcov is the average covariance between items.

3.5.2. T-test and Analysis of Variance (ANOVA)

In the first part of the questionnaire, the general information about respondents, their companies and projects are collected so that a comparison of means between population groups is to be made regarding their responses to components of Agile PM implementation. That is to say, comparison of means is to determine if there is any statistically significant difference between the means of independent groups. Both T-test analysis and Analysis of Variance methods is used for this purpose which are parametric statistical techniques. There is a very small difference between t-test and ANOVA, where t-test is performed to compare means of two population groups while ANOVA is suitable for more than two groups.

However, the statistics and mathematics behind these methods are quite different than each other. The t-test uses t-statistic to calculate the mean and variance of sample data by assuming its normal distribution. The null hypothesis tests that both groups have equal means while alternative hypothesis tests that the means of two groups are different than each other. On the other hand, ANOVA is performed based on linear regression to find the quantitative relationship between the dependent and independent variables (Wackerly *et al.*, 2002). The null hypothesis tests that all groups have the same mean, while alternative hypothesis is the difference of at least mean of one group compared to other groups.

Many different post-hoc analyses can be performed by using SPSS software following a one-way ANOVA. It has been argued by many researchers that all post-hoc tests have their own strengths and weaknesses. According to discussions between scholars at websites of different academic platforms, Tukey's Test, Scheffé's Method, Fisher's Least Significant Difference (LSD) are one of the most popular and reliable ones. In this study, Least Significant Difference (LSD) Test, which is originally developed to examine all possible pair-wise comparisons of means of groups by using t-test mathematics, is employed. The test is first developed by Fisher. The null hypothesis is rejected when the test significance level (p-value) is less than 0.05 at the 95% confidence interval. Rejecting the null hypothesis means that there are statistically significant differences between groups.

3.5.3. Structural Equation Modeling (SEM)

Structural equation modeling is a comprehensive and multivariate statistical analysis methods used for testing the relations between observed variables and latent constructs. In last two decades, it has become increasingly popular in all around the world used as quantitative research methodology especially in social sciences and marketing. SEM is a combination of statistical techniques like multiple regression analysis, confirmatory factor analysis and path analysis. However, it has got some superiorities over those methods since it enables to model independent latent variables and indicators, interactions among them, correlated independent variables, measurement error terms as well as nonlinearities. Moreover, both factor and path analyses are performed together at the same time for SEM analysis as opposed to multivariate regression and factor analysis (Xiong *et al.*, 2015).

SEM is a confirmatory method rather than an exploratory one. That is to say, the most suitable model for the research topic can be determined through an iterative process by checking validity of various models using SEM (Hoyle, 1995; Kline, 1998; Byrne, 2006). After a theoretical model constructed as a result of literature review, various complex relationships between one or more dependent and independent variables can be tested and analyzed by using SEM to find the most adequate model while both variables can be continuous or discrete.

Kline (1998) indicates that SEM involves two models which are measurement and structural models. The measurement model deals with the measurement of unobserved or latent variables by means of observed variables and measurement of validity and reliability of observed variables. Confirmatory factor analysis can be mentioned as one of the widely used measurement applications. The structural model can be defined as various multiple regression models or equations estimated simultaneously which are constructed based on the causal relationships among the constructs.

The components of SEM are represented schematically in Figure 3.4 by Xiong *et al.* (2015) which is also known as diagrammatic syntax and Ozorhon (2007) described the components of SEM and useful terminology. Observed variables, also known as measured

variables or indicators, are observable and measured directly. On the other hand, latent variables are not observable and shall be derived from measured variables. Latent variable are also referred as constructs or unobserved variables Observed variables are designated by X within square and latent variables are designated by Y within circle in Figure 3.4. Latent variables can be two different types based on type of variable. One of them is latent dependent variables which represent the effects of other constructs. The second one is latent independent variables which affect directly other variables in the model. Furthermore, those latent variables can have either direct effect or indirect effect on each other based on the initial hypothetical path diagram. The SEM enables to estimate the direct effects between constructs which is known as path coefficients indicated by r1. The indirect effect of latent variables, also known as mediator effect in the literature, is the transmittal of the partial casual effects of one latent variable on another variable over or through a third latent variable in the middle.

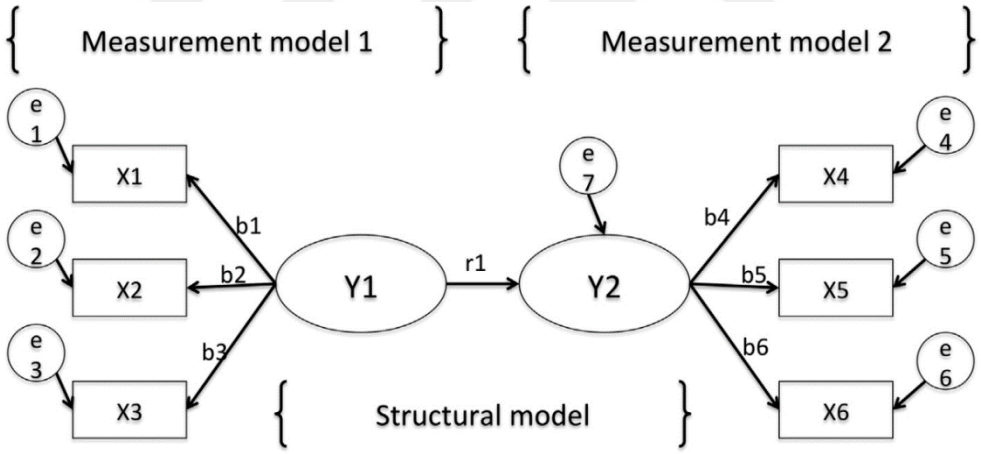

Figure 3.4. Graphical representation of structural equation model (Xiong *et al.*, 2015).

3.5.3.1. Steps of Structural Equation Modelling (SEM): Structural Equation Modeling can be carried out in four main steps as stated by Ozorhon (2007;

(i) Model specification
(ii) Model identification
(iii) Test of model fit
(iv) Model modification

(i) *Model Specification* is the way how the conceptual framework is determined along with relationships between constructs determined based on literature review and expert opinions. The relationship is modelled through specification of parameters as either free or fixed.

(ii) *Model identification* is highly dependent on the selection of estimation technique for constructed model and the specification of parameters as mentioned above. Each free parameter is expected to yield a unique value from the measured data. There are few number of methods of model estimation where maximum likelihood (MLS) and generalized least squares (GLS) are the most common ones. The selection of estimation method highly depends on distribution type and the sample size.

(iii) *Model fit or goodness of fit* can be assessed with the help of several indices as explained below;

- *Chi-Square ($\chi 2$)* is a generalized likelihood ratio comparing model with a fully saturated model. If the sample size is large, it can be inferred as a Pearson chi-square statistics with the degrees of freedom calculated as the difference between the number of observations and number of parameters. If chi-square value is low and non-significant, it indicates a better fit model. There are two main disadvantages of this model. One of them is being highly sensitive to sample size. Secondly, there is no standardized upper level agreed by scholars and statisticians.

- *Comparative fit index (CFI)* is very similar to incremental fit indexes (IFI). It basically make comparison between the existing model fit and a null model with uncorrelated latent variables which is very sensitive to sample size. The index varies from 0 to 1 and the CFI equal to or greater than 0.9 represents a good fit.

- *Non-Normed Fit Index (NNFI) or Tucker and Lewis Index (TLI)* ranges between 0 and 1 which means from poor fit to perfect fit. TLI is dependent on the average size of the correlations in the data. By convention, model with NNFI values below 0.9 needs to be rectified for better fit.

- *Root Mean Square Error of Approximation (RMSEA)* is method that the analysis of residuals enables to measure discrepancy per degree of freedom. The RMSEA is used quite commonly by researchers as a model fit parameter. Values lower than 0.10 represent good fit while values lower than 0.01 indicate perfect fit.

(iv) *Model Modification* is a step to review and rectify the model if there is no a reasonable and meaningful explanation of the data based on the estimated covariance matrix. The other reason is that model fit is not within limits specified above. The rectification can be done either by changing model parameters or by deleting parameters that are not significant.

3.5.3.2. Structural Equation Modelling (SEM) Software Packages: There are many software programs available in the market which are specialized in SEM. AMOS (Analysis of Moment Structure), LISREL (Linear Structural Relationships), and EQS (Equations) are the most common ones. In this study, AMOS is selected to analyze the research model.

3.5.3.3. Advantages of Structural Equation Modelling (SEM): Structural Equation Model (SEM) is a powerful and popular tool that is used by researches in recent years. However, it is very crucial for researchers to fully understand its benefits and limitations. SEM enables complex data analysis similar to multiple regression with additional advantages. It mainly enables to model independent latent variables and indicators, interactions among them, correlated independent variables, measurement error terms as well as nonlinearities.. SEM is a very effective way to compare alternative models in order to assess model fit since misinterpretation as a result of misspecification is quite possible in regression (Isik, 2009). The main advantages of SEM can be summarized as the following list below;

- Enables to test complex models with several indicators per construct simultaneously
- Enables to model mediating variables and evaluate direct, indirect, and total effects
- Usage of confirmatory factor analysis (CFA) to decrease measurement error
- Enables to visualize the SEM and relations through graphical modelling
- Enables to take measurement error into account by explicitly modelling error terms
- Enables to test coefficients between multiple groups

Due to complexity of structural equation modelling, there are some limitations and assumptions to be considered. In structural equation models, estimation of factor loadings, path coefficients, variances along with hypotheses are performed simultaneously if the empirical data provide enough information. Otherwise, this may lead to convergence errors or unreliable results. Since the most popular and robust technique for parameter estimation used in SEM is maximum likelihood, the sample data of observed variables should be distributed normally and large sample size should be ensured for reliable results.

4. ANALYSIS AND RESEARCH FINDINGS

In this chapter, the data collected through questionnaire survey is analyzed statistically and the hypothesized relations is tested accordingly. As mentioned in previous sections, the targeted respondents are all of construction professionals regardless of their level in the organization and discipline or company since Agile PM investigated in this research is meant to be implemented in all types and stages of construction projects. As a result of online survey, total number of response is 203. Prior to further statistical analysis, the collected data is screened for any missing data, unengaged response and outliers to ensure reliability and validity of the data. Since the online survey is conducted and it is required to response all questions before submitting survey, no missing data problem has encountered. However, after data screening, 11 number of results are removed from the data set since the response is given the same scale (1,1,1,1.. or 5,5,5,5,...) for every single survey item. Therefore, 192 is the total number of valid response taken into account in statistical analysis. In the first part of this chapter, statistical findings are summarized and descriptive statistics are presented. Analysis of Variance (ANOVA) and structural equation modelling (SEM) are also performed comprehensively. Descriptive statistics including the mean, standard error, median, standard deviation, sample variance, kurtosis, skewness, range, minimum, and maximum values etc. can be found in Appendix B.

4.1. Descriptive Statistics

As a result of questionnaire survey and data screening, descriptive statistics is determined for the data gathered from192 valid responses. The detailed presentation of descriptive statistics firstly begins with the general characteristics of the respondents, their companies and projects and continues with awareness of Agile PM and mean ranking of factors. Therefore, the following part discusses about the descriptive statistics to explain the overall picture or profile of the collected data.

4.1.1. General Information about the Respondents and their Companies

Demographic information regarding the respondent companies indicates some facts about the general profile of the companies participated in the survey. Figures below provide some important information regarding the profile of respondents and project characteristics.

Figure 4.1 shows the distribution of respondents' professional experience and position. According to figure below, majority of the respondents have got 6-10 years and 11-20 years of experience where majority of them works as either civil engineer (41%) or mid-level manager (32%) or high level manager (18%). It can be seen that respondents are similarly distributed among the age groups of 1-5 (19%), 6-10 (30%), 11-20 (35%), 21- more (16%).

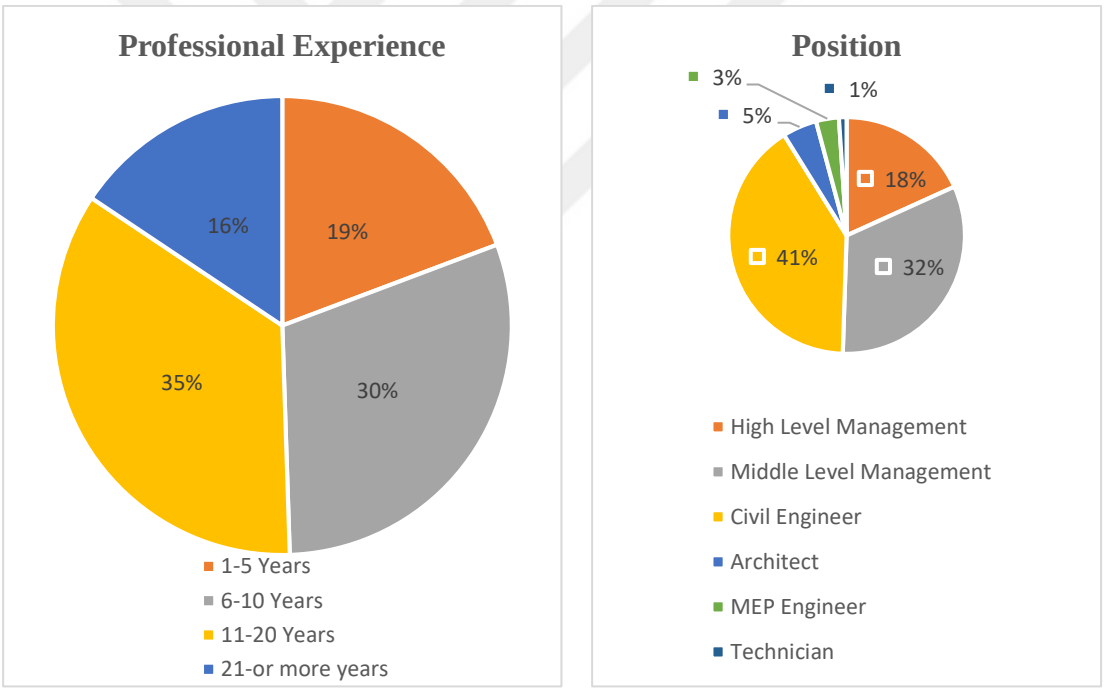

Figure 4.1. Distribution of respondents in terms of experience and position.

Figure 4.2 indicates the distribution of professional experience of respondents clustered based on their position. Referring to this figure, most of the civil engineers has got less than 10 years of experience while mid-level managers' experience varies between 6 to 20 years. As expected, high level managers is accumulated at the experience groups of 11-20 and more years.

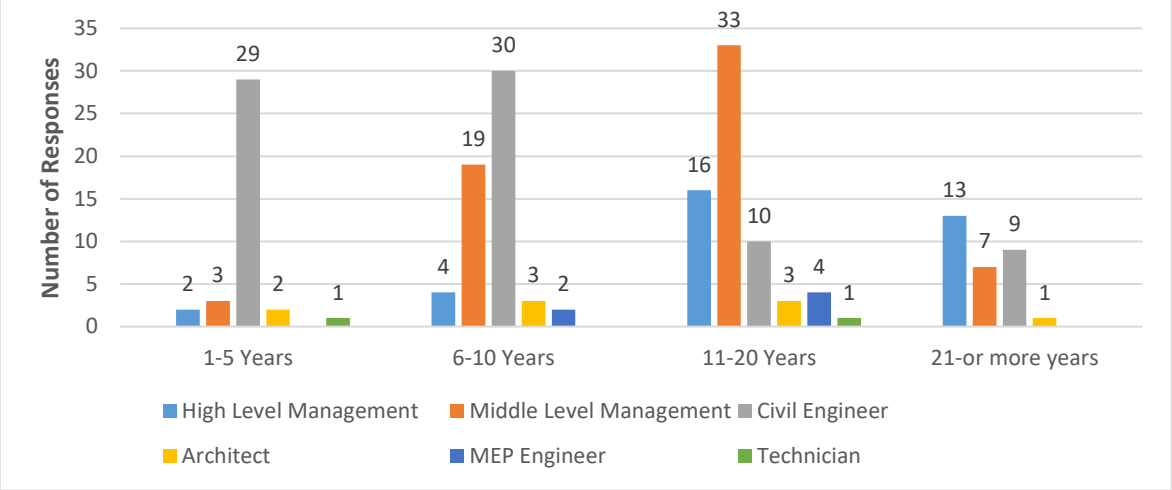

Figure 4.2. Distribution of respondents in terms of experience clustered by position.

Figure 4.3 presents the distribution of companies based on their business area. According to this figure, majority of the respondents are from contractors (42%), while remaining are from Design Consultancy (27%) and Project Management Consultancy (13%), subcontractors (13%), Employer/Client (6%) and Supplier/Vendors (2%).

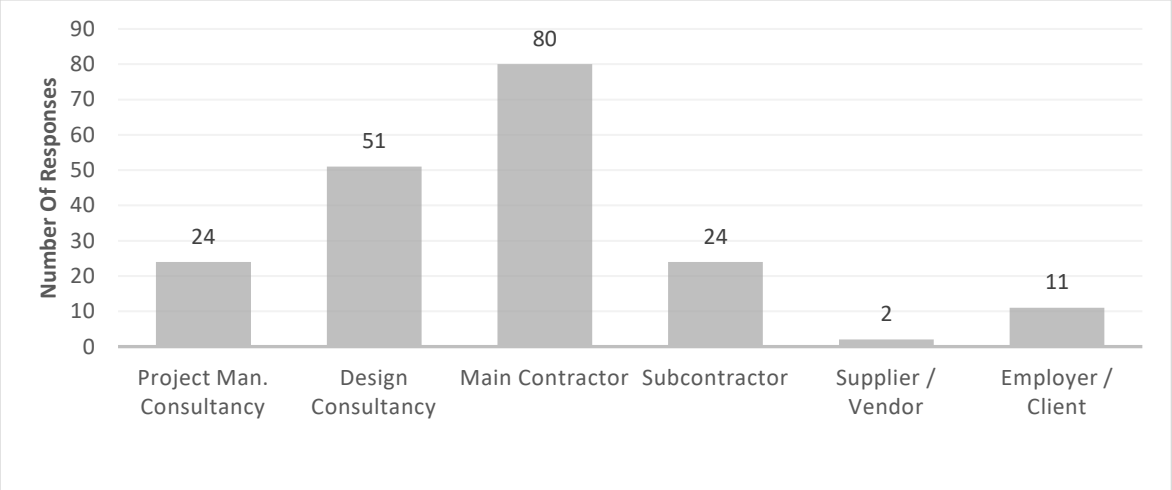

Figure 4.3. Distribution of companies in terms of business.

Figure 4.4 shows the distribution of companies' age. According to this figure, it is seen that majority of the responding firms have 21years or more of experience (56%) in the construction industry. Companies with 11-20years of experience is 22% of respondents and 16% of respondents are 6-10 years of experience.

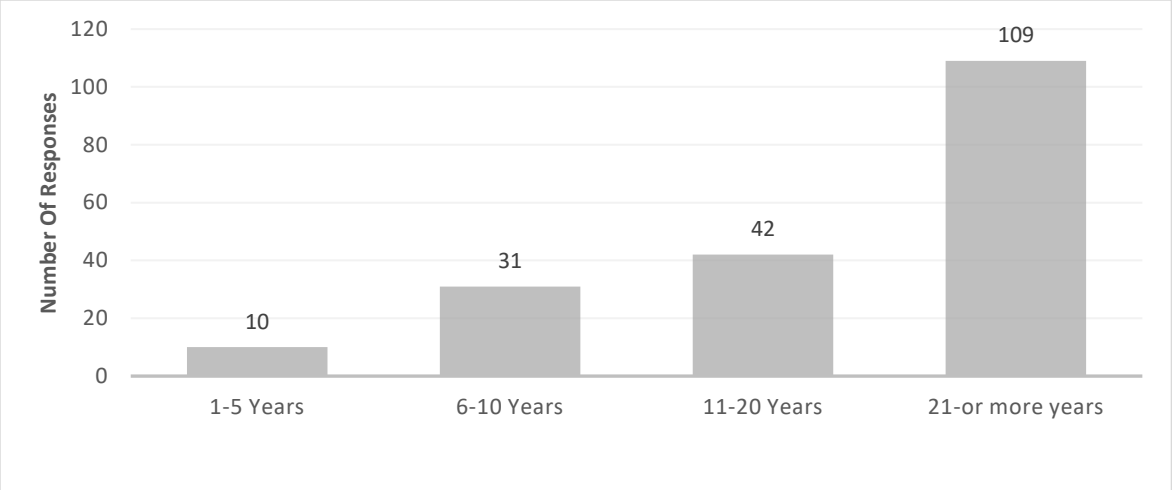

Figure 4.4. Distribution of companies in terms of their age.

Figure 4.5 indicates the distribution of company ages depending on the type of business. According to table below, it is shown that majority of the contractors have got more than 20 years of experience where age of design consultancy companies varies evenly among the age groups. It is also provided that firm age of subcontractors are mainly accumulated at age groups of 11-20 and 21 and more where employer/client has a similar trend with contractors.

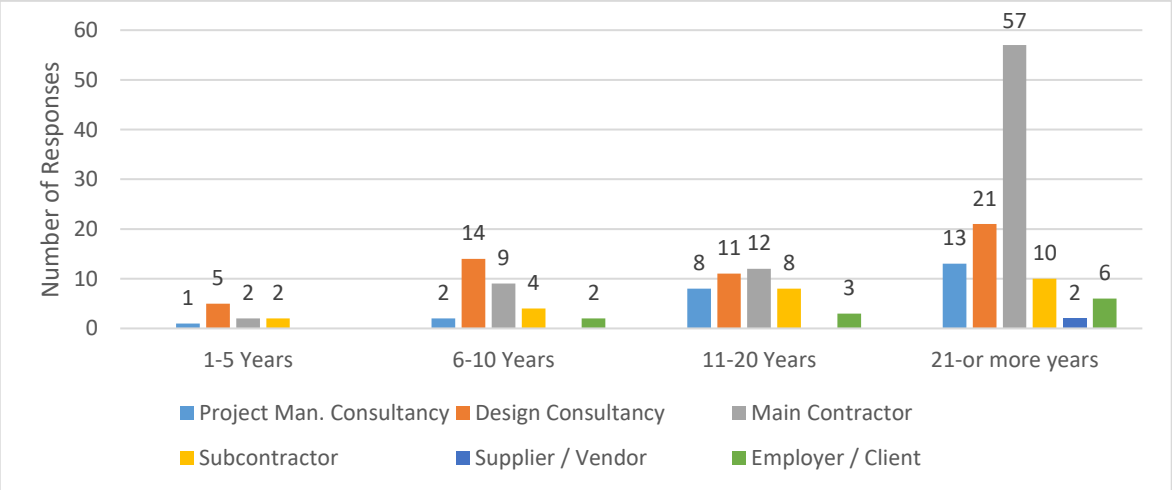

Figure 4.5. Distribution of companies in terms of age clustered by business.

Figure 4.6 shows the range of turnover of respondent companies by their business area. According to this figure, it is seen that majority of the responding firms are in the range of 100 million USD or more (29%) which are main contractors. Design consultancy firms

mainly has got turnover less than 1 million USD (16%) while significant amount of the respondents working for design consultancy doesn't know their company's turnover. Both ranges of 2-10 million (16%) and 10-50 (13%) million USD are similar in terms of number of respondent and distribution.

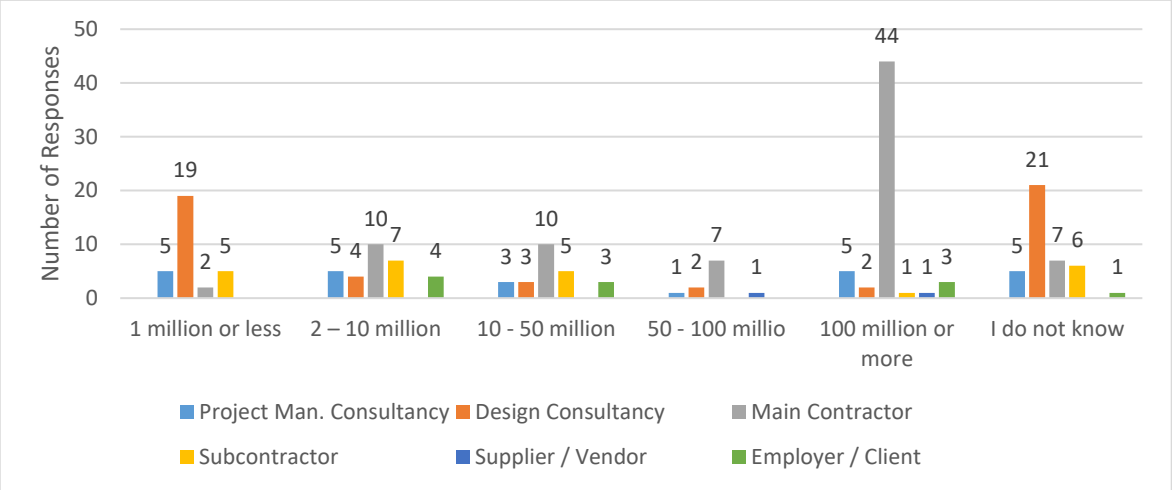

Figure 4.6. Distribution of companies in terms of age clustered by business.

Figure 4.7 shows the distribution of main project types executed by respondent companies clustered by their business area. It is seen that the main project type executed by majority of the responding firms is Building Projects (35%) which are typically led by Architects. On the other hand, contractors are evenly distributed among main type of project and design consultancy firms are mainly working on Building Projects and All types of projects (27%). Both main project type of infrastructure/civil projects (19%) and industrial projects (19%) have similar number of respondents and distribution of business area.

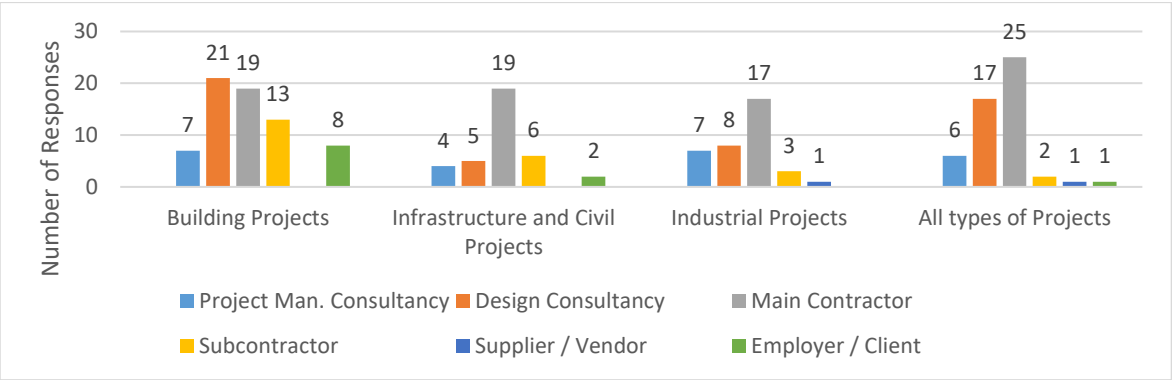

Figure 4.7. Distribution of companies' main project type clustered by business.

4.1.2. General Information about Awareness and Experience of Agile PM

In questionnaire survey, respondents are asked to respond to simple “Yes” or “No” questions which are designed to measure the awareness and knowledge of construction professionals about Agile PM implementation in Turkish construction sector. It is intended to provide demographic insight about general point of view of Turkish construction industry.

Figure 4.8 indicates distribution of previous Agile PM knowledge of construction professionals clustered by business area. Referring to figure below, 31% of the respondent stated that they knew or at least heard about Agile PM before taking this questionnaire. It is the project management companies has got the highest percentage of previous knowledge and awareness since Agile PM is a method of project management.

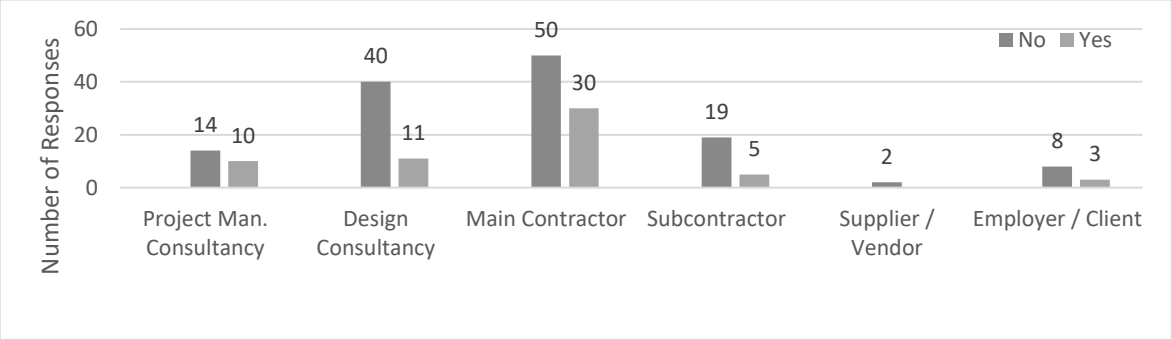

Figure 4.8. Distribution of respondents’ prior knowledge of Agile PM by business.

Figure 4.9 shows the distribution of opinion of construction professionals regarding usefulness of Agile PM with respect to company’s business area. According to figure below, most of the respondents (89%) think that Agile PM would be useful in construction projects. Respondents working for design consultancy and subcontractors have got the highest rate of affirmation of usefulness. On the other hand, contractors’ rate of statement of usefulness is the lowest since multidisciplinary team working and collaboration is quite difficult due to high population of contractors

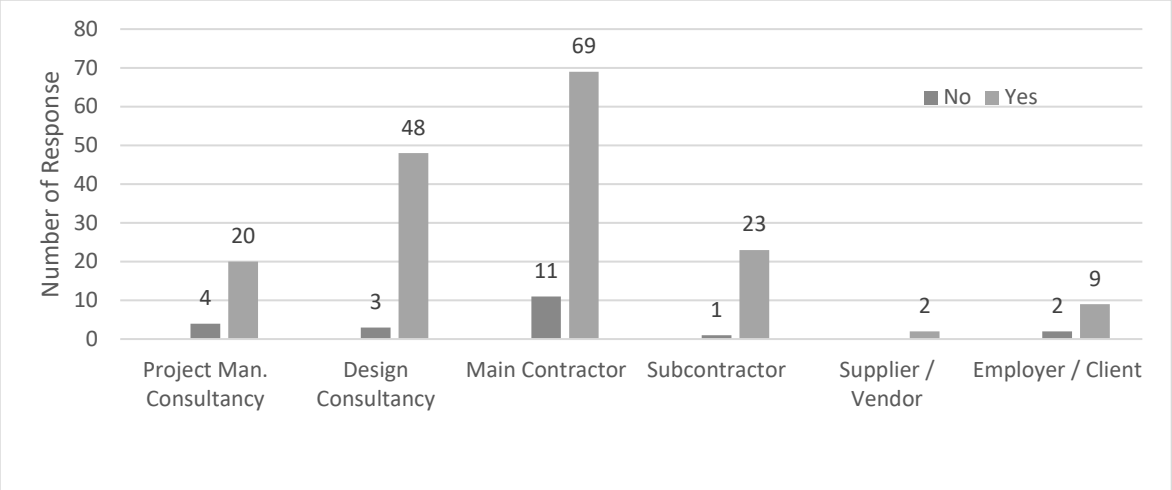

Figure 4.9. Distribution of respondents' opinion on usefulness of Agile PM by business.

Figure 4.10 designates the mean ranking of respondents' opinion on which stage of projects Agile PM would be useful. Respondents are asked to provide their opinion through a 3 point Likert scale (0: "not useful", 1: "low", 2: "moderate", 3: "high") question for each stage of the project from feasibility to operation and maintenance. This question is an optional one so mean ranking of usefulness makes more sense than number of respondents. As seen at figure below, it expected to be more useful in detailed design and construction stages where it is thought to be the least useful at operation and maintenance stage.

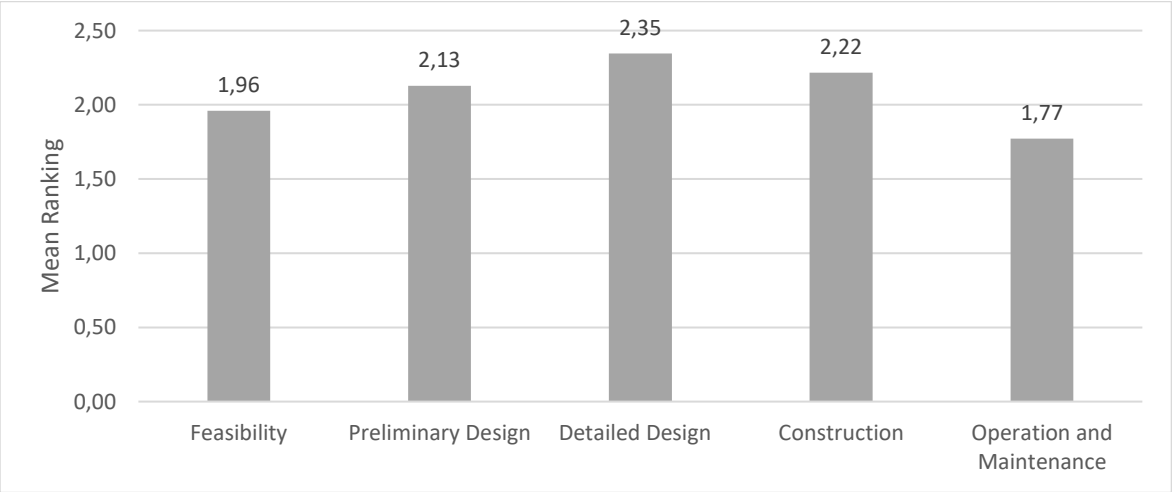

Figure 4.10. Distribution of respondents' opinion on usefulness based on project stage.

Figure 4.11 indicates the distribution of opinion of construction professionals regarding their companies' willingness to implement of Agile PM with respect to company's business area. Referring to figure shown below, 55% of the respondents thinks that their company would be willing to implement Agile PM in their future projects. It can be seen that majority of both PM and design consultancies and main contractors are more likely to implement Agile PM in future projects as more than half percent of respondent are in favor. On the other hand, majority of the subcontractors, vendors and clients don't think that their company is willing to implement Agile PM.

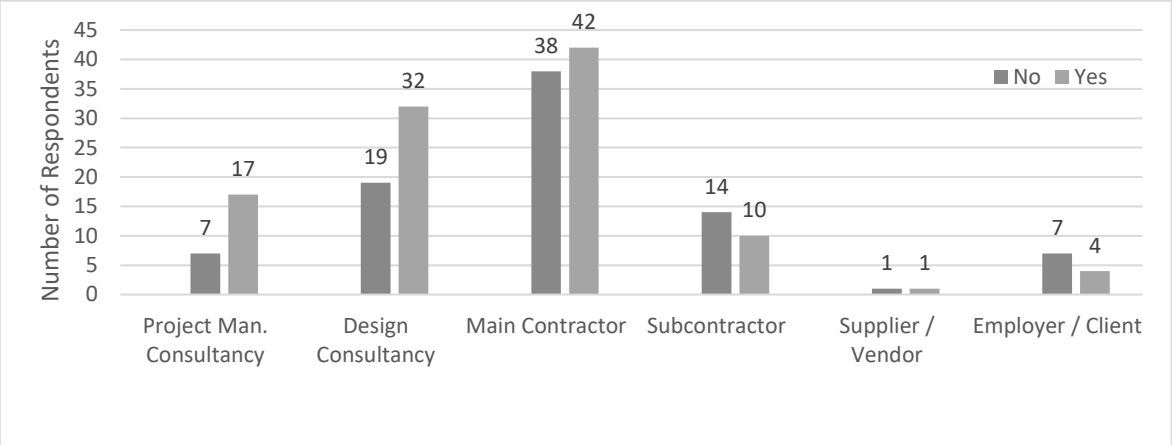

Figure 4.11. Distribution of respondents' opinion on willingness by business.

Figure 4.12 shows the distribution of experience of construction professionals regarding implementation of Agile PM with respect to company's business area. Referring to figure shown below, 26 out of 192 respondents, which is 14% of overall respondents, stated that they have implemented Agile PM or managed a project with similar principles in one of their project. It can be seen that majority of respondents implemented Agile PM is working for Contractors which is around 50%. The remaining portion of respondents is working for Project Management and Design Consultants and Subcontractors. On the other hand, there is no one from supplier or client stated to implement Agile PM. Since the population of respondents experienced Agile PM is relatively small, it is difficult to draw direct conclusions regarding the benefits and improvements derived from the data obtained through the questions 12.1 to 12.9 of questionnaire survey. Yet, the descriptive statistics of responses is given for information within the context of this study in the following paragraphs.

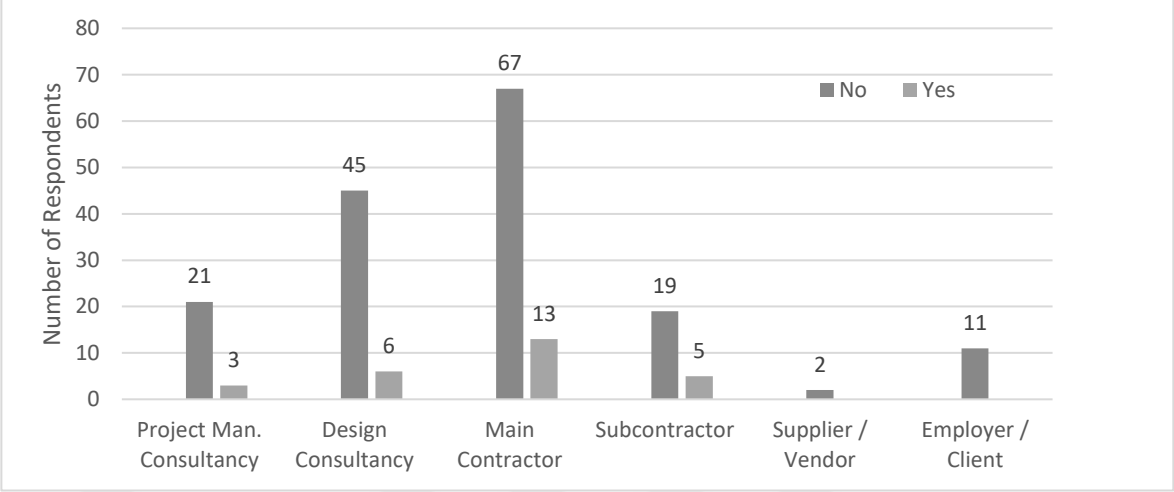

Figure 4.12. Distribution of respondents' experience on Agile PM by business.

Figure 4.13 indicates the distribution of respondents' experience of agile methods in terms of type and at which project stage. With reference to figure 4.13, 69% of respondents claimed to use internal or in-house methods of Agile PM while 31% of respondents selected scrum. This is because companies try to be agile in their projects by using similar principles with Agile PM. Referring to the second chart pie of figure 4.13, the agile methods were mostly applied during construction stage by almost 75% of respondents where 27 % of respondents selected design stage. This might be due to respondents' profile of majority working for contractor or a confusion with lean principles like Kanban as it is quite popular in recent years at construction projects to follow up work progress as well as facilitate coordination among teams closely.

The benefits and process improvements due to use of Agile PM methods was requested to be ranked by the respondents and descriptive statistics of these responses are given in figures 4.14, 4.15, and 4.16. As explained before, the discussion and conclusion based on small number of survey sample will lead to unreliable results and justifications. Therefore, figures are given only for the purpose of information. According to those figures, the impact of Agile PM on project cost and duration is mainly reduction by 1-25% while productivity, quality, collaboration and transparency of projects are reported to be increased by 1-25%, 26-50%, and 51-75%.

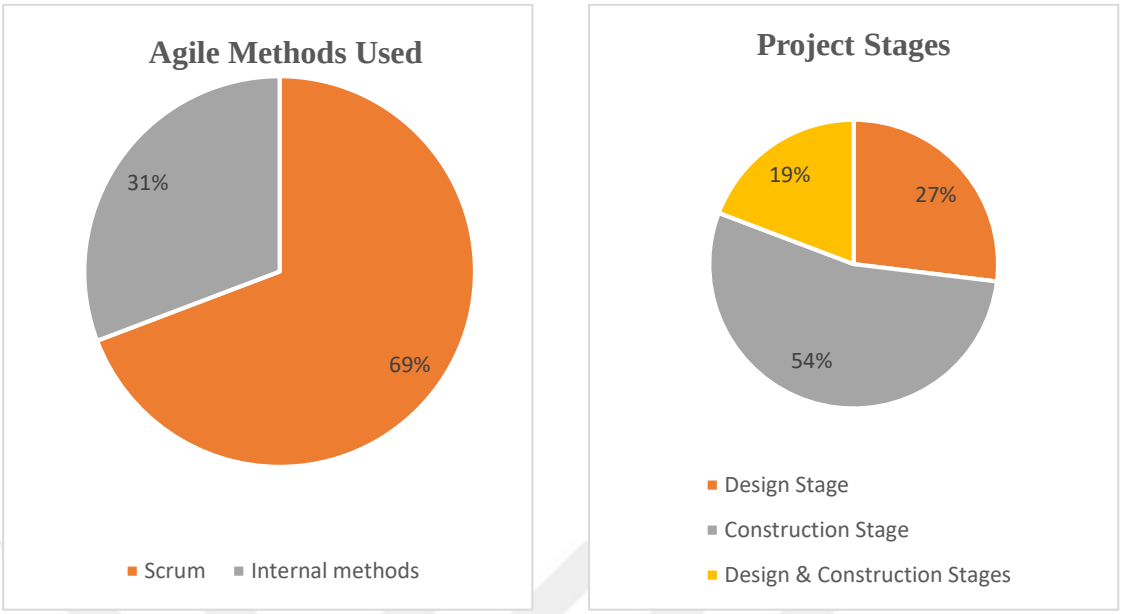

Figure 4.13. Distribution of agile methods used and project stage.

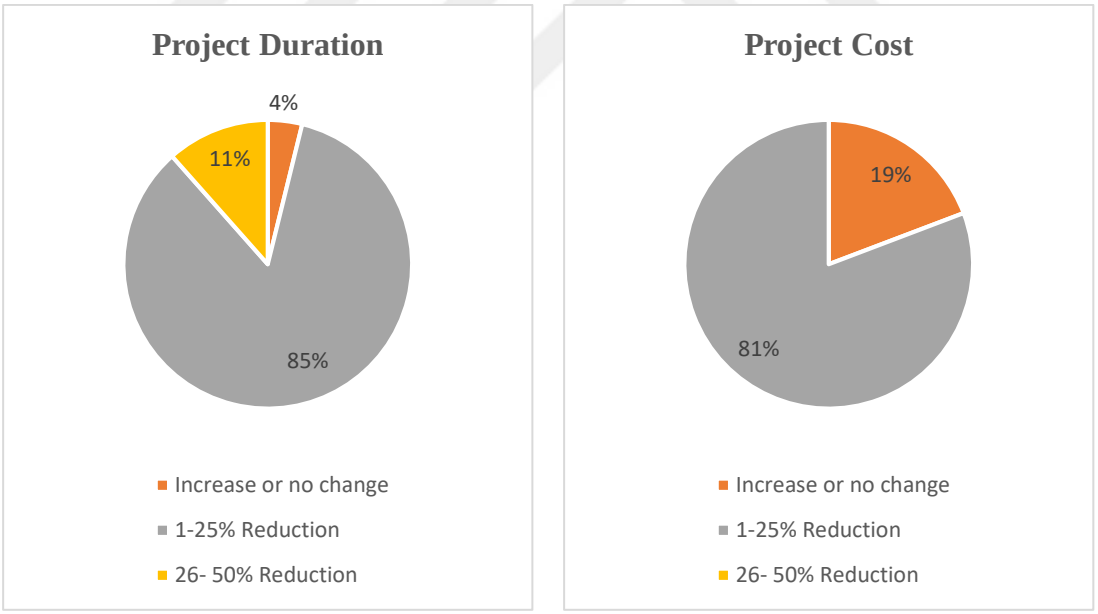

Figure 4.14. Distribution of respondents' opinion on project duration and cost.

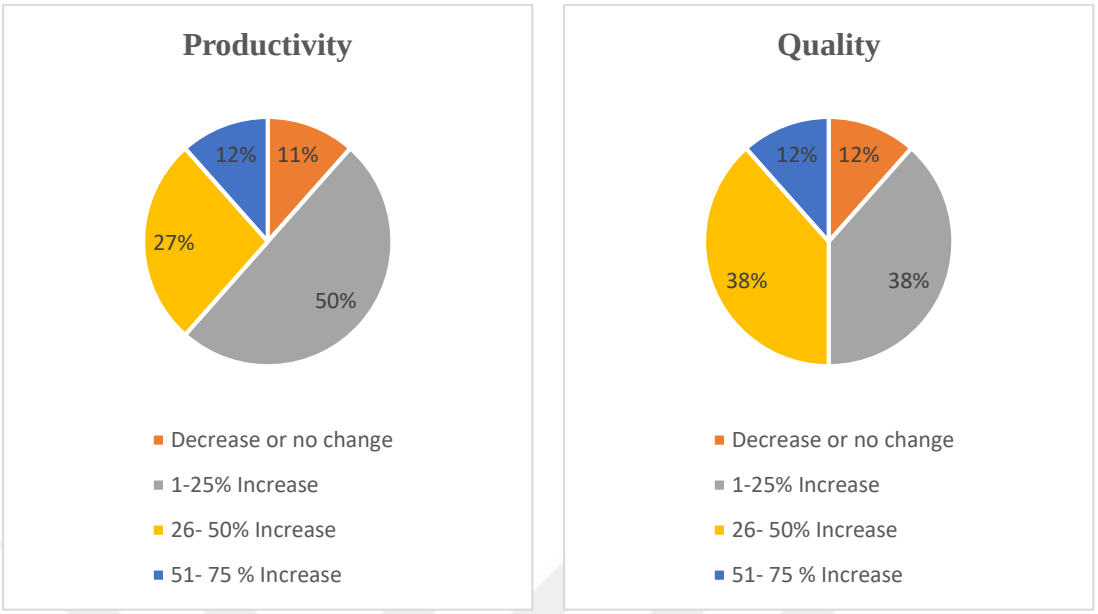

Figure 4.15. Distribution of respondents' opinion on project productivity and quality.

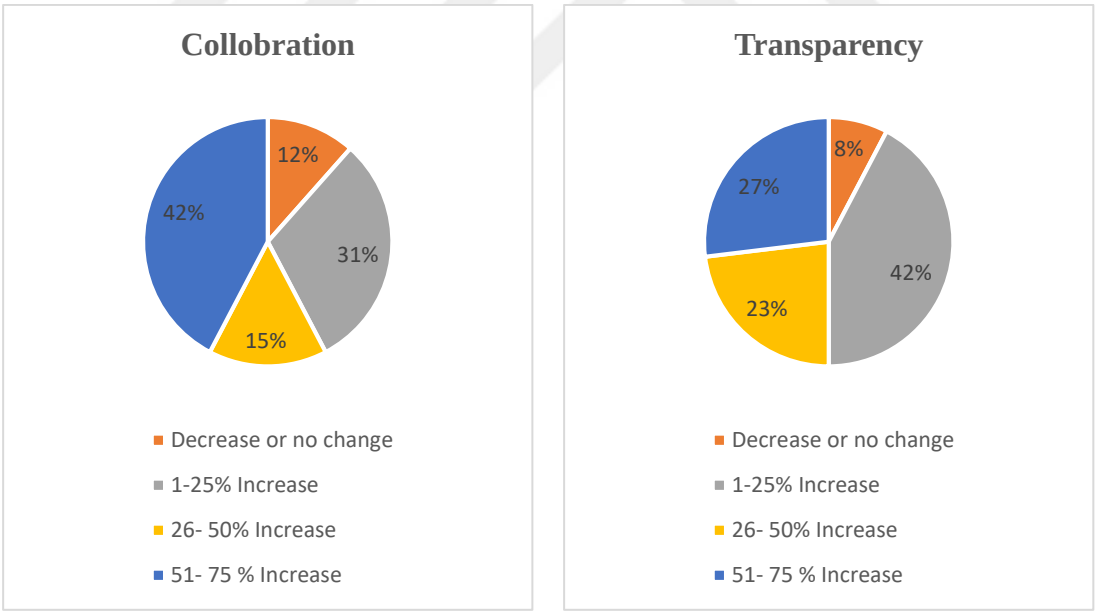

Figure 4.16. Distribution of respondents' opinion on collaboration and transparency.

4.1.3. Distribution of Rating Levels of Agile PM Implementation Factors

Factors affecting implementation Agile PM in construction projects are selected and linked to each other based on the conceptual framework explained in previous chapters of this study. These parameters are components of proposed conceptual framework which is constituted as inputs and outputs of an innovation process. The average ratings of each parameter are calculated as per mean ranking formula and presented in the following figures. Considering the high ratings provided by respondents as shown in the following figures, all parameters can be evaluated to be valid and important according to the perception of respondents. Therefore, it can be concluded that the study has reached its target population and the proposed conceptual framework of Agile PM implementation with these parameters matches well with perception and opinion of construction professionals.

4.1.3.1. Drivers of Agile PM Implementation: The abbreviations for drivers of Agile PM implementation is presented in Table 4.1 below.

Table 4.1. Abbreviations of drivers.

Abbreviation	Drivers
DR1	Responsiveness to changes and client requirements
DR2	Need for project performance improvement
DR3	Poor communication with client and stakeholders
DR4	Dynamic and uncertain project environment
DR5	Projects with high complexity and risk
DR6	Competition level in market

Figure 4.17 shows the distribution of drivers of Agile PM implementation in construction projects. According to Figure 4.17, “DR1 - Responsiveness to changes and client requirements” and “DR2 - Need for project performance improvement” parameters were found to be the most important among others. This finding is predictable since these two drivers are also mostly cited factors in the literature review. On the other hand, surprisingly “DR5 - Projects with high complexity and risk” has rated quite close to DR1

and DR2. The least important parameter of the drivers of Agile PM implementation was found to be “DR6 - Competition level in market” since the benefits of Agile PM in construction industry are yet to be proved in order to create a competitive advantage.

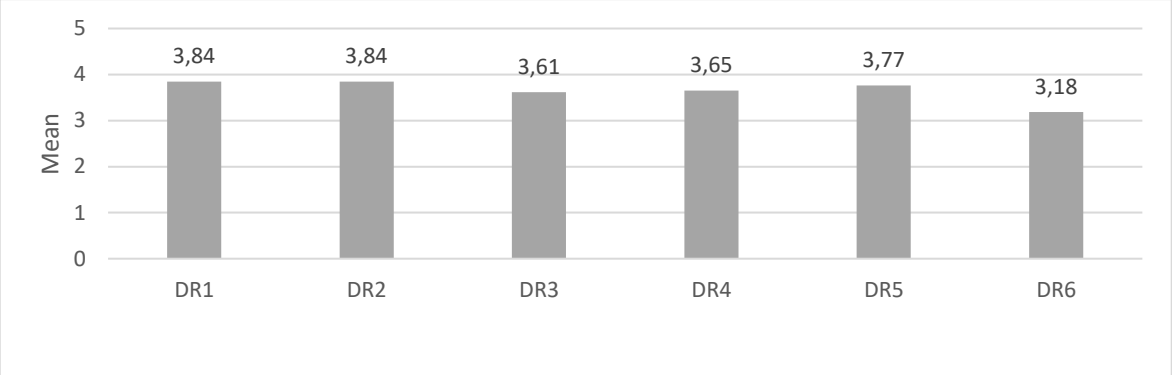

Figure 4.17. Mean ranking of drivers of Agile PM implementation.

4.1.3.2. Barriers to Agile PM Implementation: Table 4.2 presents the abbreviations for the barriers to Agile PM implementation.

Table 4.2. Abbreviations of barriers.

Abbreviation	Barriers
BA1	Resistance to organizational and cultural change
BA2	Lack of top management support and commitment
BA3	Lack of commitment and engagement of customer/client
BA4	Lack of commitment and engagement of team members and other stakeholders
BA5	Team members working on multiple projects and in different locations
BA6	Unclear benefits and methods of implementation of Agile PM in construction industry
BA7	Lack of awareness of Agile PM methods and practices
BA8	Lack of contractual aspects of using Agile PM between stakeholders
BA9	Bureaucratic project environment with multiple stages of projects acceptance
BA10	Fractured nature of construction projects with large number of stakeholders

Figure 4.18 presents the distribution of barriers to Agile PM implementation in construction projects. It can be seen that the two most rated barriers are “BA2 - Lack of top management support and commitment” and “BA1 - Resistance to organizational and cultural change” consecutively. They are followed closely by “BA7 - Lack of awareness of Agile PM methods and practices” and “BA4 - Lack of commitment and engagement of team members and other stakeholders”. “BA8 - Lack of contractual aspects of using Agile PM between stakeholders” and”BA5 - Team members working on multiple projects and in different locations” are found to be the lowest barriers among others.

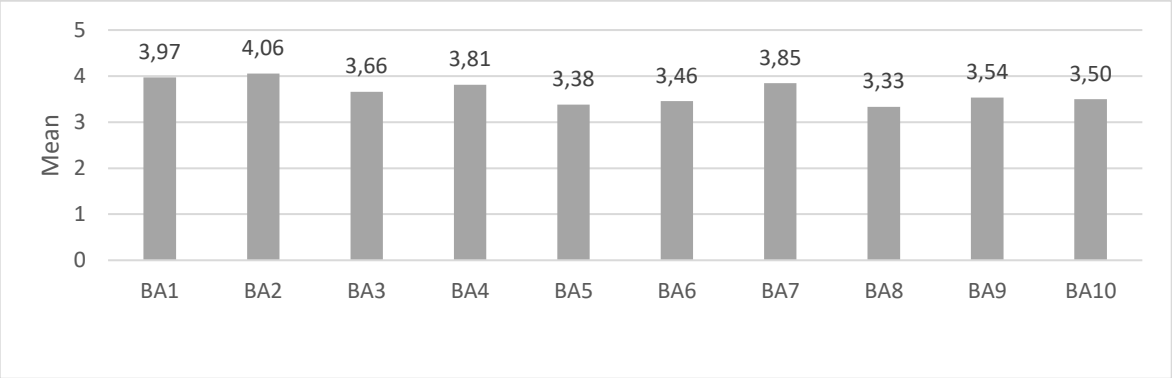

Figure 4.18. Mean ranking of barriers to Agile PM implementation..

4.1.3.3. Enablers of Agile PM Implementation: The abbreviations for the enablers of Agile PM implementation can be seen in Table 4.3 below.

Table 4.3. Abbreviations of enablers.

Abbreviation	Enablers
EN1	Short-term visualized planning for iteration and incremental delivery
EN2	Timely and continuous involvement of client
EN3	Collaborative partnering of contractor and other stakeholders
EN4	Commitment and organizational learning via short feedback loops
EN5	Organizational trust among employees
EN6	Effective leadership
EN7	Face to face communication
EN8	Promoting minimal documentation and simple solutions

Figure 4.19 shows the distribution of enablers of agile PM implementation. According to this figure, it can be seen that all factors are rated around 3.85, which proves the reliability and importance of the factors in terms of explaining enablers and . “EN3 - Collaborative partnering of contractor and other stakeholders” and “EN6 - Effective leadership” are found to be highest rated factors among other enablers. On the other hand, “EN2 - Timely and continuous involvement of client” and “EN1 - Short-term visualized planning for iteration and incremental delivery” are found to be less significant than others. However, is should be noted that all enablers are rated above 3.7 which refers to be important in the survey.

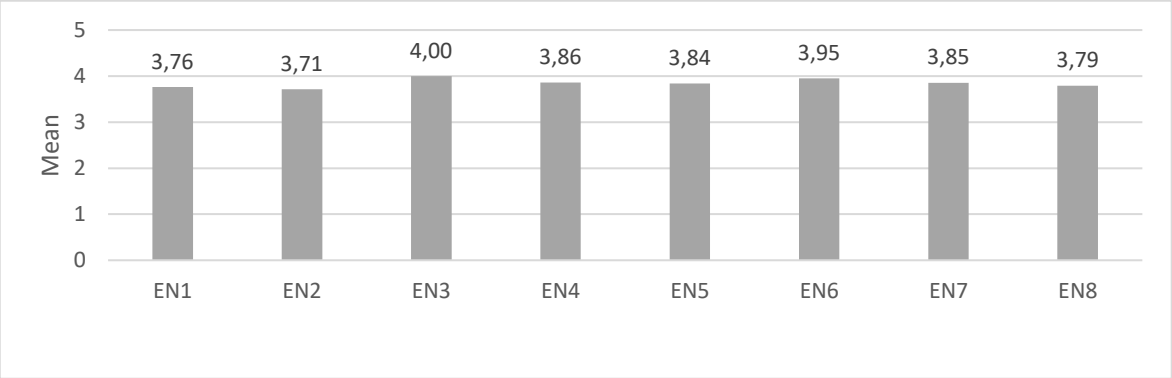

Figure 4.19. Mean ranking of enablers of Agile PM implementation.

4.1.3.4. Inputs of Agile PM Implementation: The abbreviations for the inputs of Agile PM implementation is explained in Table 4.4 below.

Table 4.4. Abbreviations of inputs.

Abbreviation	**Inputs**
IN1	Autonomous, self-organized, multi-disciplinary team
IN2	Daily stand-up meeting
IN3	Size of project team
IN4	Location of project team
IN5	Experience of project team
IN6	Consultancy and training of team members
IN7	Information technology integration and support
IN8	Internal knowledge resources

Figure 4.20 shows the ranking distribution of the inputs of Agile PM implementation. "IN7 - Information technology integration and support" and "IN1 - Autonomous, self-organized, multi-disciplinary team" are the two most rated inputs. His finding can be linked to the fact that information technology is getting very crucial in every aspect of construction projects. Respondents are also indicated that "IN5 – Experience of project team" is also highly important since the success of autonomous, multi-disciplinary teams are the core of decision making which heavily relies on experience of the team. As it can be seen from the figure below, "IN3 - Size of project team" and "IN4 - Location of project team" are found to be the least significant factors among them.

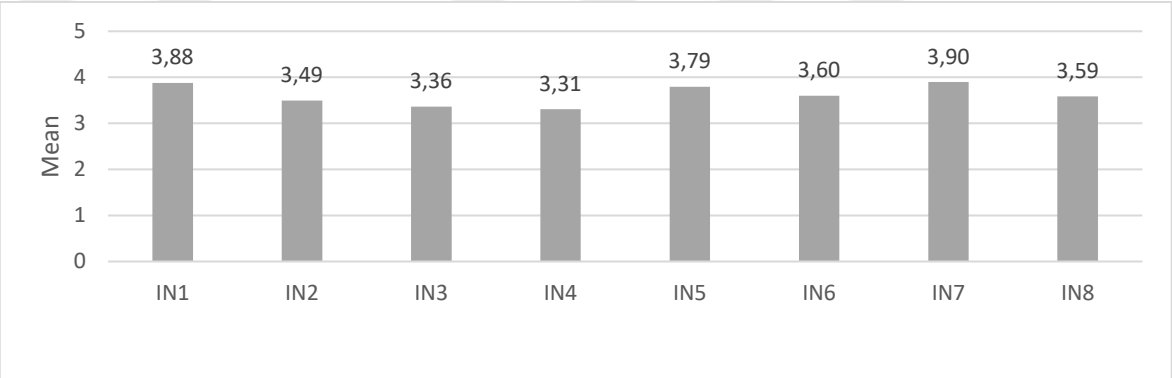

Figure 4.20. Mean ranking of inputs of Agile PM implementation.

4.1.3.5. Process Improvements of Agile PM Implementation: The abbreviations for the process improvements of Agile PM implementation is explained in Table 4.5 below.

Table 4.5. Abbreviations of process improvements.

Abbreviation	Process Improvements
PI1	Improvement of communication and collaboration
PI2	Increase in transparency and visibility of the project
PI3	Improvement of organizational learning and practices
PI4	Better response to changes
PI5	Decrease in project risk

Figure 4.21 shows the ranking distribution of the process improvements of Agile PM implementation. According to this figure, it can be seen that the top rated factor is “PI4- Better response to changes” which is the main feature of Agile PM implementation. “PI - Improvement of communication and collaboration” is the second high rated factor since Agile PM enables communication and collaboration through daily meetings and collocation of project team. However, respondents has rated “PI5 - Decrease in project risk” as less significant process improvement since risk might is usually attributed to external factors in construction projects.

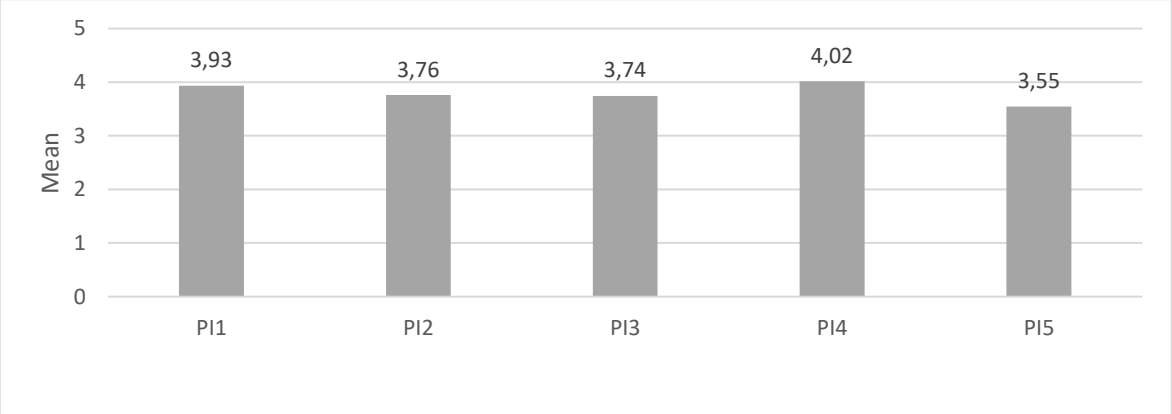

Figure 4.21. Mean ranking of process improvements of Agile PM implementation.

4.1.3.6. Benefits of Agile PM Implementation: The abbreviations for the benefits of Agile PM implementation can be seen in Table 4.6 below.

Table 4.6. Abbreviations of benefits.

Abbreviation	Benefits
PB1	Improvement of client satisfaction
PB2	Increase in project performance
PB3	Increase in project quality
PB4	Decrease in project cost
PB5	Decrease in project duration

Figure 4.22 presents the ranking distribution of the benefits of Agile PM implementation. Referring to figure below, respondents stated that “PB2 - Increase in Project Performance” is the most expected benefit of Agile PM implementation. In addition, “PB1 - Improvement of Client Satisfaction” and “PB3 - Increase in Project Quality” are also highly rated benefits. On the other hand, “PB4 - Decrease in project cost" and "PB5 - Decrease in project duration" found to be the lowest benefits among others.

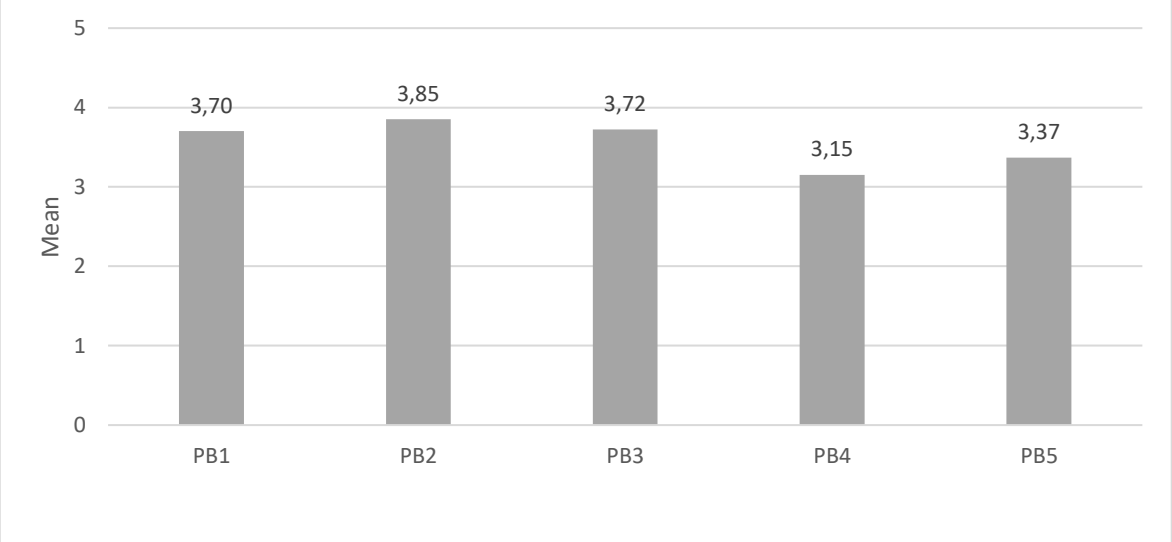

Figure 4.22. Mean ranking of benefits of Agile PM implementation.

4.2. T-test and Analysis of Variance (ANOVA)

T-test and the one-way ANOVA are two parametric statistical methods used to compare the means of groups in a given data set. There is a very small difference between them. The t-test is for comparing means of two samples while analysis of variance is for comparison of the means of more than two samples. Briefly, both methods are is used to detect differences among the means of the samples. The t-test is performed among two population and the result of the test directly indicates if there is any difference of means between two. On the other hand, the results of a one-way ANOVA only provides the information if there is any difference among groups but, no information is given which of the two groups are different than each other. Further test, namely post-hos, needs to be performed to detect which group is different from one another. Many different post-hoc analyses can be performed by using SPSS software following a one-way ANOVA. In this

study, Least Significant Difference (LSD) Test, which is originally developed to explore all possible pair-wise comparisons of means of groups by using the equivalent of multiple t-tests, is employed. The test is first developed by Fisher. For both t-test and ANOVA tests, when the test significance level (p-value) is less than 0.05 at the 95% confidence interval, it concluded that the null hypothesis is rejected. Rejection of the null hypothesis indicates that there are statistically significant differences between groups.

4.2.1 T-test Results for Factors of Agile PM Implementation

In order to explore the awareness and knowledge of construction professionals in the Turkish construction industry regarding Agile PM implementation in construction projects, there are few questions asked to respondents in the questionnaire survey. The number of these questions are 8, 9, and 11and the questions are about previous knowledge, usefulness and their companies' willingness of Agile PM implementation respectively. These questions can simply be responded as "yes" or "no" which enables to use independent samples t-test to compare means of factors of Agile PM implementation between two populations. The t-test is performed for all questions and the one carried out for companies' willingness to implement Agile PM implementation yields more meaningful results. Therefore, the results of this test is presented in Table 4.7 below.

The t-test is conducted with the help of SPSS software and only the rejected null hypotheses are presented. It means that there are statistically significant differences between groups. As shown in table below, the respondents, who thinks that their company would like to implement Agile PM in future projects, have different views on factors of Agile PM implementation compared to the ones with negative opinion for their companies' willingness to implement. The group of respondents with positive opinion has rated the following factors higher than the other group.

The drivers, which are rated higher, are "DR1 - Responsiveness to changes and client requirements", "DR2 - Need for Project Performance Improvement", "DR3 - Poor communication with client and stakeholders", "DR5 - Projects with high complexity and risk", and "DR6 - Competition Level in market". All drivers are ranked to be more important

except “DR4 - Dynamic and uncertain project environment” because the Agile PM implementation is thought to have a great potential to meet the needs of construction industry by respondents with positive opinion on their companies’ willingness.

The enablers and input are rated higher; "EN2 - Timely and continuous involvement of client", "EN3 - Collaborative partnering of contractor and other stakeholders", and "EN7 - Face to face communication", “IN2 - Daily stand-up meeting”. The respondents with positive opinion on their companies’ willingness thinks that close face to face communication with client, contractor and other stakeholders as well as daily standup meetings are more important to promote Agile PM implementation in construction projects.

Finally, respondents with positive opinion on their companies’ willingness thinks that Agile PM implementation is a promising method for all process improvements and project level benefits listed in this study. Especially the mean ranking of process improvement “PI4 – Better response to change” is the highest rated factor with ranking around 4.2 which can be regarded as the main core benefit in line with opinions of many scholars and professionals in literature. It can also be concluded that these professionals with positive opinion have motivation and commitment to implement Agile PM in their projects which makes them perfect candidate for members of agile teams for a smooth transition.

Table 4.7. T-test results for Agile PM factors according to company’s willingness.

Variables	Response	Mean	Test for Equality of Variances			t-test for Equality of Means		
			Conditon	F	Sig.	t	dof	Sig.
DR1	"No"	3,57	Equal variances assumed	3,451	0,065	-3,68	190,00	0,0003
	"Yes"	4,07	Equal variances not assumed			-3,64	171,43	0,0004
DR2	No	3,63	Equal variances assumed	0,223	0,637	-2,81	190,00	0,0054
	Yes	4,02	Equal variances not assumed			-2,83	184,87	0,0052

Table 4.7. T-test results for Agile PM factors according to company's willingness. (cont.)

DR3	No	3,33	Equal variances assumed	0,289	0,591	-3,28	190,00	0,0013
	Yes	3,85	Equal variances not assumed			-3,25	176,41	0,0014
DR5	No	3,48	Equal variances assumed	5,257	0,023	-3,45	190,00	0,0007
	Yes	4,00	Equal variances not assumed			-3,41	171,33	0,0008
DR6	No	2,98	Equal variances assumed	0,869	0,352	-2,28	190,00	0,0236
	Yes	3,35	Equal variances not assumed			-2,28	180,29	0,0239
EN2	No	3,50	Equal variances assumed	4,576	0,034	-2,60	190,00	0,0101
	Yes	3,89	Equal variances not assumed			-2,56	169,59	0,0114
EN3	No	3,73	Equal variances assumed	7,819	0,006	-3,38	190,00	0,0009
	Yes	4,22	Equal variances not assumed			-3,30	159,18	0,0012
EN7	No	3,62	Equal variances assumed	3,160	0,077	-3,01	190,00	0,0030
	Yes	4,05	Equal variances not assumed			-2,98	175,16	0,0033
IN2	No	3,27	Equal variances assumed	0,302	0,583	-2,87	190,00	0,0046
	Yes	3,68	Equal variances not assumed			-2,84	173,06	0,0051
PI1	No	3,66	Equal variances assumed	1,873	0,173	-3,36	190,00	0,0010
	Yes	4,15	Equal variances not assumed			-3,32	173,11	0,0011
PI2	No	3,51	Equal variances assumed	1,329	0,250	-2,89	190,00	0,0043
	Yes	3,96	Equal variances not assumed			-2,88	178,03	0,0045
PI3	No	3,50	Equal variances assumed	1,748	0,188	-3,20	190,00	0,0016
	Yes	3,94	Equal variances not assumed			-3,18	178,23	0,0017

Table 4.7. T-test results for Agile PM factors according to company's willingness. (cont.)

PI4	No	3,80	Equal variances assumed	0,616	0,433	-2,77	190,00	0,0062
	Yes	4,19	Equal variances not assumed			-2,72	168,80	0,0071
PI5	No	3,29	Equal variances assumed	1,833	0,177	-3,22	190,00	0,0015
	Yes	3,75	Equal variances not assumed			-3,18	170,81	0,0018
PB1	No	3,44	Equal variances assumed	1,065	0,303	-3,05	190,00	0,0026
	Yes	3,92	Equal variances not assumed			-3,03	177,55	0,0028
PB2	No	3,60	Equal variances assumed	6,107	0,014	-3,25	190,00	0,0014
	Yes	4,06	Equal variances not assumed			-3,20	169,06	0,0016
PB3	No	3,37	Equal variances assumed	4,246	0,041	-4,23	190,00	0,0000
	Yes	4,01	Equal variances not assumed			-4,17	171,48	0,0000
PB4	No	2,91	Equal variances assumed	1,464	0,228	-2,86	190,00	0,0047
	Yes	3,35	Equal variances not assumed			-2,88	185,10	0,0045
PB5	No	3,13	Equal variances assumed	2,027	0,156	-2,61	190,00	0,0097
	Yes	3,57	Equal variances not assumed			-2,63	185,05	0,0094

4.2.2 ANOVA Results for Factors of Agile PM Implementation

ANOVA test is performed to investigate whether respondents have different views on the factors of Agile PM implementation in construction projects with respect to respondents' positon. The data is rearranged for 3 number of positions which are top level management, medium level management, engineers (civil and MEP) and architects considered together as potential members of an agile project team. The difference between the mean rankings of factors affecting Agile PM implementation is explored using ANOVA test and results are

presented in Table 4.8. The rejected null hypotheses are in bold font where p-values are less than 0.05 at the 95% confidence interval. It means that there are statistically significant differences between mean rankings with respect to respondents' position.

According to the mean rankings of each group given in the Table 4.8, for the factors, whose mean rankings are found to be statistically different according to respondents' position, the mean ranking of the top level managers is always lower than medium level managers and engineers and architects, namely agile team members. This finding may be resulted from either lack of awareness of top management or resistance to organizational and cultural change of hierarchical organization structure to horizontal one. In order to understand the reason behind this difference in more detail, further post-hoc analysis (LSD Test) is carried out for each factor groups of Agile PM implementation.

The factors, which are found to be statistically significant differences between groups, are "DR1-Responsiveness to changes and client requirements", "DR4-Dynamic and uncertain project environment", "BA2-Lack of top management support and commitment", "IN1-Autonomous, self-organized, multi-disciplinary team", "IN2-Daily stand-up meeting", "IN6-Consultancy and training of team members", "PI1-Improvement of communication and collaboration", "PI2-Increase in transparency and visibility of the project", "PI4-Better Response to Changes", "PB1-Improvement of Client Satisfaction", "PB2-Increase in Project Performance", "PB3-Increase in Project Quality", "PB4-Decrease in Project Cost", "PB5-Decrease in Project Duration".

Table 4.8. ANOVA results for Agile PM factors with respect to position.

Variables	Position	Mean		Sum of Squares	df	Mean Square	F-value	p-value
DR1	1	*3,31*	Between Groups	12,8	2	6,384	7,423	0,001
	2	4,05	Within Groups	162,5	189	0,860		
	3	3,91	Total	175,3	191			
DR2	1	3,57	Between Groups	4,5	2	2,226	2,379	0,095
	2	4,02	Within Groups	176,9	189	0,936		
	3	3,83	Total	181,3	191			

Table 4.8. ANOVA results for Agile PM factors with respect to position. (cont.)

DR3	1	3,20	Between Groups	7,4	2	3,679	2,945	0,055
	2	3,71	Within Groups	236,1	189	1,249		
	3	3,71	Total	243,5	191			
DR4	1	*3,23*	Between Groups	7,6	2	3,820	3,282	0,040
	2	3,74	Within Groups	220,0	189	1,164		
	3	3,75	Total	227,6	191			
DR5	1	3,43	Between Groups	5,1	2	2,541	2,230	0,110
	2	3,89	Within Groups	215,4	189	1,140		
	3	3,81	Total	220,5	191			
DR6	1	2,77	Between Groups	7,2	2	3,613	2,852	0,060
	2	3,27	Within Groups	239,4	189	1,267		
	3	3,27	Total	246,6	191			
BA1	1	4,11	Between Groups	1,0	2	0,508	0,462	0,631
	2	3,98	Within Groups	207,9	189	1,100		
	3	3,92	Total	208,9	191			
BA2	1	*3,74*	Between Groups	5,6	2	2,788	3,277	0,040
	2	4,24	Within Groups	160,8	189	0,851		
	3	4,05	Total	166,4	191			
BA3	1	3,66	Between Groups	0,4	2	0,221	0,211	0,810
	2	3,60	Within Groups	198,6	189	1,051		
	3	3,71	Total	199,0	191			
BA4	1	3,66	Between Groups	2,5	2	1,262	1,291	0,277
	2	3,97	Within Groups	184,7	189	0,977		
	3	3,77	Total	187,3	191			
BA5	1	3,23	Between Groups	6,5	2	3,229	2,600	0,077
	2	3,65	Within Groups	234,8	189	1,242		
	3	3,26	Total	241,2	191			
BA6	1	3,37	Between Groups	1,2	2	0,582	0,533	0,588
	2	3,39	Within Groups	206,5	189	1,093		
	3	3,54	Total	207,7	191			
BA7	1	3,71	Between Groups	0,8	2	0,392	0,386	0,680
	2	3,89	Within Groups	191,8	189	1,015		
	3	3,87	Total	192,6	191			
BA8	1	3,37	Between Groups	2,7	2	1,327	1,306	0,273
	2	3,48	Within Groups	192,0	189	1,016		
	3	3,22	Total	194,7	191			
BA9	1	3,26	Between Groups	7,1	2	3,550	2,812	0,063
	2	3,79	Within Groups	238,6	189	1,263		
	3	3,47	Total	245,7	191			

Table 4.8. ANOVA results for Agile PM factors with respect to position. (cont.)

BA10	1	3,51	Between Groups	2,8	2	1,390	1,080	0,342
	2	3,66	Within Groups	243,2	189	1,287		
	3	3,39	Total	246,0	191			
EN1	1	3,51	Between Groups	3,7	2	1,851	1,868	0,157
	2	3,92	Within Groups	187,3	189	0,991		
	3	3,75	Total	191,0	191			
EN2	1	3,71	Between Groups	1,2	2	0,611	0,561	0,572
	2	3,82	Within Groups	206,0	189	1,090		
	3	3,64	Total	207,2	191			
EN3	1	3,89	Between Groups	0,6	2	0,306	0,296	0,744
	2	4,05	Within Groups	195,4	189	1,034		
	3	4,01	Total	196,0	191			
EN4	1	3,77	Between Groups	1,1	2	0,569	0,633	0,532
	2	3,97	Within Groups	170,1	189	0,900		
	3	3,82	Total	171,2	191			
EN5	1	3,63	Between Groups	3,2	2	1,577	1,561	0,213
	2	3,77	Within Groups	190,8	189	1,010		
	3	3,96	Total	194,0	191			
EN6	1	3,69	Between Groups	3,8	2	1,892	1,894	0,153
	2	4,10	Within Groups	188,8	189	0,999		
	3	3,96	Total	192,6	191			
EN7	1	3,71	Between Groups	1,1	2	0,548	0,537	0,586
	2	3,94	Within Groups	192,8	189	1,020		
	3	3,85	Total	193,9	191			
EN8	1	3,80	Between Groups	0,0	2	0,016	0,013	0,987
	2	3,81	Within Groups	221,6	189	1,173		
	3	3,78	Total	221,7	191			
IN1	1	*3,46*	Between Groups	8,0	2	3,986	3,420	0,035
	2	3,92	Within Groups	220,3	189	1,165		
	3	4,01	Total	228,2	191			
IN2	1	*3,06*	Between Groups	8,2	2	4,106	4,177	0,017
	2	3,58	Within Groups	185,8	189	0,983		
	3	3,60	Total	194,0	191			
IN3	1	3,26	Between Groups	1,8	2	0,917	0,872	0,420
	2	3,27	Within Groups	198,6	189	1,051		
	3	3,46	Total	200,5	191			
IN4	1	2,97	Between Groups	5,7	2	2,846	2,622	0,075
	2	3,29	Within Groups	205,2	189	1,086		
	3	3,44	Total	210,9	191			

Table 4.8. ANOVA results for Agile PM factors with respect to position. (cont.)

IN5	1	3,49	Between Groups	4,5	2	2,251	2,054	0,131
	2	3,79	Within Groups	207,2	189	1,096		
	3	3,91	Total	211,7	191			
IN6	1	*3,14*	Between Groups	10,0	2	5,005	4,297	0,015
	2	3,60	Within Groups	220,1	189	1,165		
	3	3,77	Total	230,1	191			
IN7	1	3,83	Between Groups	0,2	2	0,100	0,105	0,900
	2	3,90	Within Groups	179,7	189	0,951		
	3	3,92	Total	179,9	191			
IN8	1	3,31	Between Groups	5,0	2	2,524	2,214	0,112
	2	3,52	Within Groups	215,4	189	1,140		
	3	3,74	Total	220,5	191			
PI1	1	*3,51*	Between Groups	8,9	2	4,473	4,377	0,014
	2	4,15	Within Groups	193,2	189	1,022		
	3	3,95	Total	202,1	191			
PI2	1	3,37	Between Groups	7,0	2	3,511	2,990	0,053
	2	3,77	Within Groups	222,0	189	1,174		
	3	3,89	Total	229,0	191			
PI3	1	3,46	Between Groups	3,5	2	1,771	1,871	0,157
	2	3,81	Within Groups	179,0	189	0,947		
	3	3,81	Total	182,5	191			
PI4	1	*3,51*	Between Groups	11,5	2	5,726	6,310	0,002
	2	4,21	Within Groups	171,5	189	0,907		
	3	4,07	Total	183,0	191			
PI5	1	3,40	Between Groups	1,6	2	0,786	0,758	0,470
	2	3,50	Within Groups	196,0	189	1,037		
	3	3,63	Total	197,6	191			
PB1	1	*3,31*	Between Groups	7,8	2	3,883	3,331	0,038
	2	3,68	Within Groups	220,3	189	1,166		
	3	3,86	Total	228,1	191			
PB2	1	*3,43*	Between Groups	7,8	2	3,922	4,210	0,016
	2	3,92	Within Groups	176,1	189	0,932		
	3	3,97	Total	183,9	191			
PB3	1	*3,31*	Between Groups	7,4	2	3,678	3,204	0,043
	2	3,77	Within Groups	217,0	189	1,148		
	3	3,84	Total	224,4	191			
PB4	1	*2,63*	Between Groups	12,5	2	6,258	5,576	0,004
	2	3,18	Within Groups	212,1	189	1,122		
	3	3,33	Total	224,6	191			

Table 4.8. ANOVA results for Agile PM factors with respect to position. (cont.)

PB5	1	*2,83*	Between Groups	13,3	2	6,659	5,045	0,007
	2	3,40	Within Groups	249,4	189	1,320		
	3	3,55	Total	262,7	191			
1. Top Level Management, 2. Middle Level Management, 3. Civil & MEP Eng., Architect.								

- Comparison of mean ranking of drivers of Agile PM implementation with respect to respondents' position.

According to Least Significant Difference (LSD) Test results given in the Table 4.9 below, two drivers of Agile PM implementation, namely "DR1-Responsiveness to changes and client requirements" and "DR4- Dynamic and uncertain project environment", are found to be statistically different with respect to respondents' position. The results shows that mean difference of top level management compared to others is significant at 0.05 level and significant values matching with top level management are less than 0.05. Referring to mean difference given in the Table 4.9, top level managers has rated around 0.5-0.7 point less than other respondents did which is classified as moderately important with reference to mean ranking given in Table 4.8 and likert scale considered in the survey. On the other hand, medium level management and engineers and architects as potential members of an agile team has rated these factors as highly important. The reason of this difference between top level management and others can be explained due to the fact that medium level managers and engineers and architects, who are mainly working for the execution of the project compared to top management, finds Agile PM more helpful and promising to cope with changes and client requirements as well as dynamic project environment because of its iterative and incremental way of delivering the project.

Table 4.9. LSD Test - Drivers of Agile PM with respect to position.

Variable No and Name	(I) Position	(J) Position	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower	Upper
DR1 "Responsiveness to changes and client requirements"	Top Level Management	Middle Level Management	-0,734*	0,226	0,006	-1,28	-0,19
		Civil & MEP Eng., Architect	-0,591*	0,214	0,022	-1,11	-0,07
	Middle Level Management	Top Level Management	0,734*	0,226	0,006	0,19	1,28
		Civil & MEP Eng., Architect	0,14	0,143	0,579	-0,20	0,48
	Civil & MEP Eng., Architect	Top Level Management	0,591*	0,214	0,022	0,07	1,11
		Middle Level Management	-0,14	0,143	0,579	-0,48	0,20
DR4 "Dynamic and uncertain project environment"	Top Level Management	Middle Level Management	-0,513*	0,228	0,026	-0,96	-0,06
		Civil & MEP Eng., Architect	-0,519*	0,213	0,016	-0,94	-0,10
	Middle Level Management	Top Level Management	0,513*	0,228	0,026	0,06	0,96
		Civil & MEP Eng., Architect	-0,01	0,176	0,975	-0,35	0,34
	Civil & MEP Eng., Architect	Top Level Management	0,519*	0,213	0,016	0,10	0,94
		Middle Level Management	0,01	0,176	0,975	-0,34	0,35

*. The mean difference is significant at the 0.05 level.

- Comparison of mean ranking of barriers to Agile PM implementation with respect to respondents' position.

For the comparison of mean ranking of the barriers to Agile PM implementation, Least Significant Difference (LSD) Test are conducted in SPSS and the results are presented in Table 4.10. There is only one barrier, called as "BA2-Lack of top management support and commitment", where its mean ranking by top and medium level managers is statistically different with significance level (p-value) less than 0.05 05 at the 95% confidence interval. According to mean difference given in the table below, medium level management thinks that barrier of "lack of top management support and commitment" is more important than

top managers do. This difference can be explained due to the fact that medium level management requires more effective leadership and support to overcome the resistance to organizational and cultural change within the project team.

Table 4.10. LSD Test - Barriers to Agile PM with respect to position.

Variable No and Name	(I) Position	(J) Position	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower	Upper
BA2 "Lack of top management support and commitment"	Top Level Management	Middle Level Management	-,499*	0,195	0,011	-0,88	-0,11
		Civil & MEP Eng., Architect	-0,31	0,182	0,091	-0,67	0,05
	Middle Level Management	Top Level Management	,499*	0,195	0,011	0,11	0,88
		Civil & MEP Eng., Architect	0,19	0,151	0,210	-0,11	0,49
	Civil & MEP Eng., Architect	Top Level Management	0,31	0,182	0,091	-0,05	0,67
		Middle Level Management	-0,19	0,151	0,210	-0,49	0,11

*. The mean difference is significant at the 0.05 level.

- Comparison of mean ranking of inputs of Agile PM implementation with respect to respondents' position.

According to results of post-hoc analysis of LSD Test given in the Table 4.11 below, three inputs of Agile PM implementation, namely "'IN1-Autonomous, self-organized, multi-disciplinary team", "IN2-Daily stand-up meeting", and "IN6-Consultancy and training of team members", has statistically significant difference with respect to respondents' position. The results shows that mean difference of top level management compared to others is statistically different with p-value less than 0.05 level. Referring to mean difference given in the Table 4.9, top level managers has rated around 0.5-0.7 point less than other respondents did which is classified as moderately important with reference to mean ranking given in Table 4.8. On the other hand, medium level managers and engineers and architects thinks that these inputs of Agile implementation are highly important. Besides, the top

management in construction projects usually wants to be in the center of decision mechanism which contradicts with the components of Agile PM highlighted in the table below.

Table 4.11. LSD Test - Inputs of Agile PM with respect to position.

Variable No and Name	(I) Position	(J) Position	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower	Upper
IN1 "Autonomous, self-organised, multi-disciplinary team"	Top Level Management	Middle Level Management	-,462*	0,228	0,044	-0,91	-0,01
		Civil & MEP Eng., Architect	-,553*	0,213	0,010	-0,97	-0,13
	Middle Level Management	Top Level Management	,462*	0,228	0,044	0,01	0,91
		Civil & MEP Eng., Architect	-0,09	0,176	0,606	-0,44	0,26
	Civil & MEP Eng., Architect	Top Level Management	,553*	0,213	0,010	0,13	0,97
		Middle Level Management	0,09	0,176	0,606	-0,26	0,44
IN2 "Daily stand-up meeting"	Top Level Management	Middle Level Management	-,524*	0,210	0,013	-0,94	-0,11
		Civil & MEP Eng., Architect	-,543*	0,196	0,006	-0,93	-0,16
	Middle Level Management	Top Level Management	,524*	0,210	0,013	0,11	0,94
		Civil & MEP Eng., Architect	-0,02	0,162	0,905	-0,34	0,30
	Civil & MEP Eng., Architect	Top Level Management	,543*	0,196	0,006	0,16	0,93
		Middle Level Management	0,02	0,162	0,905	-0,30	0,34
IN6 "Consultancy and training of team members"	Top Level Management	Middle Level Management	-,454*	0,228	0,048	-0,90	0,00
		Civil & MEP Eng., Architect	-,626*	0,213	0,004	-1,05	-0,20
	Middle Level Management	Top Level Management	,454*	0,228	0,048	0,00	0,90
		Civil & MEP Eng., Architect	-0,17	0,176	0,331	-0,52	0,18
	Civil & MEP Eng., Architect	Top Level Management	,626*	0,213	0,004	0,20	1,05
		Middle Level Management	0,17	0,176	0,331	-0,18	0,52

*. The mean difference is significant at the 0.05 level.

- Comparison of mean ranking of process improvements of Agile PM implementation with respect to respondents' position.

For the comparison of mean ranking, LSD test is conducted in SPSS and the results are presented in Table 4.12. There are three factors of process improvements as highlighted in the table where their mean rankings according to respondents' position are statistically different with p-value less than 0.05 at the 95% confidence interval. The top management thinks that Agile PM has lesser impact on the improvement of communication and collaboration than the medium management does. In addition, the top management expects lesser effect of Agile PM on increase in transparency and visibility of the project than engineers and architects do. This can be because the benefits and methods of implementation of Agile PM in construction industry is still not clear to top management. On the other hand, medium level management and engineers and architects as potential members of agile team thinks that Agile PM enables better response to changes during project execution compared to top level management. The reason is that Agile PM encourages autonomous and multi-disciplinary team which increase the responsibility of project team on decision making so increase in the rate of responsiveness to changes by client or dynamic project environment.

Table 4.12. LSD Test – Process improvements of Agile PM with respect to position.

Variable No and Name	(I) Position	(J) Position	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower	Upper
PI1 "Improvement of communication and collaboration"	Top Level Management	Middle Level Management	-,631*	0,211	0,011	-1,14	-0,13
		Civil & MEP Eng., Architect	-0,43	0,201	0,088	-0,92	0,05
	Middle Level Management	Top Level Management	,631*	0,211	0,011	0,13	1,14
		Civil & MEP Eng., Architect	0,20	0,163	0,447	-0,19	0,58
	Civil & MEP Eng., Architect	Top Level Management	0,43	0,201	0,088	-0,05	0,92
		Middle Level Management	-0,20	0,163	0,447	-0,58	0,19

Table 4.12. LSD Test – Process improvements of Agile PM with respect to position. (cont.)

PI2 "Increase in transparency and visibility of the project"	Top Level Management	Middle Level Management	-0,40	0,229	0,080	-0,85	0,05
		Civil & MEP Eng., Architect	-,523*	0,214	0,016	-0,95	-0,10
	Middle Level Management	Top Level Management	0,40	0,229	0,080	-0,05	0,85
		Civil & MEP Eng., Architect	-0,12	0,177	0,497	-0,47	0,23
	Civil & MEP Eng., Architect	Top Level Management	,523*	0,214	0,016	0,10	0,95
		Middle Level Management	0,12	0,177	0,497	-0,23	0,47
PI4 "Better Response to Changes"	Top Level Management	Middle Level Management	-,695*	0,201	0,001	-1,09	-0,30
		Civil & MEP Eng., Architect	-,559*	0,188	0,003	-0,93	-0,19
	Middle Level Management	Top Level Management	,695*	0,201	0,001	0,30	1,09
		Civil & MEP Eng., Architect	0,14	0,156	0,383	-0,17	0,44
	Civil & MEP Eng., Architect	Top Level Management	,559*	0,188	0,003	0,19	0,93
		Middle Level Management	-0,14	0,156	0,383	-0,44	0,17

*. The mean difference is significant at the 0.05 level.

- Comparison of mean ranking of project benefits of Agile PM implementation with respect to respondents' position.

According to results of post-hoc analysis of LSD Test given in the Table 4.13 below, all project level benefits of Agile PM implementation, namely "PB1-Improvement of Client Satisfaction", "PB2-Increase in Project Performance", "PB3-Increase in Project Quality", "PB4-Decrease in Project Cost", "PB5-Decrease in Project Duration", has statistically significant difference with respect to respondents' position. The results shows that mean rankings according to respondents' position are statistically different with significance level (p-value) less than 0.05 at the 95% confidence interval. Referring to table below, the opinion of engineers and architects as potential members of agile teams about first three benefits are

not statistically in line with top level management. While top level management expects moderate level of aforementioned benefits, engineers and architects thinks that Agile PM results high level of improvement of client satisfaction, increase in project performance, and increase in project quality. This can be because the benefits and methods of implementation of Agile PM in construction industry is still not clear to top level management and there is no proven example of implementation. This makes top level management more conservative about the benefits of Agile PM. For the comparison of mean ranking of last two benefits, top level management expects lesser decrease in project cost and duration than the other respondents do. The reason is that Agile PM methods don't have direct effects on project cost and duration but it reduces the amount of change orders which will impact indirectly.

Table 4.13. LSD Test - Benefits of Agile PM with respect to position.

Variable No and Name	(I) Position	(J) Position	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower	Upper
PB1 "Improvement of Client Satisfaction"	Top Level Management	Middle Level Management	-0,36	0,228	0,113	-0,81	0,09
		Civil & MEP Eng., Architect	-,549*	0,213	0,011	-0,97	-0,13
	Middle Level Management	Top Level Management	0,36	0,228	0,113	-0,09	0,81
		Civil & MEP Eng., Architect	-0,19	0,176	0,293	-0,53	0,16
	Civil & MEP Eng., Architect	Top Level Management	,549*	0,213	0,011	0,13	0,97
		Middle Level Management	0,19	0,176	0,293	-0,16	0,53
PB2 "Increase in Project Performance"	Top Level Management	Middle Level Management	-0,49	0,231	0,093	-1,05	0,06
		Civil & MEP Eng., Architect	-,540*	0,223	0,050	-1,08	0,00
	Middle Level Management	Top Level Management	0,49	0,231	0,093	-0,06	1,05
		Civil & MEP Eng., Architect	-0,05	0,146	0,940	-0,40	0,30
	Civil & MEP Eng., Architect	Top Level Management	,540*	0,223	0,050	0,00	1,08
		Middle Level Management	0,05	0,146	0,940	-0,30	0,40

Table 4.13. LSD Test - Benefits of Agile PM with respect to position. (cont.)

PB3 "Increase in Project Quality"	Top Level Management	Middle Level Management	-0,46	0,227	0,108	-1,00	0,08
		Civil & MEP Eng., Architect	-,528*	0,212	0,036	-1,03	-0,03
	Middle Level Management	Top Level Management	0,46	0,227	0,108	-0,08	1,00
		Civil & MEP Eng., Architect	-0,07	0,175	0,920	-0,48	0,35
	Civil & MEP Eng., Architect	Top Level Management	,528*	0,212	0,036	0,03	1,03
		Middle Level Management	0,07	0,175	0,920	-0,35	0,48
PB4 "Decrease in Project Cost"	Top Level Management	Middle Level Management	-,549*	0,224	0,015	-0,99	-0,11
		Civil & MEP Eng., Architect	-,698*	0,209	0,001	-1,11	-0,28
	Middle Level Management	Top Level Management	,549*	0,224	0,015	0,11	0,99
		Civil & MEP Eng., Architect	-0,15	0,173	0,390	-0,49	0,19
	Civil & MEP Eng., Architect	Top Level Management	,698*	0,209	0,001	0,28	1,11
		Middle Level Management	0,15	0,173	0,390	-0,19	0,49
PB5 "Decrease in Project Duration"	Top Level Management	Middle Level Management	-,575*	0,243	0,019	-1,05	-0,10
		Civil & MEP Eng., Architect	-,719*	0,227	0,002	-1,17	-0,27
	Middle Level Management	Top Level Management	,575*	0,243	0,019	0,10	1,05
		Civil & MEP Eng., Architect	-0,14	0,188	0,443	-0,51	0,23
	Civil & MEP Eng., Architect	Top Level Management	,719*	0,227	0,002	0,27	1,17
		Middle Level Management	0,14	0,188	0,443	-0,23	0,51

*. The mean difference is significant at the 0.05 level.

4.3. Structural Equation Modeling (SEM)

Structural equation modelling (SEM), is a statistical method similar to multivariate regression which enables to check direct and indirect relationships between one or more dependent or independent variables. SEM has been widely used in several research studies since 1980s (Xiong *et al.*, 2015). However, the usage of SEM techniques in construction research are yet to be common as social sciences, rather to be regarded as new. As it is explained in previous chapters of this study, SEM has got two main components as

measurement model and structural model and four main steps to analyze the data collected through online questionnaire to test the hypothesis constructed between latent variables.

4.3.1 Analysis of the Measurement Model

In the first step of structural equation modeling, it is necessary to specify the relations among latent variables and to determine the measurement method of latent variables. The casual relationship is constructed between 42 number of determinants or indicators of Agile PM implementation through hypothesis defined among components as six latent variables. These latent variables are "drivers", "barriers", "enablers", "inputs", "process improvements", and "project level benefits". The data collected from a total of 192 questionnaires were analyzed by using AMOS V25.0 software. There is no strict reference for an appropriate sample size for SEM in the literature. Wolf *et al.* (2013) stated that the sample size requirements for structural equation models vary from 30 up to 450 cases.

4.1.3.1. Validity of the Agile PM Components and Indicators. The level of confidence in the degree of measurement of latent variable can be obtained by testing construct validity. In order to test the reliability and validity of the hypothesized construct, there are several sub-dimensions of construct validity where all of them needs to be satisfied. These dimensions are content validity, scale reliability, convergent validity, and discriminant validity.

"Content Validity Testing" is described as the degree of representation of the construct meaning by factors or components of the related domain (Dunn *et al.*, 1994). The theoretical definition of a domain covers its concept whose dimensions along with their meanings are clearly defined in prior literature (Bollen, 1989). Since there is no applicable formal statistical test and present for content validity, it is up to researcher's judgment and understanding (Garver and Mentzer, 1999). The components' content validity in a conceptual framework can be determined by the degree to which academic scholars and professionals have studied and discussed in their studies. An in-depth literature review and investigation was carried out to specify the observed variables that define latent variables as shown at Table 4.14 as a result of content validity.

Table 4.14. List of latent variables and measured variables for content validity.

DRIVERS	
1	Responsiveness to changes and client requirements
2	Need for project performance improvement
3	Poor communication with client and stakeholders
4	Dynamic and uncertain project environment
5	Projects with high complexity and risk
6	Competition level in market
BARRIERS	
1	Resistance to organizational and cultural change
2	Lack of top management support and commitment
3	Lack of commitment and engagement of customer/client
4	Lack of commitment and engagement of team members and other stakeholders
5	Team members working on multiple projects and in different locations
6	Unclear benefits and methods of implementation of Agile PM in construction
7	Lack of awareness of Agile PM methods and practices
8	Lack of contractual aspects of using Agile PM between stakeholders
9	Bureaucratic project environment with multiple stages of projects acceptance
10	Fractured nature of construction projects with large number of stakeholders
ENABLERS	
1	Short-term visualized planning for iteration and incremental delivery
2	Timely and continuous involvement of client
3	Collaborative partnering of contractor and other stakeholders
4	Commitment and organizational learning via short feedback loops
5	Organizational trust among employees
6	Effective leadership

7	Face to face communication
8	Promoting minimal documentation and simple solutions
INPUTS	
1	Autonomous, self-organized, multi-disciplinary team
2	Daily stand-up meeting
3	Size of project team
4	Location of project team
5	Experience of project team
6	Consultancy and training of team members
7	Information technology integration and support
8	Internal knowledge resources
PROCESS IMPROVEMENTS	
1	Improvement of communication and collaboration
2	Increase in transparency and visibility of the project
3	Improvement of organizational learning and practices
4	Better response to changes
5	Decrease in project risk
PROJECT LEVELBENEFITS	
1	Improvement of client satisfaction
2	Increase in project performance
3	Increase in project quality
4	Decrease in project cost
5	Decrease in project duration

Scale Reliability Testing: General definition of reliability is the consistency of measurement. The reliability of a construct refers to the degree of the direct relations of all variables with exclusion of the error terms from structural point of view (Bollen, 1989). The scale reliability is measured by Cronbach's alpha coefficient which indicates the internal

consistency of a construct. It is the main purpose of reliability test to understand to what degree correspondent latent variable is represented by its observed indicators.

Cronbach's alpha values of each latent variable is calculated by using SPSS and are presented in Table 4.15 below. Since all values are above 0.70, it is concluded as satisfactory with reference to recommendation made by Nunally (1978) for minimum value.

Table 4.15. Cronbach's Alpha coefficients of the latent variables.

Latent Variables	**Cronbach's Alpha Values**
Drivers	0.801
Barriers	0.806
Enablers	0.897
Inputs	0.855
Process Improvements	0.874
Project Level Benefits	0.848

Convergent Validity Testing: Convergent validity testing is performed to determine if all observed variables forming a latent variable come together to converge to a single latent variable. There are two methods used to check convergent validity which are evaluation of overall goodness of fit and assessment of factor loadings. The goodness-of-fit was checked through the ratio of $\chi 2$ to degrees of freedom (dof), comparative fit index (CFI), Tucker Lewis index (TLI), and the root mean square error of approximation (RMSEA). The results of overall model is given in Table 4.17. Convergent validity can also be assessed by checking the statistical significance of each construct's factor loading (Anderson and Gerbing, 1988). According to results of AMOS software, all factor loadings in initial model were found to be significant at $\alpha = 0.05$ and factor loadings given in table 4.16.

Discriminant Validity Testing: Discriminant validity testing is performed to ensure that any indicator of all latent variables is not highly correlated to any another indicator of all latent variables. In order to satisfy discriminant validity, it is required to prevent

constructs from measuring the same thing. This issue becomes very critical when constructs are found to be highly correlated and have natural similarities. The correlation matrices calculated for all latent variables using AMOS software are presented at Appendix C of this study and all inter-correlations are found to be below 0.90. According to Hair *et al.* (1998), values lower than 0.90 shows that there is no multicollinearity. This result shows that the constructs have discriminant validity in the model. It can be concluded that the variables are different from each other and that they are complementary.

4.3.2 Analysis of the Structural Model

In order to investigate direct and indirect relations between observed and latent variables defined as a result of extensive literature review, structural equation model (SEM) was selected for examination of the proposed conceptual model. SEM is a powerful statistical tool to test the hypotheses between the validated constructs. The proposed conceptual framework representing interrelations among the determinants of Agile PM implementation in construction projects with sample data collected as a result of questionnaire survey are analyzed.

4.3.2.1. Specification of the Model: After an in-depth literature review and expert opinions, a conceptual framework is developed to show how components and process of Agile PM implementation affect project level benefits directly and indirectly. The model showing interrelations between latent variables are presented in Figure 4.23 below.

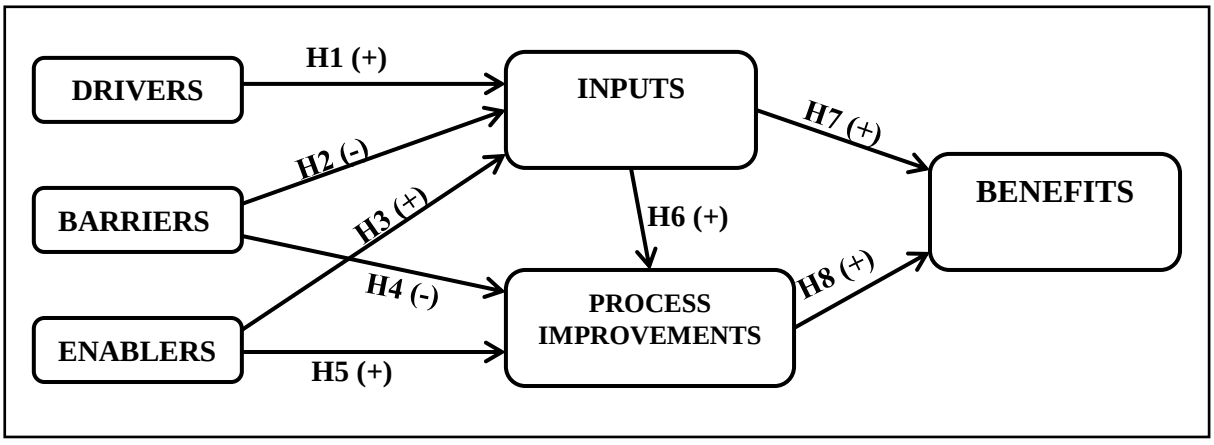

Figure 4.23. Agile PM implementation framework model.

The model can also be described as a series of the direct path equations as following;

- Inputs = path coefficient 1* drivers + path coefficient 2* barriers + path coefficient 3* enablers + error term 1
- Process Improvements = path coefficient 4* barriers + path coefficient 5* enablers + path coefficient 6* inputs + error term 2
- Benefits = path coefficient 7* inputs + path coefficient 8* process improvements + error term 3

4.3.2.2. Estimation and Identification of the Model: There are several methods available in AMOS software to analyze the model estimation as described in previous chapter. In this study, the maximum likelihood (ML) is utilized which refers to the derivation of parameter estimates. The maximum likelihood estimators are the ones maximizing the likelihood parameters of a sample that is actually observed (Winer *et al.*, 1991). According to assumptions of ML estimations, the observed variables is normally distributed. Therefore, evaluation of normality and sample size should be addressed at the first stage. As discussed in chapter 3.4.1 of this study, the skewness and kurtosis can help us to decide whether the data is normal or not. Values of skewness within the range of -1 to +1 indicate a normal distribution the data. (Hair *et al.*, 2006). In addition to that, Sposito and Skarpness (1983) claims that skewness and kurtosis values within range of +2.2 and -2.2 can be considered as normal distribution. The descriptive statistics given Appendix B shows the value of skewness and kurtosis falls within specified limits of normal distribution. Therefore, maximum likelihood is applied in the analysis of the data using AMOS software.

4.3.2.3. Evaluation of the Model Fit: Evaluation of the model fit helps us to understand to what degree the whole model explains the data. After the model fit of a SEM model is satisfactory, the proposed conceptual model is complete and ready to evaluate the relations among variables. In this study, since the model fit is achieved and evidence is shown in following tables, it is concluded that the model explains the data well. The initial structural equation model with the path coefficients is shown in Figure 4.24.

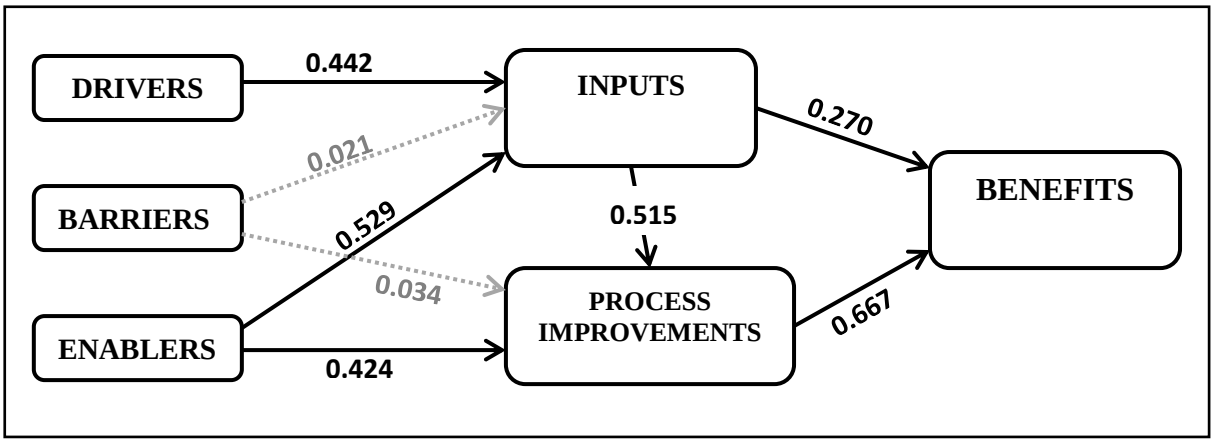

Figure 4.24. The initial structural equation model with path coefficients.

The equations are as follows based on the initial structural equation model;

- Inputs = 0.442 * Drivers + 0.021 * Barriers + 0.529 * Enablers + 0.245D (R2=0.476)
- Process Improvements = 0.034 * Barriers + 0.424 * Enablers + 0.515* Inputs + 0.138D (R2=0.675)
- Benefits = 0.270 * Inputs + 0.667 * Process Improvements + 0.101D (R2=0.783)

According to analysis results, it is found that path from barriers to both inputs and process improvements is not statistically significant at 5%. Therefore, these two paths so the hypotheses were eliminated from the model and it is re-analyzed. The modified structural equation model with path coefficients is shown in Figure 4.25.

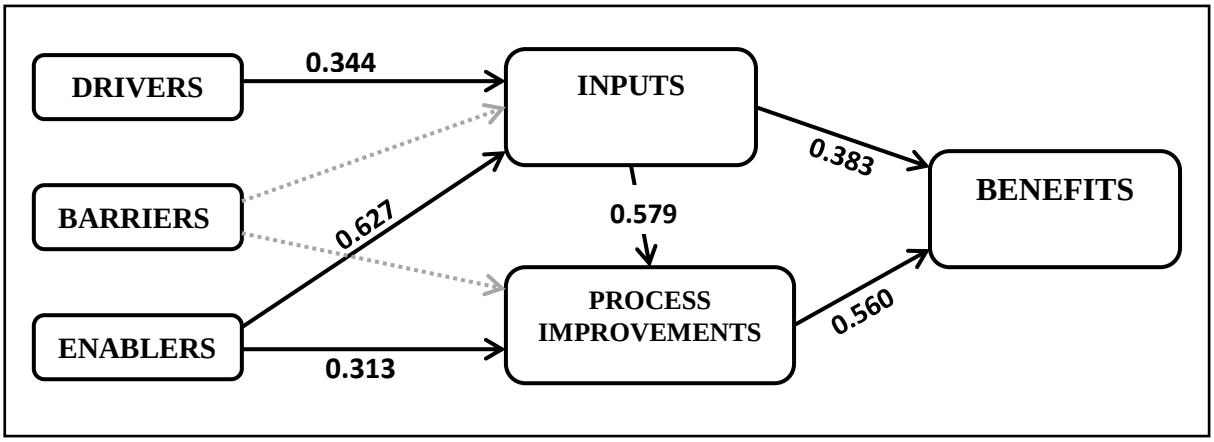

Figure 4.25. The modified structural equation model with path coefficients.

The equations are as follows based on the modified structural equation model;

- Inputs = 0.344 * drivers + 0.627 * enablers + 0.233D (R2 = 0.511)
- Process Improvements = 0.313* enablers + 0.579 * inputs + 0.140D (R2 = 0.6605)
- Benefits = 0.383 * inputs + 0.560 * process improvements + 0.089D (R2 = 0.792)

The analysis results show that drivers have a positive effect on inputs with a path coefficient of "0.344". On the other hand, enablers have a positive effect on inputs and process improvements with a path coefficients of "0.313" and "0.627" respectively. The effect of enablers on inputs can be regarded as significant due to such a high path coefficient. In addition, the inputs has a positive and significant effect on process improvement with path coefficient of 0.0579 while inputs have a positive and moderate effect on project level benefits (path coefficient: 0383). Finally, it can be seen in the model that process improvements have a positive and significant effect on project level benefits (path coefficient: 0.560). However, barriers do not have a significant relation with Agile PM implementation in construction projects. According to hypothesis, barriers are expected to have negative effects on inputs and project improvements. However, the effects of barriers is found to be insignificant due to high positive impact of the drivers and enablers on the inputs and process improvements. According to results of AMOS software, all factor loadings in final model were found to be significant at $\alpha = 0.05$ and factor loadings given in table 4.16.

Table 4.16. Latent and observed variables of initial and final model with factor loadings.

No	**Variable Name**	**Initial Model**	**Final Model**
DRIVERS			
DR1	Responsiveness to changes and client requirements	0,704	0,719
DR2	Need for Project Performance Improvement	0,693	0,745
DR3	Poor communication with client and stakeholders	0,599	0,631
DR4	Dynamic and uncertain project environment	0,579	0,664
DR5	Projects with high complexity and risk	0,728	0,731
DR6	Competition Level in market	0,528	0,498

Table 4.16. Latent and observed variables of initial and final model with factor loadings. (cont.)

BARRIERS			
BA1	Resistance to organizational and cultural change	0,459	0,448
BA2	Lack of top management support and commitment	0,495	0,473
BA3	Lack of commitment and engagement of customer/client	0,649	0,687
BA4	Lack of commitment and engagement of team members and other stakeholders	0,553	0,600
BA5	Team members working on multiple projects and in different locations	0,465	0,466
BA6	Unclear benefits and methods of implementation of Agile PM in construction	0,535	0,591
BA7	Lack of awareness of Agile PM methods and practices	0,608	0,703
BA8	Lack of contractual aspects of using Agile PM between stakeholders	0,489	0,561
BA9	Bureaucratic project environment with multiple stages of projects acceptance	0,588	0,540
BA10	Fractured nature of construction projects with large number of stakeholders	0,591	0,585
ENABLERS			
EN1	Short-term visualized planning for iteration and incremental delivery	0,646	0,698
EN2	Timely and continuous involvement of client	0,624	0,658
EN3	Collaborative partnering of contractor and other stakeholders	0,775	0,773
EN4	Commitment and organizational learning via short feedback loops	0,799	0,843
EN5	Organizational Trust among employees	0,811	0,808
EN6	Effective Leadership	0,705	0,711
EN7	Face to face Communication	0,762	0,795
EN8	Promoting minimal documentation and simple solutions	0,669	0,741

Table 4.16. Latent and observed variables of initial and final model with factor loadings. (cont.)

INPUTS			
IN1	Autonomous, self-organized, multi-disciplinary team	0,661	0,718
IN2	Daily stand-up meeting	0,507	0,493
IN3	Size of project team	0,508	0,517
IN4	Location of project team	0,577	0,562
IN5	Experience of project team	0,531	0,615
IN6	Consultancy and training of team members	0,691	0,652
IN7	Information technology integration and support	0,672	0,660
IN8	Internal Knowledge Resources	0,671	0,726
PROCESS IMPROVEMENTS			
PI1	Improvement of communication and collaboration	0,753	0,795
PI2	Increase in transparency and visibility of the project	0,791	0,801
PI3	Improvement of organizational learning and practices	0,738	0,771
PI4	Better Response to Changes	0,774	0,821
PI5	Decrease in Project Risk	0,663	0,695
PROJECT LEVELBENEFITS			
PB1	Improvement of Client Satisfaction	0,646	0,668
PB2	Increase in Project Performance	0,839	0,865
PB3	Increase in Project Quality	0,820	0,844
PB4	Decrease in Project Cost	0,601	0,579
PB5	Decrease in Project Duration	0,612	0,607

In summary, the reliability coefficient and fit indices for the initial and modified model as well as recommended values are presented at Table 4.17. The Cronbach's alpha coefficients of both initial and final model are higher than the recommended value of 0.70 (Nunnally, 1978). The $\chi 2$ to dof ratios of the final model were found to be 1.777 which is suggested be smaller than 3 by Kline (1998). In SEM, the better fit is observed when $\chi 2$ value is smaller. The Comparative Fit Index (CFI) and Tucker-Lewis index (TLI) values of higher than 0.9 also demonstrate a slightly good fit (Mandal et al., 2011; Hsieh and Tsai,

2013). Moreover, the RMSEA values below the recommended value of 0.10 also indicates good fit of the model (Kline, 1998). The correlation matrices are presented at Appendix C of this study and all inter-correlations are found to be below 0.90. According to Hair et al. (1998), values lower than 0.90 shows that there is no multicollinearity. Therefore, it can be concluded that the overall fit between the model and data is found to be satisfactory.

Table 4.17. Reliability values and fit indices for the initial and final model.

Index	Recommended Value	Initial Model	Final Model
Cronbach's Alpha	>0.70	0.946	0.952
χ2/dof	< 3	1.971	1.788
CFI	0 (no fit) to 1 (perfect fit)	0.880	0.922
TLI	0 (no fit) to 1 (perfect fit)	0.866	0.909
RMSEA	< 0.10	0.071	0.068

5. DISCUSSION OF RESEARCH FINDINGS

In this chapter, the discussion of major findings as a result of statistical analysis and structural equation modelling (SEM) will be presented and the consistency of these findings with the prior literature of Agile PM will be discussed and evaluated. In the statistical analysis part, descriptive statistics were performed to represent general profile of respondents as well as to understand the awareness and opinion of respondents regarding Agile PM implementation. Besides, calculation of mean ranking of all factors, t-test, and ANOVA test were conducted to compare the mean ranking of factors among each other with respect to different population samples. In the measurement model, the content validity of the components of the integrated framework is successfully provided through an in-depth literature review and expert opinions. The proposed framework consists of 42 indicators grouped under six constructs which are linked to each other based on hypothesized relationships. All of indicators are found to be statistically significant as a result of analysis of measurement model. In the structural model, the hypothesized relationships between latent variables were tested and insignificant paths were eliminated from the model which was the path from barriers to inputs and process improvements in this study. The SEM analysis of structural model was performed again and factor loading of indicators as wells path coefficients were acquired from the analysis model. Finally, it should be noted that the reliability and fit indices of the model is found to be satisfactory.

5.1. Awareness and Opinion of Agile PM Implementation

The data collected through questionnaire survey is analyzed statistically using SPSS software. As a result of descriptive statistics and t-test, the summary of findings is presented to provide a better understanding for the status and awareness of Agile PM implementation of construction professionals in the Turkish AEC sector. It should be noted that the following items are actual information and represent current perception of respondents.

- Majority of the respondents are from contractors (42%), while remaining are from Design Consultancy (27%) and Project Management Consultancy (13%),

subcontractors (13%), Employer/Client (6%) and Supplier/Vendors (2%). Moreover, majority of them works as either civil engineer (41%) or mid-level manager (32%) or high level manager (18%).

- The income of the majority of the respondents' firms are in the range of 100 million USD or more (29%) which are main contractors while both ranges of 2-10 million (16%) and 10-50 (13%) million USD have similar distribution. Besides, the main type of projects done by respondents' firms are building projects (35%), infrastructure/civil projects (19%), industrial projects (19%), and finally all types of projects (27%).

- It is intended to provide demographic insight about general point of view of Turkish construction industry regarding usefulness and knowledge of Agile PM. Only 31% of the respondents stated that they knew or at least heard about Agile PM before taking this questionnaire. It is the project management companies has got the highest percentage of previous knowledge and awareness since Agile PM is a method of project management.

- Majority of the respondents (89%) think that Agile PM would be useful in construction projects while only 55% of the respondents thinks that their company would be willing to implement Agile PM in their future projects.

- Respondents working for design consultancy and subcontractors have got the highest rate of affirmation of usefulness. On the other hand, contractors' rate of statement of usefulness is the lowest since multidisciplinary team working and collaboration is quite difficult due to high population of contractors

- Agile PM is expected to be more useful in detailed design and construction stages while it is thought to be the least useful at operation and maintenance stage.

- Since the ratio of respondents, who thinks Agile PM would be useful in construction projects, is quite higher than the ratio of respondents, who thinks that their companies would be willing to implement Agile PM, there should be a company level barrier

affecting the respondents' opinion. This barrier can either lack of top management support and commitment or lack of awareness of Agile PM methods and practices within company.

- 26 number of respondents which is 14% of overall respondents, stated that they have implemented Agile PM or used similar principles in one of their project. The majority of them is working for contractors which is around 50% and 69% of respondents claimed to use similar in-house methods of Agile PM. The reason is the popular use of Kanban method in construction stage and PMI (2017) argues that Kanban and Agile methods has got few common principles.

- The benefits and process improvements was requested to be ranked by the respondents who claimed to implement Agile PM methods and the discussion and conclusion based on small number of survey sample will lead to unreliable results and justifications. Therefore, Figures 4.14, 4.15, and 4.16 of descriptive statistics are given only for the purpose of information.

- According to t-test results for Agile PM implementation factors according to respondents' opinion on their company's willingness to implement, all drivers are ranked to be highly important except "DR4 - Dynamic and uncertain project environment" because the Agile PM implementation is thought to have a great potential to meet the needs of construction industry by respondents with positive opinion on their companies' willingness.

- According to t-test results, the respondents with positive opinion on their companies' willingness thinks that close face to face communication with client, contractor and other stakeholders as well as daily stand-up meetings are ranked as highly important to promote Agile PM implementation in construction projects.

- According to t-test results, respondents with positive opinion on their companies' willingness thinks that Agile PM implementation is a promising method for all process improvements and project level benefits listed in this study due to rating of factors as highly important.

- Based on ANOVA test of factors with respect to respondents' position, in general the higher the ranking of factors is provided by the lower the position of the respondent in a project. This can be explained due to the fact that decentralizing the decision making towards lower levels leads to increase in responsibility and so the motivation of team members. Another explanation is that the benefits and methods of implementation of Agile PM in construction industry is still not clear to top level management and there is no proven example of implementation. This makes top level management more conservative about the benefits of Agile PM.

- According to post-hoc analysis for barriers to Agile PM implementation with respect to respondents' position, medium level management thinks that barrier of "lack of top management support and commitment" is more important than top managers do. This difference can be explained as medium level management requires more effective leadership and support from top management to overcome the resistance to organizational and cultural change within the project team.

- Based on ANOVA analysis, the top management thinks that Agile PM has lesser impact on the improvement of communication and collaboration than the medium management does. In addition, the top management expects lesser effect of Agile PM on increase in transparency and visibility of the project than engineers and architects do. This can be because the benefits and methods of Agile PM implementation in construction industry is still not clear to top management.

5.2. Drivers of Agile PM Implementation

According to SEM results given in Table 4.16, the main drivers of Agile PM implementation are found to be the need for project performance improvement (0.745), projects with high complexity and risk (0.731), and responsiveness to changes and client requirements (0.719) based on construction professionals' opinion. As it is indicated by other scholars in literature, poor performance, low productivity, delays in project schedule, and cost overruns is usual problems of construction industry. Walker (2007) argues that the construction projects will more complex due to increasing demands of the clients. Besides,

Demir *et al.* (2014) indicates that changes are not welcomed in construction projects mainly in the execution phase since the impact of change is higher. Therefore, in order to cope with poor performance, increasing complexity of construction projects as well as changes from client and external environment, there is a need for a new and tailored project management methodology for which Agile PM is a considerable candidate.

Dynamic and uncertain project environment (0.664) and poor communication with client and stakeholders (0.631) are the other significant drivers of Agile PM implementation with high factor loadings. Hertogh and Westerveld (2010) argues that the latest project management methodologies seems to underestimate the influence of dynamic project environment. As a response, Highsmith and Cockburn (2001) claims that Agile PM assume the impossibility of reduction in variability, so minimization or elimination of change isn't the aim of Agile PM. It is interesting to note that "competition level in market" has a moderate effect on drivers with factor loading of 0.498 which is relatively lower than other variables. Since benefits of Agile PM implementation in construction projects are yet to be proved clearly, it is thought to have reasonable influence on companies' competitiveness.

Although the core concept of Agile is to cope with the dynamic aspect of a project derived from changes by client and external environment (Chin, 2004; Wysocki, 2006; Moe *et al.*, 2010), it is interesting to see that both factors of responsiveness to change and client requirements (0.719) and dynamic and uncertain project environment (0.664) have got lower factor loadings compared to others. This can be associated with the presence of change control system in construction that deals with changes and dynamic environment in a way as well as urgent need for performance improvement due to project complexity.

The analysis of the proposed Agile PM implementation framework revealed that the drivers as a construct have a direct and moderate effect with a path coefficient of 0.344 on the inputs. The direct and moderate influence seems to be reasonable since Agile PM solely is able to respond a certain portion of necessities of construction industry which are listed as drivers in this study. PMI and other researchers suggest to combine Agile PM techniques with other management methods like traditional PM, BIM and lean construction based on the requirements of projects for more successful projects (Demir, 2014; PMI Guide, 2017).

5.3. Barriers to Agile PM Implementation

As a result of questionnaire survey and SEM analysis given in Table 4.16, construction professionals indicated that the factors lack of awareness of Agile PM methods and practices (0.703) and lack of commitment and engagement of customer/client (0.687) are the major barriers of Agile PM implementation. Due to lack of proof of successful Agile PM implementation in construction industry, top management is reluctant to learn more about it and change their way of working. Besides, as it is one of the principles of Agile manifesto, regular client feedback particularly at the project development stage has vital role on the progress of the project in line with client's expectations. However, it is essential that the client or customer of the project should be willing to engage in decision making, constant feedback-loops and tight follow-ups (Adut, 2016). Therefore, it can be recommended that the company, which is willing to implement Agile PM, should first raise the awareness of Agile PM within the company and then convince the client for close collaboration to regulate expectations of both parties and increase the flow of information in the early stages of an engineering project.

Lack of commitment and engagement of team members and other stakeholders (0.600), unclear benefits and methods of implementation of Agile PM in construction (0.591), fractured nature of construction projects with large number of stakeholders (0.585), lack of contractual aspects of using Agile PM between stakeholders (0.561), and bureaucratic project environment with multiple stages of projects acceptance (0.540) influence moderately the barriers. Tian and Chen (2010) stated that the core features of good team work are the common project target to achieve and trust within team. These features improves the communication and flexibility within the team significantly. Moreover, Agile PM has been able to demonstrate a successful implementation only in the IT sector so far. Due to broad use of subcontracting in construction projects, the project coordination becomes more complex and prevent continuous flow of information (Raiden *et al.*, 2004; Egan, 1998). Moreover, highly bureaucratic project environment of construction industry contradicts with iterative and incremental delivery principle of Agile PM and makes implementation quite difficult. Finally, lack of top management support and commitment (0.473), resistance to organizational and cultural change (0.448), and team members working

on multiple projects and in different locations (0.466) are found to be moderately effective on barriers. According to Ozorhon (2013), the support and commitment of top management will help to break the resistance to organizational and cultural change and enables smooth transition within the organization. Cole (2003) tried to explain the lack of top management support and commitment due to unwillingness of top management to recognize the long-term benefits of Agile PM as opposed to short-term profit. Working on multiple projects in different locations will also create distractions to team members and lead to project interruptions so unsuccessful projects.

However, according to Vijayasarathy and Turk (2008), the most significant barriers to Agile PM implementation are organizational resistance, management apathy, and inadequate training. This statement is in line with mean ranking results given in Figure 4.18 and high occurrence in literature of barriers of both lack of top management support and resistance to organization and cultural change. Therefore, it would be reasonable to recommend that all four barriers, namely lack of top management support and commitment, resistance to organizational and cultural, lack of awareness of Agile PM methods and practices, and lack of commitment and engagement of customer/client, should be taken into account as main barriers to Agile PM implementation.

It is quite interesting to find in this study that barriers as a construct have an insignificant effect on both the inputs and process improvements of Agile PM implementation with path coefficients of 0.021 and 0.034 respectively. The relationship between these constructs was found to be statistically insignificant at 0.05 level . Therefore, those paths were removed from the initial model and modified structural equation is analyzed accordingly. According to hypothesis developed based on previous studies, barriers should have negative effects on Agile PM implementation but since the drivers and enablers have a high positive impact on the inputs and process improvements, the effect of the barriers has become negligible.

5.4. Enablers of Agile PM Implementation

The main enabler of Agile PM implementation is found to be commitment and organizational learning via short feedback loops with a factor loading 0.843 as shown in Table 4.16. For a proper and organic organizational learning, it is essential to employ a highly trained team along with bi-directional loyalty and mutual long-term commitment. Hunt (2006) argues that short feedback loops through iterations promotes flexibility and responsiveness to change in a systematic way. The main reason is that iteration based organizational learning through early and regular feedback from client and other team members enables continuous improvement of team performance and frequent adaptation process for change.

Organizational trust among employees (0.808) and face to face communication (0.795) are the other influential enablers of Agile PM implementation with high factor loadings. Organizational trust which can be defined as trust in the leadership and among employees is essential for employee's engagement and motivation. Therefore, face to face communication and trust among employees are highly significant as they enable extensive, close, transparent and informal communication between team members and stakeholders involved in the project which results in better knowledge sharing and increased motivation. Besides, collaborative partnering of contractor and other stakeholders (0.773), promoting minimal documentation and simple solutions (0.741), and effective leadership (0.711) are found to be highly effective on enablers. Construction projects are carried out by the collaborative effort of multiple organizations through the integration of design and construction. According to Egan (1998), collaborative partnering consists of two or more organizations working together for a common goal by focusing on continuous improvement, measuring progress and sharing benefits to improve project performance. Demir (2013) argued that a collaborative environment will encourage the minimization of interfaces between the contractors and designers as well as promote trust for a better project performance. Aronson *et al.* (2006) claims that effective leadership promotes the motivation and commitment of project team and remove the organizational impediments.

Finally, short-term visualized planning for iteration and incremental delivery (0.698) and timely and continuous involvement of client(0.658) have got fairly effective impact on enablers. In order to react to change and uncertainty, many scholars suggested to use short-term visual planning to evaluate progress in project along with concurrent activities by delaying decisions until the last responsible moment. Timely and continuous involvement of client especially at the stage of collection of requirements and project development are very vital to ensure that the project progress is aligned with client's expectations and priorities. However, the clients in the Turkish construction sector are often regarded to have little or no knowledge about construction projects. Therefore, contractors and designers often prefer not to interact with client in order to avoid any misleading or unreasonable demand from client.

As a result of analysis of the proposed Agile PM implementation framework, the enablers have direct and very significant effect with path coefficient of 0.627 on Agile PM implementation. It is also noted that all variables listed in this study are found to be highly effective on enablers with high factor loadings which reinforce the content validity of the integrated framework. while it has direct and moderate effect with path coefficient of 0.313 on the process improvements.

5.5. Inputs of Agile PM Implementation

As a result of questionnaire survey and SEM analysis given in Table 4.16, construction professionals indicated that autonomous, self-organized, multi-disciplinary team with factor loading of 0.718 is the main input of Agile PM implementation. Schwaber (2004) stated that teams should be self-managing, self-organizing, and cross-functional in order to iterative and incremental delivery of the project. Demir (2013) also claimed that the increased responsibility due to being a member of autonomous and self-organized teams results in higher team motivation and team satisfaction.

The other major inputs of Agile PM implementation with higher factor loadings are information technology integration and support (0.660), consultancy and training of team members (0.652), internal knowledge resources (0.626), and experience of project team (0.615). Knowledge management with the help of IT integration can help companies to reveal the

value hidden deep in their data and facilitate continuous improvement within the company (Robinson *et al.*, 2005). Han (2013) suggests that analyzing "what-if" scenarios through use of advanced IT technology can help to deal with the uncertainty of construction. IT integration in construction projects enables to centralize the project database accessible to all project participants and allows electronic document and workflow management for a more collaborative project environment. (Van Leeuwen & Fridqvist, 2006). Experience of each team members in their area of expertise will also affect significantly on collaboration and trust between them.

The indicators with the lowest factor loadings are location of project team (0.562), size of project team (0.517), and daily stand-up meeting (0.493) but can still be regarded as moderately effective input of Agile PM. PMI (2017) argues that colocation of the project team with small size enables better communication, improved team dynamics, knowledge sharing, reduced cost of learning, and commitment to working with each other. Besides, PMI (2017) asserts that daily stand-up meetings enables teams to commit each other, uncover problems, improve organization learning and work flows smoothly through the team. However, it is surprising that daily stand-up meeting do not have significant effect on Agile PM implementation although it is the core activity of Agile PM. The reason is that daily stand-up meetings are quite common especially for contractors so was not considered to have significant effect by respondents.

With reference to results of SEM analysis, the inputs have direct and very significant effect with path coefficient of 0.579 on the process improvements. On the other hand, it has direct and moderate effect with path coefficient of 0.383 on the project level benefits

5.6. Process Improvements of Agile PM Implementation

There are many major improvements as a result of Agile PM implementation in the construction industry, especially at the project level. According to factor loadings shown in Table 4.16, better response to changes (0.821) and increase in transparency and visibility of the project (0.801) are the two major process improvements of Agile PM implementation. It is indicated by many scholars that the core concept of Agile PM is to deal with the dynamic

aspect of a project derived from changes by client and external environment (Wysocki, 2006; Moe *et al.*, 2010). Moreover, increased transparency and consistent visibility enables to reduce the risk of the project with progress and improves motivation of team members along with self-satisfaction and confidence. Improvement of communication and collaboration (0.795) and improvement of organizational learning and practices (0.771) are other main process improvements of Agile PM implementation with high factor loadings. The benefits of Agile PM particularly highlighted by Kumar and McArthur (2015) are improving communication within the team and with external parties, improving efficiency by minimizing re-work, and reducing client-driven design changes late in the process. Since organizational learning is such a large part of the project and impacts on the performance of the project, its improvement has great potential in construction projects (Owen *et al.*, 2006). Finally, decrease in project risk is the least effective indicator on process improvements with factor loading of 0.695 among others yet it can be regarded as highly effective. Owen *et al.* (2006) claimed that the Agile PM handles risk is by passing it to most capable stakeholder for resolving it, regardless of initial contract through collaborative partnering. It is also noted that all indicators listed in this study are found to be highly effective on process improvements with high factor loadings which reinforce the content validity of the integrated framework. The analysis of the proposed Agile PM implementation framework revealed that the process improvements have a direct and significant effect with path coefficient of 0.560 on the benefits.

5.7. Benefits of Agile PM Implementation

As it has been indicated by many scholars that Agile PM will increase project performance by increasing working efficiency of team members (Owen *et al.*, 2006; Daneshgari, 2010; Han, 2013; Sohi *et al.*, 2016; Sonneveld, 2018). In line with this statement, results of data analysis suggest that increase in project performance (0.865) and project quality (0.844) are found to be most effective project level benefits of Agile PM implementation with high and very close factor loadings as shown in Table 4.16. Owen *et al.* (2006) explained the reasons for improvement in both defect rates and perceived quality as defects are determined and corrected much earlier because of the feedback mechanisms of Agile PM and improved collaboration.

Another main benefit of Agile PM implementation is improvement of client satisfaction (0.668) which can be regarded as highly effective on benefits. Wysocki (2006) claimed that projects executed with Agile PM results in high degree of customer satisfaction and project success because of its iterative and incremental approach with a high responsiveness to change and better understanding of client requirements. It is interesting to find out that decrease in project cost(0.607) and in project duration (0.579) affect moderately to the benefits of Agile PM management. The construction professionals think that Agile PM doesn't not have direct influence to project cost and time since the core attributes of Agile PM is to increase collaboration among stakeholders, responsiveness to change and dynamic environment as well as productivity. Besides, Owen (2006) argued that the principle of iron triangle of Agile PM is the contrary of traditional PM where traditional PM manage time and cost by fixing requirements while Agile PM consider time and cost as fixed in order to manage requirements. Therefore, Agile PM doesn't target to reduce budgeted time and cost of a project but focuses to prevent delays and cost overruns.

6. CONCLUSIONS

In today's business world, companies need to be more agile and seek to adapt to new conditions faster than before due to rapidly developing technologies, fast evolving business needs and increasing competition. Within the context of construction industry, the common problems of construction projects, which are low productivity, poor performance, insufficient quality, delays in project schedule, and cost overruns, are often associated with complexity of projects and uncertain project environment. Many construction professionals and researchers have drew attention to these problems and stressed the urgent necessity of a tailored management methodology as a response to those problems. It is also not unusual for construction industry to adopt management methods from other industries. As a result, Agile PM, which is originally developed by software developers to deal with dynamic and uncertain environments, and its implementation has become quite popular in construction industry during the last decade.

The literature of the Agile PM for IT and manufacturing industries is immense and well-established while it is very limited for construction industry. Since IT industry has developed the theoretical framework of Agile PM based on the experience gained from execution and failure of IT projects, there are many studies about exploring Agile PM in business environment and case studies than its theory. However, the current Agile PM studies within construction literature is mostly related to theoretical transformation in to construction industry and its implementation by combining with other concepts like lean construction, BIM and traditional PM. For a better understanding of components and the links between various dimensions of Agile PM implementation, an conceptual framework is proposed and investigated in this study. It is aimed to assist construction companies to understand factors of Agile PM implementation and decide on their long and short term strategies accordingly.

As a result of an extensive literature review and expert opinions, an integrated framework composed of constructs and corresponding indicators of Agile PM implementation in the Turkish construction industry is established by hypothesizing it as an

innovation process within a construction project referring to innovation framework proposed by Ozorhon (2013). The integrated framework consists of six latent variables in total where four of them, called as “drivers”, “enablers”, “barriers”, and “inputs”, can considered inputs of an innovation process and two of them, namely process improvements and project level benefits, can be regarded as outputs of innovation process. The total number of observed variables grouped under aforementioned six latent variables is 42. In order to measure and identify the importance of this framework and its components, a questionnaire survey is designed and addressed to professionals working for Architecture, Engineering and Construction (AEC) companies in Turkey. The questionnaire survey is aimed to gather data about general information of respondents and their evaluation of the factors of Agile PM implementation using a 1–5 point Likert scale. It is targeted to reach out professionals from all disciplines and levels of construction project due to multi-disciplinary feature of Agile PM and a total of number of 203 responses were obtained.

The data collected through questionnaire survey is analyzed statistically using SPSS software. The general profile of the respondents are found to be working for contractors (42%), while remaining are working for Design Consultancy (27%) and Project Management Consultancy (13%), subcontractors (13%). Besides, majority of them works as either civil engineer (41%) or mid-level manager (32%) or high level manager (18%). Building projects (35%) are the dominant project type of respondents’ companies while remaining are infrastructure/civil projects (19%), industrial projects (19%), and finally all types of projects (27%).

6.1. Summary of Major Findings

In order to provide a better understanding for the status and awareness of Agile PM implementation of construction professionals in the Turkish AEC sector, based on responses to specific questions asked in the survey and data analysis, demographic distribution of perspective of construction professionals about usefulness and awareness of Agile PM is explored and main findings are presented below:

- The ratio of respondents who knew about Agile PM before survey is 31 % which supports the barrier of lack of awareness. Moreover, it is the project management companies has got the highest percentage of previous knowledge and awareness since Agile PM is a method of project management.

- It is promising to found that 89% of the respondents finds Agile PM as useful while only 55% of the respondents thinks that their company would be willing to implement it in their future projects. The difference between these figures indicates a company level barrier which could be either lack of top management support and commitment lack of awareness of Agile PM methods and practices within company.

- Agile PM is expected to be more useful in detailed design and construction stages while it is thought to be the least useful at operation and maintenance stage.

- It is surprising to see that 14% of overall respondents have implemented Agile PM or used similar principles in one of their project and claimed to use similar in-house methods of Agile PM. The reason is thought to be the popular use of Kanban method in construction stage as method of lean construction.

- According to comparison of means of Agile PM implementation factors according to respondents' opinion on their company's willingness to implement, all drivers and process improvements are ranked to be highly important because the Agile PM implementation is thought to be promising and have a great potential to meet the needs of construction industry by respondents with positive opinion on their companies' willingness. Besides, the respondents with positive opinion on their companies' willingness thinks that close face to face communication with client, contractor and other stakeholders as well as daily stand-up meetings are ranked as highly important to promote Agile PM implementation in construction projects.

- Based on comparison of means of Agile PM implementation factors with respect to respondents' position, in general the higher the ranking of factors is provided by the lower the position of the respondent in a project. The reason is either decentralizing the decision making towards lower levels or lack of clear benefits and demonstration

to top management. Moreover, medium level management requires more effective leadership and support from top management to overcome the resistance to organizational and cultural change within the project team.

Data collected from the respondent were also analyzed using structural equation (SEM) modeling technique to validate the content and assess the hypothesized framework and relationships between constructs of Agile PM implementation with the help of AMOS software. The results of this analysis and corresponding findings are provided below;

- Drivers as a construct have a direct and moderate effect on the inputs of Agile PM implementation which seems to be reasonable as Agile PM solely is able to respond a certain portion of necessities of construction industry which are listed as drivers in this study. PMI and other researchers suggest to combine Agile PM techniques with other management methods like traditional PM, BIM and lean construction based on the requirements of projects for more successful projects. Furthermore, in order to cope with poor performance, increasing complexity of construction projects as well as changes from client and external environment which are determined as the major drivers, there is a need for a new and tailored project management methodology for which Agile PM is a considerable candidate. Agile PM implementation have reasonable amount of contribution to companies' competitiveness, since benefits of Agile PM implementation in construction projects are yet to be demonstrated clearly, Finally, due to presence of change control system in construction projects that deals with changes and dynamic environment in a way, Agile PM is needed to be implemented mainly because of desperate search of construction industry for performance improvement due to project complexity rather than responsiveness to change and dynamic environment.

- Barriers are expected to have negative effect on Agile PM implementation based on prior literature but since the drivers and enablers have a high positive impact on the inputs and process improvements, the effect of the barriers has become negligible as a result of data analysis. It can be recommended that the company, which is willing to implement Agile PM, should first raise the awareness of Agile PM within the

company and then convince the client for close collaboration to regulate expectations of both parties and increase the flow of information in the early stages of an engineering project. Moreover, lack of top management support and commitment and resistance to organizational and cultural are also major barriers to Agile PM implementation and the support and commitment of top management will help to break the resistance to organizational and cultural change and enables smooth transition within the organization.

- Enablers affect directly and significantly Agile PM implementation. It is promising to find out that all enablers listed in this study are found to be highly effective on enablers with high factor loadings which reinforce the content validity of the integrated framework. The main enabler is commitment and organizational learning via short feedback loops since iteration based organizational learning through early and regular feedback from client and other team members enables continuous improvement of team performance and frequent adaptation process for change. Moreover, face to face communication and trust among employees are also the major enablers since they enable extensive, close, transparent and informal communication between team members and stakeholders involved in the project which results in better knowledge sharing and increased motivation. Construction projects are carried out by the collaborative effort of multiple organizations through the integration of design and construction. Effective leadership promotes the motivation and commitment of project team and remove the organizational impediments. Finally, short-term visual planning to evaluate progress in project along with concurrent activities by delaying decisions until the last responsible moment enables to response to change and uncertainty reactively or proactively. The clients in the Turkish construction industry are often regarded to have little or no knowledge about construction projects. Therefore, contractors and designers often prefer not to interact with client in order to avoid any misleading or unreasonable demand from client.

- Inputs have direct and very significant effect on the process improvements while direct and moderate effect on the project level benefits. Autonomous, self-organized, multi-disciplinary is the main input of Agile PM implementation since it enables higher team motivation and team satisfaction due to increased responsibility.

Besides, knowledge management with the help of IT integration can help companies to reveal the value hidden deep in their data and facilitate continuous improvement within the company. IT integration and support through centralizing the project database accessible to all project participants which allows electronic documentation and workflow management promotes collaborative project environment significantly. PMI (2017) argues that colocation of the project team with small size enables better communication, improved team dynamics, knowledge sharing, reduced cost of learning, and commitment to working with each other. Finally, it is surprising that daily stand-up meeting do not have significant effect on Agile PM implementation although it is the core activity of Agile PM. The reason is that daily stand-up meetings are quite common especially for contractors so was not considered to have significant effect by respondents.

- Process improvements have a direct and significant effect on the project level benefits of Agile PM implementation. It is promising for the validity of this study that all indicators of process improvement construct listed in this study are found to be highly effective on process improvements with high factor loadings which reinforce the content validity of the integrated framework. The major improvements in project process are better response to changes which is core attribute of Agile PM indicated in the literature and increase in transparency and visibility of the project which enables reduction of the risk and motivation of team members. Besides, improving communication within the team and with external parties and improving the ability of organizational learning within company as being major part of construction projects are other main expected improvements of Agile PM. Owen *et al.* (2006) claimed that the Agile PM handles risk is by passing it to most capable stakeholder for resolving it, regardless of initial contract through collaborative partnering.

- One of the most significant project level benefits of Agile PM implementation is increase in project performance by increasing working efficiency of team members. Owen *et al.* (2006) explained the reasons for improvement in both defect rates and perceived quality as defects are determined and corrected much earlier because of the feedback mechanisms of Agile PM and improved collaboration. Moreover, Agile

PM results in high degree of customer satisfaction due to high level of responsiveness to change and better understanding of client requirements. Owen (2006) and PMI (2017) argued that the principle of iron triangle of Agile PM is the opposite to traditional PM where traditional PM manage time and cost by fixing requirements while Agile PM consider time and cost as fixed in order to manage requirements. Therefore, Agile PM doesn't target directly to reduce budgeted time and cost of a project but focuses to prevent delays and cost overruns.

6.2. Recommendations and Contributions to the Literature

With reference to research findings summarized in previous section, the following recommendations are provided to help construction companies to decide on their short and long term strategies while implementing Agile PM in the future.

- Based on the findings regarding low ratio of awareness of Agile PM among construction professionals, companies and institutions are advised to first try to increase awareness and knowledge of professionals along with promotion of agile culture within the firm through training, conferences or consultancy .

- Based on the findings regarding major difference between professionals opinion on usefulness and their companies' willingness of Agile PM implementation, it is recommended to ensure to get the commitment and support of top management to break the resistance to organizational and cultural change and enables smooth transition within the organization.

- According to opinion of construction professionals, it is advised to use Agile PM methods in detailed design and construction stages in line with literature.

- Based on the findings, the demonstration of clear benefits of Agile PM implementation in construction projects is not currently available which results in lack of interest and support of the top management. Effective leadership of top management is essential to overcome the resistance to organizational and cultural

change within the firm and to allow to decentralizing the decision making towards lower levels.

- Based on the direct and moderate influence of drivers on Agile PM implementation, in line with previous studies and PMI agile guidance, its recommended to combine Agile PM techniques with other management methods like traditional PM, BIM and lean construction based on the requirements of projects for more successful projects. According to findings of highly influential drivers, Agile PM is advised to be implemented mainly for the purpose of performance improvement and increased working efficiency due to project complexity rather than responsiveness to change and dynamic environment.

- Based on the findings of highly effective barriers, it is recommended that the company, which is willing to implement Agile PM, should first raise the awareness of Agile PM within the company and then convince the client for close collaboration to regulate expectations of both parties and increase the flow of information in the early stages of a construction project.

- Based on direct and significant effect of enablers on Agile PM implementation with high factor loading, it is advised to consider all enablers indicated in this study as significant to help to promote Agile PM implementation in a construction project. Therefore, it should be noted that iteration based organizational learning through early and regular feedback from client and other team members, face to face communication, trust among employees, effective leadership and short-term visual planning are the main enablers of Agile PM implementation.

- Based on finding of the involvement of client as less influential due to clients in the Turkish construction industry often having little knowledge and experience of construction projects, clients are advised to hire a project management consultancy or establish an internal team from construction professionals for better capturing of their requirement in the project so better handing of project teams.

- Autonomous, self-organized, multi-disciplinary team enables higher team motivation and satisfaction due to increased responsibility. Besides, knowledge

management with the help of IT integration can help companies to reveal the value hidden deep in their data and facilitate continuous improvement within the company. Finally, it is advised to keep daily stand-up meetings short and within the specified conversation structure.

- It should be noted that Agile PM increase in project performance by increasing working efficiency of team members. Besides, perceived quality of the project is increased as a result of the feedback mechanisms of Agile PM and improved collaboration. Finally, responsiveness to change and better understanding of client requirements increase client satisfaction significantly.

- Based on direct and significant effect of process improvements on the project level benefits with high factor loading of each indicator, companies are advised to expect to improve all of the project processes specified in this study. These are better response to changes, increase in transparency and visibility, reduction of the risk and increase motivation, improving the ability of organizational learning through improvement of communication and collaboration.

- Based on direct and very significant effect of Agile PM implementation on the process improvements and its moderate effect on the benefits while direct and significant effect of process improvements on benefits, it should be noted by companies and researchers that the major contribution of Agile PM to construction projects is the improvement of processes during project execution rather than its direct impact on the measures of project success like cost, time and quality. That is to say, Agile PM doesn't target directly to reduce budgeted time and cost of a project but focuses to prevent delays and cost overruns through improvements in responsiveness to change, transparency and visibility of the project, communication and organization learning within the project team, and finally reduction of the risk.

6.3. Limitations and Recommendations for Future Work

Limitations of the research is mainly data collection process since questionnaire survey is only administered to civil engineers in the Turkish construction companies. Since Agile PM is a management approach of cross-functional teams, the contribution of construction professionals other than civil engineers is missing in this study. In addition, rating levels of some of the factors and results of hypnotized relations between components might not be the similar if the questionnaire was addressed to construction professionals in another country. Another limitation is that the hypotheses among the components of Agile PM implementation are constructed based on literature review and expert opinions, which are subjected to the personal judgment. The framework and hypothesis of the study is constructed to investigate opinions of construction professionals so the results of this study should be considered as factual information. Finally, there is one more limitation due to relatively low level of previous knowledge of respondents about Agile PM before taking the questionnaire. According to data analysis, 31% of the respondents knew Agile PM before while remaining professionals were expected to understand the principles from the brief information given at the beginning of survey. Since the majority of respondents have professional experience of more than 6 years (almost 80%), it is assumed that the brief information given at the beginning of the survey as well as the experience and intellectual level of respondents are sufficient to fully grasp and evaluate Agile PM factors.

This study is conducted to investigate opinions and perceptions of construction professionals regarding Agile PM implementation. In future, the indicators and components similar to the ones in this study may be measured and investigated based on the project experience of construction professionals. It will be interesting and fruitful to compare the results and observe the similarities and differences between opinion and experience of construction professionals. In addition, data from construction professionals working in other countries can be collected to utilize the same framework and parameters in this study. It will be helpful to compare the results and observe the similarities and differences between Turkish and other countries' construction industry.

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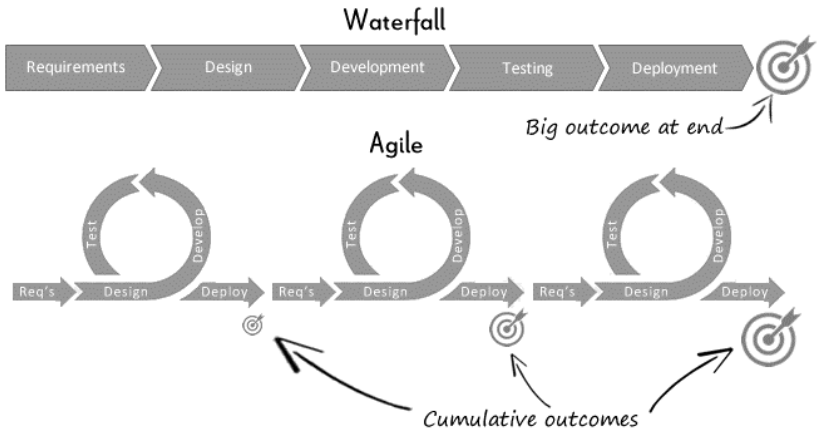
APPENDIX A: A SAMPLE OF THE QUESTIONNAIRE

A.1. Survey for Agile Project Management (PM) in the Turkish Construction Sector

In today's world, due to rapidly developing technologies, changing business needs and increasing competition, companies need to be agile and adapt to new conditions much faster in their projects. For this reason, "Agile Project Management", its use and benefits in other sectors as well as construction sector are investigated in detail. In the context of this survey, Agile Project Management is an approach based on delivering requirements iteratively and incrementally throughout the project life cycle by a small, self-organized, multidisciplinary team. It is originally created and used by software developers, according to recent academic and business studies, it is found to be 20% more successful than traditional (waterfall) project management. The purpose of this survey is to investigate the perception of professionals for current state of Agile Project Management in the Turkish AEC (Architectural, Engineering, Construction) Industry and to define the components for its implementation in Turkey such as drivers, enablers, barriers, benefits and process improvements. The data collected in this survey will remain anonymous and will be used only for academic purposes. The survey consist of 2 parts and takes about 10 minutes to participate in.

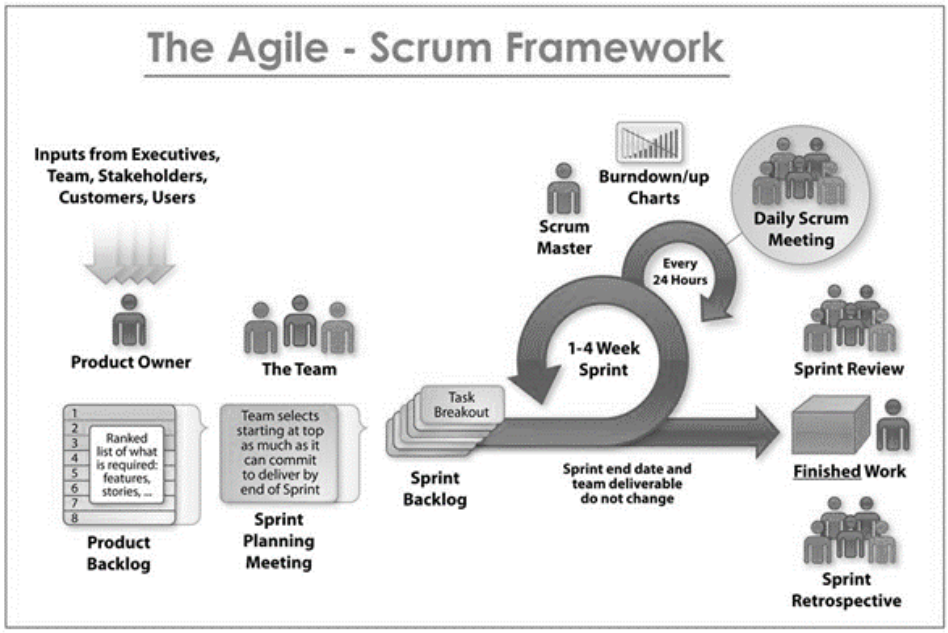
A.1.1. Background Reading

Comparison between Agile PM and Traditional (waterfall) project management is shown below,



Scrum is one of the most common frameworks applying the principles of Agile Project Management as illustrated below. Sprints, Scrums, backlogs and burndowns are all parts of Scrum.

- All the requirements of a project are identified by the participation of the employer and other stakeholders and it starts with creating a project/product backlog.
- Prioritized requirements are carried out by a self-organizing, multi-disciplinary team in sprints of 2 or 4 weeks.
- During these sprints, a short 15-minute daily stand-up meeting including the employer's representative will be held and everyone in the scrum team is aimed to be informed about the work completed, to be done and if there are any problems.
- The performance of the work done during the sprint stage is followed by burndown charts.
- At the end of each sprint, a review and a retrospective meeting is held to assess the performance of the team and project completed so far, and to decide on regulatory and remedial actions for following sprints.
- This cycle continues until the end of the project in the form of sprints.
- The goal is to improve communication, teamwork and speed of development.



A.1.2. General Information

1. Please state your experience in in Architectural, Engineering, Construction (AEC) Industry

   - □ 1 – 5 years
   - □ 6 – 10 years
   - □ 11 – 20 years
   - □ 21 – or more years

2. Please state your position in your company

   - □ Top Level Management (Board of Directors, Chief Executive Officer, General Manager, Managing Director, Project Manager, etc.)
   - □ Middle Level Management (Department Head, Branch Manager, Junior Executives, etc.)
   - □ Civil Engineer
   - □ Architect
   - □ MEP Engineer
   - □ Technician
   - □ Other (……..)

3. Please state the years of experience of your company.

   - □ 1 – 5 years
   - □ 6 – 10 years
   - □ 11 – 20 years
   - □ 21 – or more years

4. Please state the number of employee in your organization.

   - □ 1 – 10
   - □ 11 – 50
   - □ 51 – 100
   - □ 101 – 500
   - □ 501 – or more

5. What is the main business area of your company?

   - □ Employer / Client
   - □ Investor/ Financing
   - □ Main Contractor
   - □ Subcontractor
   - □ Research and Education
   - □ Project Man. Consultancy
   - □ Design Consultancy (Architecture/Structure/MEP Eng.)
   - □ Supplier / Vendor
   - □ Other (……..)

6. Please state what type of projects your company mainly is involved in.

   - □ Residential / Hotel Building Projects
   - □ Public Building Projects (Commercial, Aviation, Transportation, Education, Healthcare, Sports etc.)
   - □ Infrastructure projects (Road, Bridge, Waste, Water etc.)
   - □ Heavy construction (Dam, Maritime, dredging, etc.)

- ☐ Industrial Projects (Factory, Plant, Energy etc.)
- ☐ Other (……..)

7. Please state the approximate annual turnover of your organization? USD ($)

- ☐ 1 million or less
- ☐ 2 million – 10 million
- ☐ 10 million – 50 million
- ☐ 50 million – 100 million
- ☐ 100 million or more
- ☐ I do not know

8. Did you know about Agile Project Management before this Survey?

☐ YES ☐ NO

9. Do you think it would be useful for AEC Industry based on brief info at the beginning of Survey?

☐ YES ☐ NO

10. Which stage of the project do you think Agile PM is more useful? (Likert Scale 0-3)

Feasibility				Preliminary Design				Detailed Design				Construction				Op. and Main.			
0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3

11. Do you think your organization would try to implement Agile?

☐ YES ☐ NO

12. Have you ever utilized Agile PM methods (like Scrum) in a project?

☐ YES ☐ NO

If no, please continue with <u>Section **B**</u>

12.1. Which methods / techniques of Agile PM has been utilized?

- ☐ Scrum
- ☐ Kanban
- ☐ Internally created methods
- ☐ Daily stand up meetings
- ☐ Prioritized back logs
- ☐ Task board
- ☐ Short iterations
- ☐ Autonomous, multi-disciplinary team

12.2. In which face of the project was Agile PM utilized?

- ☐ Feasibility
- ☐ Preliminary Design
- ☐ Detailed Design
- ☐ Construction
- ☐ Operation and Maintenance

12.3. What do you think about the effect of Agile PM on project duration?

- ☐ Increase or no change
- ☐ 1-25% Reduction
- ☐ 26- 50% Reduction
- ☐ 51- 75 % Reduction
- ☐ 76-100% Reduction

12.4. What do you think about the effect of Agile PM on project cost?

- ☐ Increase or no change
- ☐ 1-25% Reduction
- ☐ 26- 50% Reduction
- ☐ 51- 75 % Reduction
- ☐ 76-100% Reduction

12.5. What do you think about the effect of using Agile PM on number of change orders issued?

- ☐ Increase or no change
- ☐ 1-25% Reduction
- ☐ 26- 50% Reduction
- ☐ 51- 75 % Reduction
- ☐ 76-100% Reduction

12.6. What do you think about the effect of Agile PM on project productivity?

- ☐ Decrease or no change
- ☐ 1-25% Increase
- ☐ 26- 50% Increase
- ☐ 51- 75 % Increase
- ☐ 76-100% Increase

12.7. What do you think about the effect of Agile PM on customer satisfaction?

- ☐ Decrease or no change
- ☐ 1-25% Increase
- ☐ 26- 50% Increase
- ☐ 51- 75 % Increase
- ☐ 76-100% Increase

12.8. What do you think about the effect of Agile PM on collaboration and motivation of team members?

- ☐ Decrease or no change
- ☐ 1-25% Increase
- ☐ 26- 50% Increase
- ☐ 51- 75 % Increase
- ☐ 76-100% Increase

12.9. What do you think about the effect of Agile PM on transparency and visibility of the project?

- ☐ Decrease or no change
- ☐ 1-25% Increase
- ☐ 26- 50% Increase
- ☐ 51- 75 % Increase
- ☐ 76-100% Increase

A.1.3. Factors for Implementation of Agile PM in Construction Industry

Please state the importance level of listed factors based on the question before table.

1. To what extent do you think the following factors create the need for Agile PM in Construction Industry? (Drivers)

#	Table A.1. Drivers of Agile PM	Very Low	Low	Medium	High	Very High
1	Responsiveness to changes and client requirements					
2	Need for Project Performance Improvement					
3	Poor communication with client and stakeholders					
4	Dynamic and uncertain project environment					
5	Projects with high complexity and risk					
6	Competition Level in market					

2. To what extent do you think the following factors impede the uptake of Agile PM in Construction Industry? (Barriers)

#	Table A.2. Barriers to Agile PM	Very Low	Low	Medium	High	Very High
1	Responsiveness to changes and client requirements					
2	Resistance to Organizational and Cultural Change					
3	Lack of top management support and commitment					
4	Lack of commitment and engagement of customer/client					

5	Lack of commitment and engagement of team members and other stakeholders					
6	Team members working on multiple projects and in different locations					
7	Unclear benefits and methods of implementation of Agile PM in Construction industry					
8	Lack of awareness of Agile PM methods and practices					
9	Lack of contractual aspects of using Agile PM between stakeholders					
10	Bureaucratic project environment with multiple stages of projects acceptance					

3. To what extent do you think the following factors help promote Agile PM in Construction Industry? (Enablers)

#	**Table A.3. Enablers of Agile PM**	**Very Low**	**Low**	**Medium**	**High**	**Very High**
1	Responsiveness to changes and client requirements					
2	Short-term visualized planning for iterative and incremental delivery					
3	Timely and continuous involvement of Client					
4	Collaborative Partnering of contractor and other stakeholders					
5	Commitment and organizational learning via short feedback loops					
6	Organizational Trust among employees					
7	Effective Leadership					

8	Face to face Communication					

4. To what extent do you think the following factors facilitate Agile PM in Construction Industry? (Inputs)

#	**Table A.4. Inputs of Agile PM**	**Very Low**	**Low**	**Medium**	**High**	**Very High**
1	Responsiveness to changes and client requirements					
2	Autonomous, self-organized, multi-disciplinary team					
3	Daily stand-up meeting					
4	Size of project team					
5	Location of project team					
6	Experience of project team					
7	Consultancy and training of team members					
8	Information technology integration and support					

5. To what extent do you think the Agile PM in Construction Industry improves processes of the project?

#	**Table A.5. Process improvements of Agile PM**	**Very Low**	**Low**	**Medium**	**High**	**Very High**
1	Responsiveness to changes and client requirements					
2	Improvement of communication and collaboration					

3	Increase in transparency and visibility of the project					
4	Improvement of organizational learning and practices					
5	Decrease in Project Risk					

6. To what extent do you think the Agile PM in Construction benefits your project Industry? (Benefits)

#	**Table A.6. Benefits of Agile PM at Project Level**	**Very Low**	**Low**	**Medium**	**High**	**Very High**
1	Responsiveness to changes and client requirements					
2	Improvement of Client Satisfaction					
3	Increase in Project Performance					
4	Increase in Project Quality					
5	Decrease in Project Cost					

APPENDIX B: DESCRIPTIVE STATISTICS

Table B.1. Descriptive statistics of general information on respondents and companies.

Statistics	**Personal Experience**	**Position**	**Company Experience**
N	192	192	192
Mean	2,47	2,45	3,30
Median	3	2	4
Std. Deviation	0,98	1,01	0,92
Kurtosis	-0,99	1,00	-0,09
Skewness	-0,03	0,62	-1,04
Range	3	5	3
Minimum	1	1	1
Maximum	4	6	4
Values of Variables	1=1-5 years, 2=6-10 years, 3=11-20 years, 4=21-or more	1=High Level Management 2=Middle Level Management 3=Civil Engineer 4=Architect 5=MEP Engineer 6=Technician	1=1-5 years, 2=6-10 years, 3=11-20 years, 4=21-or more

Table B.2. Descriptive statistics of general information on companies.

Statistics	**Company Main Business Area**	**Company Main Project Type**	**Company Turnover (USD)**
N	192	192	192
Mean	2,80	2,38	3,79
Median	3	2	4,5
Std. Deviation	1,19	1,22	1,82
Kurtosis	1,05	-1,56	-1,43
Skewness	0,80	0,16	-0,28
Range	5	3	5
Minimum	1	1	1
Maximum	6	4	6
Values of Variables	1=Project Man Consultancy 2=Design Consultancy, 3=Main Contractor, 4=Subcontractor, 5=Supplier / Vendor, 6=Employer / Client	1=Building Projects 2=Infrastructure & Civil Projects 3=Industrial Projects 4=All types of projects	1=1 mil or less, 2=2 – 10 mil, 3=10 - 50 mil, 4=50 - 100 mil, 5=100 mil or more, 6="I do not know"

Table B.3. Descriptive statistics of drivers.

Statistics	DR1	DR2	DR3	DR4	DR5	DR6
N	192	192	192	192	192	192
Mean	3,84	3,84	3,61	3,65	3,77	3,18
Median	4	4	4	4	4	3
Std. Deviation	0,96	0,97	1,13	1,09	1,07	1,14
Kurtosis	-0,06	-0,61	-0,63	-0,67	-0,16	-0,72
Skewness	-0,58	-0,37	-0,39	-0,44	-0,65	0,00
Range	4	4	4	4	4	4
Minimum	1	1	1	1	1	1
Maximum	5	5	5	5	5	5

Table B.4. Descriptive statistics of barriers.

Statistics	BA1	BA2	BA3	BA4	BA5	BA6	BA7	BA8	BA9	BA10
N	192	192	192	192	192	192	192	192	192	192
Mean	3,97	4,06	3,66	3,81	3,38	3,46	3,85	3,33	3,54	3,50
Median	4	4	4	4	3	4	4	3	4	4
Std. Deviation	1,05	0,93	1,02	0,99	1,12	1,04	1,00	1,01	1,13	1,14
Kurtosis	-0,55	1,02	-0,34	0,14	-0,63	-0,36	0,11	-0,24	-0,89	-0,69
Skewness	-0,67	-1,01	-0,42	-0,66	-0,23	-0,36	-0,70	-0,09	-0,28	-0,36
Range	4	4	4	4	4	4	4	4	4	4
Minimum	1	1	1	1	1	1	1	1	1	1
Maximum	5	5	5	5	5	5	5	5	5	5

Table B.5. Descriptive statistics of enablers.

Statistics	EN1	EN2	EN3	EN4	EN5	EN6	EN7	EN8
N	192	192	192	192	192	192	192	192
Mean	3,76	3,71	4,00	3,86	3,84	3,95	3,85	3,79
Median	4	4	4	4	4	4	4	4
Std. Deviation	1,00	1,04	1,01	0,95	1,01	1,00	1,01	1,08
Kurtosis	-0,23	-0,16	0,67	0,71	-0,46	-0,07	-0,47	0,07
Skewness	-0,52	-0,61	-1,04	-0,84	-0,57	-0,75	-0,57	-0,77
Range	4	4	4	4	4	4	4	4
Minimum	1	1	1	1	1	1	1	1
Maximum	5	5	5	5	5	5	5	5

Table B.6. Descriptive statistics of inputs.

Statistics	IN1	IN2	IN3	IN4	IN5	IN6	IN7	IN8
N	192	192	192	192	192	192	192	192
Mean	3,88	3,49	3,36	3,31	3,79	3,60	3,90	3,59
Median	4	3,5	3	3	4	4	4	4
Std. Deviation	1,09	1,01	1,03	1,05	1,05	1,10	0,97	1,07
Kurtosis	0,23	-0,33	-0,45	-0,45	-0,19	-0,12	0,75	0,13
Skewness	-0,85	-0,28	-0,16	-0,26	-0,69	-0,64	-0,87	-0,71
Range	4	4	4	4	4	4	4	4
Minimum	1	1	1	1	1	1	1	1
Maximum	5	5	5	5	5	5	5	5

Table B.7. Descriptive statistics of process improvements.

Statistics	PI1	PI2	PI3	PI4	PI5
N	192	192	192	192	192
Mean	3,93	3,76	3,74	4,02	3,55
Median	4	4	4	4	4
Std. Deviation	1,03	1,10	0,98	0,98	1,02
Kurtosis	0,44	-0,30	0,07	0,64	-0,30
Skewness	-0,91	-0,62	-0,56	-0,98	-0,42
Range	4	4	4	4	4
Minimum	1	1	1	1	1
Maximum	5	5	5	5	5

Table B.8. Descriptive statistics of benefits at project level.

Statistics	PB1	PB2	PB3	PB4	PB5
N	192	192	192	192	192
Mean	3,70	3,85	3,72	3,15	3,37
Median	4	4	4	3	3
Std. Deviation	1,09	0,98	1,08	1,08	1,17
Kurtosis	-0,12	0,19	-0,30	-0,53	-0,75
Skewness	-0,65	-0,74	-0,58	-0,18	-0,22
Range	4	4	4	4	4
Minimum	1	1	1	1	1
Maximum	5	5	5	5	5

APPENDIX C: CORRELATION MATRICES

Table C.1. Intercorrelations for the variables of drivers.

	DR1	**DR2**	**DR3**	**DR4**	**DR5**	**DR6**
DR1	1,000	0,434	0,609	0,440	0,477	0,493
DR2	0,434	1,000	0,342	0,507	0,592	0,228
DR3	0,609	0,342	1,000	0,483	0,237	0,455
DR4	0,440	0,507	0,483	1,000	0,258	-0,068
DR5	0,477	0,592	0,237	0,258	1,000	0,406
DR6	0,493	0,228	0,455	-0,068	0,406	1,000

Table C.2. Intercorrelations for the variables of barriers.

	BA1	**BA2**	**BA3**	**BA4**	**BA5**	**BA6**	**BA7**	**BA8**	**BA9**	**BA10**
BA1	1,000	0,663	0,092	0,487	0,251	-0,013	0,319	0,245	0,417	0,247
BA2	0,663	1,000	0,230	0,468	0,074	0,107	0,196	0,061	0,217	0,114
BA3	0,092	0,230	1,000	0,388	0,239	0,426	0,607	0,040	0,089	0,177
BA4	0,487	0,468	0,388	1,000	0,374	0,268	0,488	0,203	0,465	0,358
BA5	0,251	0,074	0,239	0,374	1,000	0,151	0,372	-0,037	0,531	0,429
BA6	-0,013	0,107	0,426	0,268	0,151	1,000	0,277	-0,104	0,058	0,143
BA7	0,319	0,196	0,607	0,488	0,372	0,277	1,000	0,237	0,222	0,165
BA8	0,245	0,061	0,040	0,203	-0,037	-0,104	0,237	1,000	0,136	0,020
BA9	0,417	0,217	0,089	0,465	0,531	0,058	0,222	0,136	1,000	0,681
BA10	0,247	0,114	0,177	0,358	0,429	0,143	0,165	0,020	0,681	1,000

Table C.3. Intercorrelations for the variables of enablers.

	EN1	**EN2**	**EN3**	**EN4**	**EN5**	**EN6**	**EN7**	**EN8**
EN1	1,000	0,065	0,059	0,000	0,187	0,290	0,251	0,011
EN2	0,065	1,000	0,158	0,149	-0,068	-0,081	-0,180	0,267
EN3	0,059	0,158	1,000	0,354	0,470	0,435	0,533	0,487
EN4	0,000	0,149	0,354	1,000	0,664	0,539	0,452	0,376
EN5	0,187	-0,068	0,470	0,664	1,000	0,578	0,578	0,505
EN6	0,290	-0,081	0,435	0,539	0,578	1,000	0,603	0,176
EN7	0,251	-0,180	0,533	0,452	0,578	0,603	1,000	0,264
EN8	0,011	0,267	0,487	0,376	0,505	0,176	0,264	1,000

Table C.4. Intercorrelations for the variables of inputs.

	IN1	**IN2**	**IN3**	**IN4**	**IN5**	**IN6**	**IN7**	**IN8**
IN1	1,000	0,281	0,347	0,508	0,115	0,551	0,574	0,417
IN2	0,281	1,000	0,097	0,563	0,062	0,432	0,357	0,474
IN3	0,347	0,097	1,000	0,364	0,322	0,476	0,543	0,573
IN4	0,508	0,563	0,364	1,000	0,368	0,482	0,677	0,613
IN5	0,115	0,062	0,322	0,368	1,000	0,176	0,325	0,286
IN6	0,551	0,432	0,476	0,482	0,176	1,000	0,671	0,624
IN7	0,574	0,357	0,543	0,677	0,325	0,671	1,000	0,621
IN8	0,417	0,474	0,573	0,613	0,286	0,624	0,621	1,000

Table C.5. Intercorrelations for the variables of process improvements.

	PI1	**PI2**	**PI3**	**PI4**	**PI5**
PI1	1,000	0,591	0,564	0,671	0,480
PI2	0,591	1,000	0,548	0,592	0,363
PI3	0,564	0,548	1,000	0,475	0,443
PI4	0,671	0,592	0,475	1,000	0,466
PI5	0,480	0,363	0,443	0,466	1,000

Table C.6. Intercorrelations for the variables of benefits at project level.

	PB1	**PB2**	**PB3**	**PB4**	**PB5**
PB1	1,000	0,401	0,559	0,155	0,098
PB2	0,401	1,000	0,635	0,582	0,639
PB3	0,559	0,635	1,000	0,574	0,074
PB4	0,155	0,582	0,574	1,000	0,266
PB5	0,098	0,639	0,074	0,266	1,000