Empirical Study of Agile Methodologies and Quality Management Success Factors in Pakistani Software Companies

Javed Iqbal[1, 2], Mazni Omar[1] and Azman Yasin[1]

[1]Universiti Utara Malaysia, Malaysia, {mazni@uum.edu.my, yazman@uum.edu.my}
[2]University of Peshawar, Pakistan, {javaidiq@uop.edu.pk}

ABSTRACT

The quality factor is an essential aspect and an indicator for the success of agile software development. On the other hand quality mismanagement increases the risk of software project failure. Therefore, it is essential to look at the success factor that supports the software development community to have better quality management of the project. The aim of this study is to classify the success factor of agile software development along with the most widely used agile methodology in the Pakistani software companies. For this purpose, an online survey was conducted to get insights from the practitioners of the leading software companies in Pakistan. Our survey reveals that there is a lack of empirical evidence to determine the most widely used agile methodology and to relate a particular set of agile methodologies to effective and progressive management of quality factor with the other five project management factors, which are schedule, scope, risk, budget and resources in Pakistani software companies. Correlation technique was used to analyze the research results. The correlation results suggest that the quality factor is positively correlated to the five project management factors. The budget factor has statistically significant correlation with quality factor. While all other factors found statistically insignificant. The results further suggest the most widely used agile methodologies are Extreme Programming followed by Scrum, Agile modeling and Kanban in Pakistani software companies.

Keywords: Project Management factors, Agile methodologies, software development, pakistani software companies.

I INTRODUCTION

Many trial - and – error methods have been introduced for managing and developing software in 1950's. Few methods were incremental or iterative in nature (Larman, 2003). Others were linear or sequential, knows as "Waterfall Model" or "Classical Model" (Benington, 1956). The sequential nature of the Waterfall model were often followed in the real system design (Blanchard, 2011). This approach loose the efficiency in dealing with the requirements of customer, organizing quickly changing domain, release time and budget of the project (Futrell, 2002).

In the reaction of failures of Waterfall model, the concept of agile was launched in 2001 (James, 2009). The Vee process model was also one of the software development process model that gave a resultant system (Blanchard, 2011). Agile software development methods took part to medicate the shortcomings such as complex, comprehensive documentation and expensive design of so-called "heavyweight software methodologies", in mid-1990s (Awad, 2005).

Agile methodologies have significantly improve the software quality and productivity by reducing the software development life cycle, which equivalently shares by the majority of the software companies of an area. However, a disparity in software production among software companies in Pakistan is greatly felt recently, despite the availability of similar resources and opportunities. In this paper, we try to find the remedy and the rationale behind this production disparity by conducting a comprehensive web-based survey of the professionals of the leading software companies in Pakistan. Our survey exposed that there is a lack of empirical evidence to determine the most widely used agile methodology and to relate a particular set of agile methodologies to effective and progressive management of quality factor with the other five project management factors (schedule, scope, risk, budget and resources) of the Project Management Body of Knowledge (Project Management Institute, 2008) in Pakistani software companies. The quality factor is considered to be an indication of success. For the purpose, the quality factor of the six-point star model is checked against the other five project management factors. Two methodologies that is Scrum and Kanban have been compared and analyzed previously (Lei, 2017). However, the proposed research describes the analysis of seven different agile methodologies such as extreme programming (XP), scrum, agile modeling, kanban, lean, crystal and feature driven development (FDD) in much more detail with an open choice of survey respondents. Correlation techniques were used for statistical analysis. The results showed that all factors are positively correlated with the quality factor which shows the success of the project. Furthermore, it determines the

most widely used agile methodologies in the software companies of Pakistan.

The remainder of this paper includes, Section II explains the Literature review, Section III describes the methodology used for research and Section IV presents findings and its discussions of the results. In the last, Section V concludes and recommends future work.

II LITERATURE REVIEW

A. Agile Methodologies

In the late 1990s, agile was introduced with an iterative and incremental nature. Agile is lightweight, lean software design and software development methodology that is highly computable with the rapid development of the WWW (World Wide Web) (Williams, 2010). Unlike other methods, agile methods depends on feedback system which make sure greater client satisfaction (Highsmith, 2001). Agile includes different methodologies, including: Adaptive Software Development (ASD) (Highsmith, 1997), Agile Unified Process (AUP) (Ambler, 2006), Crystal Methods (Cockburn, 2004), Dynamic Systems Development Methodology (DSDM) (Tuffs, 1999), eXtreme Programming (XP) (Anderson, 1998), Feature Driven Development (FDD) (Coad, 1999), Kanban (Ladas, 2009), Lean Software Development (Poppendieck, 2003), Scrum (Schwaber, 1996).

The criteria for project success have been reviewed by several authors. The effectiveness of Scrum and Kanban method is statistically compared in terms of their effect on project management factors for software development projects (Lei, 2017). A statistical comparison was conducted for the effects of heavyweight and lightweight methodologies on each factor of the six-pointed star model and the interdependency among factors. The outcomes suggested that lightweight methodologies are safe for small scale projects while heavyweight methodologies are best for medium and large scale tasks (Akbar, 2018). An exploratory survey was conducted for the perceptual experiences of different users involved in the software development cycle in the appraisal of factors determining software product quality (Curcio, 2016). A new software development life cycle model, ``AZ-Model,'' is introduced for software development. The popular six-pointed star model of project management is used to describe the effect of proposed model to the project (Akbar , 2017). Cost and Time Project Management Success (CTPMS), is an essential step for projects and it must dynamically address cost and time success under an agreed range (Sanchez, 2017).

B. Quality Management Success Factor

The key success of a software project is the quality, the project is considered to be successful if the customer's needs and requirements are fulfilled.

The Phrase "satisfaction of customer requirements" includes several currently agreed-upon definitions of the software quality (Kannabiran, 2011). In this study, in order to measure the software quality management success factor, the software quality of the six-point star model is checked against the other five project management factors. The survey was conducted to correlate the quality factor; the results suggested that the quality factor is positively correlated with the other five project management factor which is an indication of success.

Agile methodologies have greater client satisfaction and project success scores and an corresponding quality requirement score as traditional methodologies (Akbar, 2018)

III RESEARCH METHODOLOGY

In this paper the six-pointed star model is used for the analysis purposes of project management instead conventional input, output and process factors (Figure 1). Conventionally, the project success factors are Cost, Time and Scope (Chatfield, 2007). Afterward, an advance model that was based on six factors (schedule, scope, risk, budget, resources and quality) defined by project management body of knowledge (PMBOK4.0), plays an important role in the success of a project (Duncan, 1996; Schwaber, 1996). Figure 1 shows the six factors in the six-point star model. The model is divided into two different triangles. One of these shows the schedule, scope, and budget for the input/output factors of the project, while the other one show the factors of risk, resources, and quality are the process factors.

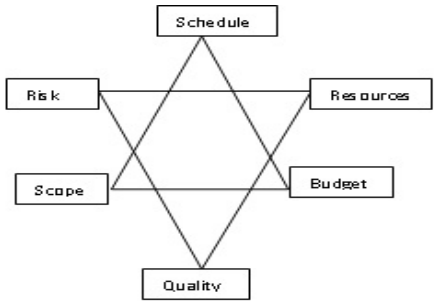

Figure 1. Project Management Factors PMBOK4.0 (Wikipedia.Org/Wiki/File:Tripleconstraint.Jpg.)

The research presented in this paper was carried out using a quantitative approach on the effectiveness of agile methodologies on software projects of Pakistani Software companies. Conventionally, these six factors Schedule, Scope, Budget, Risk, Resource and Quality play an important role in the success of a software project. Each factor has its own significance

and effect in agile software development methodologies. Our research is focused on the quality factor that how it affects the success of agile software development.

A. **Data Collection**

An online survey (using http://www.googledocs.com) has been conducted to gather numerical responses to questions from software developers working in different software development companies located in five major areas of Pakistan. For the purpose the study is adopting the questionnaire demonstrated in research by Howard Lei (Lei, 2017). The reason of adopting the questions from this study is becauae of its suitablility to measures the success of agile implementation. Example of such studies are (Akbar, 2017; 2018). The questionnaire was divided into two sections. The first section contained the general information about the respondent and their companies. The second section contains questions related to the factors of the six-pointed star model (as shown in Table 1). The study was performed from April 2017 – May 2017, the data were composed of 52 respondents involved in 52 different software companies for each factor of the project management using agile methodologies .The six-pointed star model is used to relate the survey questions to each of the factors in Table 1. Table 2 shows the Likert scale response categorization, the respondents gave their feedback to each survey question. The feedback given by each respondent for each Likert scale is associated with a numeric score and the scores are used to produce numerical survey response data. In order to analyze the survey data, Spearman's correlation techniques are performed using the stata tool (version 12).

Table 1. Survey Questions Related To Each Project Management Factor

Factor	Survey questions	Q.No
Schedule	Project team members are aware of the current progress of the project most of the time.	I
	Project teams can react and adapt to change in requirements quickly and effectively.	II
	Milestones are achieved according to schedule.	III
Scope	Project methodology and features have bounded scope	I
	The project methodology chosen makes the software product scope clear and bounded.	II
Budget	The Project is completed within the estimated budget.	I
	The Project has a good return on investment (ROI).	II
Risk	Project risks are identified and a strategy is predefined to mitigate the risk.	I
	Project opportunities are identified and exploited to the benefit.	II
Resources	Trained and skilled human resources are easily available.	I
	Software tools and techniques are available or can be adapted to the task.	II
Quality	Product quality requirements are achieved.	I
	Customers are satisfied with the delivered product.	II
	The project has been categorized as successful.	III
	The user interface has been assessed as easy by the Customers	I V

Table 2: Likert Scale Response Categories

Scale	Numerical Score
Strongly Disagree	1
Disagree	2
Neutral	3
Agree	4
Strongly Agree	5

The respondents experience is shown in Table 3, 38.46% of the respondents worked from 3 to 5 years, 30.77% of the respondents stated that they worked less than 2 years, 28.85% respondents worked from 6 to 10 years and 1.92% worked more than 10 years.

Table 3. Experience Of The Developers Working In The Software company

Respondents Experience	Less than 2 years	16 (30.77%)
	3 to 5 Years	20 (38.46%)
	6 to 10 years	15 (28.85%)
	More than 10 Years	1 (1.92%)
	Total	**52(100%)**

IV **RESULTS AND DISCUSSIONS**

In this section a statistical analysis is performed to determine the most used agile methodology. Furthermore, to relate the quality factor with other five factors of project management using Pearson's and Spearman's correlation techniques. A discussion of the results is also given.

A**. Agile Methodologies Used By Respondents**

Agile methodologies used by 52 respondents in 52 different companies across Pakistan are shown in Table 4 and 5. The respondents gave their responses to the following survey question.

Question: *What agile methodologies your company mostly uses for developing products?*

- *Extreme Programming*
- *Scrum Methodology*

- *Kanban Methodology*
- *FDD*
- *Crystal Methodology*
- *Lean Software Development*
- *Agile Modeling*
- *Others*

According to the above question some of the respondents corresponded to a single agile methodology while some of them corresponded to more than one agile methodology. Our survey results show that XP is one of the most widely used agile methodology followed by Scrum, Agile Modeling and Kanban that proves the reliability of their growing acceptance in Pakistani software companies, shown in Table 4. By looking to the results in Table 4, collectively XP has been used 24 times, Scrum 23 times, Agile modeling 20 times, Kanban 9 times, Lean 6 times, Crystal methodology 5 times and FDD has been used 3 times by 52 developers in different agile software projects.

Table 4. Total Number Of Methodologies Used By Software Developers

Methodology S.No	Methodology	No. of Respondents
1	XP	24
2	Scrum	23
3	Kanban	9
4	Agile	20
5	Lean	6
6	Crystal	5
7	FDD	3
8	Others	4

According to the results in Table 5, for the XP methodology, 12 respondents (23.08%) who stated that they used only XP in their companies, while the rest of the 12 respondents (23.07%) stated that they use XP with other agile methodologies for the development of softwares in their software companies. For the Scrum methodology, 5 respondents (9.62%) who stated that they use only Scrum, while the rest of the 18 respondents (38.45%) stated that they use Scrum with other agile methodologies for the development of software in their software companies. Also 2 respondents (3.85%) use Kanban, 3 respondents (5.77%) use Kanban and Agile, 1 respondent (1.92%) use Lean software development, 2 respondent (3.85%) used Lean software development and Agile. Some of the respondents used hybrid methods and some used formal methods for the development. One respondent (1.92%) use hybrid and 1 respondent (1.92%) stated that they do simple meetings for the development in their software companies.

B. Spearman's correlation between the factors of Project management

The quality factor examines the project needs, customers' satisfaction and the overall success of the software on the base of survey questions. For the purpose, the quality factor of the six-point star model is checked against the other five project management factors. The correlation techniques are used on survey data to make sure that the quality factor is positively correlated with the rest of project management factors. A positive correlation is found between the quality factors and other factors suggests that it is worth examining that how agile methodologies affects each of the individual factors of the project management. It concludes that this could affect the overall success of the project. The average score of all questions is calculated for each factor, as each factor consist more than two questions related to each factor for each respondent. For instance, for strongly agree (score 5), for agree (score 4) and for neutral (score 3) respectively, for question number I, II and III, by computing the average score for the respondent for the schedule factor of these questions is 4.0. Table 6 shows the average scores of each factor for all 52 respondents.

Table 5. Number Of Respondents Using Different Agile Methodologies

Serial Number	Agile Methodology	Frequency	Percentage (%)
1	XP	12	23.08
2	Scrum	5	9.62
3	Kanban	2	3.85
4	Lean	1	1.92
5	Agile	2	3.85
6	XP, Agile	3	5.77
7	XP, Scrum	2	3.85
8	XP, Spiral Model	1	1.92
9	XP, Scrum, Agile	3	5.77
10	XP, Scrum, Crystal	1	1.92
11	XP, Crystal	1	1.92
12	XP, Scrum, Kanban	1	1.92
13	Hybrid	1	1.92
14	Kanban, Agile	3	5.77
15	Lean, Agile	2	3.85
16	Scrum, Agile	2	3.85
17	Scrum, Crystal, Agile	1	1.92
18	Scrum, FDD, Agile Modeling, Lean	1	1.92
19	Scrum, FDD, Agile	1	1.92
20	Scrum, FDD, Lean, Crystal, Agile	1	1.92
21	Scrum, Iterative and incremental	1	1.92
22	Scrum, Kanban	2	3.85
23	Scrum, Kanban, Agile	1	1.92
24	Scrum, Crystal, Lean	1	1.92
25	Simple meetings with developers	1	1.92
Total		**52**	**100**

A Spearman's Correlation was used to correlate the quality factors with the other five project management factors for 52 respondents used different agile methodologies shown in Table 7. A correlation value of 1 shows a perfect correlation,

while a value of 0 shows no correlation. The results showed that the quality factor which is an obvious indication of project success found positively correlated with each of the other project factors of the six-point star model. The Table 7 also revealed that among the factors, only budget found statistically significant in relation with the quality factor. The results further suggested that no significant relationships of these factors with the quality factor except budget, which is significantly correlated with the quality factor.

The Table 7 shows that there found an insignificant positive correlation i.e. 17% of the schedule with the quality factor as the sig. (p-value) found more than 5% of the level of significance. It means that if the estimated schedule followed according to the project plan, the quality of the project will increase. A non-practical schedule may lead to problems for the project deliverables. Also, from table it is clear that factor scope observed statistically insignificantly positive correlated with quality. It means if the scope of the project is well defined, the quality of the project will also increase. A poorly defined scope leads inconsistencies in the project deliverables. There is found positive moderate correlation of 33% between the effect of budget and the quality of the project. This association observed statistically significant as the p-value for this found less than 5% i.e. (0.01) showing a significant association between budget and the quality.

A correlation coefficient in the range .2 to .4 is investigative of a small but definite relationship; a correlation coefficient in the range .4 to .7 is investigative of a moderate relationship; and a correlation coefficient in the range .7 to .9 is investigative of a strong relationship (Hair, 2003). It means that there is a statistically significant relationship between budget and quality. An unrealistic budget affects the project functionalities. So it is necessary for the software development community to have a better understanding of the cost management to produce successful software projects (Palmer, 2002).

From the table, it is also clear that there found a positive relationship between the risk and the quality of the project management i.e. 9%. This relationship also observed statistically insignificant as the p-value of the risk found .60 which is greater than 5% level of significance. It means that if the risk is properly identified, analyzed and controlled, the quality will increase accordingly. Also, the resource factor observes insignificantly positive correlated with the quality of the project. The p-value for the resources of the project management found 0.17 which is more than 5% level of significance and defining the insignificant relationship statistically. It means if the required software, hardware and developers are available, the quality of the project will increase.

Table 6. Average Scores Of Each Factor

Respondent No.	Average Schedule	Average Scope	Average Budget	Average Risk	Average Resources	Average Quality
1	3.66	4.50	4.50	4.0	4.00	4.50
2	4.66	4.00	4.00	4.50	4.00	4.25
3	4.33	3.00	3.00	4.00	4.50	4.50
4	4.33	5.00	4.00	5.00	4.00	4.50
5	4.33	4.00	4.50	3.50	4.50	3.75
6	3.66	2.50	3.50	3.00	2.00	3.50
7	4.00	4.00	5.00	4.00	4.50	4.75
8	3.66	3.00	3.00	4.00	3.50	3.75
9	3.66	3.50	3.50	3.50	4.50	4.00
10	2.33	4.00	2.00	2.00	2.00	4.00
11	4.66	3.50	4.50	3.50	3.50	4.50
12	3.33	4.50	3.50	4.00	3.00	4.00
13	4.00	4.00	3.50	4.50	4.00	4.00
14	4.00	4.00	5.00	4.00	4.00	4.25
15	3.66	3.50	4.50	4.50	3.50	4.25
16	3.66	3.00	4.00	4.50	3.00	4.50
17	4.33	3.50	4.00	4.00	3.00	3.50
18	4.33	2.50	3.50	4.50	4.00	3.25
19	5.00	2.50	4.50	4.50	4.00	4.75
20	4.33	3.50	4.00	4.50	3.00	4.25
21	3.66	3.00	4.00	4.00	3.00	4.00
22	4.00	5.00	3.50	4.00	4.00	4.50
23	4.00	4.50	3.00	3.00	2.50	4.00
24	4.00	4.00	4.00	3.50	4.00	4.00
25	4.00	2.50	4.00	3.00	3.00	4.00
26	4.33	4.50	4.00	4.00	4.00	4.00
27	4.00	3.50	3.00	4.00	2.50	4.00
28	3.66	3.00	2.50	3.00	3.00	3.75
29	3.00	3.00	4.00	4.00	4.00	4.25
30	4.66	4.50	5.00	4.50	4.50	4.75
31	3.66	4.50	4.00	3.50	3.00	4.00
32	3.33	2.50	3.00	4.00	3.00	3.75
33	3.33	3.00	2.00	2.50	2.50	4.50
34	3.33	3.00	3.00	3.00	4.00	4.00
35	4.33	4.00	3.50	4.00	4.50	4.00
36	4.00	4.00	3.50	4.00	3.00	5.00
37	4.33	4.50	5.00	4.50	4.00	3.75
38	4.33	4.50	4.50	4.00	3.50	3.75
39	4.66	4.00	4.00	4.00	4.50	4.00
40	2.66	4.00	4.00	4.50	2.50	4.00
41	4.00	4.50	3.50	4.00	3.50	4.00
42	4.33	3.50	4.00	3.50	3.50	4.25
43	4.66	4.50	4.00	3.00	4.00	4.50
44	3.66	3.00	4.00	3.50	3.00	5.00
45	3.66	4.00	3.50	3.00	3.50	4.25
46	4.00	3.50	4.00	3.50	4.00	4.00
47	4.33	3.50	3.00	5.00	2.50	3.75
48	4.33	3.50	4.00	3.00	4.00	4.00
49	5.00	3.00	4.50	5.00	4.50	5.00
50	4.00	5.00	3.50	4.50	3.50	3.75
51	4.66	4.00	3.50	4.00	3.50	4.50
52	4.00	3.50	2.50	4.50	5.00	3.75

There is a positive correlation between the quality and other factors of agile methodologies. The Spearman's correlation was used to assess the relationship between quality and other five factors with a sample of 52 respondents. The quality factor

of the project management factors found statistically positive and significantly related to the budget of the project, i.e. *rs = 0.3362 with p = 0.01*. While all other factors found statistically insignificant.

Table 7. Spearman's Correlation Between Success Of The Project And Project Management Factors For Agile Methodologies.

Factors	Spearman's Correlation with quality factor *(rs)*	Significance
Schedule	0.1787	0.20
Scope	0.0821	0.56
Budget	0.3362*	0.01
Risk	0.0727	0.60
Resources	0.1902	0.17

All project management factors have a significant role in the success of agile software development. The project management factors schedule, scope, risk and resources have positive lower correlation, but the significance level is low as compared to the budget which has high significant correlation with the quality factor. These factors with lower correlation coefficient do not mean that it has no implication on agile methodologies. In certain studies a very low correlation coefficient value can be wrongly interpreted as no significant correlation between the different factors. It is possible that a lower coefficient value still have significant effects or implications like lower correlation coefficient values in our study.

V CONCLUSION

The purpose of this study is to statistically analyze the most widely used agile methodology and to relate the quality factor with other project management factors. The outcomes suggested that budget factor is significantly correlated with the quality factor that means that the budget factor focuses on meeting the budget requirements and on achieving targeted return-on-investment (ROI).

The results further suggested that the most widely used agile methodologies are Extreme Programming followed by Scrum, Agile modeling and Kanban in Pakistani software companies.

In the future, we have the plan to compare the agile methodologies in terms of how they affect each of the individual project management factors.

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