Open Access
Baghdad Science Journal **Vol.16 (Special Issue) 2019**

DOI: http://dx.doi.org/10.21123/bsj.2019.16.2(SI).0496

The Impact of Agile Methodologies and Cost Management Success Factors: An Empirical Study

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Received 16/9/2018, Accepted 11/11/2018, Published 20/6/2019

Abstract:

Software cost management is a significant feature of project management. As such, it needs to be employed in a project or line of work. Software cost management is integral to software development failures, which, in turn, cause software failure. Thus, it is imperative that software development professionals develop their cost management skills to deliver successful software projects. The aim of this study is to examine the impact of cost management success factors with project management factors and three agile methodologies – Extreme Programming (XP), Scrum and Kanban methodologies which are used in the Pakistani software industry. To determine the results, the researchers applied quantitative approach through an extensive survey on 52 agile software development companies in Pakistan. Statistical techniques, such as Pearson's correlation and mean and standard deviation were performed to examine the results. Following this analysis, we found that cost management has a positive effect on other project management factors, which are schedule, scope, risk, resources, and quality. Furthermore, it is determined that, in general, Kanban performed better than both, Scrum and XP in the context of project management factors.

Key words: Agile methodologies, Pakistani software industries, Software cost management, Software project management.

Introduction:

In the software development community, a major concern is how a software project should be successful in terms of scheduled time, resources, cost, risk, scope and achieving the required quality. Successful software can be categorized as when the customer's needs and wants are satisfied. All these software management factors need to be achieved, and the responsibility lies solely on the project manager. Since an unrealistic cost affects the project functionalities, the management of cost and time is a vital step in a project; hence, it must vigorously address cost and time success under an agreement (1). In light of this, it is necessary for software development professionals to have a better understanding of cost management to produce successful software projects. Cost management is also an indication of successful software.

Traditional software development models, such as incremental, iterative (2) and a number of others, are linear and sequential in nature. However, these methodologies functioned poorly when handling changing customer requirements, creeping scope, achieving on-time deliveries and controlling cost (3). Many software industries and institutions have reported a number of benefits when using agile methods, such as cost reduction, greater engineering discipline, and greater project visibility (4) . Furthermore, software industries have adopted agile methodologies to increase their software productivity and quality around the globe.

The Pakistani software industry first adopted agile methodologies a decade ago. In this work, we have examined the cost management success factor in the context of project management factors for the agile methodologies. Furthermore, we also examined agile methodologies, such as Extreme Programming (XP) and the Scrum and Kanban methodologies, all of which are used by software professionals to conduct extensive online surveys throughout Pakistan. In this study, the author uses a six-point star model related to the Project Management Body of Knowledge (5), as shown in Figure 1. The six points in this model comprise the schedule, scope, cost, risk, resources and quality in the Pakistani software industry. Moreover, we have

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also examined the cost management factor with regard to other aspects pertaining to software development, such as lines of code (LOC), functional point (FP), software requirements, capability maturity model integration (CMMI) level and project size.

The rest of this paper comprises four sections. Section II explains the literature review, Section III elaborates the methodology employed for research and Section IV illustrates the findings of this work and a subsequent section is about the discussion and results. Finally, Section V concludes and recommends future work.

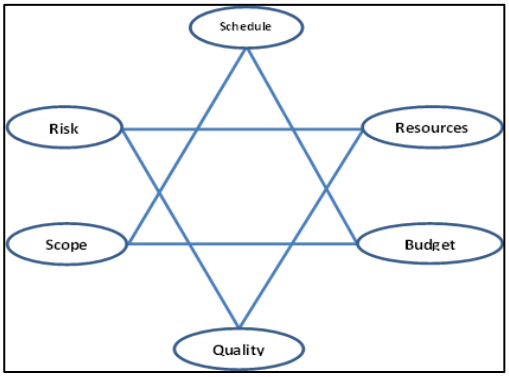

Figure 1. Six-point star model PMBOK4.0. ***(wikipedia.org/wiki/File:TripleConstraint.jpg.)***

Literature Review:

Agile methodologies and Critical Success Factors

This section elaborates upon the agile methodologies and criteria for the success of software projects. In our study, the survey, which was conducted in the Pakistani software industry, shows how these organisations are leaning towards the use of agile methods for software development. Our findings indicate that agile software development methods mediate the shortcomings of the so-called "heavyweight software methodologies". The following step briefly discusses the methodologies considered in this paper.

Extreme programming (XP)

XP welcomes change and delivers software to clients in a very short time span. Further, XP improves the values of software projects by taking on communications, simplicity, feedback, respect and courage. The main purpose of XP is to fulfil the needs of the client when the necessity arises (6). The rules and practices of XP have been modified, much like other agile processes (7), and the two versions of XP are distinctive (8). Our survey indicates that XP is among the most used agile methodologies in the surveying industry.

Scrum and Kanban methodologies

Scrum is an experienced and lightweight methodology that manages different types of iterative and incremental nature projects. Over the years, many researchers have made significant contributions to the advancement of Scrum (9). Scrum is simple and has proven to be productive in the software development environment, while many other engineering practices have also been enhanced by other agile methodologies. Generally, Scrum requires organising teams, managing the project work to be done, scheduling the iterations and optimising the delivery plan and process (10). In contrast, Kanban focuses on "just-in-time" delivery. Further, in the Kanban methodology exhibits the ability to complete the exact effort at the accurate period. Kanban focuses on software professional's skill sets and expertise in implementing the software components, which ultimately adds value to the project (11).

Several authors have reviewed the criteria, which is essential for the successful project and have found that unrealistic cost management causes software failure due to over cost. Thus, it is necessary for the software development professionals to have a better understanding of effective cost management (12). Quality, cost, scope and time have been recognized and observed to determine the level of project success (13). Successful software projects are different from the less successful one in delivering customer profit in different ways (14). The researchers statistically compared Scrum and Kanban's methodologies in the context of their effect using six-point star model (15). Next, the researchers statistically compared the effect of the traditional and agile methodologies using the six-point star model and explored the interrelationship between these factors. The outcome suggested that agile methodologies are sound for smaller tasks, while traditional methodologies are better for medium-and-large scale tasks (16). "AZ-Model", is introduced to develop the software on the basis of six-pointed star model (17).

Cost Management Success Factor

Project costing is a critical management skill, whereby a project manager is considered to be responsible to deliver the software within the scheduled time and cost while satisfying customer needs and wants. Hence, the best arrangement in terms of a software team member's cost and expertise are essentials factors in project management success (18). This study elaborates this importance by using a quantitative approach. The correlation technique is used to correlate the cost

management factor with other five factors, with research revealing that the cost factor correlates positively with all other factors of PMBOK 4.0. In addition, a recent study by (19) reveals that cost has significant positive impact on the quality of software projects. Hence, this result is a positive indication that a project will be successful.

Research Methodology:

This study was carried out using a quantitative approach to analyse the effect of the cost factor on the five other factors in the six-point star model, as shown in Figure 1. The model has two triangles: represents the input/output factors while the other one represents the process factors involved in the project. In this paper, the author also analysed the effect of agile methodologies such as Extreme Programming, Scrum, and Kanban in the context of the project management factors involved in the Pakistani software industry. Traditionally, these factors, which comprise the six-point star model, show a significant part in the success of a software project; hence, each of these factors has its own implications and effects in agile software development methodologies (15). Our research focused on the cost factor; specifically, how it affects the success of agile software development with respect to project management factors.

Data Collection:

An online survey was conducted to gather numerical responses to survey questions from software professionals throughout Pakistan. In this study, we adopted the questionnaire demonstrated in the previous research conducted by (15). For this study, the reason for adopting the questionnaire owes to its appropriateness in measuring the success of agile implementation. Examples of other similar studies are (16, 17) . The survey questionnaire was divided into two parts: the first part comprised the questions related to respondent information while the other part comprised the project management factors, as shown in Table 1. The study was performed from April to May 2017. The data were composed of 52 respondents involved in 52 different software industries for each factor of the project management using agile methodologies. To analyse the questionnaire, the researcher used statistical techniques, such as mean, standard deviation and correlation techniques using Stata version 12.

Table 1. Survey questions related to each Project management factor.

Factor	Survey questions	Question Number
Schedule	Are the team members of the project aware of the current progress most of the time?	I
	Can Project team react and adapt to change in requirements quickly and effectively?	II
	Are milestones are achieved according to schedule?	III
Scope	Is the Project methodology and features bounded?	I
	Does the project methodology chosen to make the software product scope clear and bounded?	II
Cost	Is the Project completed within the estimated cost?	I
	Does the Project achieve a good return on investment (ROI)?	II
Risk	Are project risks identified and is there any predefine strategy to mitigate the risk?	I
	Are the project opportunities identified and exploited to the benefit?	II
Resources	Are skilled human and material resources easily available?	I
	Are software tools and techniques easily available or can be adapted to the task?	II
Quality	Are product quality requirements achieved?	I
	Are customers satisfied with the delivered product?	II
	Has the project been categorized as successful?	III
	Have user interface been assessed as easy by the Customers?	IV

Table 1 shows the project management factors, with each factor relating to different survey questions that are significant to a project's success. In this questionnaire, the survey research data were collected in the form of different variables. These collected variables were assessed using a five-point Likert scale, as shown in Table 2. For quantitative analysis, a numeric score is assigned to each Likert scale.

Table 2. Agile methodologies used by survey respondents.

Agile	Frequency	Percentage
Extreme programming (XP)	22	42.31%
Scrum methodology	17	32.69%
Kanban methodology	13	25.00%

Results and Discussions:

Demographic Profile

The agile methodologies considered in this research are extreme programming, the Scrum methodology

and the Kanban methodology. According to the responses given by the respondents, extreme programming was used 42.31% of the time, Scrum was used 32.69% of the time and the Kanban methodology was used 25% of the time, respectively. Table 3 shows the agile methodologies used by 52 different respondents.

Table 3. Agile methodologies used by survey respondents.

Agile	Frequency	Percentage
Extreme programming (XP)	22	42.31%
Scrum methodology	17	32.69%
Kanban methodology	13	25.00%

According to the general information, we have also identified that 12 out of 52 were web developers, nine were project managers, eight were senior software engineer, seven were database administrator, seven were software engineers, three were quality assurance engineer, two were programmers, two were android developers and two were internees. Table 4 shows the software developers involved in the software companies. According to the respondents, 46.15% of respondents were in the range of six to 10 people.

Table 4. Company Size of respondents.

Developer	Frequency	Percentage
1 to 5 People	20	38.46
6 to 10 People	24	46.15
11 to 20 People	6	11.54
21 to 50 People	1	1.92
Total	**52**	**100.00**

Figure 2 shows that 17.31% industries are registered at CMMI level 2, while 13.46% industries are registered at CMMI level 3. Additionally, 25 industries are not registered (48.08%); however, it is important to mention that despite not being registered on CMMI, the industries have an international profile and are developing quality software both nationally and internationally.

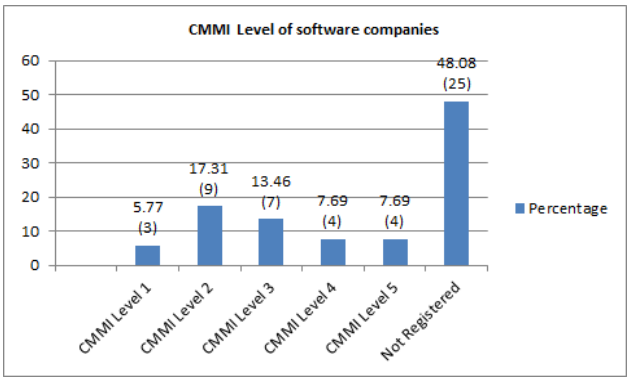

Figure 2. CMMI level of survey software industries.

Project Management Factors and Agile Methodologies

Table 5 shows the effect of project management factors on agile methodologies. To do this, we calculated the average scores of all questions for all 52 respondents pertaining to the individual factors. Each factor consists of either 2, 3 or 4 questions. For instance in Table 5, by calculating the average score for the Schedule factor, using three questions (I, II and III), this average was 3.95. The outcomes of Table 5 suggest that the Kanban methodology has a better effect on the schedule factor with a score of 4.27. Regarding the scope factor, XP leads to better performance with a score of 3.86, followed by the Scrum and Kanban methodology. For the cost factor, the Scrum methodology has a score of 3.97, ahead of the results obtained for XP and the Kanban methodology. Furthermore, for the risk, resources and quality factors, Kanban also showed the highest performance, achieving scores of 4.11, 3.69 and 4.21, respectively, followed by the other two methodologies, XP and Scrum. For the risk factors, XP and Scrum values have the same score 3.79 while the resources and quality factors have slightly different results.

Table 5. Agile methodologies and project management factors average and standard deviation values.

Factor	A.S.S	S.D	A.SC.S	S.D	A.C.S	S.D	A.R.S	S.D	A.RO.S	S.D	A.Q.S	S.D
Extreme programming (XP)	3.95	.61	3.86	**.74**	3.68	**.71**	3.79	**.76**	3.52	**.71**	4.12	.38
Scrum methodology	3.83	**.42**	3.73	**.75**	3.97	.69	3.79	**.56**	3.55	.68	4.11	**.33**
Kanban methodology	4.27	**.42**	3.42	**.49**	3.61	.68	4.11	**.50**	3.69	.80	4.21	**.49**

Average Schedule Score =A.S.S, Average Scope Score =A.SC.S, Average Cost Score =A.C.S, Average Risk Score =A.R.S, Average Resources Score =A.RO.S, Average Quality Score =A.Q.S, Standard Deviation=S.D

With the exception of the scope and cost factors, the average score for the Kanban methodology is greater than the average score of XP and Scrum, as shown in Table 5. The results column

of standard deviation suggests that the Scrum score is more deviated than the score of XP and Kanban. Thus, we can conclude that there are considerable differences in the responses given by Scrum users. The results suggest that the average and standard deviation values of the Kanban methodology are more stable and consistent with respect to project management factors, followed by XP and Scrum. In general, the Table 5 results clearly define that all these three methodologies have a positive impact on project management factors.

Comparing Lines of Code (LOC) and Function Point (FP) with respect to Project Cost

Software projects are complex to develop, and hence, the size of software projects measured in terms of LOC and FP is always a concern for the software project managers. Table 6 shows the average and standard deviation score with respect to the cost factor. The total results of Table 6 indicate that the average and standard deviation scores are similar, which thus indicates that the cost factor has a similar effect on both LOC and FP. From these results, we conclude that project size has a robust impact on the cost factor, which shows its importance and right to be considered carefully when estimating the size of the agile project using the concept of LOC and FP.

Table 6. Average score of LOC and FP with respect to the effect of cost for agile methodologies.

LOC	Cost Factor		Frequency	FP	Cost Factor		Frequency
	M	S.D			M	S.D	
< 1K LOC	3	.935	5	< 100 FP	3.86	.875	22
1K to 5K LOC	3.80	.649	15	101 to 500 FP	3.60	.626	7
6K to 10K LOC	4.03	.719	14	501 to 1000 FP	3.85	.645	4
11K to 20K LOC	3.66	.816	6	> 1000 FP	3.60	.515	19
21K to 50K LOC	3.66	.258	6				
>50K LOC	3.83	.516	6				
Total	**3.75**	**.703**	52	**Total**	**3.75**	**.703**	52

Lines of Code=LOC, Mean= M, Standard Deviation=S.D, Function Point=F.P

Correlation technique between cost factor and five other project management factors

The cost of a project is always a great concern and a complex contributor to the project manager developing successful software. The six-point star model is used to correlate the cost factor with other project management factors to determine this association. The correlation technique was based on the average score, shown in Table 5. We used Pearson's correlation technique to correlate the cost factor and project management factors for the agile methodologies used by the respondents in the software industries, as shown in Table 7. The result of the correlation analysis showed that the cost has a positive correlation with all other five factors. The cost factor is significantly correlated with schedule, risk, resources and quality factors, except the scope factor, which we found statistically insignificant as the *p*-value found a > 5% level of significance. This result indicates a strong correlation of cost factor with all other five project management factors, which leads to an indication of success for the software development.

The results suggest that the cost factor, which is important to understand and consider for future software development projects to be successful, is positively correlated with each of the project management factors contained in the six-point star model. The scores achieved by the correlation are also significant, except the scope factor, and range from 0.22 to 0.44. The overall results suggest that agile methodologies affect the project management factors that comprise the six-point star model and thus require that the software developers understand the importance of their effect on the software projects success.

Table 7. Correlation between cost factor and five other project management factor.

Factors	Pearson's Correlation with cost factor *(r)*	Significance (*p*-value)
Schedule	0.44*	.0008
Scope	0.22	.1106
Risk	0.39*	.0038
Resources	0.40*	.0028
Quality	0.29*	.0334

We performed some additional analysis to examine the effect of cost on both project size and project requirements. Figure 3 shows how the cost factor affects the software project size with regard to agile methodologies. The average score for a medium-sized project is 3.83, while for small-sized projects this is 3.78, which indicates that agile methodologies are cost effective for the medium- and small -size, agile projects as compared to very small projects with an average score of 3.64 and large projects with an average score of 3.73.

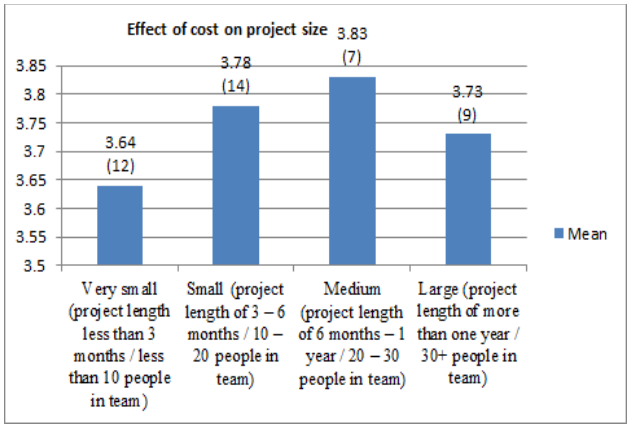

Figure 3. The average score of the project size with respect to the effect of cost factor for agile methodologies.

A customer's requirements are always a concern for the software development team that should be satisfied. Figure 4 shows the average score of software requirements and how it is affected by the cost factor. The result shown in Fig. 4 indicates that the requirements, which are unclear and uncertain, will be costlier as compared to the requirements, which are mostly clear and well defined.

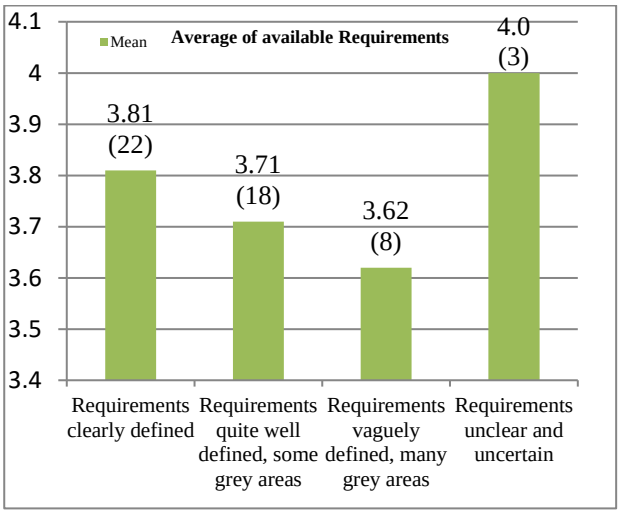

Figure 4. Average score of software requirements with respect to the effect of cost factor for agile methodologies.

The software capability maturity model (CMMI) has become a popular model employed to enhance software development processes with the aim to develop high-quality software within budget and schedule. Figure 5 shows the average score of the five levels of CMMI in the software industries with respect to the effect of the cost factor, which represents that the cost factor is more effective on a higher level of CMMI level industries as compared to not registered and CMMI level-1 industries.

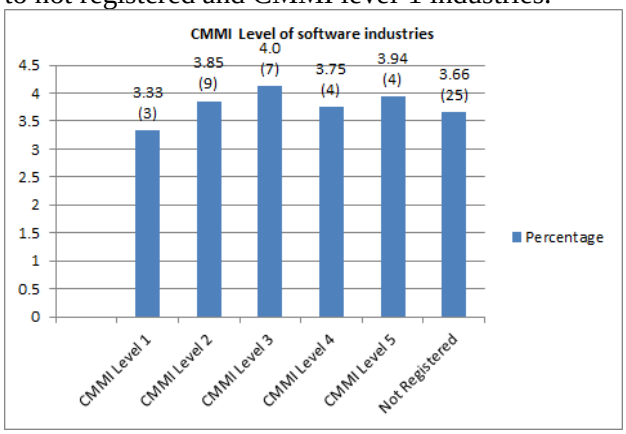

Figure 5. Average score of CMMI level of software industries with respect to the effect of cost factor for agile methodologies.

Conclusion:

Unrealistic cost management can cause software projects to fail, so this issue is worthy of closer examination so that the software development community can understand the importance of cost management for the development of successful software. A survey was conducted to determine the impact of the cost factor, which is part of the six-point star model, and also to analyse the three most frequently used agile methodologies in the context of the project management factors employed in the Pakistani software industries. The survey questionnaire was included about the software professionals, as well as the software industries, software projects, agile software development and project management factors. Mean, standard deviation and correlation techniques were used to compute and relate the cost factor with other project management factors and to analyse the effects of extreme programming and the Scrum and Kanban methodologies on these factors. The results suggested that the cost factor is positively and significantly correlated with all other factors except scope, which is slightly higher than the level of significance (0.5%). Furthermore, the results suggested that all agile methodologies lead to successful software projects, however, in general, the Kanban method shows better results as compared to other two methodologies in the context of managing the project management factors involved in the project.

In the future, we plan to consider some other aspects of agile methodologies and project management factors. The impact of the cost success management factor will be correlated with software team organisation and team commitment.

Acknowledgment:

The authors wish to thank the Universiti Utara Malaysia for funding this study under University Research Grant Scheme, S/O project code: 13853.

Conflicts of Interest: None.

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اثر منهجيات المرونة وعوامل النجاح في إدارة التكاليف: دراسة تطبيقية

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الخلاصة:

تعد إدارة تكلفة البرامج ميزة هامة لإدارة المشاريع. على هذا النحو ، يجب أن تستخدم في مشروع أو خط عمل. تعد إدارة تكلفة البرامج جزءًا لا يتجزأ من إخفاقات تطوير البرامج ، والتي بدورها تتسبب في فشل البرنامج. وبالتالي، من الضروري أن يطور المهنيون في مجال تطوير البرمجيات مهاراتهم في إدارة التكاليف لتقديم مشاريع برمجية ناجحة. الهدف من هذه الدراسة هو دراسة تأثير عوامل النجاح في إدارة التكاليف مع عوامل إدارة المشروع وثلاث منهجيات ذكية - منهجيات البرمجة المتطرفة (XP) و Scrum و Kanban التي تستخدم في صناعة البرمجيات الباكستانية. ولتحديد النتائج، طبق الباحثون منهجًا كميًا من خلال مسح موسع لـ 52 شركة لتطوير البرمجيات الذكية في باكستان. تم إجراء التقنيات الإحصائية، مثل ارتباط بيرسون والانحراف المعياري والمعياري لفحص النتائج. بعد هذا التحليل، وجدنا أن إدارة التكاليف لها تأثير إيجابي على عوامل إدارة المشاريع الأخرى، وهي الجدول الزمني، والمجال، والمخاطر، والموارد، والجودة. علاوة على ذلك، فقد تقرر أن أداء كانبان(Kanaban) بشكل عام أفضل من سكروم (Scrum)وإكس بي(XP) في سياق عوامل إدارة المشروع.

الكلمات المفتاحية: المنهجيات الذكية، إدارة تكلفة البرمجيات، إدارة مشروعات البرمجيات، صناعات البرمجيات الباكستانية