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The Challenges of Offshore Agile Software Development in Sri Lanka and Effects on the Project Outcome

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Summary

Agile development methods such as Scrum and Extreme Programming are being used by a number of software companies around the world. The offshore software industry in Sri Lanka has also started to adapt these development methods in order to meet the growing demand. However applying agile development methods in an offshore model has its own challenges and each of these challenges has an effect on the outcome of the project. Currently there has been no research done in Sri Lanka as to how each of these challenges effects the project outcome and this formed the main research question. The focus of this reassure was to study how each of these challenges effect the project outcome in terms of time, cost, scope, quality, and the overall project. The first objective was to study and contrast agile development methods with traditional waterfall based development. The second objective was to carry out a literature survey and identify the main challenges that offshore software development companies face when applying agile development methods. The five main challenges identified were, communication, achieving team coherence, following the agile development method, limitations on tools and infrastructure, and testing. The third research objective was to study how these challenges affect the project outcome. The challenges identified in the literature review were used to prepare questionnaires for three companies in Sri Lanka that practice agile development methods in an offshore model. The objective of the questionnaire was to find out how the presence of these challenges effect the project outcome and how overcoming these challenges affect the project outcome. The data gathered from the questionnaires were analyzed using Spearman's Correlation Coefficient. The results identified that communication, tools and infrastructure, following the Agile development method, and testing had a strong relationship with the project outcome in terms of time, cost, scope, quality, and the overall project outcome. Team coherence had a moderate relationship with the time, cost, scope, quality, and the overall project outcome. Based on the results, a research framework was derived which answered the research question of; how each of the challenges affect the project outcome. Finally, the concluded that all the challenges identified for this research apart from team coherence had a strong effect on the project outcome. Team coherence had a moderate effect on the project outcome.

Keywords

Agile development, communication, offshore, Sri Lanka, tools and infrastructure, team coherence, testing

1. Introduction

Offshore software development has gained wide spread adoption across the globe. In a typical offshore software development model the requirements would be gathered from the customer and these requirements would be transferred to the offshore development center which would then work on implementing the requirements into a software product. Once the software product is developed it would then be delivered to the client. This is illustrated in the diagram on Figure 1.

Traditionally software development was done through "heavyweight" techniques such as the waterfall method. However through the passage of time these heavyweight techniques were perceived to be bureaucratic, slow, demeaning, and inconsistent with the way that software development was done. As a reaction to this agile software development was born. Agile development is an umbrella term used to denote a number of software development methodologies such as Scrum, Feature Driven Development, Dynamic Systems Development Method, and Adaptive Software Development. All of these methods have the principles documented in the Agile Manifesto in common (Agile Manifesto, 2001a). The agile manifesto is a set of principles that govern agile software development (Agile Manifesto, 2001a).

As the popularity in the agile development methods grew software development companies started to adopt them more and more as their main software development approach. Gradually

offshore software development firms too started to adopt the agile methods.

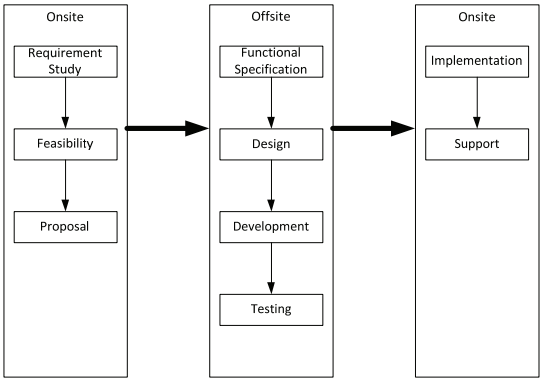

Figure 1 Offshore software development model. Adapted from Cohn, 2010

Given below are some of the key statistics for the IT Industry in Sri Lanka (Sri Lanka Association of Software and Service Companies, 2013a)

1. In year 2007 AT Kearney's Global Service Location Index (GSLI) ranked Sri Lanka amongst the top 50 global outsourcing destinations.
2. Sri Lanka was ranked 21st in the Global Services Location Index in 2011.
3. The Sri Lankan IT/BPO export earnings had a stable upward trended during the past few years and reported an export revenue of USD 255 million in 2011 with an annual growth rate of 20%

With the above information it can be concluded that the IT industry in Sri Lanka plays a major role in the country's economy and Sri Lanka is also becoming one of the places of choice when it comes to outsourcing.

A number of associations were established in order to help in the growth of the IT and BPO sector in Sri Lanka. Some of these associations are

- Sri Lanka Association of Software and Service Companies (SLASSCOM)
- Sri Lanka Association for the Software Industry (SLASI)
- Sri Lanka Software Exports Association (SEA)
- Information and Communication Technology Agency (ICTA)

Agile development techniques in Sri Lanka

As the popularity in the agile development methodologies grew software development companies started to adopt them more and more as their main software development approach. In a study conducted by the Standish Group International it has been highlighted that Agile Process is one of the top ten reasons for successful projects (Preuss, 2005). Gradually offshore software development firms too started to adopt the agile development methodology. Some offshore firms combined agile development with the traditional waterfall method to form a development process unique to each company.

The off shore software industry in Sri Lanka has seen a number of off shore companies adopt agile techniques in their software development approaches. Some companies in the offshore software industry are:

- Virtusa (Vritusa, 2013)
- EuroCenter (99X Technology. (2013).)
- Creative Solutions (Creative Solutions, 2012a)
- ExileSoft (ExileSoft, 2013)

Certain companies make it a prerequisite that engineers joining the company should have agile development experience (Navantis, 2013a).

The problem

When it comes to agile software development in an offshore model there are a number of challenges that have to be dealt with such as communication, language and cultural barriers, and following the agile method. Although there are a number of books and topics on the challenges and how to overcome the challenges (Fowler, 2006; Yaggahavita, 2011; Cohn, 2010; Microsoft, 2008; Farooq & Farooq, 2010) there has been a dearth of research done or documented evidence as to the effect each of these challenges on the project outcome. Without any detailed information on how the challenges effect the project it is difficult for organizations to prioritize and start addressing the challenges since each organization has its own priorities in terms project success. There are many cases where agile methods have been used without achieving the required benefits (Hansenne & Hibner, 2011) and there are also many situations where organizations are finding it challenging to adopt agile practices due to numerous challenges (Sidk, Arthur, & Bohner, 2007).

The purpose of this research is to study the challenges faced by offshore software development companies in Sri Lanka applying agile development methods and identify the effect each of these challenges have on the outcome of projects.

Problem Statement: How do the challenges, faced by offshore software companies in Sri Lanka practicing agile development methods effect the project outcome?

2. Literature Review

Traditional Software Development

The traditional approach to software development was the waterfall method also known as the Systems development life cycle approach (McConnell, 1996). The main purpose here is to pursue the development of information systems in a very deliberate, structured and methodical way and this approach has been in use since the 1960s (Larman, 2006).

Some of the main disadvantage in the waterfall based design approach are big upfront design, extensive documentation, and incapability to handle dynamic requirements (Cohn, 2010). A number of research findings (Larman, 2006) reinforce these shortcomings.

Agile Software Development

The term "Agile Development" is an umbrella term used for a number of incremental and iterative software development methodologies. Out of these the most popular are Extreme Programming (XP), Crystal, Dynamic Systems Development Method (DSDM), Scrum, Lean, and Feature-Driven Development (FDD).

While each of the agile development methods remain unique in its development approach all of them shared a common vision and goal as mentioned in the Agile Manifesto (2001b).

The primary advantages in using agile development methods are lower risk, early risk mitigation and discovery, easier to manage complexity, and early release.

Challenges with Agile Offshore Development

Agile development offers to solve the problems prevalent with the traditional software development approaches such as the waterfall method. The offshore software industry in Sri Lanka too has started to adopt this relatively new methodology into their software development process (Virtusa, 2013; 299xtechnology, 2013a; Creative Solutions, 2013; Softworx Technology Group, 2013).

Applying agile software development in an offshore model presents a number of challenges that have to be dealt with (Fowler, 2006; Microsoft, 2012; Cohn, 2010; Larman, 2006). Some of these challenges are present in normal agile development but is compounded by the fact that agile development happens in a distributed manner. The topics below discuss these challenges in detail.

Communication

Communication is one of the most widely spoken about challenge in both research and books when it comes to agile development in an offshore model (Microsoft, 2008; Awad, 2005; Gurram & Bondi, 2012; Bavani, 2009; Farooq & Farooq, 2009). The Agile manifesto (2011b) always encourages face to face communication between the client and the development team. However when it comes to offshore development this is a problem since the development team is located in a different country from the client. Due to the advancement in technology this is circumvented to a certain extent with the use of conference calls, video calls, online chats, and discussion forums. However there is a lot of information conveyed through face to face communication and body language that cannot be replaced by modern technologies.

Achieving team coherence

The final goal of a high performance agile development team is team coherence (Cohn, 2010). The whole team assumes responsibility and the team sticks together in order to achieve a common goal. This includes helping other team members resolve any issues. However when using agile development in an offshore manner achieving team coherence is a challenge. Sometimes team coherence is achieved in each location but not globally. For example if the two distributed teams are working in Sri Lanka and USA team coherence is achieved amongst the team in Sri Lanka and amongst the team in USA. However there is still a gap between the Sri Lankan and USA team creating a "US vs them" culture (Larman & Vodde, 2010). This finding is further enforced by past research (Yaggahavita, 2011; Gurram & Bondi, 2012).

Following the agile development method

When agile software development is practiced by distributed teams there is a tendency to modify the agile development method. At first when companies adopt agile development methods, the methods are modified on purpose to suit the needs of the company (Arefin & Korzun, 2010). After that everyone in the company is expected to follow the method along with any modifications done by the company. Due to many reasons such as tight deadlines, lacking of understanding of the agile principles, the distributed nature of the offshore development method (Hole 2008; Phalnikar, Deshpande, & Joshi, 2009), and lack of commitment to the agile development method there is always a tendency to skip or modify steps,

by pass certain steps, and not adhere to the principles of the agile method. This could lead to short term gains, however in the long term this is not favored.

Limitations in tools and Infrastructure

When practicing agile development in a distributed environment the tools and infrastructure play an important role (Schwaber, 2004). Agile development is still catching on; therefore the tools are yet to mature. These tools are ok for the happy path, but when it comes to modifications and deviations of the perfect path these tools fall short. Added to this is the fact that most of the software engineers including project managers are only starting to get used to agile development. Therefore they tend to revert to old ways when they feel uncomfortable with the new system (Schwaber, 2004) and this leads to bigger problems.

Testing

Agile development methods promote constant and early testing of the software being produced through mechanisms such as unit testing, integration testing, test automation, and continuous integration (Cohn, 2010). In agile there is no separate role called tester or quality assurance engineer which exists in traditional software development methods like waterfall. The whole team is responsible for testing and quality. However due to the distributed nature of offshore agile development achieving this is a challenge (Ullah & Zaidi, 2013). The end result is a software product with very poor quality.

Overcoming the challenges

As highlighted in the previous section there are an unique set of challenges when it comes to applying agile development techniques in an offshore context. In order to overcome these challenges approaches have been proposed by authors such as Fowler (2006), companies such as Microsoft (2008) and researchers like Filev (2006). Some of these approaches are continuous integration, good documentation, regular builds and regular status meetings.

Impact of the challenges on Project Success

Each of challenges identified above have an effect on the successful outcome of the project. For example effective communication will have a positive impact on delivering the project on time, on budget, on scope, and on quality. Similarly the rest of the challenges will also have an impact on time, cost, scope, and quality. Studying this effect forms the basis of this research and is described in detail in the following subheadings.

Objectives

The following research questions and objectives have been identified to achieve this goal (Table 1).

Table 1. Research questions and objectives

Research Objectives	Research Question	Data Source	Technique
To study the traditional software development methods. To study the agile software development techniques. To compare and contrast agile versus the traditional software development methods highlighting the advantages and disadvantages of each approach.	What are the agile and traditional software development methods?	Literature review	
To study the challenges faced when applying agile development techniques in an offshore model.	What are the challenges faced when applying agile development methods in an offshore development model?	Literature review	
To study the main factors that makes a project successful. To carry out a survey among selected companies and identify how the challenges effect the outcome of the project. To perform statistical techniques of the survey results to identify trends.	How do the challenges effect the project outcome?	Survey	Statistical techniques Hypothesis testing. Spearman's Correlation Coefficient.
To define a framework based on the research findings which organizations can use when starting to address the challenges	What is the framework to start addressing the challenges?	Results based on the defined hypothes es	Derived research framework, based on the results found in the analysis stage.

Significance of the Study

The significance of this research is two folds; theoretical and practical which is discussed below.

By understanding the challenges and its effect on project outcome the researchers hope to come up with a theoretical framework which can be used to place these challenges in context. Once the research findings have been published software organizations practicing agile development in Sri Lanka will have a more detailed explanation of the challenges and its impact on project success.

Methodology

Given below is a high level overview of the methodology that was used to conduct the research.

- **Research strategy:** Deductive reasoning.
- **Time horizon:** Cross–sectional.
- **Sampling:** Three companies were selected for the case study. All the projects done since 2010 in all three companies were used for the study.

- **Data Collection:** Questionnaires.
- **Data analysis:** Descriptive statistics for preliminary analysis and Spearman's correlation for testing the hypotheses.

3. Main concepts used for the research

Challenges in applying agile development methods in an offshore model

As per the analysis presented under the literature review chapter, when applying agile development methods in an offshore model in Sri Lanka the following critical challenges exist.

- Communication
- Team Coherence
- Following the agile development process
- Tools and Infrastructure
- Testing early and often

Measuring the challenges

The companies selected for this research practice the agile development method scrum. With this in mind each of the above mentioned challenges were measured using questionnaires.

Conceptual Framework

The above five challenges effect the project outcome of on time, on budget, on scope, and on scope. Based on this the following independent and dependent variables can be derived.

Table 2 Independent and Dependent Variables

Variable	Variable Type	Description
Communication	Independent	Measure of how well effective communication was achieved through the project. A high value for this variable indicated that communication was effective and a low value indicated that communication was a challenge for the project.
Team Coherence	Independent	Measure of how well team coherence was achieved throughout the project. A high value for this variable indicated that team coherence was achieved and a low value indicated that achieving team coherence was a challenge in the project.
Agile Development Process	Independent	Measure of how well the agile development method was followed throughout the project. A high value for this variable indicated that agile development method was properly followed and a low value indicated that following the agile development method was a challenge in the project.
Tools and Infrastructure	Independent	Measure of how well the tools and infrastructure supported the project execution. A high value for this variable indicated that the tools and infrastructure were sufficient and effectively used and a low value indicated that the tools and infrastructure were a challenge in the project execution.
Testing	Independent	Measure of how well testing was carried out throughout the project. A high value for this variable indicated that testing was properly performed and a low value indicated that testing was a challenge in the project.
Schedule Performance Index	Dependent	Measure of on time delivery of the project.
Cost Performance Index	Dependent	Measure of budget compliance of the project.
Scope	Dependent	Measure of the project achieving the required scope.
Quality	Dependent	Measure of reaching the agreed quality levels.
Project Outcome	Dependent	Measure of the final project outcome, considering on time, on budget, on scope, and on quality.

Each of the independent variables effect the dependent variables. Based on this the following conceptual framework can be derived.

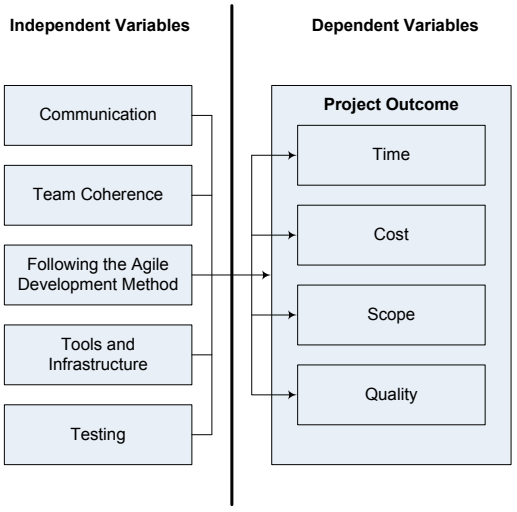

Figure 2 Conceptual Framework

Hypothesis

The aim of this research was to study the challenges offshore software development organizations face when applying agile development methods and the effect of these challenges on the project outcome. The successful outcome of a project will depend on its time compliance, budget compliance, meeting the agreed scope, and meeting the agreed quality levels.

In order to carry out the research hypothesis testing was used and the following hypothesis was derived based on the above conceptual framework.

Communication

Ho1 – There is no relationship between effective communication and the on time delivery of agile projects.

Ha1 – There is a relationship between effective communication and the on time delivery of agile projects.

Ho2 – There is no relationship between effective communication and being budget compliant on agile projects.

Ha2 – There is a relationship between effective communication and being budget compliant on agile projects.

Ho3 – There is no relationship between effective communication and being on scope on agile projects.

Ha3 – There is a relationship between effective communication and being on scope on agile projects.

Ho4 – There is no relationship between effective communication and the software quality on agile projects.

Ha4 – There is a relationship between effective communication and the software quality on agile projects.

Ho5 – There is no relationship between effective communication and the successful outcome of agile development projects.

Ha5 – There is a relationship between effective communication and the successful outcome of agile development projects.

Team Coherence

Ho6 – There is no relationship between team coherence and the on time delivery of agile projects.

Ha6 – There is a relationship between team coherence and the on time delivery of agile projects.

Ho7 – There is no relationship between team coherence and being budget compliant on agile projects.

Ha7 – There is a relationship between team coherence and being budget compliant on agile projects.

Ho8 – There is no relationship between team coherence and being on scope on agile projects.

Ha8 – There is a relationship between team coherence and being on scope on agile projects.

Ho9 – There is no relationship team coherence and the software quality on agile projects.

Ha9 – There is a relationship between team coherence and the software quality on agile projects.

Ho10 – There is no relationship between team coherence and the successful outcome of agile development projects.

Ha10 – There is a relationship between team coherence and the successful outcome of agile development projects.

Agile Development Method

Ho11 – There is no relationship between following the agile development method and the on time delivery of agile projects.

Ha11 – There is a relationship between following the agile development method and the on time delivery of agile projects.

Ho12 – There is no relationship between following the agile development method and being budget compliant on agile projects.

Ha12 – There is a relationship between following the agile development method and being budget compliant on agile projects.

Ho13 – There is no relationship between following the agile development method and being on scope on agile projects.

Ho13 – There is a relationship between following the agile development method and being on scope on agile projects.

Ho14 – There is no relationship between following the agile development method and the software quality on agile projects.

Ha14 – There is a relationship between following the agile development method and the software quality on agile projects.

Ho15 – There is no relationship between following the agile development method and the successful outcome of the project.

Ho15 – There is a relationship between following the agile development method and the successful outcome of the project.

Tools and Infrastructure

Ho16 – There is no relationship between using the proper tools and infrastructure and the on time delivery of agile projects.

Ha16 – There is a relationship between using the proper tools and infrastructure and the on time delivery of agile projects.

Ho17 – There is no relationship between using the proper tools and infrastructure and being budget compliant on agile projects.

Ha17 – There is a relationship between using the proper tools and infrastructure and being budget compliant on agile projects.

Ho18 – There is no relationship between using the proper tools and infrastructure and being on scope on agile projects.

Ha18 – There is a relationship between using the proper tools and infrastructure and being on scope on agile projects.

Ho19 – There is no relationship between using the proper tools and infrastructure and the software quality on agile projects.

Ha19 – There is a relationship between using the proper tools and infrastructure and the software quality on agile projects.

Ho20 – There is no relationship between using the proper tools and infrastructure and the successful outcome on agile development projects.

Ha20 – There is a relationship between using the proper tools and infrastructure and the successful outcome on agile development projects.

Testing

Ho21 – There is no relationship between testing early and often and the on time delivery of agile projects.

Ha21 – There is a relationship between testing early and often and the on time delivery of agile projects.

Ho22 – There is no relationship between testing early and often and being budget compliant on agile projects.

Ha22 – There is a relationship between testing early and often and being budget compliant on agile projects.

Ho23 – There is no relationship between testing early and often and being on scope on agile projects.

Ha23 – There is a relationship between testing early and often and being on scope on agile projects.

Ho24 – There is no relationship between testing early and often and the software quality on agile projects.

Ha24 – There is a relationship between testing early and often and the software quality on agile projects.

Ho25 – There is no relationship between testing early and often and the successful outcome on agile development projects.

Ho25 – There is a relationship between testing early and often and the successful outcome on agile development projects.

Population

This research was conducted as a case study involving three companies. The reason for the selecting the above three companies is as follows

- All three companies are moderate to large companies.
- All three companies had been using agile development methods for a minimum of three years.
- All three companies had a good reputation in the industry.
- All three companies were offshore branches for parent companies located in Canada, and America.

The target population from these companies was all the software projects that were completed since 2010 using agile development methods.

Data Collection

Data was collected using questionnaires. The PMO managers provided information on the project outcome and the individual resources who worked on the projects provided information on how the projects were executed.

Data analysis

Cronbach's alpha value was considered to test the reliability of the responses. Spearman's correlation coefficient was used to test the hypotheses.

Findings

From the initial investigations carried out on the research data the following were observed.

- 44% of the projects have been delivered on time, with 23% exceeding expectations, and 13% being exceptional in delivery. 19% of the projects have faced issues meeting the timelines of the client.
- Only 40% of the projects had met the budget, 60% had struggled to be budget compliant.
- 56% of the projects had met or exceeded expectations. The remaining projects had failed to achieve the required scope.
- 57% of the projects had achieved the required quality level, while the remaining had struggled to meet the required quality levels.
- The area of testing was a much neglected area. Only 63% of the projects studied had done integration testing, and 95% of the projects had not done unit testing.

Testing Hypothesis Using Spearman's Correlation Coefficient

Using Spearman's Correlation Coefficient the hypotheses presented previous were tested. Based on the test results the following hypotheses were adopted.

Communication

Ha1 – There is a relationship between effective communication and the on time delivery of agile projects.

Ha2 – There is a relationship between effective communication and being budget compliant on agile projects.

Ha3 – There is a relationship between effective communication and being on scope on agile projects.

Ha4 – There is a relationship between effective communication and the software quality on agile projects.

Ha5 – There is a relationship between effective communication and the successful outcome of agile development projects.

Team Coherence

Ha6 – There is a relationship between team coherence and the on time delivery of agile projects.

Ha7 – There is a relationship between team coherence and being budget compliant on agile projects.

Ha8 – There is a relationship between team coherence and being on scope on agile projects.

Ha9 – There is a relationship between team coherence and the software quality on agile projects.

Ha10 – There is a relationship between team coherence and the successful outcome of agile development projects.

Following the agile development method

Ha11 – There is a relationship between following the agile development method and the on time delivery of agile projects.

Ha12 – There is a relationship between following the agile development method and being budget compliant on agile projects.

Ho13 – There is a relationship between following the agile development method and being on scope on agile projects.

Ha14 – There is a relationship between following the agile development method and the software quality on agile projects.

Ho15 – There is a relationship between following the agile development method and the successful outcome of the project.

Tools and Infrastructure

Ha16 – There is a relationship between using the proper tools and infrastructure and the on time delivery of agile projects.

Ha17 – There is a relationship between using the proper tools and infrastructure and being budget compliant on agile projects.

Ha18 – There is a relationship between using the proper tools and infrastructure and being on scope on agile projects.

Ha19 – There is a relationship between using the proper tools and infrastructure and the software quality on agile projects.

Ha20 – There is a relationship between using the proper tools and infrastructure and the successful outcome on agile development projects.

Testing

Ha21 – There is a relationship between testing early and often and the on time delivery of agile projects.

Ha22 – There is a relationship between testing early and often and being budget compliant on agile projects.

Ha23 – There is a relationship between testing early and often and being on scope on agile projects.

Ha24 – There is a relationship between testing early and often and the software quality on agile projects.

Ho25 – There is a relationship between testing early and often and the successful outcome on agile development projects.

As shown in the hypotheses above all the challenges considered for this research (communication, team coherence, following the development process, tools and infrastructure, and testing) had an effect on the outcome of the project in terms of time, cost, quality, scope, and the overall project outcome.

The above hypotheses proved that effective communication is positively correlated with all four aspects of the project outcome, which are on time, on budget, on scope, and on quality, and the final project outcome. This statement is reinforced by authors such as Fowler (2006), Omair (2008), and Hjelmvik (2008) who emphasize the importance of effective communication in offshore agile development projects. Communication is one of the most widely spoken topics in distributed agile development and the research findings confirm that it has a high impact on the project outcome.

As in effective communication the above hypotheses proved that team coherence is positively correlated with all four aspects of the project outcome, which are on time, on budget, on scope, and on quality, and the final project outcome as well. This findings reinforces statements of researchers such as Yaggahavita (2011), who conclude that cultural and language difference in a distributed scrum team can lead to challenges in team coherence which in turn will lead to unsuccessful projects. Gurram and Bandi (2012) in their research identify that team coherence is an important factor in agile software development and practicing this in a distributed environment is challenging. The results of this

research further prove their statement that team coherence is an important factor in agile software projects. However compared to the rest of the challenges team coherence has a moderate correlation with the project in terms of time, cost, scope, quality, and the overall outcome.

The above hypothesis proved that following the agile development method is positively correlated with all four aspects of the project outcome, which are on time, on budget, on scope, and on quality, and the final project outcome as well. This findings reinforces statements of authors such as Larman and Vodde (2010).

In the book "Practices for Scaling Lean & Agile Development: Large, Multisite, and Offshore Product Development with Large-Scale Scrum" Larmand and Vodde (2010) have the following comments "In our experiences in India and elsewhere, the lack of engaged stakeholders (customers, managers, …) who understood and applied the agile values was the key weakness, and on the other hand, successfully shifting a group to these insights and new behaviors was the most positive win for all concerned."

The experience of the authors is confirmed by the findings of this research that following the agile development method properly contributes to the successful outcome of the project and not following the agile development process contributes in a negative way.

The above hypothesis proved that the proper tools and infrastructure is positively correlated with all four aspects of the project outcome, which are on time, on budget, on scope, and on quality, and the final project outcome as well. Schwaber (2004) states the following "Prior to scaling any project, an appropriate infrastructure must be put in place. For instance, if a project will employ multiple collocated teams, a mechanism for frequently synchronizing their work must be devised and implemented."

Smite, Moe and Agerfalk (2010) states the following "Although no single tool is strictly mandatory for a successful agile project, the right set of tools greatly facilitate realizing the various agile processes".

Prior (2011) in her research observed that on a daily basis developers spend a considerable amount of time dealing with the tools and infrastructure to complete their daily tasks. The findings of this research and observations by the researchers and authors reinforce the statement that tools and infrastructure play an important part in the outcome of the project. With the proper tools and infrastructure the project outcome is more positive.

The above hypothesis proved that testing is positively correlated with all four aspects of the project outcome, which are on time, on budget, on scope, and on quality, and the final project outcome as well. Bavani (2009) states that testing is a critical aspect when rolling out agile projects on a distributed scale. Ullah and Zaidi (2013) add to this statement that achieving proper testing is a challenging process. The findings of this research and observations by the researchers and authors reinforce these statements that testing plays an important part in the outcome of the project.

4. Framework for the effect of the challenges on the project outcome

Based on the research findings the following framework was derived (Figure 3).

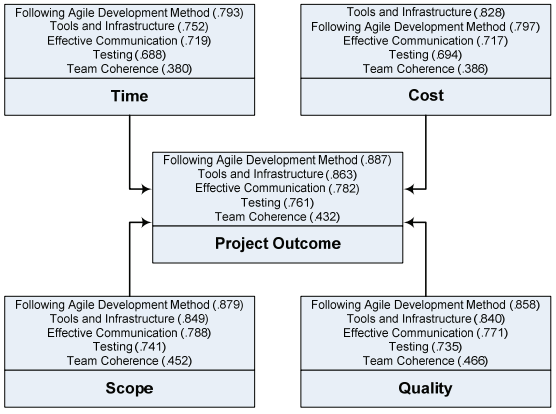

Figure 3 Research framework

5. Future Research

Since agile development is new to the software industry this research focused on three companies which practice agile development principles. These three companies have been practicing agile development principles for the last three to five years. Therefore this research was done as a case study using the three companies. A future research is to study all the software development companies in Sri Lanka that practice agile development techniques. This will bring out new findings.

Many companies new to agile development face a challenge of introducing agile development into the organization (Cohen, 2010). Although different techniques have been proposed on how to introduce agile techniques into an organization no research has been done in Sri Lanka on how successful these techniques are. Therefore a future research might be on how to introduce agile

development principles to offshore software companies in Sri Lanka.

This research focused on a subset of agile development challenges when it applies to an offshore model. However as discussed under the literature review chapter there are a number of other challenges in addition to the ones discussed in this research. A future research might consider these additional challenges and study how these impact the project outcome.

This research focused on the impact of the challenges on the project outcome, and based on this many recommendations were presented in order to overcome the challenges. A future research could be to evaluate the actual improvement of the project outcome based on the recommendations adopted.

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