RECOMMENDATIONS TO IMPLEMENT SOFTWARE METRIC PROGRAMS IN AGILE SCRUM ENVIRONMENT

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ABSTRACT

Agile Scrum is a widely used framework that helps to control complex and chaotic scenarios within the IT industry. Scrum helps to address changing requirements and deliver a shippable product increment in a short period. Moreover, Agile Scrum is based on a set of norms and best practices that revolves around the people factor. To improve the process, certain attributes of the process should be measured and based on the measurement data, need to evolve the process. Process improvement depends on the success of the ingested measurement program and how sustainable the program is.

This research intends to provide recommendations to implement software metric programs in Agile Scrum environment. The objectives associated with this research are to identify the existence of software metric programs in the Sri Lankan IT industry and find factors that influence the successful implementation of Scrum metrics.

The quantitative approach has been used when conducting the research and used an online survey form to collect data required for the analysis. Software professionals within the Sri Lankan IT industry have been considered as the population. The collected data has been cleaned and fed into the IBM SPSS tool for analysis. Descriptive statistics and inferential statistics have been performed upon the data set and conclusions derived for the sample and the population accordingly.

Descriptive analysis for demographic data revealed that most of the sample respondents follow Agile Scrum and the majority have awareness about software metrics.

'Process adherence', 'effective utilization of metric information', 'presence of professional bodies within the organization' and 'goal alignment' have a positive moderate correlation with the 'successful implementation of scrum metrics', but 'infrastructure & tools' has a positive weak correlation with the 'successful implementation of scrum metrics'.

After the analysis, the researcher identified that, 'process adherence', 'effective utilization of metric information', 'presence of professional bodies within the organization', 'goal alignment' and 'infrastructure & tools' have an impact on the successful implementation of scrum metrics. To achieve the successful implementation of scrum metrics, an organization should consider about above factors so it would help to establish a sustainable metric program within the scrum environment.

Keywords: Agile Scrum, Software Metrics, Software Metric Program

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LIST OF ABBREVIATIONS

IV – Independent Variable
DV – Dependent Variable
IT – Information Technology
QE – Quality Engineering
GQM – Goal Question Metric
KPI – Key Performance Indicator
ICTA – Information and Communication Technology Agency
SAFe – Scaled Agile Framework
ANOVA – Analysis of Variance

1. INTRODUCTION

1.1. Background

Traditional way of developing a software starts with gathering requirements, design, implementation, testing and then the deployment. But this way of development required a long time to complete the working deliverable and get the feedback. Moreover, the rework followed by the feedback involves a huge cost.

Nowadays many organizations adopt Agile scrum methodology as a process framework for developing the software. According to that framework the shippable product increment reaches the customer in short iterations (usually two to three weeks) and the fast feedback would reduce the lifecycle cost as well.

An organization can adapt the Agile scrum and develop the software based on that, but the problem is adapting a framework is not enough for a quality, time to market and a valuable software product. To improve product or process, assessing it is required and to assess, measurements should be established. If the software product and the process need to be improved, require measuring certain aspects of the product and the process. “Measuring performance and project progress is an interesting field in software engineering studies” (Kurnia et al., 2018). The way of measuring certain process attributes may differ based on the methodology used for the development. If the organization is adopting the Agile scrum framework, the metrics used should measure certain process goals like team productivity, product quality and the used metrics should focus on achieving them.

Scrum metrics are a subset of Agile KPIs. Agile metrics consist of Lean metrics and Kanban metrics. Most Agile metrics are applicable to a Scrum environment where the major focus is to measure and improve predictable software delivery and deliver maximum value to customers in every iteration.

Blindly implementing Scrum metrics won’t achieve the process improvement and the quality of the deliverable. There are certain factors to be considered when implementing Scrum metrics successfully. The sole purpose of implementing scrum metrics successfully is to improve the overall process in order to increase the value delivery.

A set of metrics will help a Scrum team to achieve delicate control of the process (Downey & Sutherland, 2013). In the industry context many companies adopt Agile scrum methodology and use several metrics to measure certain facts about product and the process. Scrum metrics are a subset of process metrics including team velocity, sprint burndown, escaped defects and defect density etc.

Software metric programs involve managing, controlling & utilizing metric data for organization-wide decision making. Merely implementing software metrics won't implement software metric programs. There should be a well-defined organization-wide process to convey metric data, interpret metric data and use them in strategic decision making. To sustain the metric program this process should be monitored periodically, identify required changes and adapt accordingly.

1.2. Motivation

Scrum metrics basically used to measure deliverables, effectiveness and the scrum team. The problem with the current context is, even though an organization utilizes metrics it does not collectively provide information for decision making.

Initially, goals to be achieved within the scrum environment should be defined and it should include the product goal itself. Even though the goals have been defined and metrics have been used to measure them, still there is an uncertainty to which extent it would help to gain the project success. In the current context there is no any systematic framework, in order to achieve successful implementation of scrum metrics and to identify which factors to be considered.

Another fact is, when the deadlines are tight, and the time boxed sprint is ending there might be a compromise between software measurements.

1.3. Research Scope

This research focuses on identifying factors which affect the successful implementation of software metrics in the Agile Scrum environment. There are three main objectives that come with the research problem. One is to find the existence of software metric programs in the Sri Lankan IT industry which follows Agile Scrum methodology. Next one is, find factors that influence the successful implementation of Scrum metrics. Third one would be, provide recommendations to implement software metric programs in the Agile scrum environment. Software metrics are the key instrument to measure certain attributes of the software and the process followed.

Major categories of software metrics would be product & process metrics. Within this research context, process related metrics is a major concern.

1.4. Problem Statement

Agile scrum framework drives software development teams to adhere to a certain set of practices and key concepts which has been depicted in Agile Manifesto. Scrum is a specific Agile methodology where development progresses in timeboxed iterations. The team is a self-leading team guided by the Scrum Master.

For self-driving teams, goal setting, measuring and assessing them is an important fact because increase of the value delivery depends on the process improvement.

Measure deliverables, effectiveness and the scrum team itself is required to improve the process as well as achieve the required goals.

Industry adopts various metrics for the purpose of process improvement. Adopting metrics does not improve the process unless the team defines the goals to be achieved then define the metrics to measure and achieve the goals. Metric implementation within Agile Scrum environment is not a onetime task but a journey which achieves several milestones.

This study focuses on identifying the factors that help for successful implementation of Scrum metrics and provide recommendations to implement software metric programs in Agile Scrum environment.

1.5. Research Objectives

The researcher intends to achieve the below objectives.

- To identify the utilization of software metric programs within Sri Lankan IT industry.
- Find factors that influence the successful implementation of Scrum metrics.
- Provide recommendations to implement software metric programs in the Agile scrum environment.

1.6. Research Significance

Identifying the factors that affect the successful implementation of Scrum metrics serves as the key focus of this research. Through that provide the recommendations to implement software metric programs in Agile Scrum environment. Recommendations can guide for successful implementation of Scrum metrics within Agile Scrum teams and the metric program implementation within the organization. Proper establishment of Scrum metrics can lead to gain evidence-based data to improve key performance areas and continuous improvement of the process.

End goal of this continuous process improvement is to increase the quality of the deliverable, time to market and the scrum team satisfaction.

1.7. Outline

The background for the research, motivation, scope, problem definition, objectives, and research significance are described in Chapter 1. Chapter 2 describes the related work about the Scrum framework, software metrics, Scrum metrics, software metric programs, and challenges in software metric programs. The research methodology is defined in Chapter 3. It consists of the steps followed to conduct the research, survey questions, information related to population and sample. Chapter 4 is dedicated to the data analysis segment of the research. The findings from the research, recommendations, and future work are explained in the Chapter 5. The appendix consists of an online survey questionnaire and the company list.

2. LITERATURE REVIEW

2.1. Agile Scrum Framework

Agile software development is more than a practice or a framework, but an umbrella term used to describe a set of frameworks rely on four values and the twelve principles described in Agile Manifesto. There are several types of agile methodologies used in software development environments like Scrum, XP (Xtreme Programming), Kanban, Crystal and Dynamic System Development Method (DSDM).

The Agile Scrum framework helps to produce products with value and utilize a process with productivity with its capability of resolve adaptive problems (Schwaber & Sutherland, 2017). Scrum is a team based iterative approach used to control and manage the chaos resulting from conflicting interests from the project team which is shown in Figure 2.1. Journey with Scrum enables communication and cooperation within teams to remove impediments. Rather than traditional methods, Agile Scrum will produce value delivery within a short time (Cervone, 2011).

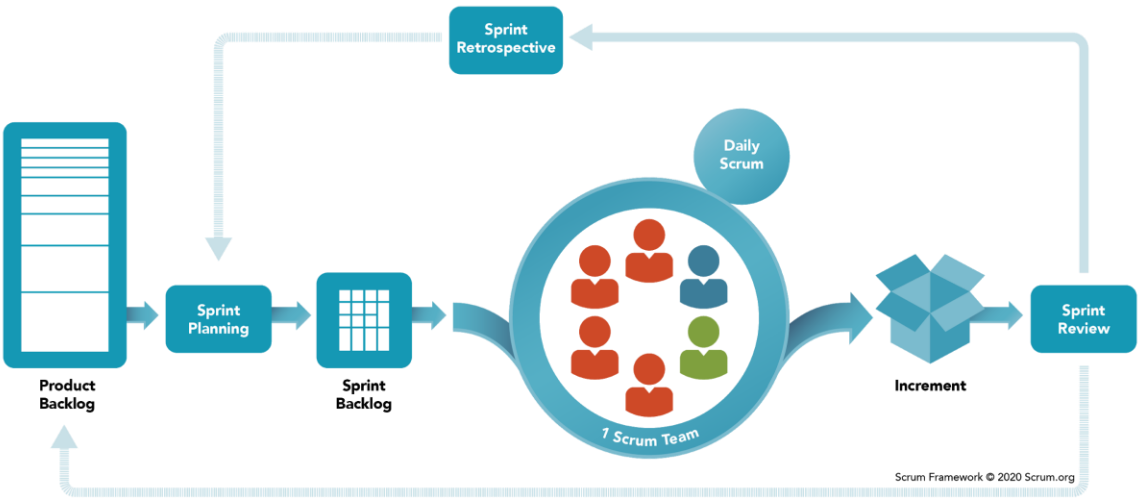

Figure 2. 1: Scrum Framework. Source: Scrum.org, 2020.

“Scrum is not a methodology but a framework that administers predefined limits to a moderate self-organizing team so they can reach the extreme productivity” (Downey & Sutherland, 2013).

Scrum works with the core concept of Sprints which is a time-boxed duration usually two to three weeks where the shippable product increment has been getting developed. As shown in the Figure 2.2 Scrum consists of set of roles, events and artefacts.

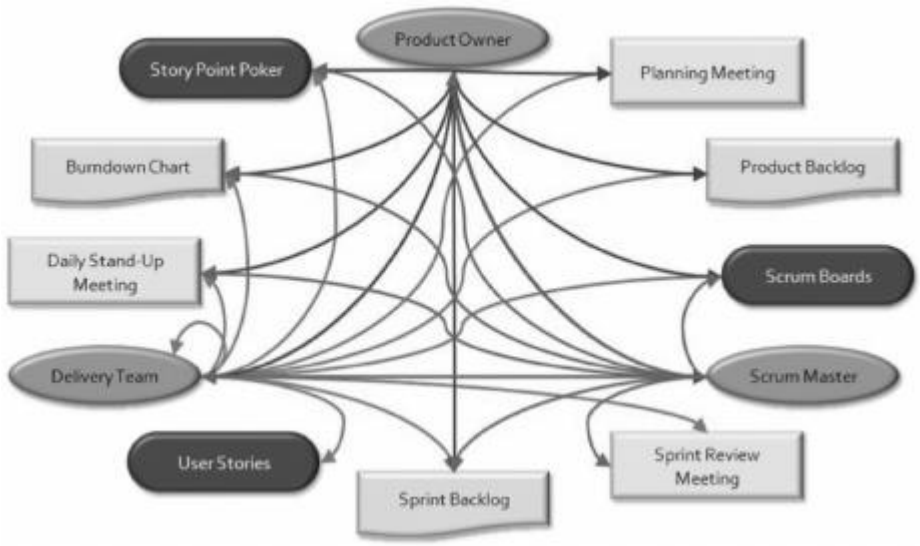

Figure 2. 2: Scrum Ecosystem. Source: (Downey & Sutherland, 2013).

2.1.1 The Scrum Team

The Scrum team consists of the product owner, scrum master and the development team. Usually Scrum teams are self-organized cross functional teams rather than directed by an individual person. The Scrum teams produce deliverables within time-boxed iterations, so fast feedback is an advantage for improvements with reduced life-cycle cost (Schwaber & Sutherland, 2017).

- **Product Owner**

Product owner is responsible for the value delivery of the product increment developed by the development team. Product owners are accountable for prioritizing the product backlog in order to optimize the value delivery. Clearly describe product backlog items and ensure that the product backlog items have been prioritized to achieve the goals and missions.

- **Scrum Master**

Scrum master services could be decomposed based on three parties. “Scrum master’s services to the product owner, development team and the organization” (Don’t Forget to Read This: Scrum Master Interview Questions: 51 Ways to Identify CandidatesAge of ProductAge of Product, 2021). Scrum master coaches the development team about scrum theories, practices and values. Removing impediments from the scrum teams and making sure that the team identifies the sprint goal and the mission (Sprints | Atlassian, 2021). Moreover, facilitating scrum ceremonies as needed. Scrum master works as a servant leader to the scrum team.

- **Development team**

The development team consists of individuals who are accountable for the delivering of shippable product increment at the end of each Sprint. And they are aware of the definition of done before releasing the product increment. The team is self-directed and cross functional. The team is aware of the goal for the sprint. “Scrum recognizes no titles for development team members, regardless of the work being performed by the person” (Schwaber & Sutherland, 2017).

2.1.2 Scrum Events

#	Scrum Event	Description
1	Daily Scrum	Time boxed meeting around 15 minutes where the team inspect the progress towards the sprint goal. Address three basic questions. What has been achieved last to this Scrum, from this Scrum to next scrum what is going to be achieved, any impediments blocking the work in progress.
2	Sprint Planning	A time boxed meeting to plan what to be achieved within the upcoming Sprint. This is a collaborative effort done by the Scrum team. What to be delivered in the upcoming Sprint and what work to be done in order to achieve that is the main purpose. During the planning, items are pulled from the product backlog into the Sprint backlog. The development team has the final say in how much of the high priority work it can accomplish during the Sprint (The Four Scrum Events and How to Use Them, 2021).
3	Sprint Review	Demonstrate what things have been "Done" and "Not Done" at the end of the Sprint. The Scrum Team and the stakeholders get together and review the product increment and refine the product backlog based on the feedback.
4	Sprint Retrospective	The sprint retrospective is dedicated to discussing about what went right, what went wrong during the sprint and potential improvements identified for the process improvement.

Figure 2. 3: Scrum Events

2.1.3 Scrum Artifacts

Scrum artifacts are dedicated work or values that facilitate transparency and the capability of inspection and adoption within the process.

- **Product Backlog**

"A product backlog (or simply backlog) is a list of work items (e.g., user stories, outstanding bugs, various chores) used by software teams to coordinate work to be done" (Sedano et al., 2019). Product backlog is a dynamic entity and product owner is the accountable person for maintaining and prioritizing it.

- **Sprint Backlog**

Sprint backlog consist of product backlog items pulled out from the product backlog, in order to accomplish Sprint work. This emerge throughout the sprint and maintained by the development team. The sprint backlog is the artifact that represents the list of work that should be achieved by the development team (Schwaber & Sutherland, 2017).

2.2. Software Metrics

"Major rationale for using metrics is to improve the software engineering decision making process from a managerial and technical perspective" (Fenton & Neil, 1999) .Software metrics tend to measure certain aspects of software product, process and the project in order to improve both product and the process. "Good metrics grow more sophisticated as we understand more about what we're trying to measure" (Pfl, 2008). Software metrics help to understand cost and quality of the software product and the process and provide an idea about how predictable the software project is. "Good metrics should enable the development of models that are efficient of predicting process or product spectrum. Thus, optimal metrics should be, simple precisely definable so that is clear how the metric can be evaluated" (Singh Rawat & Kumar Dubey, 2012).

The software metric should be objective or simply it should define how the metric should be evaluated. To measure certain product, process or a project there might be set of metrics. But metric selection should be based upon the goal to be achieved. Software metrics should be easily obtainable at a reasonable cost, valid and robust according to Rawat, Mittal & Dubey (2012). Validity of a software metric relies on whether the metric measure what it is supposed to measure. Robustness of a metric means it should adopt to changes in the product or process.

2.2.1 Software Metric Types

- **Product Metrics**

To measure quality-related attributes of software, product metrics have been used (Singh & Devi, 2011). These metrics have been used to gain insights into the performance of the software product, size, complexity (function of size), and reliability. To increase readability & clarity, style-related metrics also used within the

industry. Product metrics help to measure above mentioned key areas of the software and improve the quality of the product.

- **Process Metrics**

The process which has been used to create the deliverable, measured with process metrics. Specific attributes of the process need to be measured, in order to improve it. Integral parts of the process like effort, cost incurred, reusability and productivity can assess with these metrics. Process metrics will assess above aspects of the process and provide information about the process status and based on that, can improve the process.

- **Project Metrics**

Measuring the project & adjust it based on measurement data, helps to improve the overall project plan. Impediment removal & risk elimination are also a by-product of using project-related metrics (Singh Rawat & Kumar Dubey, 2012). The current status of the project could be measured by project metrics and based on that, can measure the progress of the project.

Theory underlying is, that a measurement must consider at least nine factors (Kaner, 2000). All factors consolidated into Table 2.1.

Table 2. 1: Factors to consider in choosing measure: (Kaner, 2000)

#	**Factor**	**Description**
1	Attribute to be measured	This describes what needs to be measured like software quality, productivity and predictability.
2	The instrument that measure the attribute	Metrics are the instruments used to measure certain attributes. As an example, tester effectiveness measured by bug count.
3	Relationship between attribute and the instrument	Describes the mapping between attribute and the measurement. The degree of confidence about the measurement when the attribute fluctuates.
4	Probable side effect of using the instrument to measure the attribute	Both good and bad side effects might happen when the measurements are in place. Make numbers look better sometimes downgrade the attribute quality.
5	Scope of the measurement	To which extent the measurement should be used.

6	Appropriate scale for the attribute	Depend on the attribute the scale might vary. Bug counts consider as an absolute scale.
7	Variation of the attribute	Need an underlying approach to track the attribute variation with the measurement.
8	The scale of the instrument	Appropriate scale for the measurement.
9	Variation of measurements made with this instrument	Track the measurement error thus it would make the reading more standardized.

2.3. Software Metric Programs

Software metric programs (MPs) are a systematic way of managing, assessing and optimizing software products, processes, and related resources. "However, implementing successful MPs remains a challenge" (Tahir et al., 2016). If an organization consists of a measurement-based framework, software development process and the product quality itself could be drive to an effective destination. Entities utilizing software metric programs have an advantage over others who are used to traditional ways because product & process improvement is an inherent nature of software metric programs (Offen, 1997).

Software metric programs should establish as a continuous, evolutionary process, and the metric program is a cohesive entity that can drive in different directions based on the requirement. Before establishing complex processes within the organization, a robust project management culture should implement in the organization (Iversen & Mathiassen, 2000).

Software metric programs involve a set of activities including determining required data for the metric program, planning the measurement approaches, identifying tools required to gather and analyse data and how to exploit, utilize and distribute metric data across the organization for the purpose of product and process improvement.

2.3.1 Basic Problems with Software Metric Programs

"Metric Programs most of the time lack sustainability, clear objectives, correct measurement instruments, resources, time and budget" (Tahir et al., 2016) .

Metric programs can optimize or bring chaos to the project depend on the way it manages. To manage and retain a software metric program requires a lot of financial effort. The return on investment may vary between two extreme ends of function and

dysfunction. Below mentioned facts serve as the root cause for metric program failures (Dekkers & Mcquaid, 2002).

- Lack of understanding about what attributes to be measured.
- Utilization of metric data in an improper and incorrect way so it would disrupt the success of the project as well as the organization.
- Does not consider about human factor and analyse metrics in a pure technical perspective. In other words, without consider how the metric utilization would affect the knowledge intensity of the software development process.

The survival rate of metric programs throughout two years is 20 percent according to the analysis of Howard Rubin, as Figure 2.4 shows (Dekkers & Mcquaid, 2002).

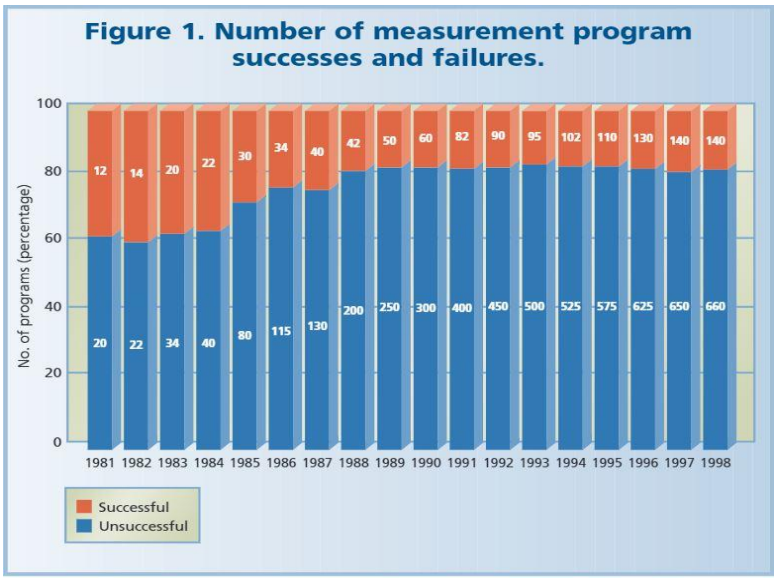

Figure 2. 4: Measurement program success and failures: (Dekkers & Mcquaid, 2002)

2.3.2 Characteristics of Successful Measurement Programs

Not only technical perspectives but also human actors contribute to the success of the metric programs. Success was defined as being a function of (Berry & Jeffery, 2000):

- "The extent to which measurement and analysis are regularly used to inform management and technical decision-making" (Berry & Jeffery, 2000).

- "The extent to which improvements in an organization's performance can be attributed to the use of measurement and analysis in the organization" (Berry & Jeffery, 2000).

There are seven most important factors effecting the organization's successful measurement program according to Dekkers and Mcquaid (2002).

- **Set solid measurement objectives**

Organizations need tracking and control over the processes to reach certain goals. Measurement programs help to reach goals. For that need well planned measurement objectives.

- **Make measurement part of the process**

Measurements should not be an overhead to the process but should be an integral part of the process to gain the return on investments.

- **Better understanding of the measurement**

Organization should make decisions based on the measurement data not with the gut feeling. The management knows what to measure and the instruments used to be measured. The corrective actions are based on the measurement data and better combination of metrics would provide measurements data for key decision makings.

- **Focus on cultural effect**

Implementing a measurement program effect the human factor involved with the organization. The way people behave after the metric program implementation and how they will resist or embrace the new concept might vary.

- **Create an environment to collect and report accurate data**

Understanding the current situation helps to proceed with potential improvements. Another important fact is giving access to measurement data to people where the sole purpose of measurement program is to improve.

- **Cultivate a predisposition to change**

If a certain attribute decreases, need to find the root cause and take corrective actions based on metric data.

- **Identify suitable set of measurements**

During the implementation phase of a metric program, selecting a set of metrics to measure the improvement effort is important. When change the attributes within the products or process it is important to adapt the measurements accordingly.

2.4. Scrum Metrics

Perfect metrics provide ScrumMaster a precise foundation to drive the team because metrics provide inferences on team performance vs impediment removal (Downey & Sutherland, 2013). Scrum metrics should harness to improve the development process, evaluate the impact to the development process, monitor the project progress, predictability of the project and the product quality. Scrum metrics also cater to certain measurement goals as shown in Figure 2.5.

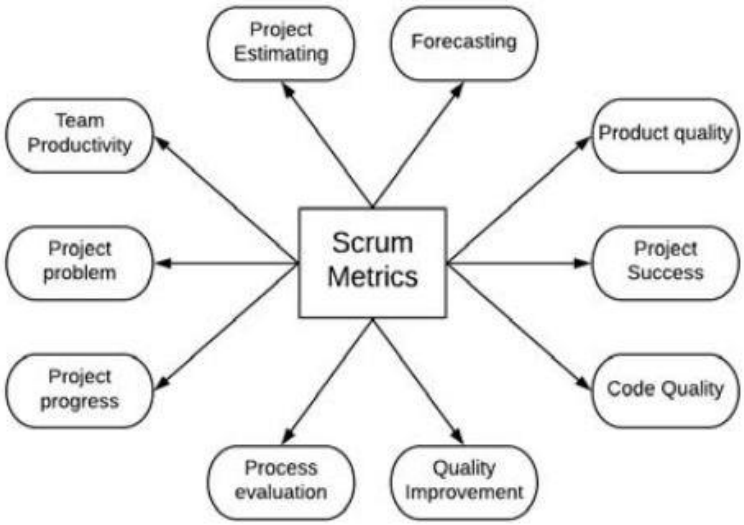

Figure 2. 5: Software measurement goals: (Kurnia et al., 2018)

Certain scrum metrics could be classified into few areas based on the scrum ceremonies followed. Figure 2.6 depicts them.

Scrum Metric	Description
Velocity	Describe how many user stories were completed by the team (11 Scrum Metrics and Their Value to Scrum Teams, 2021). This is a subjective measurement captures the team's progress.
Work capacity	Product of a total number of team members multiplied by the total number of workable hours. When committing for sprint story points this should be considered.
Sprint level effort burndown	Depicts the progress within the sprint. Shows the number of hours remaining to complete planned work for the Sprint (11 Scrum Metrics and Their Value to Scrum Teams, 2021). At a glance can get an idea whether the team is in schedule or not.
Escaped defects and defect density	Important when measuring the product quality. Escaped defects show the number of defects experienced in the production which has been escaped without detection. Defect density means number of defects per software size specially the lines of code (LOC) (11 Scrum Metrics and Their Value to Scrum Teams, 2021). It is obvious to watch upon it and check whether the defect density does not show extensive deviations when the code base grows.
Defect severity index	Defect Severity Index (DSI) = Sum of (Defect * Severity Level) / Total number of defects
Work in progress	A predictability measure where stabilizing the flow and the best practice is to limit the work in progress.
Unplanned work	Essential to detect and eliminate the waste from scrum teams.
Skill versatility	Describe the skill variation within scrum teams.
Deliver on time	Deliver the targeted features within the schedule. Usually measured as a ratio of features completed in the planned schedule.
Focus factor	Velocity ÷ Work capacity.
Level of automation	Describes the degree of test automation coverage within the sprint.

Figure 2. 6: Scrum metrics

2.5. Factors Effecting the Successful Implementation of Scrum Metrics

The Scrum metrics act as an instrument to monitor and improve the process and help for planning, tracking, and apply changes within the Scrum teams (Elbahnasy & Mohsen , 2017). Based on the metric data, the Scrum team can improve or keep going as it is (Elbahnasy & Mohsen , 2017). Merely implementing scrum metrics won't help for the process improvement. Successful implementation of scrum metrics can improve product and process quality, predictability and team's direction towards the productivity.

Below segments emphasis on factors effecting the successful implementation of scrum metrics.

2.5.1. Process Adherence [Agile Scrum]

Software metrics are grouped by measurement objectives and scrum events goal (Kurnia et al., 2018). Software metrics related to Agile Scrum could be classified in to four major groups. They are sprint planning, daily scrum, sprint review and retrospective. Proper adherence to Agile Scrum would impact successful implementation of scrum metrics. If a project team follows scrum principles and values, the team would adopt scrum ceremonies within the project. Agile Scrum is a cohesive entity with different modules which have interconnections and needs to monitor those modules to keep the consistency of that ecosystem. A well-defined set of metrics will assess certain measurable attributes and based on that will advise on how to control the process (Downey & Sutherland, 2013).

2.5.2. Required Infrastructure and Tools

Tools will remove complexities associated with attribute analysis related to software metrics. A connection between metric data analysis and the utilization of tools for that activity is evident (Padmini et al., 2015). A proper infrastructure and usage of project management and collaboration tools like JIRA and Azure DevOps have a positive impact on metric implementation within the Agile Scrum environments. Sprint level effort burn down, velocity and work in progress are few visual instruments could be generated with tool support. High level overview of such instruments provides a clear picture of how the project is in progress. Metric implementation is not enough without frequent usage of it in day today activities. The tool support has a positive impact on metric implementation since it gives a real time picture of the instrument so even the small decision could be made upon that picture.

2.5.3. Effective utilization of metric information in decision making about the process improvement

Scrum metrics collectively provide information for the process improvement. The utilization of software metrics at management and technical levels will improve the decision-making power within the organization (Fenton & Neil, 1999). Team utilize metrics to gain an idea about the team productivity, product quality and predictability.

Such kind of best practices effect the successful implementation of scrum metrics since it improves the information gathering for process improvement. If the team believes in decision making based on data rather than the gut feeling it would be easy to adopt scrum metrics effectively.

2.5.4. Goal Alignment / GQM (Goal Question Metric)

The concept behind GQM is, a framework to determine the metric selection based on goal setting, question formulation (how we can achieve objectives?) and select metrics to answer them (Berander & Jönsson, 2006). There should be a purpose for the selected metrics. Figure 2.7 depicts three tier model for GQM.

- The conceptual level (Goal): Objectives of the metrics.
- The operational level (Question): Set of questions reflecting how the objectives should be achieved.
- The quantitative level (Metric): Collection of metrics used to answer the questions.

Figure 2. 7: Three levels of GQM (Berander & Jönsson, 2006)

According to the literature sources, goal alignment can define metrics to be used within the environment. Based on goals to be achieved metrics are introduced.

2.5.5. Presence of Professional Bodies within the organization / Upper Management Positive Attitude towards the Metric Program

Software managers can be motivated to use metrics information in their decision-making (Gopal et al., 2005).

Professional bodies within the organization means, board of directors within the organization and dedicated professionals appointed for process improvement-related activities within the organization.

According to institutional theory, there are certain forces which drive the organization to adopt policies and practices. Metric implementation is an organizational wide process and the upper management support is necessary to continue and sustain that effectively. Since the metric implementations comes with a cultural change within the organization and the decision making based on metric data, the management

commitment is important to institutionalize the norms behind the metric program. Set of metrics to be used and how it can be utilized to achieve project goals as well as organizational goals would reflect the upper management commitment to the metric programs.

2.6. Data Analysis Approaches

Below sections describe about quantitative data analysis approaches used by the researcher during the data analysis phase.

2.6.1. Cronbach's Alpha Method

"Cronbach's alpha is a measure of the internal consistency or reliability between several items, measurements or ratings" (Bujang, Omar & Baharum, 2018). In other words, it checks the reliability of questions used to measure each factor. The value of alpha depicts, how closely related a set of items as a group. Figure 2.7 shows Cronbach's alpha interpretations.

Alpha Coefficient Range	Strength of Association
< 0.6	Poor
0.6 - 0.7	Moderate
0.7 - 0.8	Good
0.8 - 0.9	Very Good
< 0.9	Excellent

Figure 2. 8: Cronbach's Alpha Interpretations

2.6.2. Descriptive Analysis

Descriptive analysis provides a high-level summary of the collected data. If the analysis is univariate, it involves the distribution of a single variable. Distribution of that variable could be depicted in a tabular format, graphs, bar/pie charts or scatter plots. Usually it involves its central tendency (mean, median and mode), dispersion (range, variance and standard deviation) and the shape of distribution (skewness and kurtosis).

When the analysis involves more than one variable, need bivariate and multivariate approaches for the analysis. In bivariate analysis, it describes the relationship between

two variables. In other words, it involves quantitative dependence including the correlation between two variables.

2.6.3. Pearson Correlation Coefficient

Measures the association between two continuous variables. It shows not only the strength of the association between two variables but also the direction of the relationship. Degree of correlation shows in the Figure 2.8.

Size of Correlation	Interpretation
±0.81 – ±1.0	Very strong correlation
±0.61 – ±0.8	Strong correlation
±0.41 – ±0.6	Moderate correlation
±0.21 – ±0.4	Weak correlation
0.0 – ±0.2	Weak to no correlation

Figure 2. 9: Rule of Thumb Interpretation for Pearson Correlation

2.6.4. Linear Regression

Linear regression is used to predict the value of the dependent variable based on the independent variables. When the research involves two or more independent variables, multiple regression is required for the analysis.

2.6.5. Inferential Analysis

Unlike descriptive statistics, inferential analysis makes judgements for the population based on the sample data. It makes inferences from sample data for more generic conditions.

2.6.6. Hypothesis Testing

Assess the strength of the findings derived from the sample and construct an approach to make inferences to the population is known as hypothesis testing (Davis & Mukamal, 2006). The association between independent and dependent variables is

depicted in the hypothesis statement. That relationship could be directional or non-directional. If there is no association, that state represents the null hypothesis.

Positive or negative variation between two variables is known as the directional hypothesis. Non-directional hypothesis is a two tailed hypothesis which does not define a direction of the change occur between two variables. Null hypothesis does not define a relationship between two variables. Usually denotes as H_0.

- **T- test**

"A t test is a type of statistical test that is used to compare the means of two groups" (Kim, 2015).

- **ANOVA test**

Analysis of variance provides the foundation to reject the null hypothesis and accept the alternative hypothesis.

2.7. Discussion

Table 2.2 show the summary of factors effecting the successful implementation of scum metrics. After reviewing below mentioned sources, more than ten factors were identified and consolidated in to five major factors. Some sources emphasize more than one factor.

Table 2. 2: Summary of Factors

Reference	**Process adherence [Agile Scrum]**	**Required infrastructure & tools**	**Effective utilization of metric information**	**Goal alignment/ GQM**	**Presence of professional bodies within the organization/up per management positive attitude towards the metric program**
(Ktata & Lévesque, 2010)	×				
(Downey & Sutherland, 2013)	×				
(Ktata & Lévesque, 2010)		×			

(Fenton & Neil, 1999)			×		
(Ktata & Lévesque, 2010)				×	
(Perkusich et al., 2017)					×
(Elbahnasy & Mohsen , 2017).	×				
(Dekkers & Mcquaid, 2002)			×		×
(Tahir et al., 2016)				×	
(Iversen & Mathiassen, 2000)			×		
(Offen, 1997)		×		×	
(Singh & Devi, 2011)			×		
(Berry & Jeffery, 2000)			×		×
(Ktata & Lévesque, 2010)	×			×	
(Perkusich et al., 2017)		×			

2.8. Conclusion

Researcher found five factors effecting the successful implementation of scrum metrics after reviewing several literature sources. Process adherence [Agile Scrum], Required infrastructure & tools, effective utilization of metric information, Goal alignment/GQM and Presence of professional bodies within the organization/upper management positive attitude towards the metric program have been identified as independent variables.

3. RESEARCH METHODOLOGY

3.1. Introduction

This chapter describes about the approach of the research used to achieve the research objectives mentioned in the Chapter 1. Section 3.2 describes about the research approach; Section 3.3 is dedicated to the conceptual framework which is the foundation for this research. Section 3.4 discusses about the hypothesis development.

3.2. Research Approach

The researcher utilized a quantitative approach to conduct the research and attain the objectives mentioned in Chapter 1. Main objectives come as find factors that influence the successful implementation of scrum metrics and provide recommendations to implement software metric programs in the Agile scrum environment. Figure 3.1 describes the step by step approach followed when conducting the research.

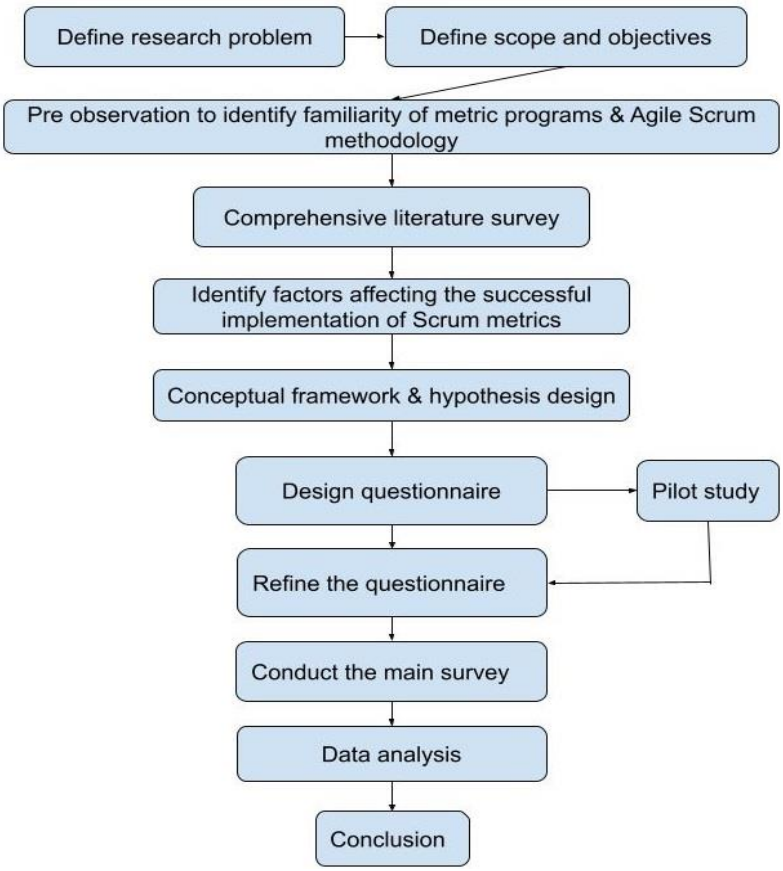

Figure 3. 1: Research Approach

After defining the research problem, the scope and the objectives were identified to carry out the research based on the Agile Scrum environment.

Initial pre-observation was conducted to identify the familiarity of the software metric programs and usage of Agile Scrum as a development framework within the software industry. The responses received from that observation, considered as a fact to conduct the research furthermore. A comprehensive literature survey was conducted and covered the areas about Agile Scrum framework, software metrics, scrum metrics and software metric programs. Factors effecting the successful implementation of scrum metrics were identified during the literature survey. Initially fourteen factors were identified and after consolidation of similar factors, five factors were formulated. Conceptual framework has been developed with the five independent variables and the dependent variable as the successful implementation of scrum metrics. Based on the conceptual model the hypotheses were identified. Structured questionnaire has been designed to extract demographic information and information related to the predefined conceptual model. Five-point Likert scale-based questions were used to gather information related to dependent and independent variables. Pilot study was done after distributing the questionnaire among 25+ IT Professionals. 30 data points have been used to do the reliability analysis. After the reliability analysis, few changes have been applied to the initial questionnaire and started the main survey. After gathering the data, Data analysis has been performed with the IBM SPSS tool. Based on the data analysis recommendations and conclusions were provided.

3.3. Conceptual Framework

After the comprehensive literature survey, the researcher developed the conceptual model to depict the relationship between independent variables and the dependent variable. The conceptual model is a simplified structure that represents the hypothesis of a research (Adom et al., 2018)
‘goal alignment /GQM’, ‘presence of professional bodies within the organization’, ‘Process adherence [Agile Scrum]’, ‘effective utilization of metric information’, ‘Required infrastructure and tools’ identified as independent variables and ‘Successful implementation of Scrum metrics’ serves as the dependent variables. Figure 3.2 shows the conceptual model utilized throughout this research.

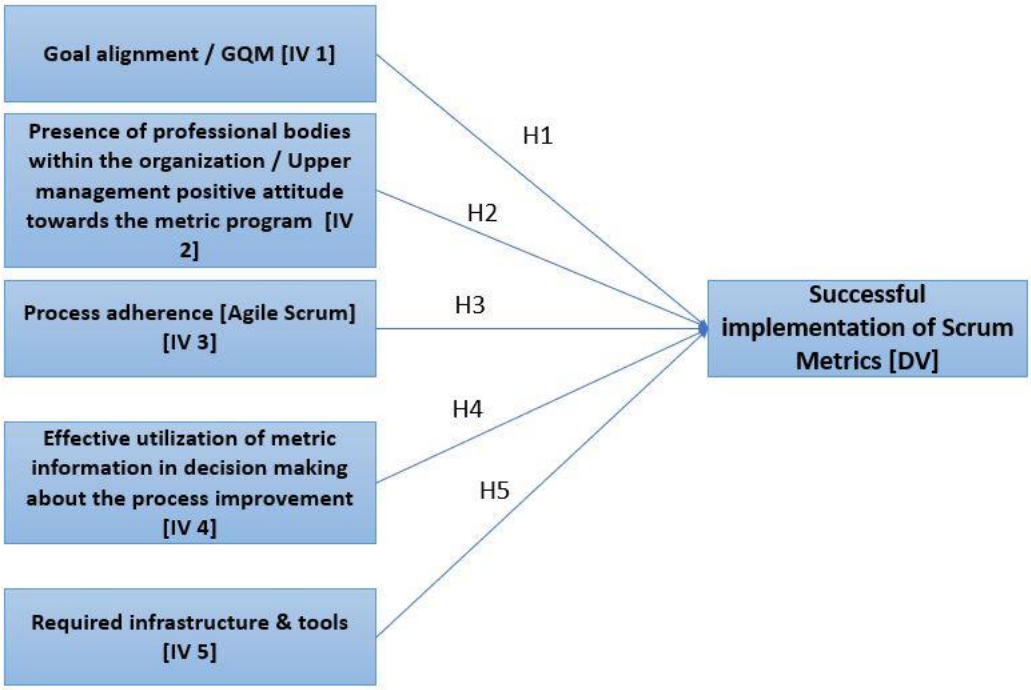

Figure 3. 2: Conceptual Framework

3.4. Hypotheses Development

The researcher formulated below hypothesises based on the conceptual framework depicted on the Figure 3.2. These hypotheses predict the relationship between independent and dependent variables. Both alternative and null hypotheses were tested during the research process.

Goal Alignment / GQM

$H1_a$ - Goal alignment / GQM has an impact on successful implementation of scrum metrics

$H1_0$ - Goal alignment / GQM does not have an impact on successful implementation of scrum metrics

Presence of Professional Bodies within the Organization / Upper Management Positive Attitude towards the Metric Program

$H2_a$ - Presence of professional bodies within the organization/ Upper management positive attitude towards the metric program has an impact on successful implementation of scrum metrics

$H2_0$ - Presence of professional bodies within the organization/ Upper management positive attitude towards the metric program does not have an impact on successful implementation of scrum metrics

Process Adherence [Agile Scrum]

$H3_a$ - Process adherence [Agile Scrum] has an impact on successful implementation of scrum metrics

$H3_0$ - Process adherence [Agile Scrum] does not have an impact on successful implementation of scrum metrics

Effective Utilization of Metric Information in Decision Making about the Process Improvement

$H4_a$ – Effective utilization of metric information in decision making about the process improvement has an impact on successful implementation of scrum metrics

$H4_0$ – Effective utilization of metric information in decision making about the process improvement does not have an impact on successful implementation of scrum metrics

Required Infrastructure & Tools

$H5_a$ - Required infrastructure and tools has an impact on successful implementation of scrum metrics

$H5_0$ - Required infrastructure and tools does not have an impact on successful implementation of scrum metrics

3.5. Questionnaire Design

Based on the conceptual model, questionnaire was designed. Questionnaire consists of two major parts. One is to collect demographic information. The other is to collect information required to prove above mentioned hypotheses.

Figure 3.3 & Figure 3.4 shows the summary of finalized questionnaire. Except the questions dedicated for demographic information, other questions are structured questions with 5-point Likert scale based (Strongly Agree, Agree, Undecided, Disagree, Strongly Disagree). For each variable depicted in the conceptual model, questions were added. After the reliability analysis, few adjustments were done to the questionnaire.

Questionnaire was published as a Google form and distributed among 300+ IT professionals.

No	Question (Answer: 5-point Likert scale [Strongly agree, Agree, Undecided, Disagree, strongly disagree])	Goal Alignment / GQM	Presence of Professional Bodies / Upper Management Attitude towards the Metric Program	Process Adherence [Agile Scrum]	Usefulness of the Provided Information	Required Infrastructure & Tools	Successful implementation of Scrum metrics
1	There is always a purpose for the used scrum metrics within the project	×					
2	Investments in process improvement activities lead to improved quality and reduced rework and lifecycle costs (Gopal et al., 2005)		×				
3	Software managers are motivated to use metric information in their decision making (Gopal et al., 2005)		×				
4	Organization is having an appropriate procedure to collecting metrics data, analyse it and utilize it for process improvement		×				
5	Metric status and results are provided to management on a regular basis		×				
6	Scrum metrics are important factors to drive the project successfully		×				
7	Organization continuously improve the metric program		×				
8	Scrum metrics help to increase the product quality		×				
9	Project team perform scrum events within the project i. Daily scrum ii. Backlog refinement iii. Sprint planning iv. Sprint planning			×			
10	"Project team sets and understands the sprint goal and how success will be measured" (Sprints | Atlassian, 2021)			×			
11	"Project team have a well-groomed backlog with priorities and dependencies in order" (Sprints | Atlassian, 2021)			×			
12	"Project team has a good understanding of velocity, and that it reflects things like leave and team meetings" (Sprints | Atlassian, 2021)			×			
13	"Team members sketch out tasks for all stories, bugs, and tasks that come into the sprint" (Sprints | Atlassian, 2021)			×			
14	"Once a decision or plan is made, team captures that information in the project management or collaboration tool"			×			

Figure 3. 3: Summary of Questionnaire – Part1

	(Jira/Azure DevOps) (Sprints | Atlassian, 2021)						
15	"Team Don't pull in too many stories, overestimate velocity, or pull in tasks that can't be completed in the sprint" (Sprints | Atlassian, 2021)			×			
16	"Team break down stories that are large or have high uncertainty" (Sprints | Atlassian, 2021)			×			
17	"The product owner describes the objective (or goal) of the sprint and what backlog items contribute to that goal" (Sprints | Atlassian, 2021)			×			
18	"The development team plans the work necessary to deliver the sprint goal" (Sprints | Atlassian, 2021)			×			
19	"The development team understand how they can or cannot deliver sprint goal" (Sprints | Atlassian, 2021)			×			
20	Team member have the idea of DOD			×			
21	Scrum metrics collectively provide information in making decisions about the improvement effort to the project (Iversen & Mathiassen, 2000)				×		
22	The team utilize scrum metrics to make decisions about the team i. Productivity ii. Product quality iii. Predictability				×		
23	The team drives based on the evidences gained through the metrics rather than the gut feeling				×		
24	Team uses project management /collaboration tools JIRA/Azure DevOps)					×	
25	"Defining successful measurement Frameworks are to start small with the most important measurements and grow slowly as the organization matures" (Berander & Jönsson, 2006)						×
26	Project team has a good understanding about what metrics are important						×
27	Project team uses scrum metrics i. Velocity ii. Work capacity iii. Sprint level effort burn down iv. Escaped defects & defect density v. Defect severity index vi. Work in progress vii. Unplanned work viii. Skill versatility ix. Delivery on time x. Focus factor xi. Level of automation						×

Figure 3. 4: Summary of Questionnaire – Part 2

3.6. Population and Sample Selection

Determine the population and the sample size is important in a quantitative research. This section describes about the population and the sample size dedicated for this research.

3.6.1. Population

The researcher focuses on 'Software professionals who are having experience of working in Agile Scrum environments' as the target audience when collecting data. 'The experience' might be past or present. If a software professional is having an experience in Agile scrum environment, he/she can answer the questions within the questionnaire.

According to "National IT – BPM Workforce Survey 2019 conducted by Information and Communication Technology Agency of Sri Lanka, total ICT workforce predicted for year of 2018 is 81,741" ("National IT-BPM Workforce Survey 2019 |ICTA," 2019). The researcher identified 81,741 as the population size dedicated for this survey.

3.6.2. Sample Size

The researcher calculated the sample size after taking the population size as 81,741, confidence level as 95% and the confidence interval as 5% (Sample Size Calculator - Confidence Level, Confidence Interval, Sample Size, Population Size, Relevant Population - Creative Research Systems, 2012). With above mentioned parameters sample size has been identified as 382.

Convenience sampling method has been used for this study where the researcher reached to IT professionals via emails, social media (LinkedIn) and WhatsApp. "The convenience sampling method includes members of the population who are available to the researcher" (Naderifar et al., 2017). Some participants distributed the online survey that they've been received to their colleagues as well.

3.7. Data Collection Process

This study had two major data collection phases. One is the pilot study which has been described in the section 3.8. The other one is the main survey which also described in the section 3.9.

The initial survey questionnaire has been designed using Google forms and distributed among known IT professionals through LinkedIn, WhatsApp, Microsoft Teams and through emails. When distributing the survey, different job categories were

considered. Data collected from initial phase have been used for the pilot study and the section 3.8 describes it further.

After the data analysis of the pilot survey, the questionnaire has been refined. The refined questionnaire mainly distributed to the connections of the researcher via LinkedIn and the initial participants to the pilot study have been asked to distribute the questionnaire to their colleagues.

3.8. Pilot Study

Pilot study is an important factor for a quantitative research because it would help to identify shortcomings of the questionnaire and refine it. Before conducting the pilot study, the questionnaire has been refined to accommodate same type of answers for a given variable.

The questionnaire for the pilot study has been distributed among known IT professionals. Before distributing it, the job category and the years of working experience in the Agile scrum environment were considered.

30 data points were collected in the initial phase and it has been utilized for the reliability analysis. Reliability analysis has been described in the section 3.8.1. Based on the reliability analysis and the feedback gained from the experts within the industry, the questionnaire has been refined.

3.8.1 Reliability Analysis

Reliability analysis is required to measure the internal consistency between questions used to measure a variable. According to the conceptual model, the research consists of 1 dependent variable and 5 independent variables. To measure each variable, the researcher formulated set of questions. In order to measure the consistency, the Cronbach's alpha method has been used. This method has been discussed in the section 2.6.1. IBM SPSS software has been used for the analysis and the Figure 3.5 depicts the alpha values gained for each variable.

Variable	No. of Questions	Cronbach's Alpha Value
IV1: Goal Alignment / GQM	2	0.580
IV2: Presence of Professional Bodies / Upper Management Attitude towards the Metric Program	7	0.854
IV3: Process Adherence [Agile Scrum]	16	0.872
IV4: Usefulness of the Provided Information in Making Decisions about the Improvement Effort	5	0.699
IV5: Required Infrastructure & Tools	3	0.645
DV: Successful implementation of Scrum metrics	13	0.794

Figure 3. 5: Summary of Reliability Analysis

According to the Figure 3.5, IV2, IV3, IV4 and DV having a higher internal consistency between questions but for IV1 and IV5 is having a low consistency between questions. The researcher retained only one question for IV1 and IV5 which can measure the variable effectively so eliminated the requirement for conducting the pilot study again.

3.9. Main Survey

Main survey has been conducted with the refined questionnaire which shows in the Figure 3.3 & Figure 3.4. The questionnaire has been distributed among IT professionals via LinkedIn and WhatsApp as well as email flyers. Participants have been asked to distribute the survey that they've been received to their colleagues who works in different job categories like software development, quality engineering, delivery (project management), DevOps etc.

40% of the responses were received within the first 10 days after the initial publishing of the survey. But the response rate got decreased after the 1st month. The researcher had to do some follow ups on the participants who have been sent the survey with.

Finally, 222 responses have been received and the response rate is 58%. The research has been conducted with 85% of confidence level and 5% of confidence interval.

4. DATA ANALYSIS

4.1. Introduction

The data analysis process followed upon the data set obtained from the online survey, will be described in this chapter. In the initial stage, descriptive analysis has been conducted for the demographic data. Then statistical analysis is conducted to identify correlation between each IV and DV. Consequently, carried out the hypothesis testing. Regression analysis conducted for the data set to identify the impact of IVs upon the DV. Inferential analysis carried out to derive inferences from sample in order to identify how the population might behave.

4.2. Data Collection

Data collection process started at the end of March 2021 and concluded at the end of June 2021. The online survey form has been distributed among know IT professionals via email, LinkedIn and WhatsApp. In the month of April 2021, researcher observed a hike of responses and decrease has been observed at the end of June 2021.

4.3. Data Analysis Tools and Techniques

Data analysis is conducted using IBM SPSS 28 tool. Descriptive analysis derived insights for the sample data and depicted using graphs and charts. Correlation analysis involved with the hypothesis testing. Regression analysis carried out after that and inferential analysis instruments have been involved to derive insights related to the population.

4.4. Data Pre-processing

Data collected through the online survey from has been checked and cleansed before process through the IBM SPSS tool. 4 respondents have been mentioned, ‘Waterfall’ as the development method followed so at the initial stage those responses have been excluded. Automatic recode has been applied for Likert scale-based responses where ‘Strongly Agree’, ‘Agree’, ‘Undecided’, ‘Disagree’, ‘Strongly Disagree’ converted into numeric values. Later composite variables have been created for the further analysis. Composite variables have been created by taking the summation of responses gained for questions mapped into each composite variable and divide the summation

by number of questions mapped. Calculation can be justifiable since all the questions mapped into each composite variable were asked in the same direction and the same scale has been used.

4.5. Descriptive Analysis for Demographic Data

Descriptive analysis has been carried out for the collected demographic data to gain an insight about distinct attributes within the sample. Visual descriptors like graphs and charts have been generated for selected attributes within the sample.

4.5.1. Classification of the Sample by Development Process Followed

According to section 4.4, few respondents have been mentioned 'Waterfall' as the development methodology. Those records have been excluded in the initial stage.

87.39% out of the sample respondents are following Agile Scrum methodology. 9.91% following Kanban and rest of the 0.27% are following XP and other Agile practices. Kanban, XP and other Agile practices does not consider as outliers because the respondent having Scrum experience in previous projects.

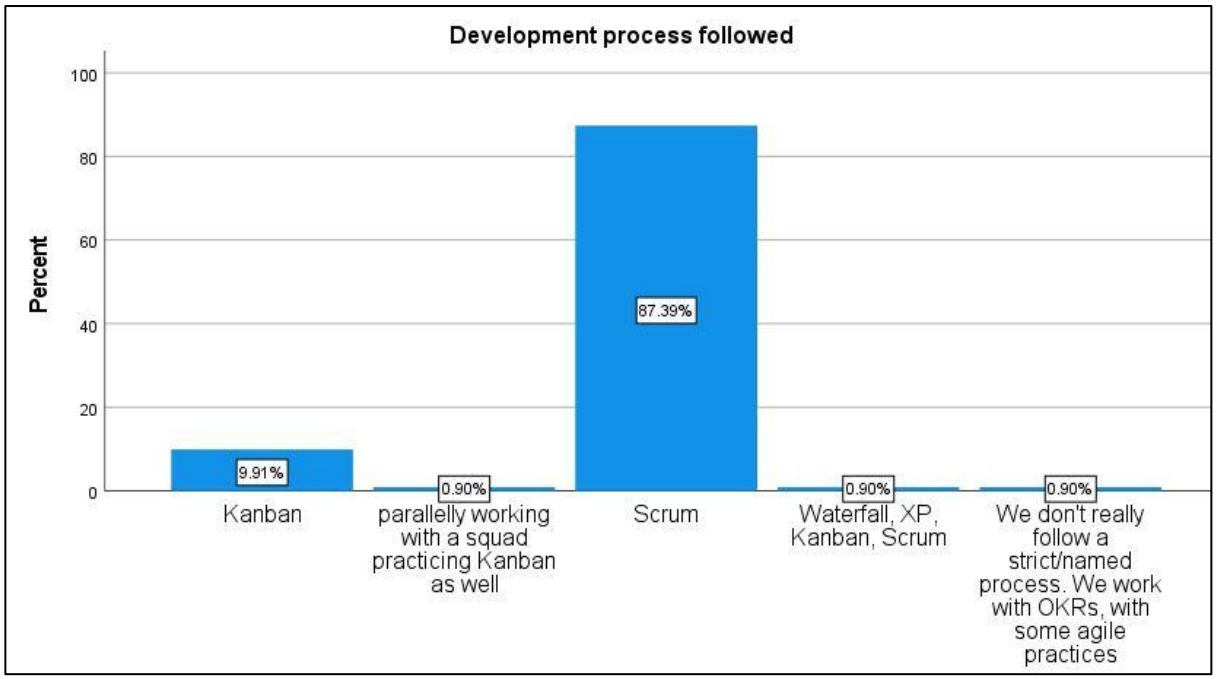

Figure 4. 1: Development Process Followed

4.5.2. Classification of the Sample by Education Level

70.27% of the respondents have mentioned bachelor's degree as the highest level of the education completed. 28.83% have been completed the master's degree and 2 people of 222 (0.90%) respondents having a PhD/MPhil as the highest level of education completed. The researcher believes that respondents having the process related concept knowledge since all respondents having at least a bachelor's degree completed.

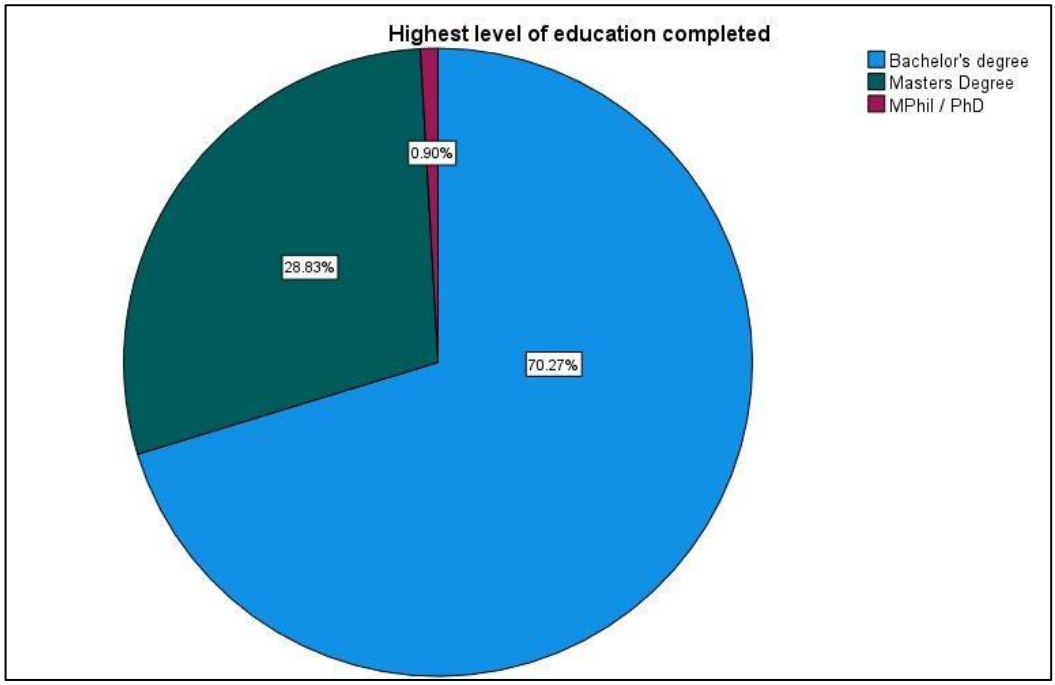

Figure 4. 2: Highest Level of Education Completed

4.5.3. Classification of the Sample by Job Category

Table 4. 1: Distribution of the Job Category Across the Sample

Job Category	Frequency	Percent
Associate QE/Intern	6	2.7%
Delivery (Project Manager/Business Analyst)	40	18
Development (Software Engineer/Full Stack Engineer/Tech	92	41.4%

Lead/Solution or Technical Architect)		
Operation (Application Engineer/System or Support Engineer/DevOps Engineer/Database Administrator)	10	4.5%
QE Lead	12	5.4%
QE Manager	6	2.7%
Scrum Master	2	0.9%
Senior QE/QE	44	19.8%
Software QA Architect	2	0.9%
Technical Specialist QE	6	2.7%
UI/UX Engineer	2	0.9%

41.4% respondents coming from the development category and 34.23% from the quality engineering background. Delivery (project manager/business analyst) role covers 18% from the sample. Operations related roles cover 4.5%. Scrum master role covers 0.9% and UI/UX role also covers 0.9% from the sample. The researcher observed that, majority of the respondents came from the development and quality engineering background. Table 4.1 summarize the distribution of job category across the sample.

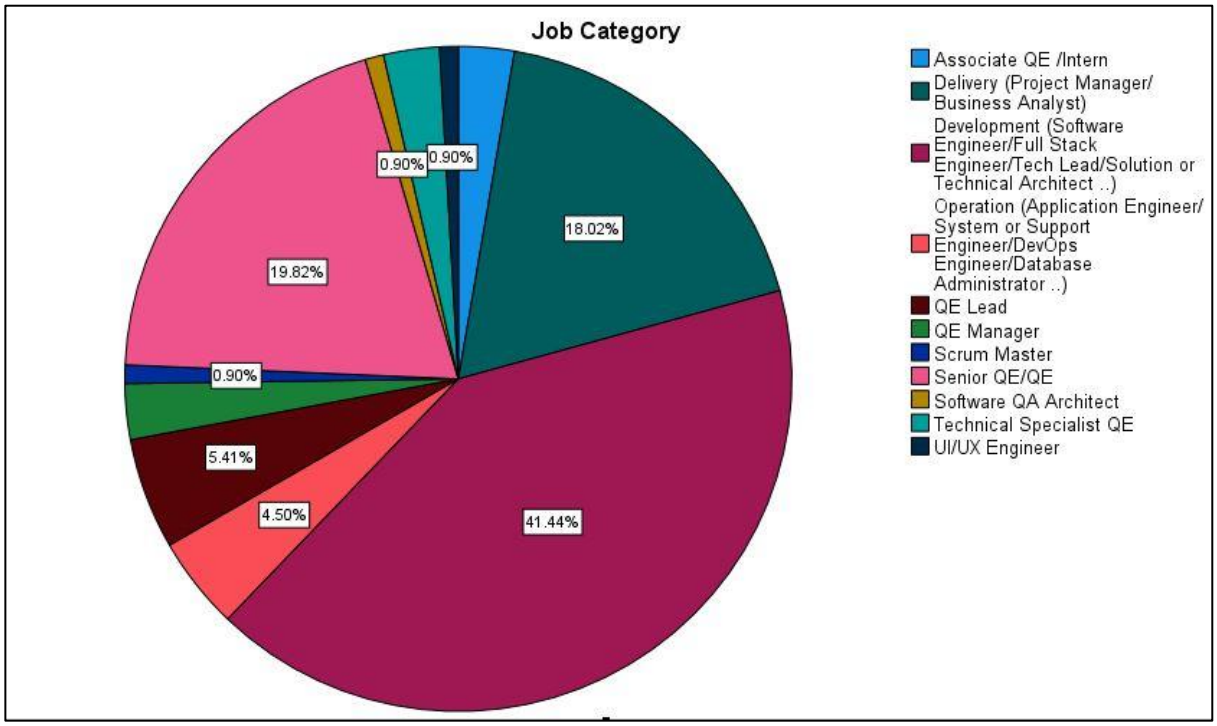

Figure 4. 3: Job Category

4.5.4. Classification of the Sample by Number of Employees in the Organization

Majority (27.03%) of the respondents stated that their organization is having employees between 0-100. 18.92% is having their organization employees between 101-300. Number of employees between 301-600 within their organization represents 20.72% from the sample. 18.02% of the responses saying that their organization is having employees between 601-1000. Minority (15.32%) stated that their organization is having more than 1000 employees. The researcher observed that most of the sample represents respondents from small and medium size organizations. Since most of the small and medium companies form Scrum teams, the researcher believes the respondents having enough experience to answer survey questions in a reliable way. Even large-scale companies also having Agile in scaled level, they also having the process related experience.

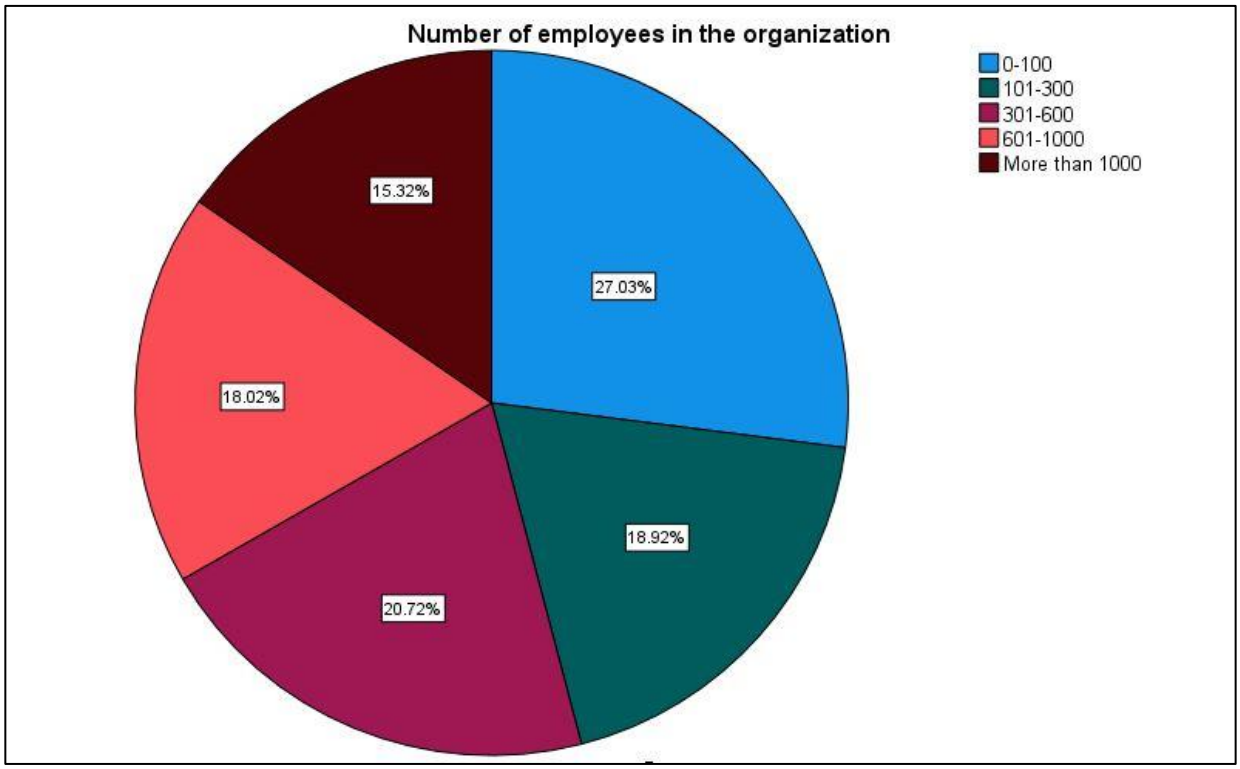

Figure 4. 4: Number of Employees in the Organization

4.5.5. Classification of the Sample by Years of Experience in IT Industry

The researcher can observe that almost all respondents having enough experience to respond about Agile Scrum related practices and software metric related processes. Table 4.2 depicts the distribution of the years of experience in IT Industry. Majority of the sample (32.4%) respondents stated that they have 3 to 5 years of experience in IT industry and the same percentage of respondents having the experience of 5 to 10 years.

Table 4. 2: Distribution of the Years of Experience in IT Industry

Experience	Frequency	Percent
Less than 3 years	26	11.7%
3 to 5 years	72	32.4%
5 to 10 years	72	32.4%
More than 10 years	52	23.4%

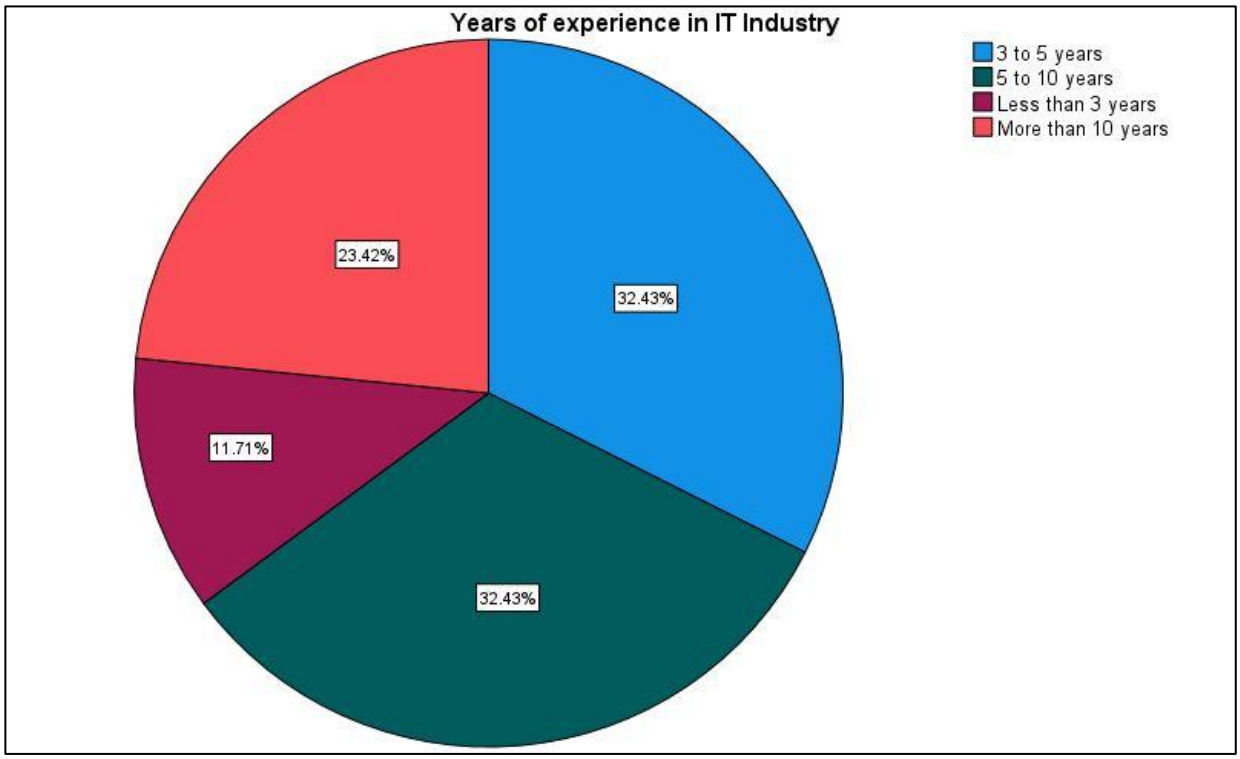

Figure 4. 5: Years of Experience in IT Industry

4.5.6. Classification of the Sample by Software Metric Awareness

Majority (81.98%) of the respondents having an awareness about software metrics as a terminology or as a practice followed. The researcher has been identified this fact as an added advantage for the response efficacy. 18.02% of the respondents are not aware about software metrics.

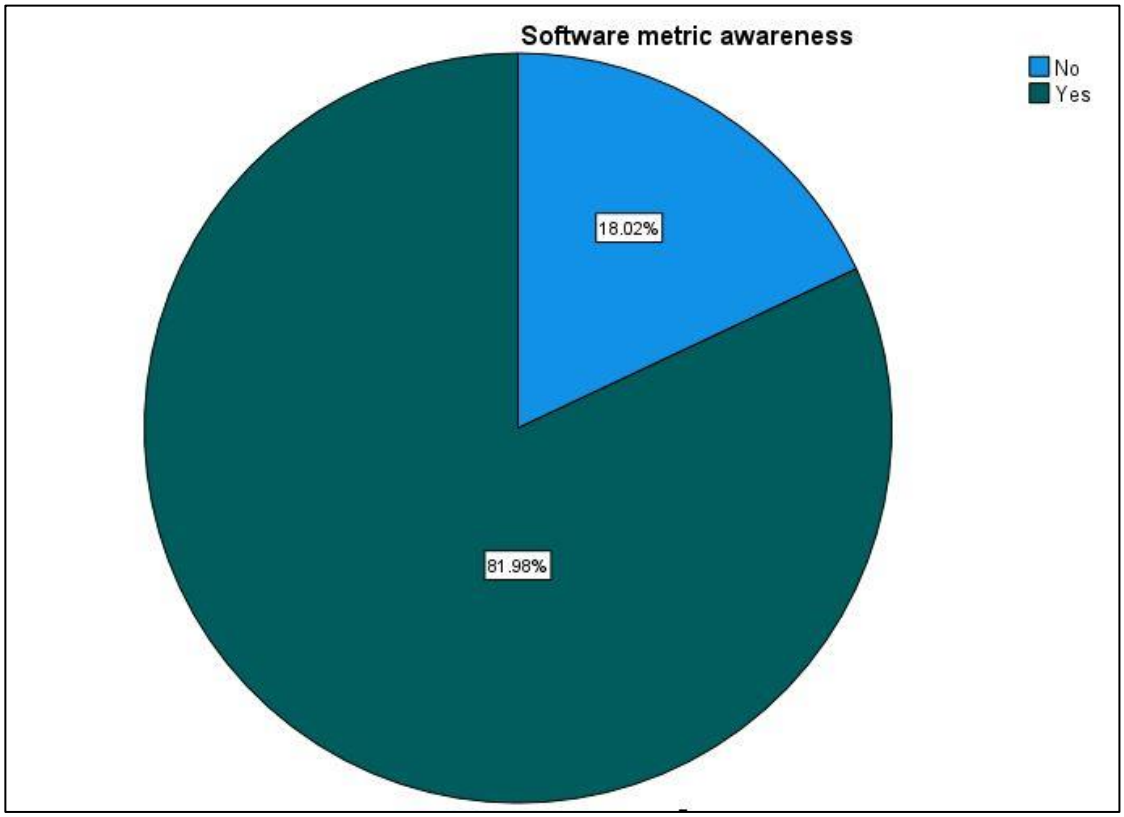

Figure 4. 6: Software Metric Awareness

4.6. Reliability Analysis

Reliability analysis has been conducted after the data collection from the pilot study. The purpose of reliability analysis is to find out the validity of questions before conducting the actual survey. In other words, measure the internal consistency between questions mapped for each IVs and the DV. Internal consistency or the reliability between questions are high if the Cronbach's alpha value is more than 0.7. Further information has been included in section 3.8.1. According to Table 4.3, all questions are having high internal consistency, so the actual survey has been conducted with the

refined questionnaire and the reliability analysis has been considered when doing the refinement.

Table 4. 3: Summary of finalized reliability analysis

<table>
<tr><th></th><th>Variable</th><th>Cronbach's Alpha</th></tr>
<tr><td rowspan="5">Independent</td><td>Process Adherence [Agile Scrum]</td><td>Reliability Statistics
<table><tr><th>Cronbach's Alpha</th><th>Cronbach's Alpha Based on Standardized Items</th><th>N of Items</th></tr><tr><td>.872</td><td>.879</td><td>16</td></tr></table></td></tr>
<tr><td>Required Infrastructure & Tools</td><td>Only one question has been mapped. No need to calculate alpha.</td></tr>
<tr><td>Effective utilization of metric information</td><td>Reliability Statistics
<table><tr><th>Cronbach's Alpha</th><th>Cronbach's Alpha Based on Standardized Items</th><th>N of Items</th></tr><tr><td>.699</td><td>.719</td><td>5</td></tr></table></td></tr>
<tr><td>Goal alignment/GQM</td><td>Only one question has been mapped. No need to calculate alpha.</td></tr>
<tr><td>Presence of professional bodies within the organization/upper management positive attitude towards the metric program</td><td>Reliability Statistics
<table><tr><th>Cronbach's Alpha</th><th>Cronbach's Alpha Based on Standardized Items</th><th>N of Items</th></tr><tr><td>.854</td><td>.860</td><td>7</td></tr></table></td></tr>
<tr><td>Dependent</td><td>Successful implementation of Scrum Metrics</td><td>Reliability Statistics
<table><tr><th>Cronbach's Alpha</th><th>Cronbach's Alpha Based on Standardized Items</th><th>N of Items</th></tr><tr><td>.794</td><td>.791</td><td>13</td></tr></table></td></tr>
</table>

4.7. Inferential Analysis

After the descriptive analysis for demographic data, inferential analysis has been carried out to derive conclusions beyond the sample data. In other words, derive generalized conclusions for the intended population. This analysis has been carried out

to identify correlation between variables and further continued for hypothesis testing. Regression analysis has been carried out to identify the relationship between independent and dependent variables.

4.7.1. Correlation Analysis

Correlations							
		Process Adherence	Infrastructure & Tools	Usefulness of the provided information	Goal alignment	Successful implementation of Scrum Metrics	Presence of professional bodies
Process Adherence	Pearson Correlation	1	.452**	.482**	.345**	.452**	.544**
	Sig.(2-tailed)		< .001	< .001	< .001	< .001	< .001
	N	222	222	222	222	222	222
Infrastructure & Tools	Pearson Correlation	.452**	1	.175**	.241**	.324**	.290**
	Sig.(2-tailed)	< .001		.009	< .001	< .001	< .001
	N	222	222	222	222	222	222
Usefulness of the provided information	Pearson Correlation	.482**	.175**	1	.434**	.561**	.471**
	Sig.(2-tailed)	< .001	.009		< .001	< .001	< .001
	N	222	222	222	222	222	222
Goal alignment	Pearson Correlation	.345**	.241**	.434**	1	.466**	.450**
	Sig.(2-tailed)	< .001	< .001	< .001		< .001	< .001
	N	222	222	222	222	222	222
Successful implementation of Scrum Metrics	Pearson Correlation	.452**	.324**	.561**	.466**	1	.543**
	Sig.(2-tailed)	< .001	< .001	< .001	< .001		< .001
	N	222	222	222	222	222	222
Presence of professional bodies	Pearson Correlation	.544**	.290**	.471**	.450**	.543**	1
	Sig.(2-tailed)	< .001	< .001	< .001	< .001	< .001	
	N	222	222	222	222	222	222
** Correlation is significant at the 0.01 level (2-tailed).							

Figure 4. 7: Summary of Correlations

Figure 4.7 shows the correlation between all independent variables and dependent variable. Since all variables are considered as continuous, Pearson's product-moment correlation have been used. From the IBM SPSS tool Pearson bivariate correlation

analysis have been used. ‘Process adherence [Agile Scrum]’ independent variable is having a positive moderate correlation with the dependent variable (Successful implementation of Scrum Metrics) according to the rule of thumb depicted in Figure 2.8. ‘Infrastructure & Tools’ variable is having a positive weak correlation with the dependent variable. ‘Effective utilization of metric information’, ‘Goal alignment/GQM’ and ‘Presence of professional bodies within the organization’ variables having a positive moderate correlation with the dependent variable according to the Figure 4.7.

4.7.2. Hypothesis Testing

In section 3.4, the hypotheses associated with this research have been defined. In order to validate the hypotheses, correlation analysis has been performed.

- **Hypothesis 1 - Goal Alignment / GQM**

$H1_a$ - Goal alignment / GQM has an impact on successful implementation of scrum metrics

$H1_0$ - Goal alignment / GQM does not have an impact on successful implementation of scrum metrics

		Goal_alignment	Successful_implementation_of_scrum_metrics
Goal_alignment	Pearson Correlation	1	.466**
	Sig. (2-tailed)		<.001
	N	222	222
Successful_implementation_of_scrum_metrics	Pearson Correlation	.466**	1
	Sig. (2-tailed)	<.001	
	N	222	222

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 4. 8: Summary of Correlation Analysis for the Variable Goal Alignment / GQM

According to the Figure 4.8, ‘Goal alignment / GQM’ and ‘Successful implementation of Scrum metrics’ having <.001 significant value which is less than 0.01. The

researcher accepts the alternative hypotheses $H1_a$ and rejects the null hypothesis $H1_0$.These two variables having a correlation of 0.466, which implies a positive moderate correlation. The researcher concluded goal alignment / GQM has an impact on successful implementation of scrum metrics.

- **Hypothesis 2 - Presence of Professional Bodies within the Organization / Upper Management Positive Attitude towards the Metric Program**

$H2_a$ - Presence of professional bodies within the organization / Upper management positive attitude towards the metric program has an impact on successful implementation of scrum metrics

$H2_0$ - Presence of professional bodies within the organization / Upper management positive attitude towards the metric program does not have an impact on successful implementation of scrum metrics

		Presence_of_professional_bodies	Successful_implementation_of_scrum_metrics
Presence_of_professional_bodies	Pearson Correlation	1	.543**
	Sig. (2-tailed)		<.001
	N	222	222
Successful_implementation_of_scrum_metrics	Pearson Correlation	.543**	1
	Sig. (2-tailed)	<.001	
	N	222	222

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 4. 9: Summary of Correlation Analysis for the Variable Presence of Professional Bodies within the Organization

According to the Figure 4.9, 'Presence of Professional Bodies within the Organization' and 'Successful implementation of Scrum metrics' having <.001 significant value which is less than 0.01. Due to that null hypothesis has been rejected and alternative hypothesis has been accepted. These two variables having a correlation of 0.543 and it leads to the conclusion that they've got a positive moderate correlation. This summary interprets that the presence of professional bodies within the organization / upper management positive attitude towards the metric program has an impact on successful implementation of scrum metrics.

- **Hypothesis 3 - Process Adherence [Agile Scrum]**

$H3_a$ - Process adherence [Agile Scrum] has an impact on successful implementation of scrum metrics

$H3_0$ - Process adherence [Agile Scrum] does not have an impact on successful implementation of scrum metrics

		Process_adherence	Successful_implementation_of_scrum_metrics
Process_adherence	Pearson Correlation	1	.452**
	Sig. (2-tailed)		<.001
	N	222	222
Successful_implementation_of_scrum_metrics	Pearson Correlation	.452**	1
	Sig. (2-tailed)	<.001	
	N	222	222

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 4. 10: Summary of Correlation Analysis for the Variable Process Adherence

Figure 4.10 shows 'Process Adherence' and 'Successful implementation of Scrum metrics' having <.001 significant value which is less than 0.01. The researcher rejected the null hypothesis and accepted the alternative hypothesis. Two variables having a 0.452 correlation which is moderate positive. The researcher concludes that the process adherence [Agile Scrum] has an impact on successful implementation of scrum metrics.

- **Hypothesis 4 - Effective Utilization of Metric Information in Decision Making about the Process Improvement**

$H4_a$ - Effective utilization of metric information in decision making about the process improvement has an impact on successful implementation of scrum metrics

$H4_0$ - Effective utilization of metric information in decision making about the process improvement does not have an impact on successful implementation of scrum metrics

		Usefulness_of_the_provided_Information	Successful_implementation_of_scrum_metrics
Usefulness_of_the_provided_Information	Pearson Correlation	1	.561**
	Sig. (2-tailed)		<.001
	N	222	222
Successful_implementation_of_scrum_metrics	Pearson Correlation	.561**	1
	Sig. (2-tailed)	<.001	
	N	222	222

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 4. 11: Summary of Correlation Analysis for the Variable Effective Utilization of Metric Information

According to the summary gained from IBM SPSS tool 'effective utilization of metric information' and 'Successful implementation of Scrum metrics' variables having <.001 significant value which is less than 0.01. Then the null hypothesis has been rejected and the alternative hypothesis $H4_a$ has been accepted. These two variables having a 0.561 correlation which is moderate positive and effective utilization of metric information in decision making about the process improvement has an impact on successful implementation of scrum metrics.

- **Hypothesis 5 - Required Infrastructure & Tools**

$H5_a$ - Required infrastructure and tools have an impact on successful implementation of scrum metrics

$H5_0$ - Required infrastructure and tools does not have an impact on successful implementation of scrum metrics

		Infrastructure_tools	Successful_implementation_of_scrum_metrics
Infrastructure_tools	Pearson Correlation	1	.324**
	Sig. (2-tailed)		<.001
	N	222	222
Successful_implementation_of_scrum_metrics	Pearson Correlation	.324**	1
	Sig. (2-tailed)	<.001	
	N	222	222

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 4. 12: Summary of Correlation Analysis for the Variable Required Infrastructure & Tools

According to Figure 4.12, 'Required Infrastructure & Tools' and 'Successful implementation of Scrum metrics' variables having <.001 significant value which is less than 0.01. Then the null hypothesis has been rejected and the alternative hypothesis $H5_a$ has been accepted. Both variables having a 0.324 correlation which is weak in strength and directed towards the positive direction. The researcher observed that required infrastructure and tools have an impact on successful implementation of scrum metrics.

4.7.2.1. Summary of Hypothesis Testing

Hypothesis	Null hypothesis	Alternative hypothesis	Correlation strength	Correlation direction
Goal alignment / GQM has an impact on successful implementation of scrum metrics	Rejected	Accepted	Moderate	Positive
Presence of professional bodies / Upper management attitude towards the metric program has an impact on successful implementation of scrum metrics	Rejected	Accepted	Moderate	Positive
Process adherence [Agile Scrum] has an impact on successful implementation of scrum metrics	Rejected	Accepted	Moderate	Positive
Usefulness of the provided information in making decisions about the improvement effort has an impact on successful implementation of scrum metrics	Rejected	Accepted	Moderate	Positive
Required infrastructure and tools has an impact on successful implementation of scrum metrics	Rejected	Accepted	Weak	Positive

Figure 4. 13: Summary of Hypothesis Testing

4.7.3. Multiple Linear Regression

In the regression analysis phase, multiple linear regression has been used to identify the relationship and the variance between dependent variable and independent variables. With the multiple linear regression, the researcher can get an idea about the influence that an independent variable has on the dependent variable and the strength of the influence as well. The researcher uses five independent variables and one dependent variable for the regression analysis, so the model overfitting won't occur when deriving the model.

4.7.3.1. Testing Assumptions for Multiple Linear Regression

Before performing the multiple linear regression, there are four assumptions to be tested on the data set. If those assumptions have been met, the feasibility to perform the multiple linear regression could be justified. Regression residuals must be normally distributed (normality), linear relationship has been assumed between dependent variable and the independent variables (linearity), residuals should be homoscedastic and distributed in a rectangular shape (homoscedasticity) and independent variables should not be too highly correlated (absence of multicollinearity) are the assumptions (statistics solutions, 2021).

- **Assumption 1: Normality**

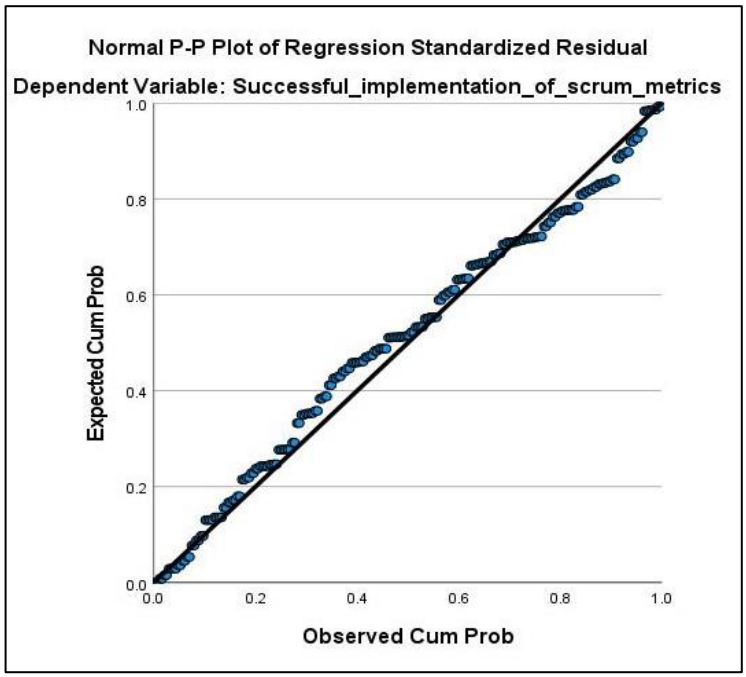

Figure 4. 14: Normal P-P Plot of Regression Standardized Residuals

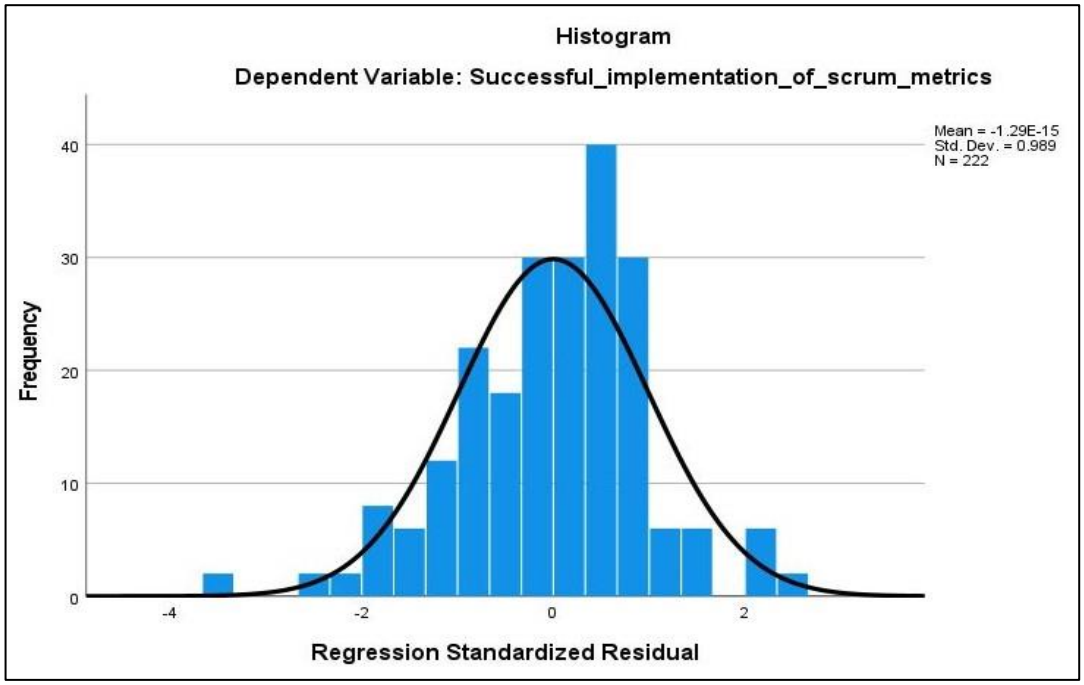

Figure 4. 15: Histogram for Regression Standardized Residuals

According to Figure 4.14, the dots are closer to the diagonal line, which depicts the residuals are distributed normally. The researcher can observe that the first assumption 'normality' has been met. Figure 4.15 also depicts the normality of regression standardized residual distribution.

- **Assumption 2: Linearity**

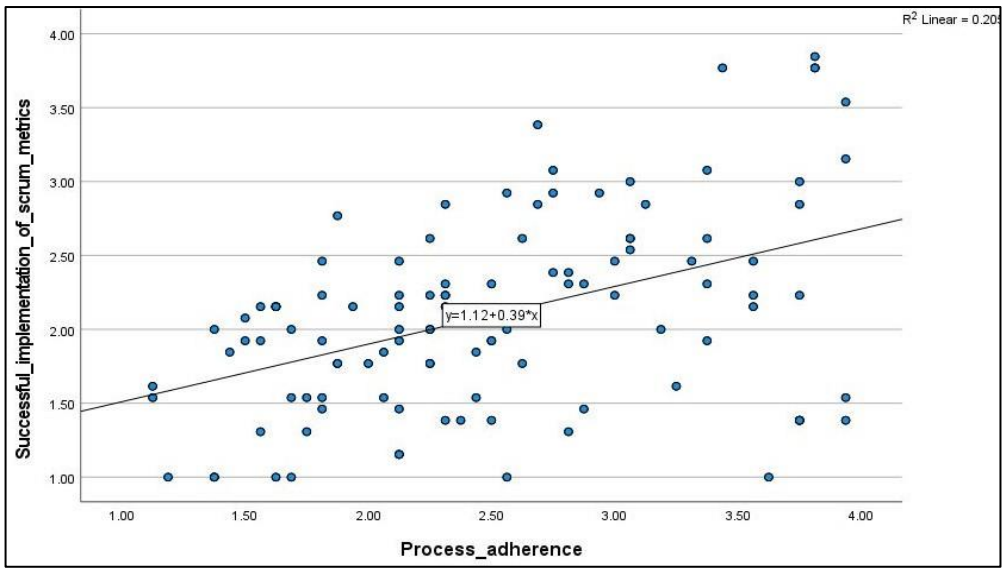

Figure 4. 16: Scatter Plot for Process Adherence vs Successful Implementation of Scrum Metrics

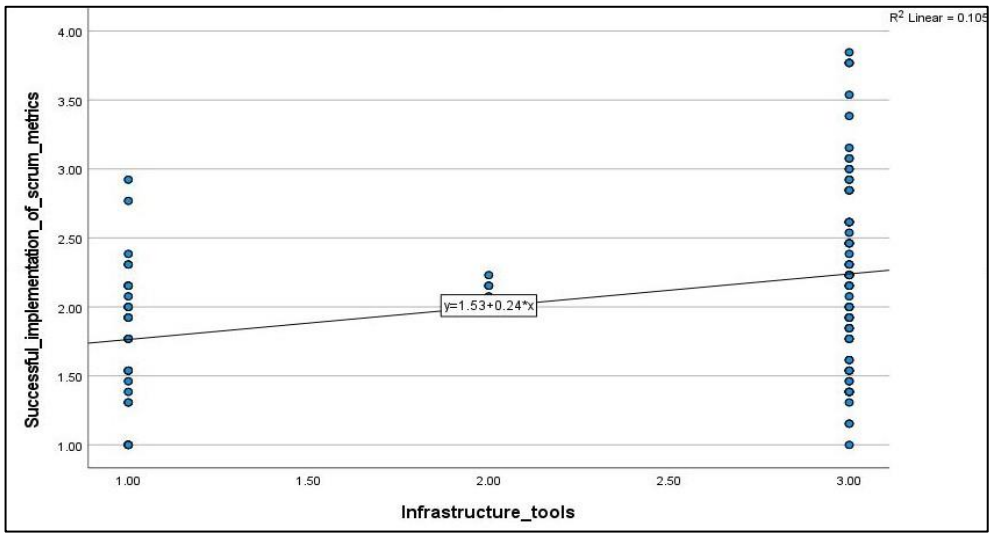

Figure 4. 17: Scatter Plot for Infrastructure & Tools vs Successful Implementation of Scrum Metrics

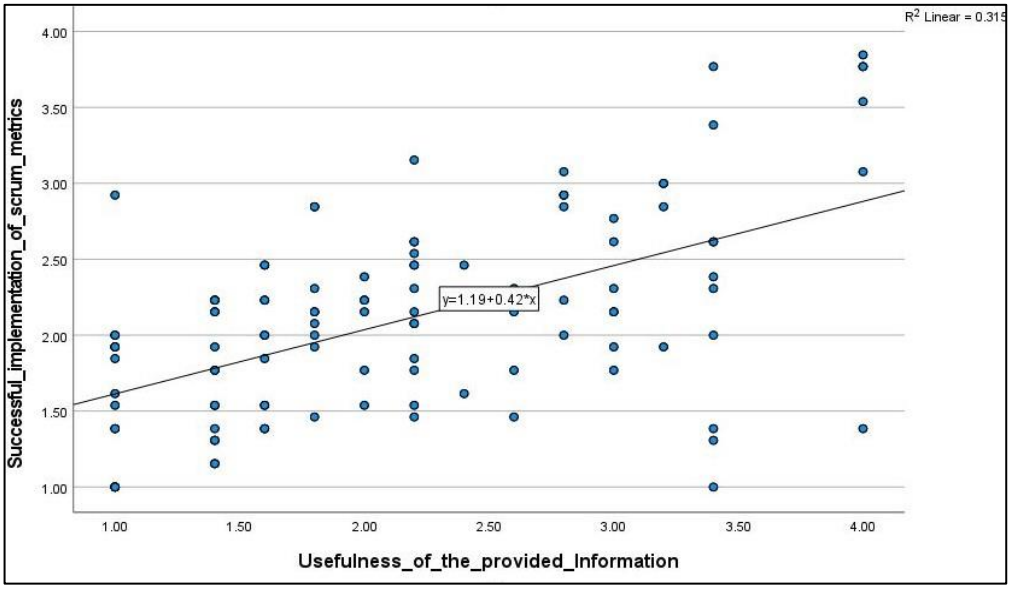

Figure 4. 18: Scatter Plot for Effective Utilization of Metric Information vs Successful Implementation of Scrum Metrics

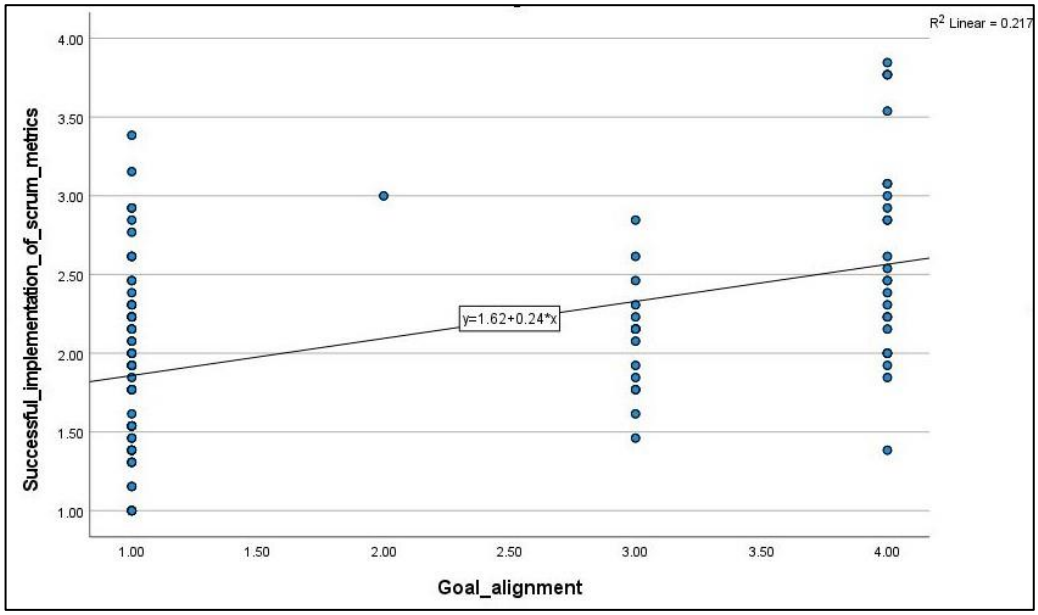

Figure 4. 19: Scatter Plot for Goal Alignment vs Successful Implementation of Scrum Metrics

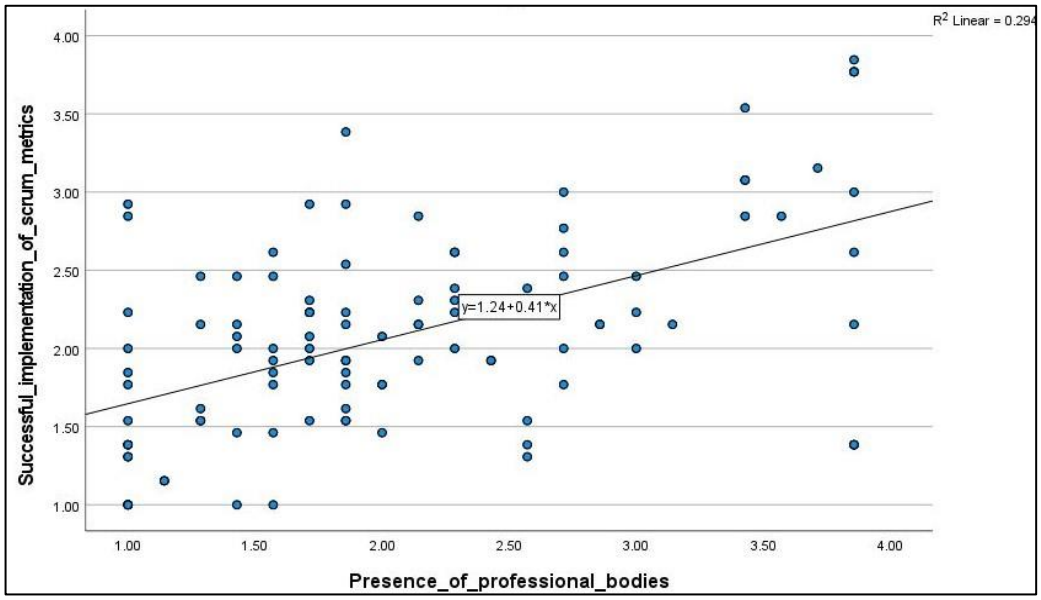

Figure 4. 20: Scatter Plot for Presence of Professional Bodies within the Organization vs Successful Implementation of Scrum Metrics

According to Figure 4.16, Figure 4.17, Figure 4.18, Figure 4.19 and Figure 4.20, the scatter plots depict positive linear relationship between each independent variable and

the dependent variable. The researcher observed that the second assumption "linearity" has been met.

- **Assumption 3: Homoscedasticity**

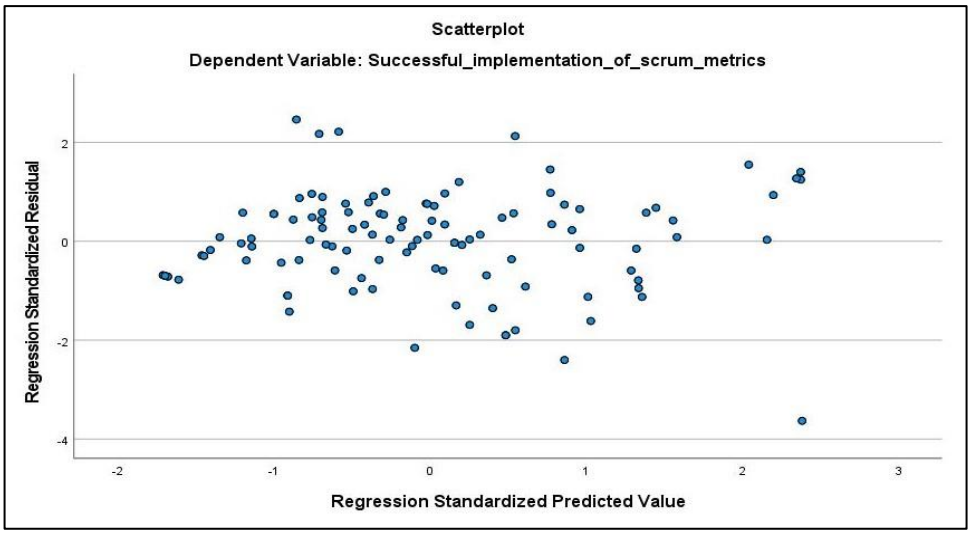

Figure 4. 21: Scatter Plot for Variation of Residuals

According to Figure 4.21, residuals predicted by the model increase against the standardized residuals obtained alongside the X-axis. The variation of the residuals is roughly similar, and the distribution of dots is a random but not a cone shaped one. The researcher concludes that the 3rd assumption 'homoscedasticity' has been met.

- **Assumption 4: Absence of Multicollinearity**

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	.675	.127		5.311	<.001		
	Process_adherence	.033	.058	.038	.560	.576	.551	1.815
	Infrastructure_tools	.100	.042	.136	2.397	.017	.779	1.284
	Usefulness_of_the_provided_Information	.247	.047	.329	5.311	<.001	.653	1.531
	Goal_alignment	.082	.030	.163	2.777	.006	.723	1.383
	Presence_of_professional_bodies	.192	.049	.254	3.941	<.001	.600	1.665

a. Dependent Variable: Successful_implementation_of_scrum_metrics

Figure 4. 22: Scatter Plot for Variation of Residuals

According to Figure 4.22, VIF (Variance Inflation Factor) for each independent variable does not exceed 10. The researcher can observe that the 4th assumption, 'absence of multicollinearity' has been met.

4.7.3.2. Multiple Linear Regression Analysis

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.678[a]	.460	.447	.48980	2.013

a. Predictors: (Constant), Presence_of_professional_bodies, Infrastructure_tools, Goal_alignment, Usefulness_of_the_provided_Information, Process_adherence

b. Dependent Variable: Successful_implementation_of_scrum_metrics

Figure 4. 23: Model Summary for Regression Analysis

"In the multiple linear regression, model summary table depicts the strength of the relationship between model and dependent variable" (Model Summary - IBM Documentation, 2016). R (multiple correlation coefficient) represents the linear relationship between obtained and model predicted value for the dependent variable. According to Figure 4.23, R value obtained from the derived model is 0.678. The researcher concludes that the correlation between the observed and the predicted value of dependent variable is strong.

R^2 (coefficient of determination) represents the variance of dependent variable (successful implementation of scrum metrics) which could be predicted by the independent variables (process adherence, infrastructure and tools, goal alignment, presence of professional bodies and usefulness of the provided information). R^2 value obtained from the model is 0.460 and it indicates that the 46% percent of variation of the dependent variable could be predicted by the independent variables mentioned in the Figure 4.21. R^2 interprets the model accuracy as well as the model fit, and this implies the observed data well fit to the model.

In the model specification, the researcher performed the Durbin-Watson test to identify the degree of autocorrelation. Figure 4.23 depicts that the Durbin-Watson value is 2.013, which means less degree of autocorrelation can be detected.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	44.089	5	8.818	36.755	<.001[b]
	Residual	51.820	216	.240		
	Total	95.909	221			

a. Dependent Variable: Successful_implementation_of_scrum_metrics

b. Predictors: (Constant), Presence_of_professional_bodies, Infrastructure_tools, Goal_alignment, Usefulness_of_the_provided_Information, Process_adherence

Figure 4. 24: Analysis of Variance (ANOVA)

According to the Figure 4.24, significance level obtained from analysis of variance is <0.001 which is smaller than the significance level 0.01 (significance level considers for the current research). This reading implies that, the alternative hypotheses validated in the section 4.7.2, could be accepted with further justifications. In other words, independent variables ('process adherence, 'infrastructure and tools', 'goal alignment, 'presence of professional bodies within the organization' and 'effective utilization of metric information') having a significant influence on the dependent variable ('successful implementation of scrum metrics').

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	.675	.127		5.311	<.001		
	Process_adherence	.033	.058	.038	.560	.576	.551	1.815
	Infrastructure_tools	.100	.042	.136	2.397	.017	.779	1.284
	Usefulness_of_the_provided_Information	.247	.047	.329	5.311	<.001	.653	1.531
	Goal_alignment	.082	.030	.163	2.777	.006	.723	1.383
	Presence_of_professional_bodies	.192	.049	.254	3.941	<.001	.600	1.665

a. Dependent Variable: Successful_implementation_of_scrum_metrics

Figure 4. 25: Summary of Coefficients

According to the Figure 4.25, coefficient values of predictors ('effective utilization of metric information', 'presence of professional bodies within the organization' and 'goal alignment') are significant to the derived model since the significance level

considers for the current research is 0.01. Rest of the independent variables are not significant to the model.

- **Regression Equation**

DV - Dependent variable
PA - Process adherence
IT - Infrastructure & tools
EUMI - Effective utilization of metric information
GA - Goal alignment
PPB - Presence of professional bodies within the organization

$$DV = 0.675 + 0.033 \times PA_{iv} + 0.100 \times IT_{iv} + 0.247 \times EUMI_{iv} + 0.082 \times GA_{iv} + 0.192 \times PPB_{iv}$$

5. RECOMMENDATIONS AND CONCLUSION

5.1. Conclusion

According to section 1.5, identifying factors that influence the successful implementation of Scrum metrics is a major objective associated with this research. Data analysis process described in chapter 4 implied that 'Process adherence', 'Effective utilization of metric information', 'Goal alignment', 'Presence of professional bodies within the organization' having a moderate positive correlation with the dependent variable ('Successful implementation of scrum metrics'). 'Infrastructure & tools' having a weak positive correlation with the dependent variable.

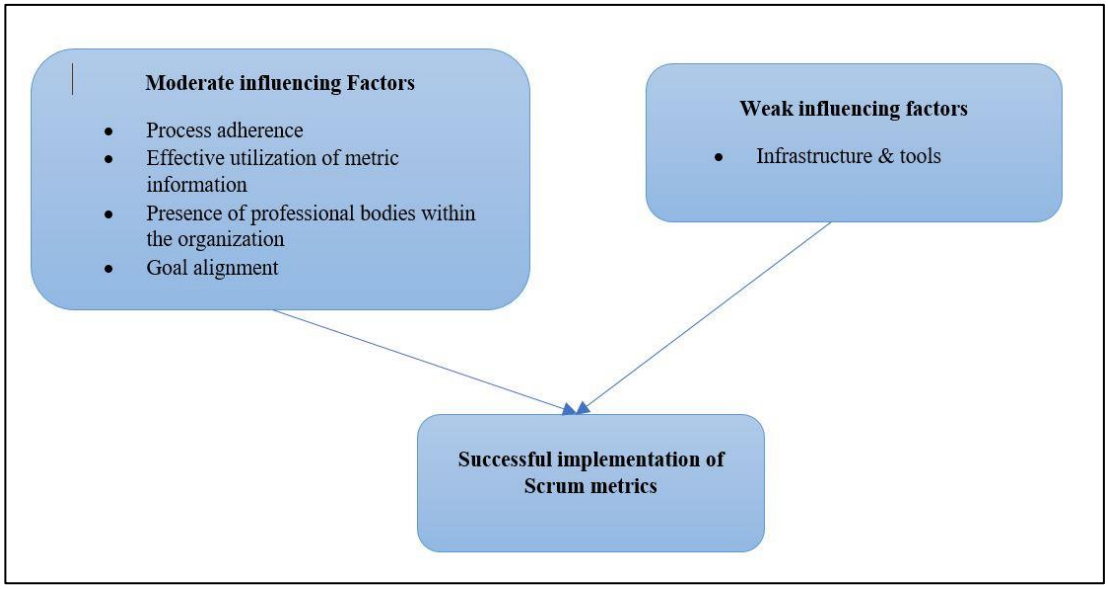

Figure 5. 1: Summary of Influencing Factors for Successful Implementation of Scrum Metrics

The researcher concludes that the factors depicted in the conceptual model in the section 3.3, having an influence for the dependent variable ('successful implementation of scrum metrics'). The conceptual model derived through the literature review and the discussions with the subject matter experts. After the data analysis phase, hypotheses derived from the conceptual model have been accepted.

5.1.1. Accomplish Research Objectives

In the section 1.5, the researcher describes about the research objectives. After the data analysis, insights were derived related to the research objectives. Further elaborated facts related to research objectives described below.

- **Find the existence of software metric programs in the Sri Lankan IT industry who follow Agile Scrum methodology**

One of the major of objective of this research is to find out the existence of software metric programs within Sri Lankan IT industry. Not only about the existence but also find out about the awareness about software metric programs is part of this objective. According to section 4.5.6., 81.98% of the respondents aware about software metrics but 59.4% of respondents aware about software metric programs. The researcher concludes that, awareness about software metrics among IT professionals are high but awareness about software metric programs are low. Based on responses, software metric programs do exist in Sri Lankan IT industry.

- **Find factors that influence the successful implementation of Scrum metrics**

The researcher formulated the conceptual model for the research with five independent variables and the dependent variable (successful implementation of scrum metrics). After the data collection and analysis, specially through inferential analysis, the strength and the direction of independent variables have been identified and summarized with Figure 5.1. 'Process adherence', 'Effective utilization of metric information, 'Presence of professional bodies within the organization' and 'Goal alignment' having a positive moderate influence on the 'Successful implementation of scrum metrics'. 'Infrastructure & tools' having a positive low influence over the successful implementation of scrum metrics. Conclusion would be the independent variables derived at the initial stage of the research, influencing the successful implementation of scrum metrics.

- **Provide recommendations to implement software metric programs in the Agile scrum environment**

Identifying factors that influence the successful implementation of scrum metrics, would help to derive recommendations to implement software metric programs in Agile scrum environment. Through the data analysis phase, the researcher identified the strength and the direction of independent variables with the dependent variable.

In order to implement software metric programs within Agile scrum environment, the factors identified throughout the research should be adopted with considering the strength of the correlation. This should be the foundation and gradually should implement an ongoing process to develop and improve the metric program. Section 5.2 describes these facts in a detailed manner.

5.2. Recommendations

According to the current research, 'process adherence [Agile Scrum]' has a moderate positive correlation with the successful implementation of scrum metrics. If an organization needs to implement scrum metrics, first need to consider establishing a robust process and adhere to the Agile Scrum process properly. To establish this, the Agile Scrum values should be understood by the entire organization. From top to the bottom, that mindset should be conveyed and committed to that process. The employees should be educated about the Agile scrum process through workshops and by encouraging them to follow certain certifications. The teams should be willing to self-drive without waiting for a conventional team lead to pinpoint them what to do. The entire organization should tend to follow scrum ceremonies properly and the scrum artifacts like product backlog and sprint backlog should be maintained properly. The 'Process adherence' is not a one-time activity but should be an ongoing activity with continuous improvements based on the evaluation of the process.

According to this study, the researcher identified that depending on the organization size, the process adaption should be customized. For small or medium-sized organizations, the conventional process adherence for Agile scrum could be utilized. But for large-scale organizations, Agile scrum at a scaled level should be utilized. Unless Agile Scrum related best practices, values and principles cannot ingest into the organization so it will make a hindrance to implement scrum metrics and related metric programs successfully.

Since 'effective utilization of metric information' also has a moderate positive correlation with the successful implementation of scrum metrics, the organization should have a well-established norm to utilize metric data for decision making. The members within the scrum teams as well as the upper management should have an understanding, of how the metric data could be used to identify, predict and improve product quality as well as productivity. The organization should educate employees and need to disclose the organizational missions. If the organization has a long-term goal to adapt data-driven decision making, should communicate that with employees and educate how to achieve it, then the employees can adhere to that. Not only Scrum teams but also upper management should tend to make decisions based on metrics

rather than the gut feeling. Frequent evaluation of the process of decision making based on metric data and improve the process based on that also recommended in this context. Through increasing the usefulness/effectiveness of the provided information, successful implementation of scrum metrics could be increased.

'presence of professional bodies within the organization' has a positive moderate correlation with the successful implementation of scrum metrics. Investment for process improvement is recommended and should establish the mindset to gain the proper return on investment. Upper management should gain the well-interpreted metric data to drive decisions within the organization. Another recommendation is to a frequent analysis of project status based on metric data and refine the metric program accordingly. Upper management should establish the commitment to the metric program in the policy level within the organization.

'Goal alignment/GQM' factor also has a positive moderate correlation with the successful implementation of scrum metrics. When selecting metrics for a project, the goal question metric approach should be considered. The scrum team should set goals to be achieved and formulate a set of questions about how those goals could be achieved, then select a set of metrics based on that. Within an organization, from project to project this could be different so the GQM approach should be reviewed and refined from the project level. If this approach could be refined, successful implementation of scrum metrics could be achieved at the project level. To achieve this, all members of the scrum team should be educated about the process so they can actively participate in the process.

'Infrastructure & tools' having a positive weak correlation with the successful implementation of scrum metrics. Implement required infrastructure and tools for metric programs to collect and process metric data is recommended. Implement relevant dashboards to visualized insights specially for the upper management would help to successful implementation of scrum metrics. Proper infrastructure and tools (JIRA, Power BI, Azure DevOps etc.) utilization would increase the return on investment and make the metric program management easier and more reliable.

5.3. Limitations of the Research

The researcher identified certain limitations associated with the current study. During the initial phase, the identified sample size is 382, where confidence level is 95% and the confidence interval is 5%, but number of responses receive was 222. The confidence level associated with the research is 85% and the confidence interval is 5%.

The researcher concludes that if the expected number of responses were received the accuracy of the data analysis could have been increased.

The questionnaire consist of 37 questions and the respondents' focus towards the questions might get reduced in between so the responses given might not be based on the actual perspective.

4.5% of the respondents represent Operations (Application Engineer/System or Support Engineer/DevOps Engineer/Database Administrator) sector within the IT industry. Sometimes operations sector does not directly involve with Agile scrum processes so that would affect the authenticity of responses.

5.4. Future Works

According to the study, 81.98% respondents aware about software metrics but 59.4% of the respondents aware about software metric programs. As a future research direction, it is worth to identify the reasons for the lack of awareness about software metric programs within IT industry.

Since most of the large-scale organizations practice Agile scrum in scaled level, the researcher having a concern to extend the research to identify the factors effecting the successful implementation of scrum metrics in environments where practicing Agile in scaled level.

It is worthwhile to identify a framework to implement software metrics within organizations regardless of the development process followed and provide recommendations to implement sustainable metric programs.

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APPENDIX A: SURVEY QUESTIONNAIRE

Recommendations to Implement Software Metric Programs in Agile Scrum Environment

I am a postgraduate student of the Department of Computer Science and Engineering, University of Moratuwa. As partial fulfilment of the Master of Business Administration (MBA) in IT program, currently, I am engaged in a research study on;

"Recommendations to Implement Software Metric Programs in Agile Scrum Environment".

Therefore, I would appreciate it if you could spare a few minutes of your precious time to complete and submit the below questionnaire.

All the information you provide will remain completely confidential and will be used solely for academic purposes only.

Thank You,

I.R Nadeesha Prabhashini Gnanaratne | nadeesha.18@cse.mrt.ac.lk
MBA in IT (2018)
Department of Computer Science & Engineering
University of Moratuwa
Sri Lanka

* Required

Section 1: Demographic Information

1. Years of experience you have in IT Industry *

- Less than 3 years
- 3 to 5 years
- 5 to 10 years
- More than 10 years

2. Job Category *

- Operation (Application Engineer/ System or Support Engineer/DevOps Engineer/Database Administrator ...)
- Quality Assurance
    - -Associate QE /Intern
    - -Senior QE
    - -QE Lead
    - -Technical Specialist QE
    - -QE Manager
- Development (Software Engineer/Full Stack Engineer/Tech Lead/Solution or Technical Architect ...)
- Delivery (Project Manager/ Business Analyst)
- Other:

3. What is the highest level of education you have completed? *

- Bachelor's degree
- Master's Degree
- MPhil / PhD

4. How many employees are there in your organization? *

- 0-100
- 101-300
- 301-600
- 601-1000
- More than 1000

5. Which category does your organization belong to? *

- Product-based

- Service-based
- Both
- Other:

6. Have you had working experience in an Agile scrum environment? *

- Yes
- No

7. Which development process are you following right now? *

- Scrum
- Kanban
- XP
- Waterfall
- Other

8. Are you aware of software metrics? *

- Yes
- No

9. Which Professional certifications do you have? *

- ISTQB
- Certified Scrum Master
- SAFe Certifications
- PMP/CAPM
- Other

10. Are you aware of software metric programs? *

- Yes
- No

Section 2: Process Adherence [Agile Scrum]

<table>
<tr><td>11</td><td>Project team perform scrum events within the project *
<table>
<tr><td></td><td>Strongly agree</td><td>Agree</td><td>Undecided</td><td>Disagree</td><td>Strongly disagree</td></tr>
<tr><td>Daily scrum</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Backlog refinement</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sprint Planning</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sprint review</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sprint retrospective</td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>12</td><td>Project team sets and understands the sprint goal and how success will be measured *
Strongly Agree
Agree
Undecided
Disagree
Strongly Disagree</td></tr>
<tr><td>13</td><td>Project team have a well-groomed backlog with priorities and dependencies in order *
Strongly Agree
Agree
Undecided
Disagree
Strongly Disagree</td></tr>
</table>

<table>
<tr><td>14</td><td>Project team has a good understanding of velocity, and that it reflects things like leave and team meetings *
Strongly Agree
Agree
Undecided
Disagree
Strongly Disagree</td></tr>
<tr><td>15</td><td>Team members sketch out tasks for all stories, bugs, and tasks that come into the sprint *</td></tr>
</table>

	• Strongly Agree • Agree • Undecided • Disagree • Strongly Disagree
16	Once a decision or plan is made, team captures that information in the project management or collaboration tool (Jira/Azure DevOps) * • Strongly Agree • Agree • Undecided • Disagree • Strongly Disagree
17	Team Don't pull in too many stories, overestimate velocity, or pull in tasks that can't be completed in the sprint * • Strongly Agree • Agree • Undecided • Disagree • Strongly Disagree
18	Team break down stories that are large or have high uncertainty * • Strongly Agree • Agree • Undecided • Disagree • Strongly Disagree
19	The product owner describes the objective (or goal) of the sprint and what backlog items contribute to that goal * • Strongly Agree • Agree • Undecided • Disagree • Strongly Disagree

20	The development team plans the work necessary to deliver the sprint goal * • Strongly Agree • Agree • Undecided • Disagree • Strongly Disagree
21	The development team understand how they can or cannot deliver sprint goal * • Strongly Agree • Agree

	• Undecided • Disagree • Strongly Disagree
22	Team member have the idea of DOD * • Strongly Agree • Agree • Undecided • Disagree • Strongly Disagree

Section 3: Required Infrastructure & Tools

23	Team uses project management /collaboration tools JIRA/Azure DevOps) * • Strongly Agree • Agree • Undecided • Disagree • Strongly Disagree

Section 4: Effective utilization of metric information

24	Scrum metrics collectively provide information in making decisions about the improvement effort to the project * • Strongly Agree • Agree • Undecided • Disagree • Strongly Disagree
25	The team utilize scrum metrics to make decisions about the team *

	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
Productivity					
Product quality					
Predictability					

26	The team drives based on the evidences gained through the metrics rather than the gut feeling * • Strongly Agree • Agree • Undecided • Disagree • Strongly Disagree

Section 5: Goal alignment/GQM

27	There is always a purpose for the used scrum metrics within the project * • Strongly Agree • Agree • Undecided • Disagree • Strongly Disagree

Section 6: Successful implementation of Scrum Metrics

28	Defining successful measurement frameworks are to start small with the most important measurements and grow slowly as the organization matures * • Strongly Agree • Agree • Undecided • Disagree • Strongly Disagree
29	Project team has a good understanding about what metrics are important * • Strongly Agree • Agree • Undecided • Disagree • Strongly Disagree
30	Project team uses scrum metrics *

	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
Velocity					
Work capacity					

Sprint level effort burndown						
Escaped defects & Defect density						
Defect severity Index						
Work in progress						
Unplanned work						
Skill versatility						
Delivery on time						
Focus factor						
Level of automation						

Section 7: Presence of professional bodies within the organization

31	Investments in process improvement activities lead to improved quality and reduced rework and lifecycle costs * • Strongly Agree • Agree • Undecided • Disagree • Strongly Disagree
32	Software managers are motivated to use metric information in their decision making * • Strongly Agree • Agree • Undecided • Disagree • Strongly Disagree

33	Organization is having an appropriate procedure to collecting metrics data, analyze it and utilize it for process improvement * • Strongly Agree • Agree • Undecided • Disagree

	• Strongly Disagree
34	Metric status and results are provided to management on a regular basis * • Strongly Agree • Agree • Undecided • Disagree • Strongly Disagree
35	Scrum metrics are important factors to drive the project successfully * • Strongly Agree • Agree • Undecided • Disagree • Strongly Disagree
36	Organization continuously improve the metric program * • Strongly Agree • Agree • Undecided • Disagree • Strongly Disagree
37	Scrum metrics help to increase the product quality * • Strongly Agree • Agree • Undecided • Disagree • Strongly Disagree

APPENDIX B: COMPANY LIST

#	Company Name
1	Wiley Global Technology (Pvt) Ltd
2	Pearson Lanka (Pvt) Ltd
3	Geveo Australasia (Pvt) Ltd
4	Virtusa (Pvt) Ltd
5	IFS R&D
6	99x Technology (Pvt) Ltd
7	Sysco Labs (Pvt) Ltd
8	Mitra Innovations
9	hSenid Business Solutions (Pvt) Ltd
10	CAMMS
11	Aeturnum Lanka (Pvt) Ltd
12	ISM APAC (Pvt) Ltd
13	Embla Software Innovations (Pvt) Ltd
14	Zone 24x7 (Pvt) Ltd
15	Inova IT Systems
16	Bhasha Lanka (Pvt) Ltd
17	John Keells IT
18	DirectFN (Pvt) Ltd
19	Cero 360 (Pvt) Ltd
20	PickMe (Pvt) Ltd
21	CMS (Pvt) Ltd
22	Tiqri (Pvt) Ltd
23	Cloud Solutions International
24	Hitachi Digital (Pvt) Ltd

Less than 10% of the respondents represent each company mentioned above, so responses are not too biased to a specific company.