# Framework for Applicability of Agile Scrum Methodology: A Perspective of Software Industry

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***Abstract*—Agile scrum methodology has been evolved over the time largely through software industry where it has grown and developed through empirical progress. The research work presented in this paper has proposed a framework by identifying critical elements for applicability of agile scrum methodology in software industry. The proposed framework is based on four elements, i.e. technical, people, environmental and organizational. The proposed framework is validated through statistical analysis, i.e. Structural Equation Modeling (SEM) after collecting data from software industry personals who are working on agile methodologies. The research concludes that 15 out of 18 hypothesis were found significant which include Training & Learning, Societal Culture, Communication & Negotiation, Personal Characteristics, Customer collaboration, Customer commitment, Decision Time, Team Size, Corporate Culture, Planning, Control, Development, Information Administration, and Working Environment.**

***Keywords*—Scrum agile methodology; framework; software industry; critical factors***

## I. Introduction

The main focus of agile methodology is customer satisfaction through continuous delivery. The use of agile method creates high quality product and environment [15]. In software development, scrum is an iterative methodology that depends on agile principles included in the Agile Manifesto [5], [18]. Moreover, Scrum is described as a light development method [8], [31] that provide complete insight, quick adaptability, working within small, dedicated autonomous and self-organized teams [4]. According to Sverrisdottir [25], Scrum has a strong position which can be defined in terms of visibility, effective process, fast development, roles, collaboration emphasis and understanding [26]. There are three parts of scrum teams which are scrum master, product owner and team member.

Companies have taken benefit from scrum because it enhances the quality and efficiency. Moreover, scrum is the mainstream of agile methodology in software industry. By adopting Scrum, organizations are getting more prominent benefit, collaboration, correspondence, participation of the development group, effectiveness, self-confidence among the improvement group and product management [7].

In this research, efforts have been made to address the following questions:

RQ1: What are the influencing factors for the applicability of agile scrum methodology from the perspective of software industry?

RQ2: Does there any framework exist in the literature for the applicability of agile scrum methodology?

The rest of the research paper is organized as: Section II provides background and motivation of this research. Section III describes analysis and identification of critical factors. Section IV explains proposed framework. Section V describes results and discussions. Finally, Section VI concludes research discussed in this paper.

## II. Background and Motivation

The literature available on agile scrum methodology and framework is limited to a few numbers of studies [1], [4], [12]. These studies include: Sincharoenpanich [12], Janeth López-Martínez [10], Dyba and Dingsoyr [17], Cho and Juyun Joey [20], Qumer et al. [30], Vlietland and van Vliet [23], Moe [34], Rola [28], Lei et al. [11], Campanelli et al. [22], Sverrisdottir [25], Chan et al. [21], Misra et al. [35].

In Sincharoenpanich et al. [12], three factors were used for implementing scrum, i.e. organization, people and technical [33]. Organizations are enhancing the effectiveness and quality of project management by implementing the Scrum methodology. Organizational problem covers the ineffective Scrum meeting, lack of client participation, poor workplace, and poor document maintenance. People problem covers the ineffective communication and lack of needed skills. Technical problem covers the poor planning/working schedule and inefficient sprint planning [27].

Janeth López-Martínez [10] described scrum's adoption issues and recommended a framework consisting of people, project, process and organization [19].

Dyba and Dingsoyr [17] in their research on scrum, grouped studies into four themes that is introduction and adoption, social and human factors, perceptions on agile methods and comparative studies. In another study, it is found that the introduction of Scrum led to decrease of overtime, and developers participated in study suggested the use of Scrum in future projects. The developers were more satisfied with the product, and identified that Scrum process [2] promoted more

communication and customer involvement. The study also described the differences in traditional and agile development on the basis of communication, organizational structure, development model and manages the quality.

According to Vlietland and van Vliet [24], scrum is the common agile method which by principle allows the IT development centers to pay attention on IT functionality. The framework is divided in seven parts, i.e. standardized emphases, littler, visit discharges, regular reflection and adjustment, cross-practical groups, consistent development and tracking, parallel testing and constant joining. The scrum framework additionally gives little direction at the alignment of working procedures between Scrum groups.

Lei et al. [11] highlighted the differences between scrum and kanban which are two dominant agile project management techniques. The research evaluates the efficiency of kanban and scrum techniques in terms of its implications for project delivery and management. Numerical analysis was performed on survey responses. The factors included in proposed framework were project scope, budget, quality, schedule, risk, and resources [19].

Misra et al. [35] discussed two success factors which are organizational and people factors. Organizational factor consists of Customer satisfaction, Commitment, Collaboration, Team Distribution and Size, Decision Time, Control, Corporate Culture and Planning. People factor consists of Learning and Training, Societal Culture, Personal Characteristics, Communication & Negotiation and Competency.

Apart from these studies, we were unable to find studies which were relevant to our research. These papers were highly suitable to address our research questions and in finding critical factors to develop framework for applicability of agile scrum methodology.

## III. Analysis and Identification of Critical Factors

The relevant research papers, identification of critical factors and extraction of key factors are provided in Table 1.

TABLE I. Critical Factors Identified from Literature and their Mapping on Factors

| Research Paper | Critical Factors | Key Factors |
|---|---|---|
| "Critical Factors for Implementing the Scrum Software Development Methodology." | Three factors are used for implementing scrum i.e. people of that organization, organization itself and technical details.<br>Organizational Problem<br>✓ Customer Commitment<br>✓ Management Support<br>✓ Tools and Technology support<br>✓ Work place | **Organizational factor**<br>**People factor** |
| | People Problem<br>✓ Learning and training<br>✓ Communication<br>Technical Problem<br>✓ Requirement<br>✓ Testing<br>✓ Development | **Technical factor** |
| "Problems in the Adoption of Agile-Scrum Methodologies: A Systematic Literature Review." | Recommended an agile adoption framework to be used for:<br>✓ People<br>✓ Process<br>✓ Project<br>✓ Organization | **People factor**<br>**Process factor**<br>**Organizational factor** |
| "Empirical Studies of Agile Software Development: A Systematic Review." | Traditional improvement and agile differences on the basis of primary supposition are:<br>✓ Organization Method<br>✓ Information Administration<br>✓ Correspondence<br>✓ Development Model<br>✓ Manage the Quality | **Technical factor**<br>✓ Information administration<br>✓ Development model.<br>✓ Manage the quality.<br>**People factor**<br>✓ Correspondence |
| "An Exploratory Study on Issues and Challenges of Agile Software Development with Scrum." | Factors can be included in this research are:<br>• Human Resource Management Factor<br>✓ Training<br>✓ Collaboration<br>✓ Multiple Responsibilities<br>✓ Structured Development Process Factor<br>✓ Scrum Framework<br>✓ Unit and Integration testing<br>✓ Formal code review<br>✓ Documentation<br>✓ Use cases<br>✓ Coding standard<br>✓ Information System and Technology Factor<br>✓ Communication<br>✓ Bug tracking System<br>✓ Version Control | **People factor**<br>✓ Human Resource Management<br>**Process factor**<br>✓ Structured development process<br>**Technical factor**<br>✓ Information system and technology factor<br>**Environmental factor** |

| Research Paper | Critical Factors | Key Factors |
|---|---|---|
| | system<br>✓ Environmental Factor<br>✓ Customer involvement<br>✓ Common Tool and Problems between Teams<br>✓ Working Environment | |
| "An Evaluation of the Degree of Agility in Six Agile Methods and its Applicability for Method Engineering." | This element checks the hold of a technique as far as:<br>✓ Team Size<br>✓ Project Size<br>✓ Code Style<br>✓ Development Style<br>✓ Abstract Method<br>✓ Technology Environment<br>✓ Business Culture<br>✓ Physical Environment | **Technical factor**<br>✓ Development Style<br>✓ Technology Environment<br>✓ Code style<br>**Organization factor**<br>✓ Team size<br>✓ Project size<br>✓ Business culture<br>**Environmental factor**<br>✓ Physical environment |
| "A Teamwork Model for Understanding an Agile Team: A Case Study of a Scrum Project." | Dickinson and McIntyre model can utilized seven centre elements of teamwork which are:<br>✓ Leadership<br>✓ Monitoring<br>✓ Coordination<br>✓ Communication<br>✓ Team orientation<br>✓ Remarks<br>✓ Backup. | **Organization factor**<br>✓ Leadership<br>✓ Monitoring<br>✓ Team orientation<br>**People factor**<br>✓ Communication<br>✓ Coordination |
| "Conceptual Model of Working Space for Agile (Scrum) Project Team". | Highlighted the significance of Distributed agile software development having a framework for<br>✓ Collaboration<br>✓ Correspondence | **Organization factor**<br>✓ Collaboration<br>**People factor**<br>✓ Correspondence |
| "The Role of the Product Owner in Scrum-Comparison | In software development, Scrum has a strong position which can be defined as | **Technical factor**<br>✓ Fast development |

| Research Paper | Critical Factors | Key Factors |
|---|---|---|
| Between Theory and Practices." | ✓ Visibility<br>✓ Effective process<br>✓ Fast development<br>✓ Roles<br>✓ Collaboration emphasis<br>✓ Understanding<br>The most important measure is the functionality of the product; this measure followed by other factors such as<br>✓ Quality<br>✓ Time/schedule<br>✓ Financial aspects.<br>There are three parts of scrum teams are:<br>✓ Scrum master<br>✓ Product owner<br>✓ Team member | **People factor**<br>✓ Understanding Quality<br>**Organization factor**<br>✓ Financial aspects<br>✓ Collaboration<br>✓ Time/schedule |
| "Acceptance of Agile Methodologies: A Critical Review and Conceptual Framework." | The framework proposed in this research addresses three factors which are:<br>✓ Motivation related<br>✓ Ability related<br>✓ Opportunity related factors.<br>The details of these factors is given below:<br>1. Motivation related factors:<br>✓ Subjective norm<br>✓ Career importance<br>✓ Organizational culture<br>✓ Top management support<br>✓ Voluntaries<br>2. Ability related factors:<br>✓ Experience<br>✓ Self-efficacy of software development management<br>✓ Training<br>✓ External Support<br>3. Opportunity related factors<br>• Teamwork<br>✓ Mutual Understanding<br>✓ Arduous Relationship | **Organization factor**<br>✓ Motivation Related<br>**People factor**<br>✓ Ability Related<br>✓ Opportunity Related |

| Research Paper | Critical Factors | Key Factors |
|---|---|---|
| | ✓ Negotiation | |
| "Identifying Some Important Success Factors in Adopting Agile Software Development Practices." | In this paper, two success factor have been discussed which are:<br>Organizational factor<br>✓ Customer satisfaction<br>✓ Decision Time<br>✓ Customer collaboration<br>✓ Team Distribution<br>✓ Team Size<br>✓ Customer commitment<br>✓ Corporate Culture<br>✓ Control<br>✓ Planning<br>People factor<br>✓ Training & Learning<br>✓ Societal Culture<br>✓ Communication & Negotiation<br>✓ Personal Characteristics<br>✓ Competency | **Organization factor**<br>**People factor** |

## IV. Proposed Framework

After identification of critical factors and extraction of key factors as discussed in previous section, next step was to develop framework. The key factors were analyzed in detail and four factors were selected to develop framework. The selected key factors finally included in the proposed framework which are people, organizational, technical and environmental. The proposed framework is shown in Fig. 1.

### A. Justification of Framework Variable

The suitability of selected key factors is discussed below.

#### 1) People factor

People are most significant part of any organization and project. People make decisions and work on the projects and eventually decide whether organization goals are reached or not [14], [20]. This factor is divided into four sub factors which includes: Training & Learning, Societal Culture, Communication & Negotiation and Personal Characteristics [28], [35].

##### *a) Personal characteristics*

Personal characteristics can be measured in terms of communication skills, honesty, collaborative attitude, motivation, eagerness to learn and sense of responsibility [35].

##### *b) Communication and negotiation*

Communication and Negotiation can be measured in terms of:

- People who work in similar time area.
- Quickly and effectively with support, customers, developers, operations, business areas and management [28].
- Communicate with others with great motivation and faith [32].

##### *c) Societal culture*

Societal culture can be measured in term of progressive attitude, generally communicative and team members with comparable social culture [35].

##### *d) Training and learning*

Training and learning can be measured with the determination of the readiness to train team members and continuously learn from one another through professionally guided negotiation and mentoring than formal trainings [35].

#### 2) Technical factor

In this factor, there are two sub factors which are development and information administration.

##### *a) Development*

The key factors included in the development are:

- Team should create development plan of encountered.
- Problems during scrum meetings [12].
- Short, iterative and people centric development [20].
- Sustainable development is promoted throughout.
- Organization.
- Processes, approaches and easy design are practices of software development methodology [17].

##### *b) Information administration*

Information administration is about heavy documentation based on tacit knowledge management [9], [17], [20].

#### 3) Organizational factor

In this factor, there are nine sub-factors which are Customer Satisfaction, Collaboration, Commitment, Decision Time, Corporate Culture, Team Distribution and Size, and Planning and Control [12], [35].

##### *a) Customer satisfaction*

Customer satisfaction discusses how organization provides software development projects high precedence in order to achieve customer satisfaction [35].

##### *b) Customer collaboration*

Customer Collaboration is about how customer can closely collaborate with scrum team members [28], [35]. Scrum methodology has characteristics of providing help for product development, i.e. close collaboration between the development and organization teams, approval of changing requirement, good communication, and proper documentation of the project [12], [14].

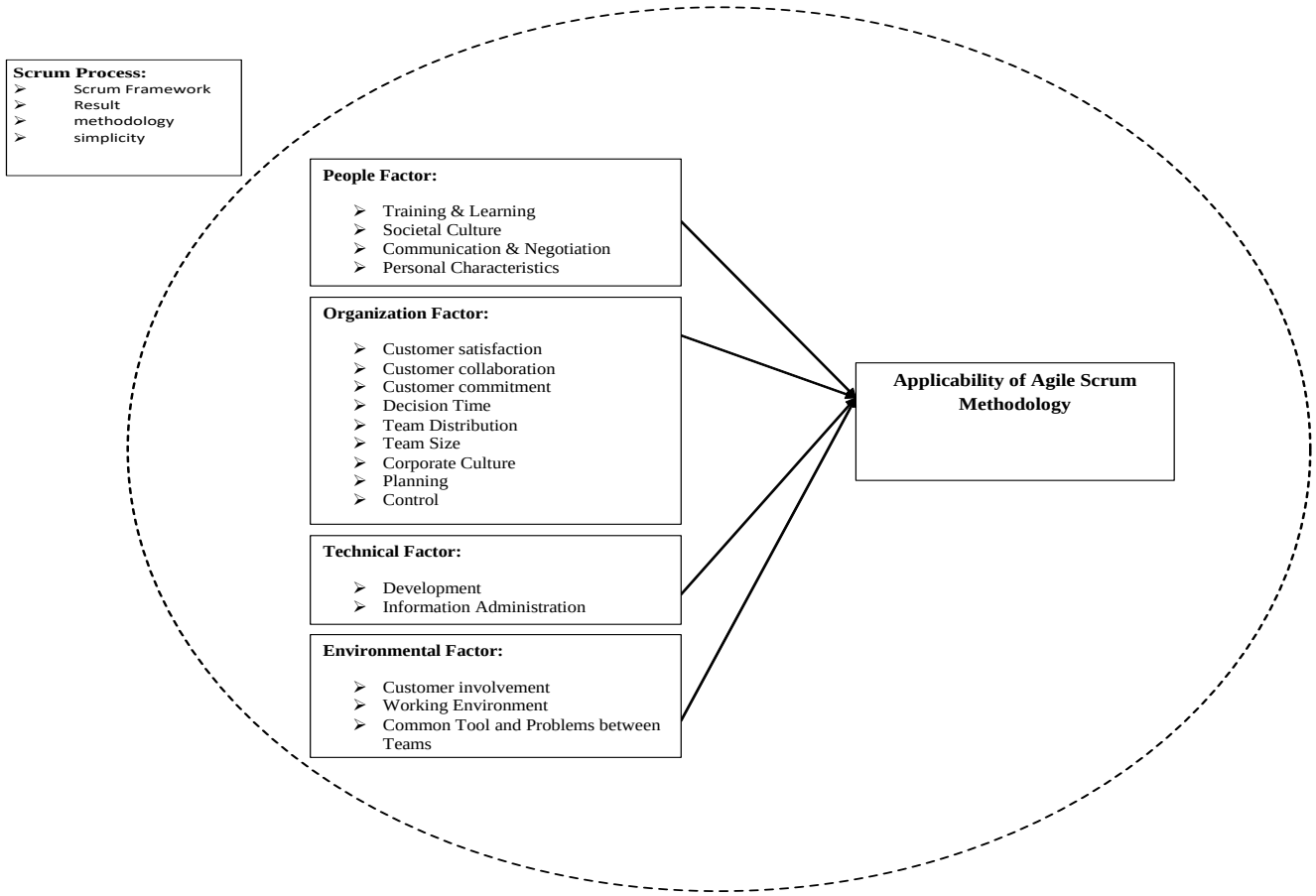


Fig. 1. Framework for applicability of agile scrum methodology.

*c) Customer commitment*

Customer commitment is about engagement of customers in the project [35]. A good relationship between team members and customers will help the project to run smoothly [32].

Customer commitment facilitates teams to avoid risk of delivering dissatisfying solutions.

*d) Decision time*

Decision time is about how to make vital projects decision quickly within short time period [35].

*e) Team distribution*

Team distribution is about organizational involvement in distributed international projects that will be affected by the cultural and political state [35]. How closely other team members interacting within or outside the organization are geographically located. The geographic distribution and the location of the teams are significant factors because of local politics, behavioral habit, situations and culture that greatly affect efficiency of the project team [35].

*f) Team size*

Team size is about the number of team member in a group which may have significant impact on the level of correspondence between team members. If there are more team members in a project then it is recommended to break them into smaller teams [29], [30], [35].

*g) Corporate culture*

Corporate culture defines how organization persuades immediate feedback from customers. Organizational culture can be user centric.

*h) Control and planning*

Control and planning discusses that software development teams relies on casual, informal and undocumented strategies and team has qualitative control [35].

*4) Environmnental factor*

In this factor, there are three main factors which are customer involvement, working environment and common tool and problems between teams [20]. Organization provides high quality environment to the team members [29], [30] by fulfilling needs of team member and trusting them to complete their jobs. The developer ought to work in an environment that suits them and is persistent. They require trust of other team members to accomplish high confidence level [20]. The organization ought to recognize how much documentation is suitable for each project based on the context of the development environment [20].

TABLE II. HYPOTHESIS TABLE

| Hypothesis | Description | Path |
|---|---|---|
| H1 | Training & Learning will have a positive influence over the People Factor. | TL → PF |
| H2 | Societal Culture will have a positive influence over the People Factor. | SC → PF |
| H3 | Communication & Negotiation will have a positive influence over the People Factor. | CN ↔ PF |
| H4 | Personal Characteristics will have a positive influence over the People Factor. | PC → PF |
| H5 | Customer satisfaction will have a positive influence over the Organizational Factor. | CS → OF |
| H6 | Customer collaboration will have a positive influence over the Organizational Factor. | CC → OF |
| H7 | Customer commitment will have a positive influence over the Organizational Factor. | CC → OF |
| H8 | Decision Time will have a positive influence over the Organizational Factor. | DT → OF |
| H9 | Team Distribution will have a positive influence over the Organizational Factor. | TD → OF |
| H10 | Team Size will have a positive influence over the Organizational Factor. | TS → OF |
| H11 | Corporate Culture will have a positive influence over the Organizational Factor. | CC → OF |
| H12 | Planning will have a positive influence over the Organizational Factor. | P → OF |
| H13 | Control will have a positive influence over the Organizational Factor. | C → OF |
| H14 | Development will have a positive influence over the Technical Factor. | D → TF |
| H15 | Information Administration will have a positive influence over the Technical Factor. | IA → TF |
| H16 | Customer involvement will have a positive influence over the Environmental Factor. | CI → EF |
| H17 | Working Environment will have a positive influence over the Environmental Factor. | WE → EF |
| H18 | Common Tool and Problems between Teams will have a positive influence over the Environmental Factor. | CTP → EF |

*a) Customer involvement*

Customer involvement is very important to the success of the product. This part discusses how customers are fully involved in software development and perform tasks mutually in development team. According to agile method, customer should be part of product development [12]. Organizations ought to request customers to take part in the decision making process and devise quality approach for the execution of their project [20].

*b) Working environment*

Working environment means providing an environment that supports and helps team members in accomplishing their tasks [20]. An open working environment is recommended by the Scrum method which can facilitate developers to work easily, help in self-organization, and promotes communication [12].

*c) Common tools and problems between teams*

Common tools and problems play an important role in Environmental factor. The use of tools can help team members in reducing number of bugs in software development. Similarly, collaboration among team members can help in resolving conflicts [20].

### B. Research hypothesis

The key factors selected for proposed framework were used to develop hypothesis. The derived hypotheses are provided in Table 2.

## V. RESULTS AND DISCUSSION

The data analysis is performed by employing statistical techniques. There are two ways to conduct data analysis through statistical methods:

- ✓ Descriptive Statistics
- ✓ Inferential Statistics

In this research, both statistical methods were used for data analysis.

### A. Descriptive statistics

Descriptive statistics uses information to explain it in the form of graphs and diagrams. This method is used in this research to define the frequency of each field of survey items.

*1) Reliability analysis*

The common method of internal consistency [6] is to measure reliability of each factor of the framework and its correlation with other survey items. Cronbach alpha technique is used to measure the reliability of the factors/constructs [13]. SPSS 20.0 is used to perform reliability analysis [16]. According to Cronbach alpha the value greater than 0.6 is considered "Acceptable". Table 3 shows the values of Cronbach alpha.

TABLE III. FACTORS INTERNAL CONSISTENCY

| Factors | Cronbach Alpha Value | Cronbach alpha based on standardized items | Level of Reliability |
|---|---|---|---|
| Communication & Negotiation | 0.756 | 0.759 | Good Reliability |
| Personal Characteristics | 0.811 | 0.811 | Good Reliability |
| Corporate Culture | 0.675 | 0.670 | Acceptable Reliability |
| Development | 0.666 | 0.660 | Acceptable Reliability |
| All Items | 0.829 | 0.883 | Good Reliability |

### B. Inferential statistics

The analytical techniques are confirmatory factor analysis, hypothesis testing, and model fitting which are forms of inferential statistics. The inferential statistics is used to draw conclusions from a sample of subjects.

*1) Structural equation modeling*

The structural equation modeling (SEM) describes relations between latent and observed variables in different kinds of theoretical models. Different theoretical models are tested and hypothesized in Structural Equation Modeling (SEM). For analyzing conceptualized hypotheses, SEM model involves different statistical test such as path analysis, confirmatory factor analysis, explanatory analysis and regression analysis. In this study, the model is measured through confirmatory factor analysis (CFA). AMOS 20.0 is used to perform the confirmatory factor analysis (CFA) using the Maximum likelihood estimation (MLE) process [3].

*a) Fitness of SEM model*

The Model Fitness shows the values of Goodness of Fit Index (GFI), Tucker-Lewis Index (TLI), CMIN/DF, Adjusted Goodness of Fit Index (AGFI), Comparative Fit Index (CFI) and Root Mean Square Error of Approximation (RMSEA). The Fitness of SEM model of data is resolved through few metrics presenting how data is very well proposed in model and does model fit to data. The model fitness indexes values are shown in Table 4.

TABLE IV. DIFFERENCE MODEL FITNESS

| Factors | My Values | Recommended Values |
|---|---|---|
| TLI | 0.757 | =>0.90 |
| GFI | 0.833 | =>0.90 |
| CMIN/DF | 1.504 | <= 3 |
| AGFI | 0.808 | =>0.8 |
| CFI | 0.777 | =>0.9 |
| RMSEA | 0.049 | <=0.08 |

Thus, the value of RMSEA is less than 0.08 and CMIN/DF value less than 3 means the data represent a good model fit of data.

*b) Testing hypotheses*

Table 5 shows the regression weights, the hypothesis testing is performed, 15 out of 18 hypotheses are significant in determining the acceptance of Framework for applicability of Agile Scrum Methodology. However, hypothesis H9 (Team Distribution), H16 (Customer Involvement), and H18 (Common Tool and Problems between Teams) were found to be insignificant.

TABLE V. REGRESSION WEIGHTS

| Hypothesis | AMOS Relationship | P | Status |
|---|---|---|---|
| H1 | People Factor→ Training & Learning | 0.015 | Significant |
| H2 | People Factor→ Societal Culture | 0.015 | Significant |
| H3 | People Factor→ Communication & Negotiation | 0.013 | Significant |
| H4 | People Factor→ Personal Characteristics | 0.017 | Significant |
| H5 | Organizational Factor→ Customer satisfaction | | |
| H6 | Organizational Factor→ Customer collaboration | 0.029 | Significant |
| H7 | Organizational Factor→ Customer commitment | 0.025 | Significant |
| H8 | Organizational Factor→ Decision Time | 0.020 | Significant |
| H9 | Organizational Factor→ Team Distribution | 0.058 | Not significant |
| H10 | Organizational Factor→ Team Size | 0.037 | Significant |
| H11 | Organizational Factor→ Corporate Culture | 0.028 | Significant |
| H12 | Organizational Factor→ Planning | 0.015 | Significant |
| H13 | Organizational Factor→ Control | 0.016 | Significant |
| H14 | Technical Factor → Development | 0.017 | Significant |
| H15 | Technical Factor → Information Administration | 0.014 | Significant |
| H16 | Environmental Factor → Customer involvement | 0.072 | Not Significant |
| H17 | Environmental Factor → Working Environment | 0.017 | Significant |
| H18 | Environmental Factor → Common Tool and Problems between Teams | 0.070 | Not Significant |

## VI. CONCLUSION

Agile scrum methodology is most commonly used in software industry however, framework for Agile Scrum methodology is lacking in existing literature. This research has proposed a framework for applicability of agile scrum methodology based on four factors, i.e. organizational, technical, people and environmental.

These four factors are further divided into sub factors. People factor consists of “training and learning”, “personal characteristics”, “communication and negotiation” and “societal culture”. Organizational factor consists of customer

collaboration, commitment, satisfaction, decision time, team distribution, size, and planning and control. Organizational factor is needed in order to perform collaboration within organization. Environmental factor consists of three sub factors, i.e. "customer involvement", "working environment" and "common tools and problems". This factor is required as customers are fully involved in software development. Technical factor consists of two sub factors, i.e. "development" and "information administration".

All these factors act as key building blocks in the proposed framework. To prove the applicability and authenticity of proposed framework, survey questions related to each factor were designed. The participants involved in survey were experts from software industry. The results from the survey were validated through reliability (Cronbach alpha) and SEM model of AMOS.

From the results, it can be concluded that the proposed framework addresses the existing gap in literature by providing a generic framework that could be used by organizations for applicability of agile scrum methodology. This research contribution opens an opportunity to conduct more extensive research in this area.

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