

## Using Qualitative System Dynamics in the Development of an Agile Teamwork Productivity Model

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**Abstract**— Improvement in agile software development will not be achieved without considering that there is a large number of factors affecting agile teamwork productivity. The objective of this study is to explore what factors influence agile teamwork productivity, and how these factors interacted. This is achieved through a two-phase approach. The first phase involves reviewing relevant literature, performing a set of in-depth interviews with agile team members and conducting a survey to identify productivity factors. The survey has been administered to 60 respondents from 18 agile software companies in Bangladesh. The second phase involves the construction of qualitative system dynamics model (causal loop diagrams) of agile teamwork productivity with the findings from the first phase to analyze the productivity influence factors. The findings from the first phase reveal the most perceived factors are motivation, team effectiveness and team management. Social hierarchy culture influences self-managed agile team from correct implementation of agile practice. Although, the most followed organizational structure is horizontal, Scrum is leading agile practice among the participating companies. Lack of management support is found to be the most mentioned reason for any failed agile project. The resulting qualitative model is expected to provide more insight into the agile teamwork dynamics and establish a basis for a further quantitative modelling.

**Keywords**— agile teamwork productivity; influence factors; qualitative system dynamics; social hierarchy culture; team effectiveness; causal loop diagram.

### I. INTRODUCTION

The objective of any software company is to be efficient and productive by being cost effective and time optimum. Agile process places more emphasis on people factors in the project. Therefore, agile teamwork productivity is one of the most important aspects in achieving project success at different stages of a project. Improvement in agile software development will not be achieved without considering that there is a large number of factors affecting agile teamwork productivity. It is important to identify the most influential ones among the factors and develop policies to manage them. A better understanding of the factors influencing agile teamwork productivity can enable team management to determine where efforts are to be directed in order to improve productivity.

This paper explores which factors influence agile teamwork productivity and how these factors impact productivity of agile team. It thereby revises and extends previous contribution [1], by an in-depth discussion of the complex inter-related structure of different factors. A System Dynamics (SD) based approach has been used to model agile teamwork productivity influence factors. SD introduced by Jay Forrester of the MIT in the 1960s as a modelling and simulation methodology for studying complex system [2].

There are different factors that affect the productivity of traditional software development teams as pointed out by previous researchers [3][4]. Although agile approaches have become popular with a wide variety of organizations, there is insufficient evidence on the effect of agile productivity factors [5]. However, agile teamwork productivity is a function of various controllable and uncontrollable factors [6]. Software productivity across many projects, culture and practice varies extensively even if the same type of software is developed [7]. The software industry is also different from country to country as are the resource availability, the laws, which govern it and the developer's cost [8]. In addition, actual productivity measurement becomes more difficult when agile software developers perform knowledge-related tasks (e.g., creating, storing, sorting, retrieving, applying and acquiring knowledge) where the product is usually intangible, rarely has single way of doing it, and it is difficult to quantify [6]. Since knowledge is complex and hard to evaluate, it is difficult to interpret the productivity of the agile team member's simply by Source Line Of Code (SLOC) or function points produced per unit of time/cost [7]. Measuring the same code gives different results with different code counters since there is no universal standard for Line Of Code (LOC) [9]. Story points, used in agile software development, are very subjective and metrics based on story points cannot be used to compare between teams, units or organizations [10].

It would be helpful if the productivity influence factors can be controlled by the Project Manager (PM) when establishing and managing an agile project. "You cannot control what you cannot measure" [11]. Nevertheless, it is difficult to measure agile teams' productivity [10]. In view of the fact that agile software development empowers self-managing teams instead of forming traditional project management. Consequently, project has less control on the

management level. To overcome this limitation and domination project activities, a clear list of influences on productivity in agile software development is needed. Agile team members also should learn to interpret and direct productivity factors regularly as they are self-managed. The researchers have highlighted the value of team learning to help organization achieving team effectiveness, better ways to resolve problem and improve productivity.

In an earlier work [1], identification of agile teamwork productivity influence factors was conducted on seventeen software companies in Bangladesh. The study showed the main perceived factors impacting on agile team member's productivity were team effectiveness, team management, motivation and customer satisfaction. Lack of management support was found to be the most mentioned reason for any failed agile project.

This extension of the previous work added more software companies and survey respondents from agile teams to provide a better understanding of agile teamwork productivity influence factors. The qualitative model of agile teamwork productivity is developed from these sources using commanding cause and effect feedback loop.

Moreover, if the cause-effect relationships between the factors can be clarified and quantified, quantitative models or formulations could be established. Therefore, the future contribution of this research shall provide a strategic (quantitative) model that tells the PM in advance about the degree of impact these factors will have on teamwork. Using the proposed model, PM may identify the origin of a decrease in productivity. As a result, the agile teamwork productivity may be improved by implementing of management strategies.

The rest of this paper is organized as follows. Section II includes a literature review, Section III presents the research method and design. Section IV describes the survey results and Section V explores the structure of the qualitative SD model. Section VI presents causal loop diagram validation and Section VII describes some limitations of this work. Finally, Section VIII contains the conclusion and future work.

## II. LITERATURE REVIEW

Agile adoption is growing within organizations for accelerating software delivery and productivity, it is essential to discern whether the factors influencing productivity remain the same in all context [6].

Dingsoyr et al. described agile software development as a sociotechnical system comprised of human (socio) and technical entities, the culture of the society in which the system works is crucial [12]. Technological interventions do not increase sociotechnical system effectiveness if they are not supported by social (self-managing team and group) components of the system. Thus, recent focus on agile software development has increased interest in analysing self-managing agile team and how to effectively make team productive [12].

According to the Agile Manifesto, it focuses on individuals and interactions between people (teamwork) over processes and tools [13]. Therefore, agile software

development is influenced by the underlying values and background of the people involved with development process. These personal characteristics of the people are very much influenced by their local tradition [14]. A survey study by Verner et al. reveals that teamwork productivity factors differ across countries and, culture influences teamwork's decision-making process, problem solving approach, social interaction, satisfaction and expectation [15].

There are several studies that attempted to assess the impact of some of the influencing factors on agile teamwork productivity. Besides, agile surveys have been conducted mostly on development process and overall view of agile practices [16][17][18]. However, these surveys do not elaborate much on productivity factors, and do not consider how they are related. Only Melo et al. analysed the major factors influencing agile teamwork productivity using the team's perception as one potential dimension to understand their overall productivity [6][18]. Through perceptions, they found that team management is the most influencing factor on agile team productivity.

SD technique has been applied in software engineering fields for modelling purposes, which is important for the organization and the project. SD is well suited for studying complex systems where unknown attributes of system properties are less visible [2]. There are few researches that attempted to evaluate the impact of some of the influencing factors on productivity separately using SD [5][19][20][21]. However, the complex inter-related structure of all the major factors influencing the teamwork productivity was not considered by the previous works. Abdel-Hamid and Madnick attempted to integrate system dynamics modelling and project dynamics insights with traditional software development processes [19]. In [21], Abdel-Ahmed investigated the effect of various management policies on development cycle time, quality and effort. However, his works adopt the waterfall method, which limits their applicability in recent software project and more importantly, does not focus on the agile principles.

In another research, Rodrigues proposed methods by which system dynamics modelling can be integrated with principles of project management [22]. In [23], the authors discussed whether agile project will fit within the common system dynamics project management structures or it has a unique structure. An analysis of factors that impact on productivity during agile web development and maintenance phases was conducted by Kong et al. [5]. However, it does not explicitly show the interrelations of different variables that influence the effectiveness of teamwork. Cao et al. created an integrative system dynamics model of agile software development for investigating refactoring and its impact [24]. The authors investigated the dynamics of agile software development and the impact of agile practices on cycle time and customer satisfaction using SD [24]. Modelers have also investigated schedule pressure effects on the dynamics of iterative development cycles [25].

In addition, evaluation of individual productivity may not affect the productivity of other team members [18]. These ideas provide a motivation to study teams'

productivity, not individuals. A number of studies exist on teamwork in agile software development on a range of topics relevant to composition of team [26], task-effective norms in teams [27], team member's motivation [28], and the importance of a team vision. Yet others have focused on how team uses daily stand-up meetings to communicate [26], how team makes decisions [29] and how to achieve self-management [26].

Another stream of research has focused on team performance in agile software development to analyse the teamwork. Team performance refers to evaluation of the results of the teamwork. Moe et al. used a team performance model to explain teamwork in a project adopting Scrum: The Dickenson McIntyre model [12]. Melo et al. used the 'Input Process Output' model to identify team productivity factors in a multiple case study [6]. Boehm reported in his productivity estimation model, Constructive Cost Model (COCOMO), that productivity of a software development project is mostly affected by the development team and their team management [30]. Scacchi also identified that poorly managed or organized project's productivity was mostly lower than those projects, which were well managed [26].

Throughout the literature review, it has been observed that there is a lack of well-established dynamic theory about agile teamwork. This study seeks to fill this gap by developing an integrated model, which represents the inter-related structure of productivity influence factors and how they impact (positively or negatively) agile teamwork's productivity. In order to do so, this study applies a system dynamics approach, which can study complex system by exploring underlying associations and connections between the components of a system that normally are not discovered by the input-output-process type of models used in organizational studies. Focusing on people and teamwork aspects of agile team, this paper makes use of two team effectiveness models for better analysis of agile software development teamwork productivity. Two models, the Salas and the Dickenson McIntyre models are used, which focus on team effectiveness, and mainly on internal aspects of the team [12][23][26]

### III. RESEARCH METHODOLOGY

The shortcoming of previous research studies lies in their not considering the complex inter-related structure and causal relationships of different factors (hard and soft) affecting the agile teamwork productivity. Thus, this study aims to develop a productivity model to analyse the interactions among the main factors of agile software development teamwork productivity. The research question in this study is therefore "*which factors do have an influence on agile teamwork productivity, and in what way (positively or negatively)?*" To answer this question, a qualitative system dynamics approach has been used to capture the interactions and causal relationship between the influencing factors. SD is a simulation methodology enables to model complex system considering all the influencing factors [31]. There are many modelling techniques developed and used so far, according to the modelling objective and perspective. However, system dynamics

modeling chosen for this research because it provides a systematic method for description, exploration and inspection about the dynamic behavior of complex systems [32]. SD methodology has been applied by many researchers [31][33][34][35] for studying and managing complex feedback system, where feedback is understood as a closed sequence of causal relationships. The concept of a feedback loop reveals that any actor in a system will eventually be affected by its own action.

Figure 1 presents a flowchart of the main stages and activities involved in creating and validating the qualitative (Causal Loop Diagrams CLD) model of the agile teamwork productivity. As it can be seen in this flowchart, model building in SD begins with identifying and listing (Step 1) those factors that have a major influence on the output.

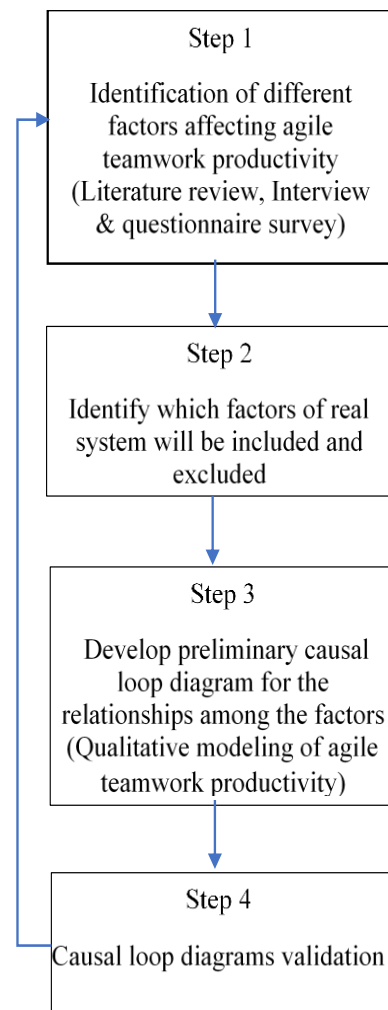


Figure 1. The development stages of the proposed qualitative SD agile teamwork productivity model

There are several methods established to identify those influences such as observation, discussion, interviews, existing data and survey [2]. This study chose to develop a questionnaire and conduct a semi-structured interview with responses based on the perception and observation of agile practitioners in Bangladeshi software companies. Survey research has been used because questionnaires are reasonable, completed within limited time and data can be interpreted through simple descriptive statistics [18]. Interviews were semi-structured in which interviewer did not strictly follow a specific set of questions. It allows more open-ended questions for a discussion with the interviewee [14]. Thus, semi-structured interview has been adopted to explore the views of the factors impacting agile productivity in the team's perception and how they influenced. Team members are central to the software development and consequently, they directly influence the team's productivity [36]. Therefore, team member perceptions used as a survey response in this study to analyse teamwork productivity influence factors.

Step 2 involves selection of factors to be included in the CLD. Then the qualitative model of teamwork productivity is constructed (Step 3) using causal relationships (cause and effect feedback loops) among identified factors affecting teamwork productivity. Model validation is conducted (Step 4) to ensure that the model adequately represents the real system.

#### A. Identification of different factors affecting agile teamwork productivity

**Data collection:** There are three important objectives of collecting information; to determine what factors affected productivity of agile team members, to determine how these factors impacting project productivity in the team's perception and to determine the significance of the factors.

1) *Literature review:* Keywords such as "productivity", "agile productivity influence factors", "system dynamics" and "agile teamwork" were used to search for related work in digital libraries. Significant findings from related work were not only helped in identifying some factors but also helped in the determination of the impact the factors have (positive or negative) on other variables in the project. The estimation of this impact would be vital in the calibration of the SD model.

2) *Interview:* Primarily, to collect qualitative data, a set of semi-structured interviews and face-to-face discussions were conducted with twelve key project members from four software companies in Bangladesh. All of the respondents had experience in agile software development methods, such as XP and Scrum. The roles of the respondents included project managers, scrum masters, developers and project owners. The semi-structured interviews mainly focused on their working team, their team productivity influence factors and experience of introducing agile practices in Bangladesh.

3) *Questionnaire/survey:* In an attempt to identify the perceived influencing factors and their impact on agile team members, data was collected with the help of online survey.

a) *Questionnaire design:* Using the factors identified in literature review and interview, a questionnaire consisting of 17 questions was developed [37]. Most of the questions were based on a previous global survey on agile methods conducted by [16] and country specific survey on agile productivity factors [18]. The questionnaire was structured in 4 parts. The first section was on demographic data, information about the project and organization. The respondents' details included their experience with agile methods, current position, current working project and status, working team size and organization name. The organizational profile included details about its' main activity, structure, size, mostly followed agile method, agile practice adopted and mostly used programming language. The second section was on perception of success/failed project and criterion for measuring/perceiving productivity. The third section was a set of 35 productivity influence factors. The last section was taken for any additional comments in order to allow the respondents to express their opinion more freely. To measure significance of agile teamwork productivity influence factors, the respondents were asked to indicate the strength (high, medium or low) for each factors that they perceived influenced their productivity.

b) *Questionnaire administration and selection of respondents:* The questionnaire was emailed to a total of 25 software companies in Bangladesh, requested for distribution within the organization through Human Resources departments. The company selection criteria for this preliminary study were: companies using agile methods for at least 1 year, developing software for both offshore and local market, and top listed software companies in Bangladesh [38]. Survey notifications were also sent to members of Agile-related group (Agile Bangladesh) with announcements on the Facebook group. 60 responses from 18 companies responded to the questionnaire. In the online survey, respondents were requested to fill up the questionnaire based on ongoing project or they had completed recently (regardless whether the project outcome was positive or negative). Data were collected throughout a period of eight months in 2017 (January-August). In order to ensure the quality of data, team members were all self-selected by their organization based on their work roles as members of existing agile teams. Therefore, respondents responded to survey questionnaires were already aware of agile team environment and mostly experienced. The filled-in questionnaires were then analysed to identify factors, which have major influences on agile teamwork productivity. Currently, more software companies are being requested to participate in this survey, as the plan is to collect more than 150 responses from different agile teams.

4) *Author's assumption*: Where necessary, author's assumptions are used in the development of the model. Such assumptions will be permitted and perhaps, moderated by experienced agile practitioners via interviews and questionnaire.

#### B. Selection of factors for inclusion in the model

**Data analysis**: Factors affecting agile teamwork productivity are rarely independent of the others, but a set of factors interacting with each other to build the final result [19]. The important factors identified in literature and interviews were taken as a starting point for the system approach in this research. In total, 35 factors were chosen for preliminary analysis. In order to create a system model to analyse the teamwork productivity, it is required to determine the importance of the individual factor, their correlation with one another and their effects on productivity itself. The agile team members were asked to fill in the questionnaire to indicate the strength (high, medium or low) of the factors that they perceived influenced their productivity [35].

The procedure followed to extract the agile team member's perception of the influence factors affecting their productivity can be summarized in the following steps:

1. Convert the qualitative scale to a quantitative one. The qualitative scale of high, medium or low was converted to a number scale of 3, 2, and 1, respectively.
2. Find the total score of each factor for frequency analysis. Then, the arithmetic mean of the total counts was calculated to eliminate the factors below the average (Table I) mean 2.26.
3. Cronbach's Alpha ( $\alpha$ ) coefficient for internal consistency reliability was calculated for the identified factors [39]. Cronbach alpha ( $\alpha$ ) is widely used as an estimator for reliability tests [39]. In a good solution for indicating high internal construct validity, Cronbach alpha ranges between zero and one - the larger the value, the more stable the factors. Generally, the value of 0.70 is accepted as the minimum desired value of reliability [39]. In this study, the 35 factors were tested for internal consistency, using the 60 respondent's data. The results, shown in Table I had values ranging from 0.877 to 0.887, all of which were considered acceptable (Cronbach's alpha higher than 0.70) and Cronbach's alpha for 35 factors was .885
4. From step 2, twenty factors (Table I, highlighted) were selected as the most influential ones (above average mean)

#### IV. SURVEY RESULTS

This study used reliable survey instruments, that can be helpful for comparing new results with the previous studied results [16][18]. However, there is no data available on the state of agile development in Bangladeshi software companies to interpret this study sample representativeness.

Interestingly, this study also found some similarities between Bangladesh and worldwide surveys [16][18].

This section presents a summary of the results found in this research. Characteristics of the sample software companies and respondents can be found in Figure 2 to Figure 11. As can be seen from Figure 2 – Figure 4 summarizes the respondents profile. The results show that 35% of the respondents cover the range 2-5 years of experience of using agile methods.

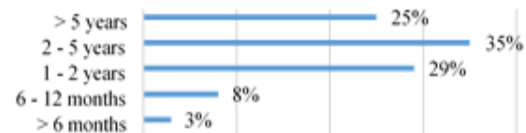


Figure 2. Agile practices experience

The respondents were working in various positions in their organizations, ensuring diversity in the survey. Figure 3 and Figure 4 present the team role of the respondents in their organizations and the respondent's main team assignment.

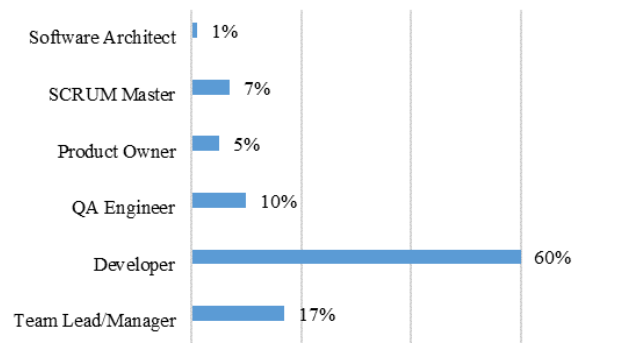


Figure 3. Team role in the project

60% indicated themselves as developer, 17 % as team leader/ manager, 10% as QA engineer, while the remaining 13% of the respondents are active in other roles, such as Scrum master, product owner and software architects. The majority of respondents (85%) are working on development project and 12% on maintenance project (Figure 4)

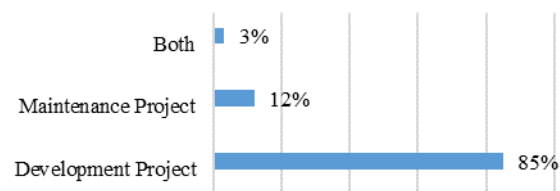


Figure 4. Main team assignment

TABLE I. AGILE TEAMWORK PRODUCTIVITY INFLUENCE FACTORS-QUESTIONNAIRE RESULTS FROM FREQUENCY ANALYSIS: ARITHMETIC MEAN, STD. DEV AND INTERNAL CONSISTENCY TEST

SI	Factors	Description	Mean	Std. Dev	Cronbach's Alpha
1.	Staffing	The right persons should be selected	2.73	.482	.882
2.	Size of team	Small and mixed team	1.93	.362	.885
3.	Project Complexity	Database size, architecture, complexity of interface to other system, code, interface complexity to hardware and software, logical problem	1.97	.551	.883
4.	Team Leadership	Shared leadership can be shown by several team members	2.57	.621	.880
5.	Mutual performance monitoring	Being aware of other team members' performance	2.37	.637	.881
6.	Backup Behavior	Being available to assist other team members when needed	2.32	.651	.879
7.	Team orientation	Assigning high priority to team goals and participating willingly in all relevant aspects of the team	2.48	.651	.881
8.	Adaptability	Response to changing conditions, internal or external	2.45	.622	.883
9.	Feedback	Giving, seeking, and receiving of information among team members	2.48	.624	.880
10.	Mutual trust	Shared belief that team members will perform their roles and protect the interests of their team-mates	2.62	.524	.881
11.	Coordination	Team members executing their activities in a timely and integrated manner	2.75	.474	.880
12.	Communication	Exchange of information between two or more team members in the prescribed manner and using appropriate terminology	2.65	.606	.882
13.	Team members are appreciated for working long hours	Team incentive for working overtime to finish a job	1.72	.761	.884
14.	Team reward	Overtime reward for working extra time (then or later)	1.93	.733	.882
15.	Adequate technical training for team	Offering appropriate training for new technologies	2.57	.563	.880
16.	Adequate team skills training for team	Communication, organization, interpersonal, etc.	1.78	.415	.885
17.	Turnover	Staff leave or entry in the project team	1.93	.733	.884
18.	Key personnel Stayed throughout the project	Impact of personnel turnover on team	2.37	.610	.882
19.	Reuse	Software products, processes, artifacts, including components, frameworks, and software product line	2.38	.585	.879
20.	Goals	Establishment is critical for the success of the team	2.37	.637	.879
21.	Intra group wage inequality	Fair wage	1.90	.775	.883
22.	Dealing Cultural differences	Cultural differences among offshore organization	2.15	.659	.882
23.	Self-management	Most work-related decisions are made by the members of team rather than manager	2.13	.430	.887
24.	Task variety and Innovation	Team get chance to learn the different tasks the team perform to meet the workload needs of the team	2.40	.694	.877
25.	External Dependencies	Waiting for customer acceptance/for a component; interacting with external customers; publishing version of system/of data model across different environments	1.90	.511	.884
26.	Tool Usage	Use of CASE tools	2.13	.623	.880
27.	Programming Language	Programmer's experience and skills	2.13	.747	.883
28.	Schedule Pressure	The impact of intangible project pressure	1.95	.429	.884
29.	Pair Programming	Two programmers working collaboratively to develop software	1.80	.514	.883
30.	Resource constraints	e.g. timing, reliability, storage, team size, and project duration	2.37	.637	.878
31.	Team Management	Quality of management, conflict management, task assignment, administrative and formal coordination	2.55	.565	.880
32.	Motivation	To work on the project and in the company	2.57	.593	.880
33.	External project factors	Customer involvement, Customer expectation, Customer satisfaction	2.30	.696	.879
34.	Culture	Agile requires a true cultural change from plan-based approach, not only a simple change in the processes used	2.10	.796	.879
35.	Working environment	Suitability of the workplace to do creative work, collocation, e.g., windows, natural light, size of room and desk, meals provided	2.33	.629	.878

Majority of the respondents' (42%) software organization's size is small, between 30-50 people (see Figure 5). However, 30% of organizations employ 100-150, and 12% employ more than 150 people.

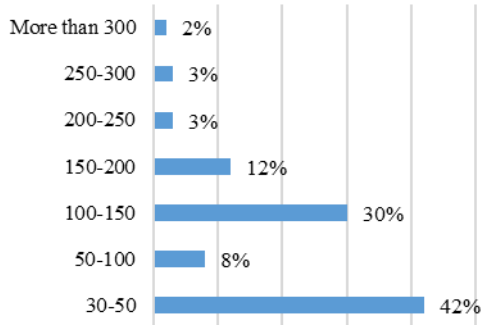


Figure 5. Size (people) of the software companies

As can be seen from Figure 6, Scrum is extensively used by the software companies. 97% indicated Scrum and 3% chose Kanban and XP. Scrum is the most popular Agile methodology also in [16][18].

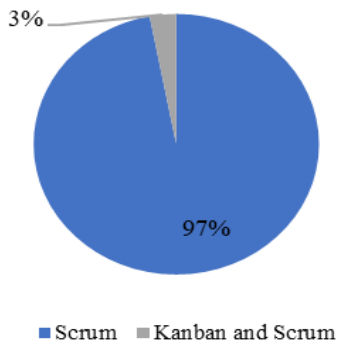


Figure 6. Most followed agile development method

According to the respondents (50%), the frequently used programming language in their organization is C# and then JavaScript followed by Java (see Figure 7).

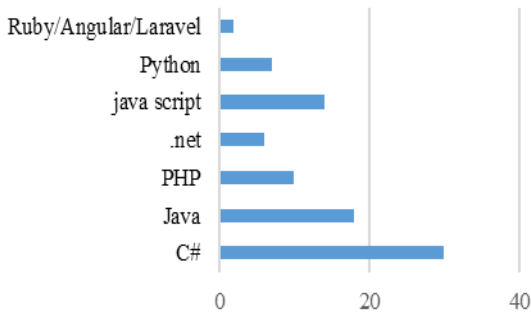


Figure 7. Programming languages use in software companies

Regarding the agile practices in use by the participating software companies, the results are well aligned with the results of similar survey [16]. Figure 8 presents the most adapted practices are daily standup meeting, release planning, stories and retrospective.

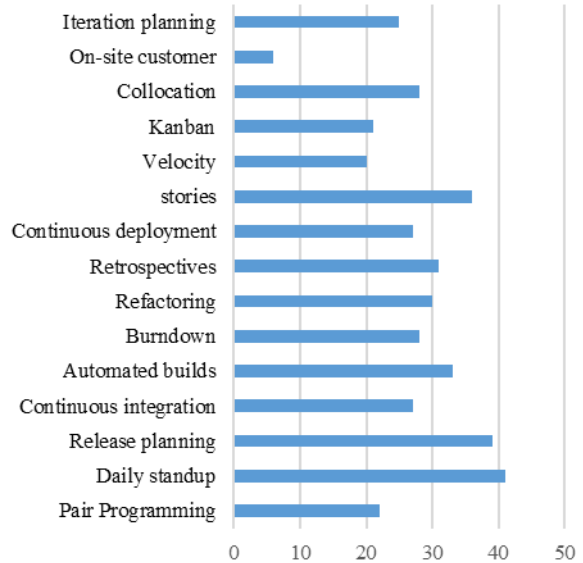


Figure 8. Agile practice adopted in software companies

Figure 9 shows that lack of management support (e.g., resource constraint, team design choice and motivation) is the main reason for failure in agile projects. In addition to this, respondents have mentioned another three more reasons in this extension of the previous study [1][40]. Integration failure, frequent change request and substantial funding crisis are mentioned by the survey respondents.

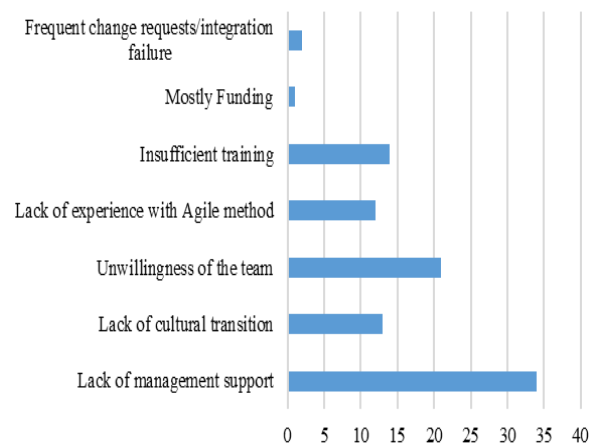


Figure 9. Main reason for failure in agile project

Lack of experience with Agile methods and the company culture are indicated as project failure reasons in similar surveys [16]. The most recent survey on Agile

acceptance and success or failure project results indicate lack of experience with Agile methods and the company culture are main project failure reasons [16].

In most of the interviews, the team members could not define productivity as their performance measurement. A large number of them mentioned that team management has their own ways of measuring productivity. Although at the end of the project, the management assessed their productivity on the basis of timeliness and quality. At the same time, ten interviewees and survey respondents (Figure 10) also mentioned customer satisfaction as a criterion for measuring or perceiving productivity. Customer satisfaction is very important to software development companies in Bangladesh as a rising market for outsourced software destination. This study result also confirms latest worldwide survey studies that have shown customer/user satisfaction is the number one measure of an agile project's success [16].

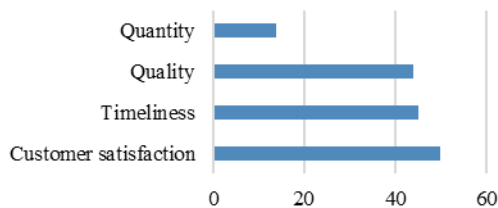


Figure 10. Criterion for measuring or perceiving productivity

According to the product owner interview, dealing with cultural differences among offshore organization influences teamwork productivity. Two main reasons behind this are time and culture differences.

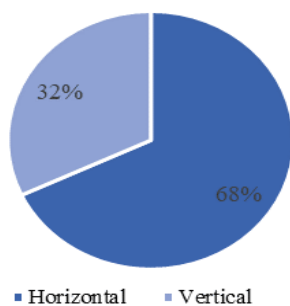


Figure 11. Organizational structure

Sometime it becomes difficult to keep contact with the offshore client on urgent issues due to time difference between places. Moreover, offshore client's expectations are different, both in terms of their general culture and their views on life and work. Project developed within western cultures are different from eastern cultures. For example, daily traffic condition consumes most of the working time in Bangladesh, which makes the developers less motivated. Since staff are not rewarded enough for working long hours.

However, schedule pressure can be easily dealt with overtime working because it is inexpensive in Bangladesh.

Five interviewees (project leads and managers) mentioned that culture is a big barrier for working in an agile team. Even though it is not one of the most influential factors mentioned by survey respondents. The survey result shows (Figure 11) that the participating software companies' organizational structure and coordination are primarily horizontal (68%), where coordination processes are usually provided by an individual team member who communicates directly with other members or users on a one-to-one basis [18][41]. On the other hand, vertical coordination (32%) is usually implemented through project managers. The horizontal structure of agile involves self-organizing teams that work in an iterative fashion and deliver continuous additional value directly to customers [41]. Although the practice of self-organized teams conflicted with the cultural responses of social hierarchy. According to Balasubramaniam et al., Social hierarchy recommends a top-down approach to decision making, which is different from a participatory approach and hinders teamwork [41]. In Eastern culture, workplace hierarchies are common practice of being superior to others in authority, power, or status that are commonly accepted by subordinates. Team members look for clear instructions and accept their supremacy, also their own dependency on the superiors.

Based on results found in the interview and survey of this study, it is perceived that social hierarchy is embedded in Bangladeshi software organizations and affects the implementation of agile principle. In agile development, communication links together all other teamwork processes. Therefore, regular and informal meeting should take place among team members. The survey result shows that project/team management has more influence on productivity than the self-management. Beside that most popular agile practice among the participating companies is Scrum and there is no such role of project manager. In the agile approach, team should be self-managed and work is coordinated by the team members [23].

From this scenario, it is evident that, even though most followed organizational structure is horizontal, social hierarchy culture significantly influences agile teamwork productivity. It is because the way team members communicate with team and customers, and more often to respect official hierarchy/top management (cultural norm in Bangladesh), communication occurred between members at the same levels of the organizational hierarchy [41].

In addition, sometimes language barrier hinders communication. Cultural transitioning from individual work to self-management team requires a reorientation not only by developers but also by management. This changeover of organizational culture and institutional process take time and resources. These begin from changes of individual perception and for this reason, project managers prefer fresher as a team member. Their software companies like to groom up with several activities such as training, community, and conference than changing traditional mind set up of the team members.



Stable teams are associated with higher productivity, so avoiding changing team members to keep key personal throughout the project has great influence on productivity (Table I and Figure 12). Sustainable pace is an essential part of agile development, and only by working regular hours at a reasonable level a team can produce good flow of work [6]. Productivity grows over time through the development of the teamwork practices by team learning process and not by doing overwork or compromising the quality to increase team's productivity [18]. Moreover, teams are not rewarded enough for working long hours (Table I). This study findings also indicate that schedule pressure has less impact on productivity and; timeliness and work quality are the most mentioned criterion for measuring or perceiving productivity (Figure 12).

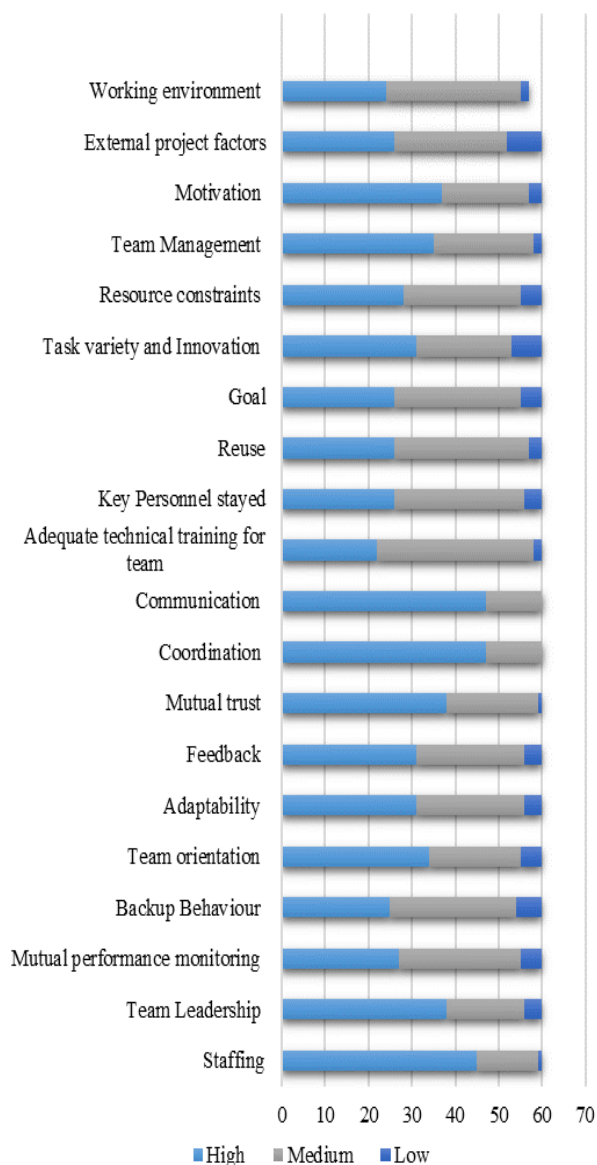


Figure 12. Agile team perception of productivity influence factors

Figure 12 provides highlights of the most influencing productivity factors that are perceived by the agile team members. This study results show that agile teamwork is highly dependent on team effectiveness. Offshore clients' satisfaction (external factors dependency) is very important for the organization. Team leadership and team orientation are very important for teamwork motivation. The factors impacting on agile teamwork productivity mentioned by the team members suggested that feedback, team orientation, communication, coordination and mutual trust improve team effectiveness. Eventually, this will enable team to learn how to effectively manage relationship within team in order to become more productive.

In sum, the study results show that some traditional productivity factors (from Table I) are still influential factors to agile software development teamwork productivity, even with the adoption of the agile practices. A transition to self-managing agile team is one of the biggest challenges when introducing agile development in Bangladeshi culture. Agile implementation needs the mindset change of all the team members; investment in training and learning oriented activities will make the Agile team members more productive.

#### V. QUALITATIVE MODELLING OF AGILE SOFTWARE DEVELOPMENT TEAMWORK PRODUCTIVITY

Software development productivity is a function of complex set of "hard" and "soft" factors [2]. Most of the data required to understand the development and dynamics needed to determine the factors that influence agile teamwork productivity mainly are concerned with soft factors [4][13]. The SD approach is capable of incorporating the soft factors, which can have an important influence on the agile teamwork. Soft factors such as productivity, motivation, team management efficiency, customer satisfaction, skillfulness and team effectiveness may be included and represented visually as a CLD. In the following section, the complex inter-related structure of different influence factors is modelled using qualitative SD approach (CLD). Vensim [42], free SD modelling software package is used for this research work.

##### A. Causal Loop Diagram (CLD)

Each factor that affects agile teamwork productivity is itself affected by other factors [18]. Some factors may be the reaction of the same action [31]. In system dynamics, this reaction is called feedback. There are two types of feedback – reinforcing feedback and balancing feedback. Sometimes a feedback (or a reaction) does not occur immediately – the process contains delays. Dynamic system can be drawn as a model with circles of causality – including actions, feedbacks and delays [2].

Technically, a CLD consists of words or phrases, which are linked by curved arrows, each of which has attached sign (positive or negative) and occasionally a time delay symbol [2]. The arrow represents a causal relationship between two factors. The sign is symbolized by '+' indicating the two related variables change in the same direction, or '-' showing the two linked variables change in

two different directions; and the time delay is shown by ‘//’ crossing the arrow.

Overall conceptual model (influence diagram) of agile teamwork productivity is presented in Figure 13, which is developed by identified factors in research Step 1 and then linking these factors to show their influences. For each of these links, the relationship is indicated as positive in the case of the same variation for both connected factors and negative for the opposite case.

The SD is based on the ground that these underlying influences are crucial to project management and need special attention [22]. This resulting model is used to understand and explain factors and feedback relationships between the influencing factors over time.

#### B. Analysis of causal links between agile teamwork productivity influence factors

A CLD of an identified research problem is developed by already established ideas and research in addition to the researcher’s mental model [2]. This section summarizes some of the most influential productivity factors based on causal loop diagrams developed by [5][21] for software development productivity. The elaborated relationships are presented with the help of CLD for some essential factors from Table I, in order to get a basic understanding of the feedback concepts. To keep the readability of CLD, it has been divided into two sub models (Figure 14 and Figure 15).

Starting with actual teamwork productivity in Figure 14, which is positively influenced by potential teamwork productivity and a number of complex factors as identified from the study. The proposed agile teamwork productivity model is based on the following state:

Actual productivity = potential productivity – losses due to faulty processes [21]. Where losses due to faulty process mainly refer to communication overhead and motivational losses. Potential productivity represents the best possible use of resources and the maximum level of productivity the team can produce.

As seen in Figure 14, team morale positively influences work quality, as highly motivated team generate fewer errors and less rework. Expecting higher quality and high team morale, in turn increase the customer satisfaction [34]. The result of increased customer satisfaction is a decrease in external factor’s influence on teamwork productivity and thus have an indirect (positive) effect on motivation. Customer satisfaction is one of the indicators of productivity [6] and less external factors along with team morale and motivation positively influence the overall teamwork productivity. Working environment, reward and salary directly influence motivation. Goals set by team management is a future condition to motivate them to work towards its accomplishment and morale development in the team [43]. High level of team morale to the project will increase the development motivation. The impact factors to the level of motivation include the relationships of the team, team management, individual salary, working environment, reward etc.

Figure 15 compiles the cause-effect relationships connecting team effectiveness, team management, motivation, learning factors with teamwork productivity.

Agile software development emphasizes teamwork in self-organizing teams more than traditional development methods do. It is useful to learn how team works effectively in order to better understand the factors, together, influence the productivity of agile teamwork. This study considers an adapted form of Salas Big Five teamwork theory [26] and the Dickinson and McIntyre model of team effectiveness [23] for the betterment of agile teamwork. These two models focus on team effectiveness, and mainly on internal components of teamwork. At the same time, both of the models consider the teamwork activity as a learning loop in which teams are identified as self-managed, adaptable and dynamically changing over time [23]. These self-managed agile teams are usually responsible for managing, monitoring and executing their own tasks. It also requires a double-loop learning, which is a characteristic of self-managing agile teams to change underlying values and assumptions [26]. The findings from the survey include the productivity influence factors that also comply well with Salas [26] and Dickinson and McIntyre’s [23] teamwork components.

Figure 15 shows how the team effectiveness is built within a team and how it affects the engagement of the team in learning-oriented activities (learning factors).

Mutual trust concept is based on shared belief that the team members feel accepted and respected for their feedback. Without sufficient trust, team members will spend time and energy protecting, checking, and inspecting each other as opposed to mutual performance monitoring [44]. It is evident that trust is a prerequisite for shared leadership, feedback, and communication. Team members may not be willing to participate or share information if they fear being perceived for incompetent performance. The degree of the mutual trust, adaptability, team orientation, coordination and communication can be impacted by the experience of working together. More the team members understand each other, higher the ability of the team to identify problem in a short time frame and hence increase teams’ potential productivity [5].

The team inspiration to engage with the learning factors is positively related to the team effectiveness in regard to team orientation and mutual performance monitoring and feedback present in an agile team. This perception is represented in the CLD (Figure 15) by the factor motivation, which offers support to team members to overcome the fear that arises when they face difficult situations. Therefore, the higher the level of motivation, the more secure team members feel, and the more willing they become to involve in learning-oriented activities. As the project proceeds, the team members increasingly engage in learning activities, they interact and coordinate more, hence the potential team productivity increases.

Dickinson and McIntyre model suggests that team leadership and team orientation promote team members’ capability to monitor their team members’ performance

[23]. Consequently, it enhances team effectiveness, which leads to improved team productivity.

The team effectiveness, including team management efficiency, are both influenced by skillfulness and might be enhanced by training. Training strengthen the teams' process knowledge, which in turn improves team members' skills and capabilities. Teams' expertise is further influenced by individual learning, which is characterized by individual work experiences [45]. Individual learning positively influences organizational learning, which can be further created through shared experiences [45].

The team motivation is also affected by the behavior of the team management. According to Melo, agile team management is the most important factor in achieving agile team productivity [5]. A supportive team management tends to provide constructive feedback and encourage team to involve on task variation. However, a team management, which follows social hierarchy, promote a top-down approach to decision making, as opposed to a participatory approach, significantly influenced the way team members communicated with each other. Under this kind of team management, agile team members will avoid any unwanted situation where they can face problem and restrain from learning-oriented activities. As a result, team productivity decrease, the team management efficiency decrease, indicating a perceived need for team/technical training, as represented in Figure 15.

Another factor that influences skillfulness is pair programming, which is one of the key practices influencing team productivity [16][18]. However, this factor is not encouraged in Bangladeshi software companies. Management does not want to engage two resources for single work due to increase in expenses. It is mostly practiced by the developers when they need assistance to complete a difficult work.

Getting the right person with suitable skills and knowledge for an agile team is a difficult job for the software companies in Bangladesh. Staffing (right person selected) happened to be as one of the most important factors impacting teamwork productivity, as Table I and Figure 12 show. Consequently, team design choice becomes a significant influencing factor for agile teamwork productivity (Figure 13). It affects the amount of knowledge that team members must apply to improve the team task (Figure 15).

## VI. CAUSAL LOOP DIAGRAM VALIDATION

"All models are simplified representations of reality. Therefore, they are wrong by definition, yet they may be useful for particular purposes." [2]. This qualitative model's purpose is to provide a better understanding of the factors and mediators that influence agile teamwork productivity. At this stage, its validity is assessed based on how clearly it can explain insight dynamics of the system. Exact precision of SD forecasting models is not expected. For this reason and to recognize the rightness of the diagrams, the following criteria have been used to study the fitness of the causal

diagrams to fulfil the objectives of the study (adapted from Coyle [46], p46):

- Have the purpose and the target audience for the diagram carefully chosen?  
The target shown in all diagrams is the influence of the productivity factors. The diagrams show the linkage between the factors up to the stage where it influences the team productivity.
- Are the factors, which it includes consistent with the purpose?  
All the factors included in the CLD affect the productivity of the agile teamwork, which is the purpose of the study (Table I).
- The objective of system dynamics is policy analysis against a range of circumstances, so are the policies clearly shown in the diagram?  
The objective of the causal diagrams shown in this study is to show how the factors influence the productivity as a first step toward developing a complete quantitative model, which will quantify these relationships in future work.

To clarify the causal relationship between the factors and teamwork productivity and as a step towards building the qualitative model, most influential factors have been concluded with two sub-causal analysis diagrams. That explains the relationship between the factors and the mediator(s), which have direct influence on the agile teamwork productivity using prior theoretical knowledge extracted from the literature, interviews and survey.

## VII. LIMITATIONS OF THE STUDY

There are a number of limitations to this study. First, this study was limited to 60 respondents and 12 interviewees from 18 software companies. It was challenging to get access to more software companies due to time constraint and its access to appropriate resources was limited.

Respondents were carefully chosen from different roles within the agile team in order to get different perspectives of productivity in the context of Bangladesh software Industry.

Another limitation of this study is the agile team members' perceptions used as a response. However, with survey, this study relies on what the respondents provided to the researcher. It is possible that the respondents' perception may change and be different after the end of the project. To minimise the impact of this effect, the survey and interviewees' responses were compared for factors selection to include in the model. The questionnaire used for this study had been used successfully in other research and was developed after a detailed literature review [15][18]. Some of the questions were included in the survey after getting knowledge about the working conditions of software companies in Bangladesh from the interview sessions.

This CLD models certainly contains inherent limitations and is not complete because it only focuses on a limited number of important soft factors and it does not present explicitly the reinforcing/ balancing loop and delay.

The scope of this empirical findings considers the Bangladeshi software companies as a case study, which can

**CONCEPTUAL MODEL OF AGILE TEAMWORK PRODUCTIVITY**

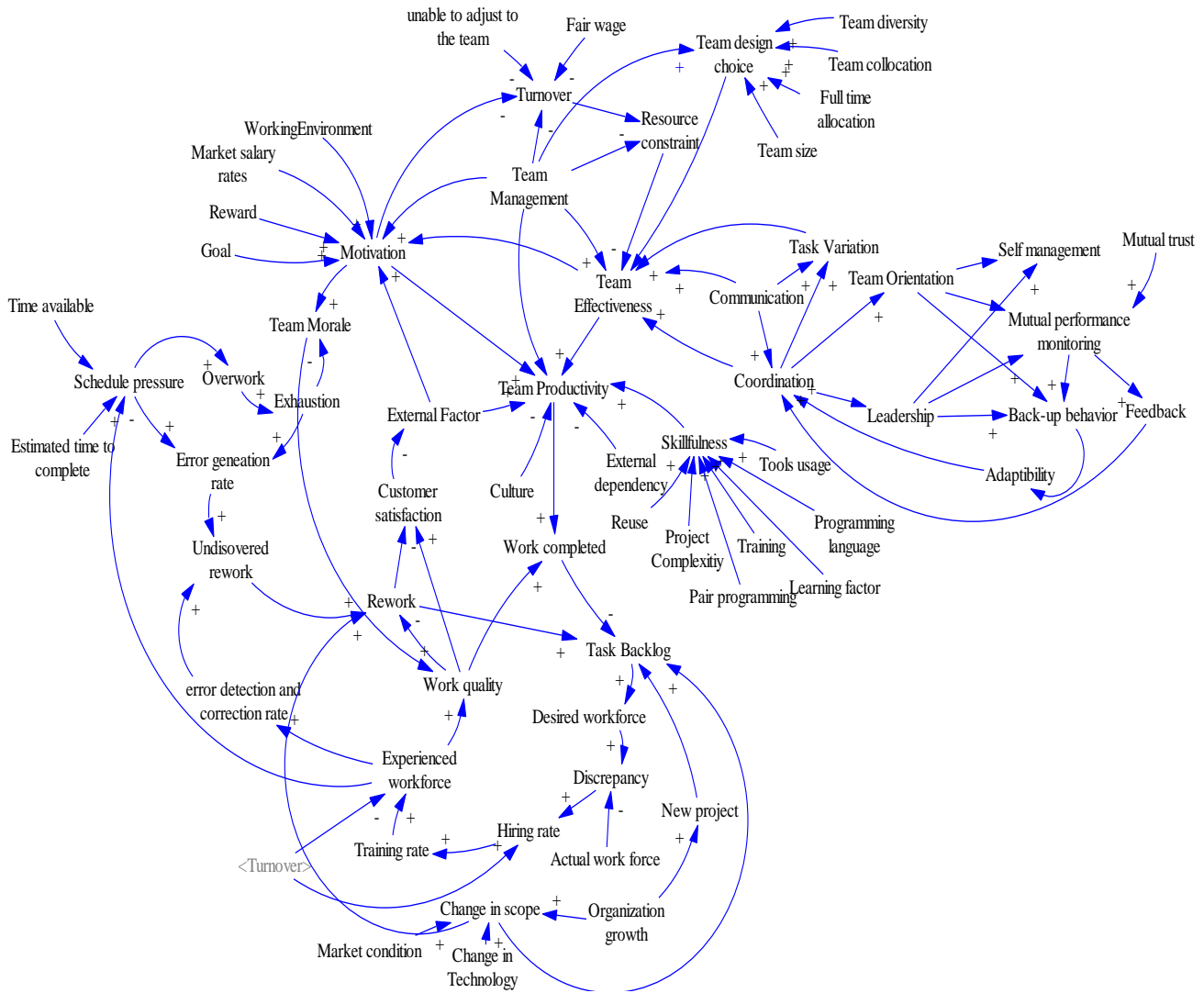


Figure 13. Overall conceptual model of Agile teamwork productivity

in turn make the research results beneficial to these companies. All the data used in this study is collected from the software companies who have voluntarily participated in this research. Therefore, findings from this study should be generalized with caution. While the findings may be specific to the contexts studied, analytic generalization could facilitate the application to other types of culture, background and environment.

**VIII. CONCLUSION AND FUTURE WORK**

The productivity of the development team is important for successful software project. The agile team, which is the most dynamic element and the human input in the software development industry, gain more interest to study their productivity. This research aimed to present a system

dynamics based approach to model agile teamwork productivity. In order to achieve this, the main factors that affect teamwork productivity were determined via two-phased approach, where in the first phase a systematic literature review, interview and survey of different agile teams were conducted to collect and select impacting factors, and they were evaluated and ranked to identify the most influential ones. The second phase involved the development of qualitative SD model (causal loop diagram) of agile teamwork highlighting the different influencing factors. The findings of this stage are the main influencing factors, which are motivation (external factors, customer satisfaction), team effectiveness (communication, coordination, mutual trust, leadership) and team management (staffing, Key personnel Stayed throughout the

project, team design choice). Moreover, this study used two team effectiveness models- Salas [23] and the Dickenson McIntyre [12] model for better understanding and analyzing inter aspects of agile team. The most cited and influential factors were: Coordination, Communication, mutual trust and staffing (right person selected for the team). These factors were the most important for effective teamwork and team management in the agile teamwork productivity.

According to study results, lack of management support is found to be the most mentioned reason for any failed agile project. The most followed organizational structure is horizontal and most followed agile method is Scrum. In addition, this study finds that due to social hierarchy culture influences, self-manage agile team may not fully fit in their organization. This factor also hinders agile transformation from plan driven to self-managed agile team.

As a future work, survey (statistical) data will be used to estimate influencing factors (hard and soft) to quantify the effects of the factors on productivity. The outputs will be applied in quantitative modelling of team productivity via SD approach and assess the ability of the model to duplicate historical data when measurable data are available.

The proposed CLD model will be used as a basis for developing stock and flow model of SD method. Further research need to be conducted for qualitative in-depth studies of the causes behind the results in regard to certain factors and the model against a real-world agile software development project. The proposed SD model of agile teamwork productivity will provide more strategic observance and competence about the effectiveness of different managerial policies based on non-straight forward cause-effect relationships hidden in the system.

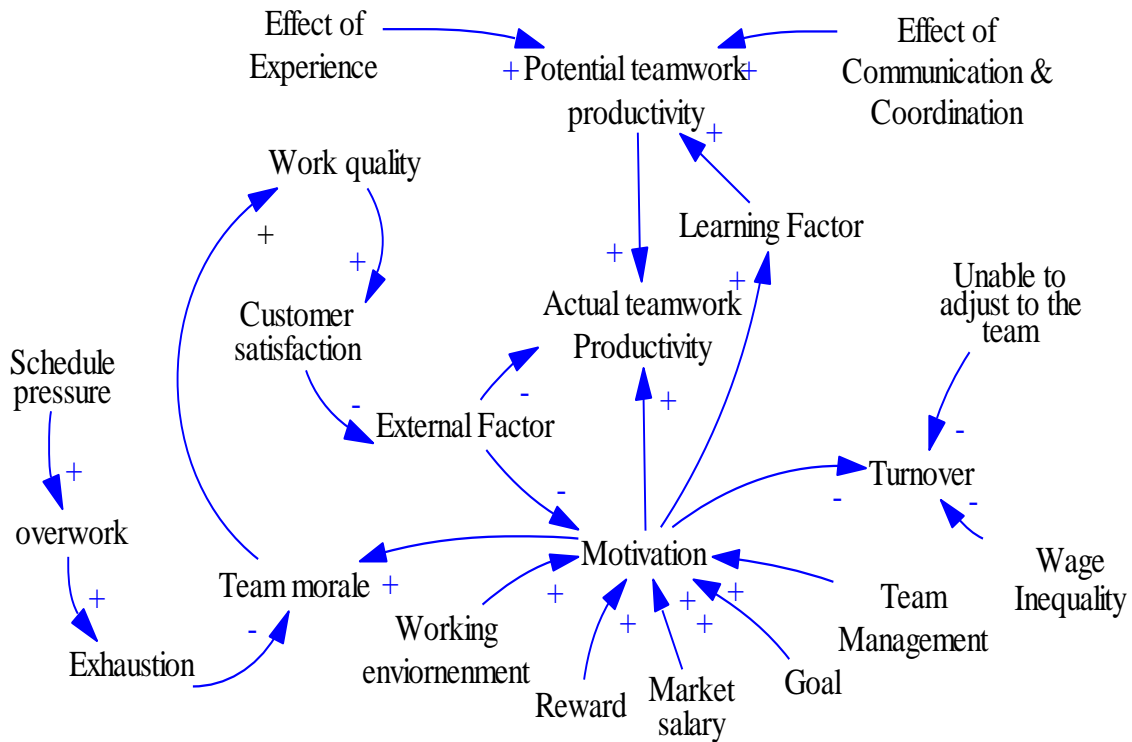


Figure 14. Causal loop diagram 'the influence of motivation on productivity' sub-model



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