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Factors Influencing Productivity of Agile Software Development Teamwork: A Qualitative System Dynamics Approach

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Abstract— **Agile method emphasizes on the people factors and strength of teamwork that simplify the development process. A highly productive team throughout an agile software development process is very instrumental in achieving project success. Consequently, understanding of how individual behaviour and productivity are affected by teamwork within an agile team becomes critical. Identifying factors that impact productivity will result in improvement of teamwork. Hence, a need emerges to recognise the significant ones. Doing so will enable project team management to determine the areas where to concentrate efforts in order to improve productivity. The objective of this research is to identify and analyse agile teamwork productivity influence factors by using system dynamics (SD) approach. Identification of main factors influencing productivity and how they impact agile teamwork are carried out through interviews, survey and literature review. From the perspective of agile team members, the four most perceived factors impacting on their productivity are team effectiveness, team management, motivation and customer satisfaction. Lack of agile team management support is found to be the most mentioned reason for failed agile project. The complex interrelated structure of different factors affecting agile teamwork productivity is modeled using influence diagram and Causal Loop Diagram (CLD) for qualitative analysis.**

Keywords- agile teamwork; productivity; influence factors; qualitative system dynamics.

I. INTRODUCTION

A highly productive team is the most important factor in achieving project success at different stages of an agile software development. For efficient management and a better control over the agile project team, it is important to understand the team dynamics and effects related to agile practices that influence the development team's productivity.

Research has been largely carried out to identify productivity influence factors in traditional software development. There are four main factors generally discussed [1]: the product being developed (characterization of the specific software), people (team members, capabilities, experience, and motivation), project (management and resourcing) and processes (tools and software methods). However, agile teamwork productivity is a function of various controllable and uncontrollable factors [2]. The relationships between some of these factors and productivity may change under new software engineering practice and culture [3]. The factors change over time as expectations change. 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 [2]. 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 [3].

Despite the increasing acceptance of the agile methods, insufficient research has been empirical on the effect of influence factors of software development productivity [5]. A better knowledge of the factors and the mediators that influence agile teamwork productivity could help determine where to focus management efforts to improve productivity.

Since the agile project team is the most dynamic element in the software development sector, improving team productivity has become a target for software companies in everywhere. The aim of this study is to identify and understand the complex interdependences and underlying structures at the team's perception level, which influence agile teamwork productivity over time. To achieve this goal, this paper determines the major factors impacting teamwork productivity in Bangladeshi software companies through a survey and interviews that have been conducted with agile teams and apply SD to model teamwork productivity. The major factors are to be modelled using a CLD based on the Authors' earlier work in [11]. This CLD will be used to examine the internal dynamics existed within the team and the organizational resources that are used to support them.

The scope of this empirical finding considers the Bangladeshi software companies as a case study, which can in turn make the research results beneficial to these companies.

The remainder 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

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qualitative SD model. Section VI describes some limitations of this work. Finally, Section VII describes the conclusion and future work.

II. LITERATURE REVIEW

There are several studies that attempted to assess the impact of some of the influencing factors on agile teamwork productivity. Only Melo et.al [2] analysed the major factors influencing agile teamwork productivity using the team's perception as one potential dimension and found that team management is the most influencing factor on agile team productivity. There are few researches [6][7][8] that attempted to evaluate the impact of some of the influencing factors on productivity separately using SD. However, the complex inter-related structure of all the major factors effecting the teamwork productivity was not considered by the previous works. Abdel-Ahmed [7] investigated the effect of various management policies on development cycle time, quality and effort. His works however adopt the waterfall method which limits their applicability in recent software project and more importantly, does not focus on the agile principles.

In addition, evaluation of individual productivity may not affect the productivity of other developers [9]. These assumptions provide motivation of study team, not individuals.

Melo et al. used the 'Input Process Output' model to identify team productivity factors in a multiple case studies. Dingsoyr et al. [16] described agile software development as a sociotechnical system comprised of human (socio) and technical entities. Technological interventions do not increase sociotechnical system effectiveness if they are not supported by social components of the system. Such team interactions are one of the important parts in agile software development. Thus, recent focus on agile software development has increased interest in analysing self-managing agile teams and how to effectively make team productive [16]. 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 agile teamwork's productivity. In order to do so, this study applies a SD approach, which can study complex system by exploring underlying relationships 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.

III. RESEARCH METHODOLOGY

The methodological approach of this research is based on the SD, as a modelling and simulation methodology enables to model complex system considering all the influencing factors [19] over time. SD modelling has been chosen for this research because it provides a systematic method for description, exploration and analysis about the dynamic behavior of complex systems [18]. SD methodology has been applied by many researchers [19][20][24][25] 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.

A number of diagramming tools are used in SD to capture the structure of systems, including causal/influence diagrams, stock and flows. Each causal link is assigned a polarity, symbolized by '+' indicating the two related variables change in the same direction, or '-' showing the two linked variables vary in two different directions [18].

A. Identification of different factors affecting agile teamwork productivity

Data collection: The model developed for this work is based on data collected from the software companies in Bangladesh. Identification of the factors was initially carried out through an intensive literature review. A set of semi-structured interviews and face-to-face discussions were also conducted with 12 key project members from 4 software companies including project managers, scrum masters, developers, project owners, and considering also different experience profiles.

Using the factors identified in this first step, a questionnaire [26] was developed and distributed to a total of 25 software companies in Bangladesh. Only 17 companies (1 from each) responded to the questionnaire. The criteria for company selection of this preliminary study were: companies using agile methods for at least 1 year and top listed companies developing software for both offshore and local market.

Data were collected throughout a period of 3 months in 2017 (January-March). 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.

The returned forms were then analysed to identify major influence factors. Currently, more software companies are being requested to participate in this survey, as the plan is to collect more than 100 responses from different agile teams.

B. Selection of factors for inclusion in the model

Data analysis: The important factors identified in literature and interviews were taken as a starting point for the system approach in this research. Initially 38 factors were chosen for preliminary analysis. In order to create a system model, it is required to determine the importance of the individual factors, their correlation with one another and their effects on productivity itself. The agile team members were asked to fill in the form to indicate the strength (high, medium or low) of the factors that they perceived influenced their productivity [25].

The procedure followed to extract the agile team member's perception of the productivity influence factors:

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 as to eliminate the factors below the average (Table. 1) mean.

3. Cronbach's alpha coefficient for internal consistency reliability [21] was calculated for the selected factors (Table I, highlighted factors).

4. From step 2, nineteen factors (Table I, highlighted) were selected as the most influential ones. Reliability coefficient for 19 factors was .867 (alpha), which indicates good internal consistency of the factors in the scale [21].

IV. SURVEY RESULTS

Characteristics of the sample software companies can be found in Table II. Fig. 1 presents the agile practices adopted by the participating software companies and it shows daily stand up meeting mostly used by all of them. Fig. 2 shows that lack of management support is the main reason for failure in agile projects. In most of the interviews, the team members mentioned that team management have their own way 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, 10 interviewees also mentioned customer satisfaction as a criterion [Fig. 3]. Customer satisfaction is very important to software development companies in Bangladesh as a rising market for outsourced software destination. According the product owner interview, dealing with cultural differences among offshore organisation influences teamwork productivity. Sometimes 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.

Five interviewees (project leads and managers) also mentioned that culture is a big barrier for working in an agile team. This factor affects communication between team members. In addition, sometimes language barrier hinders communication. Transitioning from individual work to self-management team requires a reorientation not only by developers but also by management. This changeover takes time and resources. For this reason, these project managers prefer fresher as a team member. Their software companies like to groom up with training than changing mind set up of the team members. Besides that, self-management and adaptability are considered key for agile development. But these two factors have less influence (Table. 1) on agile teamwork productivity and mostly depend on well project management.

Fig. 4 provides highlights of the most influencing productivity factors that are perceived by the agile team members. This study results show that the effectiveness of an agile team lies in the interrelations of the identified factors such as communication, coordination, adaptability, feedback, leadership and self-management. Project manager is usually a technical lead and top-level management makes many management decisions since the majority of the projects are outsourced projects. Getting the right person selected (staffing) with suitable skills and knowledge for an agile team is a difficult job for the software companies in Bangladesh as Table I and Fig. 4 show.

TABLE I. ARITHMATIC MEAN OF QUESTIONNARIE RESULTS FROM FREQUENCY ANALYSIS

SL	Factor	Mean	SL	Factor	Mean
1	Culture	**2.23**	20	What is the staff turnover rate in the project	**1.82**
2	Staffing	**2.76**	21	Reuse	**2.17**
3	Size of team	**2.29**	22	What is the software reuse level in the project	**2.00**
4	Project complexity	**2.23**	23	Goals	**2.29**
5	Team Leadership	**2.52**	24	Intra group wage inequality	**1.94**
6	Mutual performance monitoring	**2.41**	25	Team measurement	**2.17**
7	Backup Behaviour	**2.41**	26	Self-management	**2.17**
8	Team orientation	**2.52**	27	Task variety and Innovation	**2.41**
9	Adaptability	**2.35**	28	External Dependencies	**2.17**
10	Feedback	**2.70**	29	Tools usage	**2.29**
11	Mutual trust	**2.76**	30	Programming language	**2.05**
12	Coordination	**2.70**	31	Schedule pressure	**2.29**
13	Communication	**2.82**	32	Impact of Pair programming on productivity	**2.11**
14	Staff are appreciated for working long hours	**1.76**	33	Resource constraints	**2.41**
15	Staff are rewarded (then or later) for working long hours	**2.11**	34	Project Management	**2.58**
16	Adequate technical training for team	**2.41**	35	Motivation	**2.58**
17	Adequate team skills training for team	**2.35**	36	External project factors	**2.41**
18	Team member turnover	**1.64**	37	Dealing with cultural differences among offshore organizations	**2.17**
19	Key personnel stayed throughout the project	**2.23**	38	Working environment	**2.35**

TABLE II. CHARACTERISTICS OF PARTICIPATING SOFTWARE COMPANIES

Characteristic	Category	Number	%
Main team assignment	Development project	10	58.82
	Maintenance project	7	41.17
Team role	Project manager	4	23.52
	Developer	6	35.29
	Software engineer	3	17.65
	Team lead	2	11.77
	Quality assurance engineer	2	11.77
Experience in agile practice	1-2 years	8	47.8
	2-5 years	7	41.2
	More than 5 years	2	11.8
Development method	Scrum	17	100
Size of the company (person)	30-50	2	12
	50-100	1	6
	100-150	5	29
	150-200	6	35
	200-250	1	6
	250-300	1	6
	More than 300	1	6

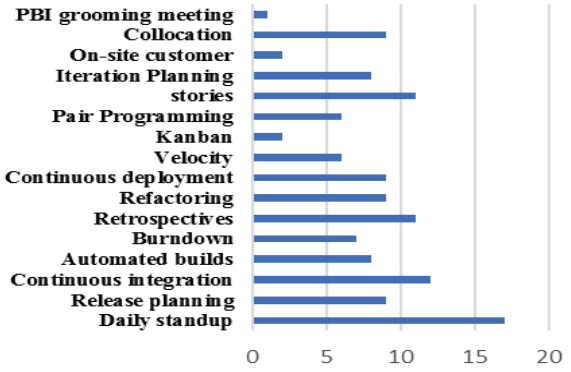

Figure 1. Agile practices adopted in software companies

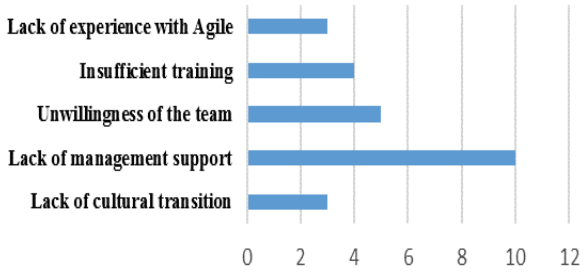

Figure 2. Main reasons for failure in agile projects

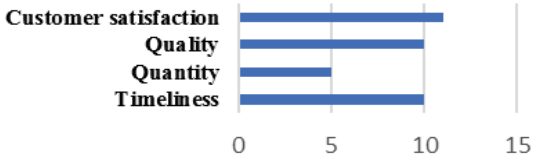

Figure 3. Criterion for measuring or perceiving productivity

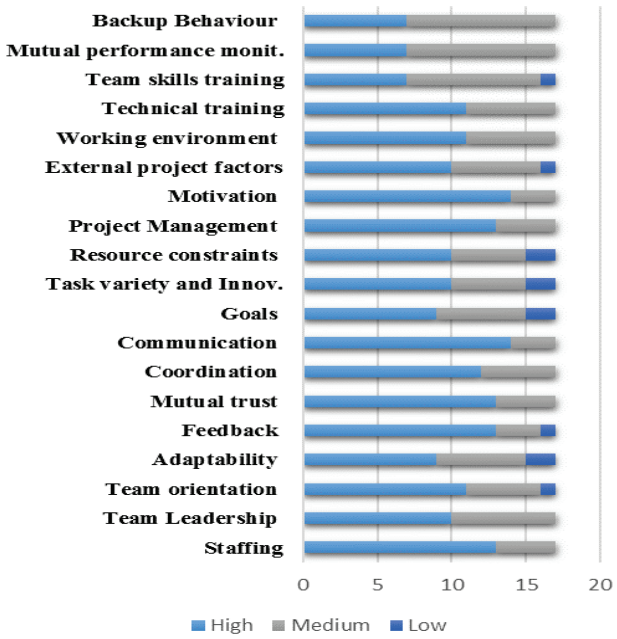

Figure 4. Agile team perceived productivity influence

V. QUALITATIVE MODELING OF AGILE SOFTWARE DEVELOPMENT TEAMWORK PRODUCTIVITY

To fulfill the research aim, an empirical qualitative system dynamics model developed by [6] will be adapted and used as a main reference. Fig. 6 presents the overall conceptual model (main factors) of agile teamwork productivity. It shows all the main influence factor's affect found in this study. Distinct from previous studies [7][24] this model represents the team dynamics, which is a collection of "soft factors" [23] and effects related to agile methods that influence the teamwork's productivity. The soft factors that can affect the software development teamwork productivity include motivation, team management efficiency, customer satisfaction, skillfulness and team effectiveness. Teams require a complex mixture of factors that include organizational support, individual skills and also teamwork skills [10] to work effectively. Productivity of an organization is not only an outcome of the skillfulness in a team, but dependent on team effectiveness, the ways in which individuals feel and how they perceive their team members [21]. Ignoring team in the software development process or managing them in an inappropriate way can have a high impact on their productivity and team effectiveness [22].

Within the model (see Fig. 5), it is shown team-learning processes can improve team effectiveness. When a new developer joins a development team, the better the communication process works, the faster the new developer can become productive and the learning curve reduced. These learning activities are likely to create a positive change and to influence the productivity.

The developed CLD (Fig. 5) is based on *Actual team productivity = potential productivity – losses due to faulty processes* [7]. *Actual Team productivity* (Fig. 5) is a stock representing the level of productivity the team can achieve over the time and it affects *software development rate* directly. Actual team productivity refers to how the team performs (the results they get and the level of effort they put in). Potential productivity refers to the maximum level of productivity the team could produce based on the individual or team skill and ability of each member in the team and the resources available. Losses due to faulty processes relate to the issues that can get in the way of team productivity, preventing the team from reaching its potential productivity. Losses are normally due to two main areas: motivational faults/losses and communication and coordination overhead. There are various factors affecting agile teamwork productivity positively including skillfulness, motivation, and project management efficiency. There are some other factors affecting teamwork productivity negatively including exhaustion, external dependency, culture and resource constrains [Fig. 6].

Fig. 6 illustrates that motivation is positively related to team effectiveness. In consequence, motivated team involves with team learning processes over time and can be increased team effectiveness.

VI. LIMITATIONS OF THE STUDY

There are a number of limitations to this study. First, this study was limited to 17 survey responses and 12 interviewees within 17 software companies. It was difficult to gain access to more software companies due to time constraint. Within the interviewees, they were carefully chosen from different roles on 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. The questionnaire used for this study had been used successfully in other research [7][20] and was developed after a detailed literature review. Some of the questions were included in the survey after getting knowledge about the working condition of software companies in Bangladesh from the interview sessions.

Finally, the CLD is not complete because it only focuses on the influence factors. The multiple feedback processes and delays are not incorporated in this model.

CAUSAL LOOP DIAGRAM OF MAIN PRODUCTIVITY INFLUENCE FACTORS

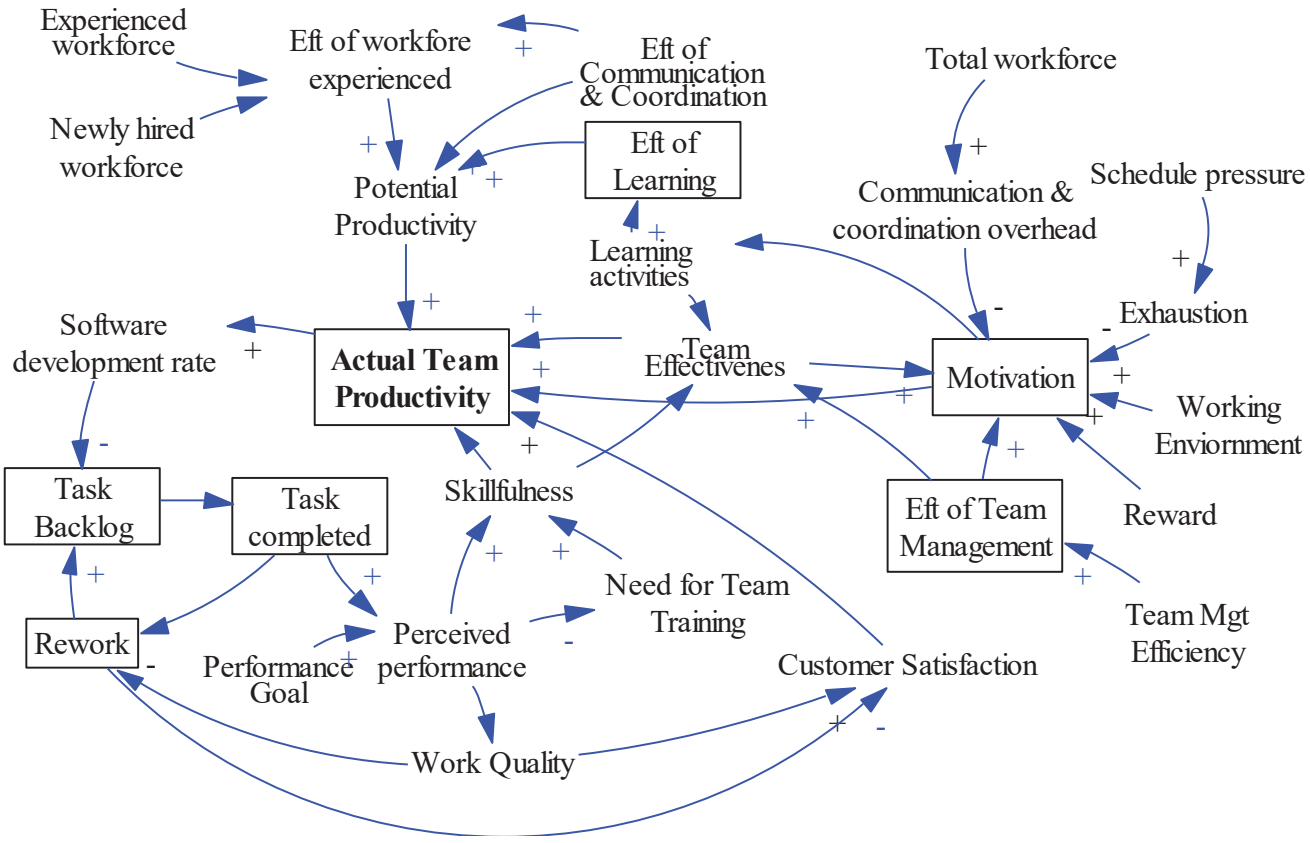

Figure 5. Causal loop diagram of Agile teamwork productivity

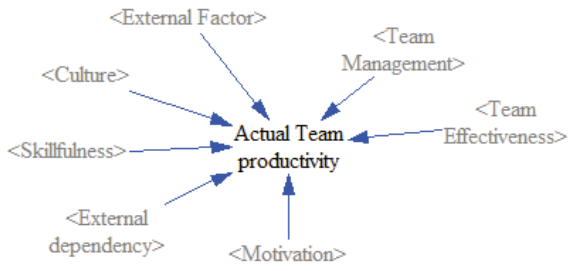

Figure 6. Main factors affecting Agile teamwork productiviy

VII. CONCLUSION AND FUTURE WORK

Teamwork productivity determines the overall project performance in an agile software development process. Therefore, it has gain more interest to study team member's productivity. Agile team members should be taught to interpret and manage productivity factors regularly as they are self-managed. Productivity improvement programs would become effective only if all the variables are simultaneously controlled and monitored. Researchers have tried to quantify and measure how soft factors and social aspects affect teamwork productivity. Agile Software development process must be analyzed as a behavioral process [22]. Therefore, coordinating and managing an agile team is a vital activity for software companies and team dynamics have a direct influence on teamwork productivity. One effective solution to improve productivity is to look into the factors influencing productivity and also have a dynamic strategical model that tells the project manager in advance the degree of impact that these factors will have on team productivity. In order to achieve that, the main factors that affect teamwork productivity are determined.

The validation of the conceptual model against a real-world agile software development project will be presented in future research. Furthermore, this qualitative CLD will be used as a basis for a stock and flow model development of the quantitative SD method.

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