Measuring Software Project Agility:

A Special focus on SCRUM Practices in India

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Abstract—**Agile project management thrives on a highly flexible and pliable business environment. This requires a rigorous approach for continuous process improvement. Simplicity of operation, continuous feedback mechanism and rapid delivery are the key pillars that give the foundation for robust project agility.**

Amongst the various agile methods prevalent today, the popularity of SCRUM can be stemmed from its flexibility to adapt to constantly changing business environment, as the study reveals.

The objective of the study was to understand how many India headquartered Information Technology (IT) firms are adequate to apply agile methodologies. If a company is adequate enough; then what is the level of suitability towards project agility. Key Information Technique (KIT), as a method of exploratory research, was used to consult Agile Coaches, Project Managers and Senior Employees in the IT sector to understand the factors that influence successful implementation of projects using agile methodologies. The above mentioned panel helped identify companies in India which practice agile methodologies with profound success. SCRUM appeared to emerge as the most popular agile method charted by IT companies in India. Primary data was collected from over 100 companies, out of which there were 81 valid cases. Considering the differences in the procedural approaches to Agility across IT companies, the study designed an Agility Index. This Index is equipped to measure the extent to which a firm is agile. Subsequent to this, the study also discovers that there are essentially three factors that contribute to the successful implementation of agility.

While the factors appear to be relatively obvious, these are statistically proved to have significant influence on the cumulative percentage of agility presence.

The factors are – a) Number of members involved in the project, b) Years of experience of the person part of the agile practices and lastly, c)Number of clients served by the respective companies

Keywords—Agile Project Management; SCRUM practices; agile methodologies; Measurement of Agility

I. INTRODUCTION

Koskela and Howell (2002) in their landmark paper distinguished the need for paradigm change in the discipline of project management. They clearly brought out that transformation of this order would require better integration between theory and practice.

Software development project requirements are elusive and volatile. Traditional project management approach can be somewhat ineffective in such an unpredictable environment (Hass, K. B. 2007). Large number of risk factors in a software development relates to *managing user relationships and user expectations*, software development teams find it challenging to respond to these changing requirements. (Schmidt et al. 2001).

The advent of agile project management came into being in the year 2001, when some prominent software process practitioners arrived at a consensus on "How software development trends could produce better results?" The outcome was the Agile Alliance and the *Manifesto for Agile Software Development,* which states that : the "highest priority is to satisfy the customer through early and continuous delivery of valuable software." (Agile manifesto, 2001)

This paper is an attempt to bring forth a convergence between the evolving theories of project agility and the upcoming practices in software companies.

II. LITERATURE REVIEW

Agile project management is about the ability to manage and adapt to change (Augustine S et al., 2005). Agile methodologies helps software projects to face the dynamic changing business requirements of the customers. Moving from a traditional software methodology to the agile is very challenging due to the nature of software projects which are adapting to the changing environment, business dynamics, and

continuous process improvement (Nerur S et al., 2005). Agile methodologies as stated by researchers, can be debatable, the focal aspects are simplicity, speed, feedback and rapid delivery of changing business and customer requirements. Agile approaches are more code centric as opposed to requirement engineering, where documentation for knowledge sharing is one the major focus criteria (Paetsch F et al., 2003). Agile methodology is best suited for projects which have changing requirement, either due to people or technology as the value of product delivered to customers is very important. (Highsmith J et al., 2003). Agile principles in practice state the following characteristics : assume simplicity, embrace change, enabling the next effort is also a goal, incremental change, maximize stakeholder value, manage with a purpose, multiple project views, rapid feedback, working software is the primary goal of the project(Alleman G, 2002).

There are various Agile methods discussed in literatures.This paper focuses on the SCRUM framework which is one of the largely followed Agile methods. The other methods that very few companies follow based on the survey are EXTREME Programming and Crystal Methodologies.

SCRUM as described by Schwaber(2002) is an agile process that accepts the development process as unpredictable, complex to be planned in advance. Planning ahead is very common approach in traditional project management, but may not be the case with every software projects. SCRUM focuses on situation when it is difficult to plan ahead, where feedback from customers plays a very vital role.   SCRUM is implemented through three roles as shown in Table I

TABLE I : Roles and Responsibilities

Role	Responsibilities
Product Owner	Represents the interests of everyone with a stake in the project and its resulting system. Maintains the Product Backlog ,i.e., a prioritized list of project requirements with estimated times to turn them into completed product functionality.
Team	Responsible for developing functionality. Teams are self-managing, self-organizing ,and cross-functional, and they are responsible for figuring out how to turn Product Backlog into an increment of functionality within iteration and managing their own work to do so. Team members are collectively responsible for the success of each iteration and of the project as a whole.
ScrumMaster	Responsible for managing the Scrum process, i.e., for teaching Scrum to everyone involved in the project, for implementing Scrum so that it fits within an organization's culture and still delivers the expected benefits, and for ensuring that everyone follows Scrum rules and practices.

Source : Marcal et al., 2007, Mapping CMMI project management process areas to scrum practices

The software product is developed in SPRINTS i.e. Tasks are done in increments by the self-organizing team. Sprint a 30 period of development, initiated with Sprint planning meeting where the team as described in Table 1 collaborate to plan for the next Sprint (Schwalber, 2004). SCRUM concentrates on how teams can produce software in a constantly changing environment. (Schwaber K. and Beedle M, 2002).

III.   CHALLENGES OF MOVING TO AGILE METHODOLOGIES

Agile methods impact people and project elements. It gives a reasonable approach for high degree of change and uncertainty in software development projects. Selection of an Agile method should be carefully considered by the project manager after evaluating the project characteristics**.** It is an alternative methodology provided to project manager for software development and management, when the required processes and product delivered are important to the customers**. (**Coram M. and Bohner S, 2001).

Agile methods as stated in CIO.com article are a set of umbrella terms for a set of approaches that are interactive, incremental and collaborative.   Team self-motivation and users active involvement is one the major part of the agile methodologies. There is a lot of resistance, moving from traditional to Agile methods due to the approach of Agile as it is a lot of cultural change in many organizations. The teams have to be self organizing and cross functional.

According to Barry Boehm, both Agile and plan- driven methods form part of planning spectrum. Hybrid approaches that combine both methods are feasible and necessary. Trends are moving closer to agile methods, to meet the disparate needs of customer's requirements and project characteristics (Boehm B, 2002)**.** Literature states that Agile software development approaches address to survive in the turbulent environment by taking into account the market demands, retain quality and expecting innovation that meet customer needs (Highsmith J. and A. Cockburn, 2001).

IV.   RESEARCH METHODOLOGY

IT companies being highly sensitive to fast changing customer requirements, implementation of agile processes in projects is a natural progression. At this backdrop, this paper attempts to measure agility in software development projects, using a widely used framework called SCRUM. Apart from SCRUM, the other popular frameworks used under the agile methodologies are Extreme Programming, Crystal methodologies.

In our study which dealt with 100 odd companies, we could identify only two companies practicing frameworks, other than SCRUM. Hence, we considered these companies as exceptions, rather than practice.

Lee and Xia (2010) provide an agile development literature where they discuss variables that influence project agility. Similar paper published by Chow and Cao (2008) discusses critical success factors in agile software projects. Based on such prior research, we prepared a list of variables which was used to interview twenty five experienced practitioners like agile coaches, project directors, etc. The purpose was to converge the list and identify the variables influencing project agility in the Indian context. Four factors

emerged as common variables from the discussions held. These are – number of members involved in the project, individual years of experience, experience across various project models (agile, waterfall) and number of clients served.

Based on the above, a questionnaire was prepared that included the practices of various agile frameworks and the four variables that emerged as significant during the previous interview conducted on 25 experts.

To collect our sample, we considered data from companies which have well-defined processes throughout the organization along with clear guidelines, focus and documentation. Based on the above requirement that defined the population frame, the sample was selected from Capability Maturity Model (CMM) Level 3 companies only (Weber et al, 1993). Though 960 companies come under this category, only 100 CMM Level 3 companies responded to our questionnaire through web survey. Out of these 100 companies which are either of completely Indian origin or multinational companies with Indian operation, 84 companies' responses were considered to be valid. This constituted our sample. As mentioned earlier, out of these 84 companies, two companies were following Kanban Process, one was following Crystal and the rest, i.e., 81 companies followed SCRUM as a method for project agility.

Hence, the second section was only related to the respondents who were practicing SCRUM, i.e., 81 respondents. These 81 respondent also included scrum coaches and few project directors, other than project managers and project leads. Based on a 10-point scale (10 being high and 1 being low), the respondents were required to answer to the questionnaire that captures 10 practices under SCRUM methodology. The questionnaire was a combination of the above and also included questions targeted to the four variables that influence project agility.

The authors failed to identify any tangible research that measures software project agility, its practice and effectiveness in the Indian context. India being the IT hub of the world, such a study was assumed to have immense significance. Though academic research is scarce, the extent of use and the level of interest in agile methods seem to be increasingly high.

The researchers hence felt the need for investigating the practice of agile methods and the extent of its agility, in the Indian context by interviewing agile coaches and agile practitioners.

A. Data Collection

The questionnaire consisted of two sections. The first section had questions related to demographics of the target population. It included questions pertaining to position held and responsibilities in the organization, projects in which agile methodology has been applied, total experience of using agile methods, and similar details. It also included questions on agile practices followed in a company. Within the SCRUM

framework, they were asked to rate the practices according to the level of importance given by the organization. All practices were measured on a 10 point scale, with 10 being the highest rating. This section helped in deriving the agility index for each company.

In this context, it is worthwhile to discuss, how the agility index was developed. Let us first consider one of the practices, out of the ten considered for the study. For a single practice there were 81 SCRUM responses, each being responded on a scale of 10. Hence, the maximum total of this data can be 810. Let us assume that based on the actual data collected the total of this data is 405. Based on this, we calculated the weight that can be assigned to this practice. In this case, it will be equal to 405/810 = 0.50. These weights were then converted to percentage values. In similar fashion, we calculated the weights for all the 10 practices under the SCRUM methodology. These weights were later multiplied with the actual values of each of the practices for each respondent to calculate the index for that company.

Based on the weights of factors associated with the practices followed in the SCRUM framework by different companies, the following equation was used to arrive at the project agility index (the weights are in percentage terms).

PAI= 32.72 * (Clearly Defined Product Owners) + 80.0 * (Team has a sprint backlog) + 86.79 * (Daily Scrum) + 67.41 * (Demo after every Sprint) + 64.07 * (Define Done Criteria) + 46.91 * (Retrospective after every Sprint) + 61.48 * (PO has a product backlog) + 23.46 * (Sprint Planning meetings) + 31.48 * (Time boxed iterations) + 55.93 * (Team members sit together).

This equation with the weights or coefficients were used to derive the Project Agility Index for all the relevant respondents, representing different companies.

This value of agility index was again converted to a percentage value for each respondent, by dividing each value by the highest agility index value from the 81 responses. In this way we derived the cumulative percentage of agility for all the respondents from different projects and companies. The agility index value ranged between 28.40 percent and 39.55 percent. The cumulative percentage of agility had the highest value as the benchmark index with a value of 100, followed with the rest. This lowest cumulative percentage of agility was registered as 0.72 percent.

The second section of the questionnaire captured the four variables (mentioned earlier) which are suspected to influence the project agility index.

The questionnaire was validated by Agile coaches and researchers who work on qualitative and quantitative methods, Their feedback was considered to refine the questionnaire.

After collection of the data, regression was conducted considering the project agility index as the dependent variable and the four variables that influence project agility as the independent variables.

The tables below mentions the profile of the respondents from whom the data was collected. Table II gives a frequency distribution of the respondents in terms of number of years of their experience in managing agile projects. Out of the 81 respondents, 17 of them have 3 to 5 years of experience, which represents 20.98 percent of the population surveyed.

TABLE II: Respondents' Years of Experience

Years	Frequency	Percent
Less than 3	0	0
3-5	17	20.98
6-8	38	46.91
9 and above	26	33.22
Total	81	100

Table III gives a frequency distribution of the number of members involved in the team of a project. Out of 81 respondents, 41 of them have a team size of 10 to 19 members in a project which represents 50.61 percent of the population surveyed.

TABLE III: Number of Team members in a project.

Team member size	Frequency	Percent
Less than 10	2	2.46
10-19	41	50.61
20-29	36	44.44
30-39	1	1.32
40-49	1	1.32
Total	81	100

Table IV gives a frequency distribution of the number of clients served by the company. Out of 81 respondents, 22 of them have served around 4 to 5 clients which represents 27.18 percent of the population surveyed.

TABLE IV: Number of clients served

Number	Frequency	Percent
Less than 3	1	1.32
4-5	22	27.18
6-7	47	58.02
8-9	11	13.58
Total	81	100

Since the fourth variable, *Experience across various project models*, doesn't have any significant impact on the level of agility, its frequency distribution has not been included.

B. Data Analysis

This research is an exploratory study to develop a generic framework to measure the relative level of agility of companies. Based on the responses from various companies spread across various geographical locations in India and diversified domains, the above framework is developed. It captures how the different forms of practices within SCRUM can impact the index of agility in a project. The second part of the study looks at the relevance of the agility index in terms of the factors that influence it (Williams and Monge, 2001).The success is gauged using multiple regression analysis, where the relative predictive importance of the independent variables

was tested against the dependent variable, project agility index.

According to McClave and Benson (1988), the general multiple regression models, assuming that there are *k* independent variables, can be written as follows:

$$Y = K_0 + K_1 x_1 + K_2 x_2 + K_3 x_3 + K_4 x_4 + e_i$$

where, *Y* is the dependent variable and $x_1, x_2, ..., x_p$ are the independent variables, K_i is the regression coefficient, and e_i is the random error component. The value of the coefficient K_i determines the contribution of the independent variable xi, given that the other x variables are held constant and K_0 is the y-intercept. The sign of the coefficient also determines the direction of the relationship between the dependent and the independent variable. As per our earlier discussions, we have a total of four independent variables, hence, the above equation. The dependent variable in our case is the measurement of project agility index.

C. Assimilating the factors

A general survey was conducted among scrum coaches, directors of various organizations to assimilate the various factors that could affect the variation in above mentioned measurement of Agility model, where each individual in an organization, and so is the case across various organizations, (all following Agile methodology) weigh the scrum practices on different scales. Based on the responses that we received, the predominant factors that according to most could have affected this range of responses are:

- Number of members involved in the project.
- Individual years of experience
- Experience across various project models (Agile, Waterfall).
- Number of Clients served.

V.   USING THE REGRESSION MODELS

Based on the above hypothesis factors the analysis was performed on two levels – Multiple Regression model and Stepwise regression model. In the first model, all the 4 independent variables were entered into a regression model at the same time; with the expectation that the calculation of the coefficients would take into account the interaction of all other variables being present. The independent variables get relative importance which accounts for their criticality in the contribution towards the dependent variables. Those variables which get top scores would be considered to be a critical success factor.

In the regression model, a stepwise regression procedure was carried out in order to come up with the most appropriate variables that have significant contribution in predicting well the results of the Agility Index.

In Stepwise Regression, there are steps and in each step an independent variable enters the model. In the first step the independent variable with the highest influence on the dependent variable enters the model, followed with subsequent steps. Independent variables stop entering the model, when the explanatory power on the dependent variable no longer exists.

VI. INFERENCES FROM THE REGRESSION ANALYSIS

In our case, we find that the first independent variable that enters the model is *Years of Experience*. This variable has an explanatory power (as represented by the R-Squared value) of 32 percent on Project Agility Index. As the coefficient of the independent variable is positive it implies that higher the years of experience of the person who is implementing agile projects, higher is his chance of success.

The second variable that enters in the second step is *Number of Members*. This variable has 16.7 percent incremental contribution to the explanatory power of the dependent variable. The coefficient of this variable, interestingly, is negative. This implies, "Too many cooks spoil the broth." In other words, if the number of members in the software project, which is supposed to be agile, is high, then the chances of success is low. Hence, we can infer from this observation that projects which are agile would look for a lean organizational structure.

TABLE V: Step wise Regression Output

Step	Variables	Coefficient	R^2 change	p-value	t-value
	Constant	32.13	-	0.0000	28.194
1	Years of experience	0.2828	-	0.0001	4.2353
2	Number of members involved in the project	-0.0876	0.0532	0.0066	-2.7914
3	Number of clients	0.2719	0.0373	0.0306	2.2025

The third and the last independent variable that has emerged to have a significant impact on project agility is *Number of Clients*. An important aspect to be noted is that the number of years of experience in agile project management does not necessarily capture the number of agile projects successfully executed. For example, two respondents may have equal years of work experience in managing agile projects, but the number of clients handled can be very different. This independent variable, *Number of clients* has a 10 percent incremental contribution on the total explanatory power of the model. After inclusion of this independent variable, the total explanatory power of the regression model comes up to 41 percent. This last independent variable also has a positive relationship with the dependent variable. This would imply that more the number of clients served, higher is the agility level of the projects. If a project manager is successful in implementing agile projects, his rate of completion of projects is faster and more efficient and hence would be able to serve more clients. On the other hand, if

there are more projects to be handled, successful completion is not possible, unless the projects are agile. Hence, the relationship between number of projects managed and number of clients served is not unidirectional.

As discussed earlier, the sequence in which the independent variables influence the dependent variable is given in the form of steps in first column in Table V. Based on the p-values, we can come to the same conclusion, as well. The first independent variable – *Years of experience* has the lowest p-value, implying the highest influence on the dependent variable. This is followed by *Number of Members* involved in the project and finally *Number of Clients*. The third independent variable, *Number of clients* has the highest p-value, though it is still significant at 99 percent level of confidence. The last independent variable, *Experience across various project models* had a p-value higher than 0.10 and hence did not emerge as a significant variable in stepwise regression.

VII. CONCLUSIONS

Academic research in software agile methods is in a nascent stage (Lee and Xia, 2010). Such research in the Indian market context is practically non-existent. This paper serves to fill that gap by a) Developing a software agility index and b) Finding the factors that influence project agility in a business landscape.

The project agility index developed here can be used by companies to calculate their level of agility by using the importance given to different practices under SCRUM framework. To fortify the agility index, it is worthwhile to look at the best practices followed by global companies practicing agility for an extended span of time, handling a high number of complex projects within a given year. A global perspective will also help us achieve a higher benchmark for the agility index.

Three variables emerged as significant contributors to influence the project agility index. They are: a) Number of years of experience of the respondent implementing agility, b) Number of members involved in the project and c) Number of clients served by the respondent.

In this study the agility index has been framed based on the inputs given by IT companies based in India, which may or may not capture the true scenario followed by all Indian companies. The sample considered for the study may not be completely representative of the larger population. The findings were limited to SCRUM framework due to the lack of access to companies which are following other practices. To cover a holistic picture, this study can be extended to other frameworks of agile methodologies.

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