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Prioritize Agile Software Development Factors Using Analytical Hierarchy Process Approach

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ABSTRACT

Software projects are considered to be successful, if they are completed in time and within budget. But, in traditional methodologies, a lot of projects got over budget and take more time for completion than required. To overcome these challenges, agile software methodologies came into market formally in 2001 and there is enough evidence in the market to say that agile methodologies are performing better than traditional. Now the need arises to know the factors which were making it successful and out of these factors, which one are the most important. Firstly, after reviewing the literature, five factors have been found which are responsible for success of agile projects (organization, people, process, project and technical factor) and took the four different criteria's (time, cost, scope and quality) to measure the success of software projects. An expert questionnaire method was used to find the significant factors. Analytical hierarchy process was used and project factor came out to be the most important factor.

***Keywords*Agile software development, Analytical hierarchy process, Extreme programming, Success factors, Scrum.**

I. INTRODUCTION

Agile software development (ASD) was an outcome of a huge number of project failures in traditional software development even though companies have having vast experience in implementing traditional approach. Agile development came in 2001 when many practitioners sat together and named it as an umbrella term for various customized software methodologies.Agile development focused and committed to faster development of product, better quality, building customer relationship and welcome changes in the project at any time. Agile increasing feat was revealed in various reports, survey results, experiments and case studies [1]. The 98% respondents of 11th annual report survey conducted by versiononestated that their organizations have recognized the achievement of agile while doing projects and the most used agile methodologies were Scrum and hybrid of Scrum/Extreme Programming (XP)[2]. Scrum approach was basically used to cope with the software projects whereas XP was used to accomplish project level activities for software development. The survey results by [3] showed that agile teams were more dedicatedon business value and improving the productivity rather than traditional teams. When traditional development used, the results showed that it mostly upset the morale of teams severely. Now the questions arises, "which are important factors for ASD projects success and which factor plays a vital role for decision making of project manager". The decision making was important as agile

not only used in software development but also used in textile industry, automotive industry, mobile applications and robots development[4]. This paper is structured as follows: Introduction section explained the importance of ASD. Section 2 provided an overview about the literature associated with ASD, section 3 described about the research methodology, section 4 explained about the AHP, section 5 discussed results and calculation and last section 6 mentioned about the conclusion of the paper.

II. RELATED WORK

In year 2006, the authors [5] have discussed about agility drivers, agility abilities and agility criteria for success of ASD. The criteria on which project was measured whether it was successful were cost, time, quality and scope. The authors [6] have studies various articles till year 2005 and have included only 36 articles for the review. These 36 articles were also grouped into four different aspects which were related with adoption, people factors, perception about agile and benefits & limitations of agile with other methodologies. The authors [7]explored and found five factors which were directly or indirectly related with agile projects. These were named as process, project, technical, organization and people factors which were further comprised of different variables. Projects were considered to be successful if they were completed within cost, time, scope and quality. The authors [8] have revealed about the importance of organization factor in the agile usage methods.The results indicated a significant association between agile usage methods and organization culture. The authors [9] explained in detailed about organization dimension and people dimension and used survey method to statistically proofthe success factors required for the software project. The authors [10] have discussed and proposed project factors and people factors that impact the efforts, time and cost of software projects. This study showed that project factors were of very high importance and cost, time and effort for medium sized companies can be estimated efficiently. The authors [11] have done a qualitative approach and grouped eight factors into four dimensions named as people, project, organization and methods and proper understanding of these factors have indicated an increase in value of software and success rate of software projects. In this study, [12]authors have explored the literature and suggested a conceptual framework. The framework comprised of four factors and these were organization, process, people and technology. This framework was not validated using confirmatory factor analysis. The authors [13] have identified critical factors of Scrum methodology in Srilankaand they were named as people, communication, process and organization. All these four factors were found significantly related to success of software projects. This same study can be conducted and validated in different countries.In year 2015, authors [14]have proposed a contingency fit model and have found three factors for success of software projects. These were organization, team and customer related factors. This contingency fit model indicated to match project characteristics and methodology with these three factors to make project successful. This model was conceptual and validation of this model was not performed using empirical data. The authors in their study [15] have also identified six dimensions for the software projects, these were process, project, product, technical, organization and project dimensions and gave a conceptual framework. From the literature review, it was found that many authors have cited enough these five main factors for software projects, these were project, process technical, organization and people and mainly four criteria

(cost, time, scope and quality) for measuring project success. These factors and criteria for project study has been taken in the present study.

III. RESEARCH METHODOLOGY

The factors were mainly adapted from the study [7], [9], [16]. The drive of this investigation was to rank the important factors for the software project so that it helps project managers for effective decision making on the basis of criteria like time, cost, quality and scope. Five factors were adapted from literature and the expert opinions and help project managers in decision making. After adaptation of these factors, a survey was conducted from agile field experts and each expert has been asked to rate the factors and criteria's in pairwise matrix with the scale of 1 to 9. 1 was used for equally preferred, 3 for moderately preferred, 5 for strongly preferred, 7 for very strongly preferred and 2,4,6,8 were used for intermediate values[17]. The experts were from industry and academia and they were total 30 in number. All the experts were having more than 3 years of experience and have handled more than one agile project. These experts have filled pairwise comparison matrix for five factors and criteria's individually. Then, average score of all experts were taken in the comparison matrix table. Analytical hierarchy process (AHP) was performed on this table to calculate prioritize vector, composite index (CI) and composite ratio using excel for factors and criteria's.At the end combined composite weight was calculated and on the basis of this combined composite weight, the factors were ranked from 1 to 5.

IV. ANALYTICAL HIERARCHY PROCESS

AHP technique was widely accepted and used in decision making in case of multi criteria but with a common objective.AHP was used in ASD after defining overall objective, criteria and decision alternatives [18]as shown in Fig 1.

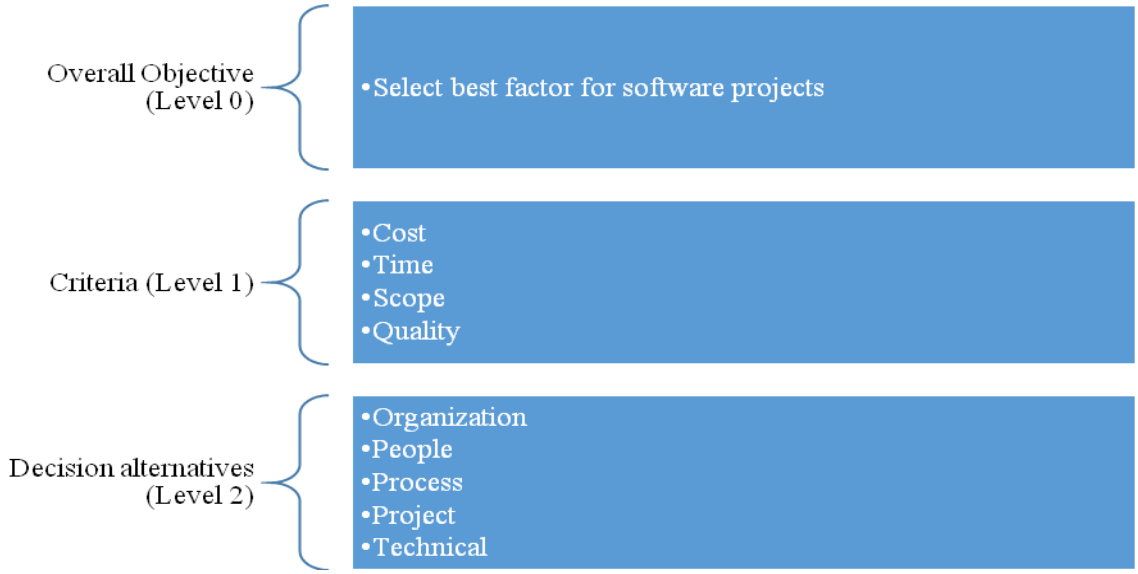

Figure 1: AHP process for factors

In AHP, firstly find the decision alternatives and make the pairwise comparison wise chart of decision alternatives and calculate the prioritize vector and Eigen vector so that ranking of factors can be done and Consistency Ratio (CR) should be less than 0.1 so that it shows that results were consistent [19].

V. RESULT & DISCUSSION

To calculate the weights for criteria or priority vector, take combined average for comparison matrix or priority matrix which was given by experts' opinions. Comparison matrix was of size 4*4 as there are four criteria's. Now, divide each column entry in matrix by the sum of the column and then take the average of each row.To know whether results were consistent or not, calculate CR and it should be less than 0.10. All the pair wise results for all criteria's were shown in Table 1.

CR= (Consistency Index) /(Random Index) **(1)**

Consistency Index = (λ_{max}-t)/ (t-1) **(2)**

wherematrix size denoted by and highest eigen value denoted by λ_{max}

Table 1: Criteria (level 1) based paired comparison matrix with respect to overall objective

	Cost	Time	Scope	Quality	Priority Vector	λ (Eigen value)	Results
Cost	1.00	0.33	0.33	0.33	0.10	4.00	λ_{max}= 4.15
Time	3.00	1.00	3.00	1.00	0.37	4.19	CI = 0.05
Scope	3.00	0.33	1.00	0.33	0.17	4.20	RI = 0.90
Quality	3.00	1.00	3.00	1.00	0.37	4.19	CR = 0.05 (Acceptable)

Table 2: RI (Random index)

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.45

Source: [18]

The paired comparison matrix was performed for factors with cost, time, scope and quality respectively. Table 3, Table 4, Table 5 and Table 6 showed paired matrix respectively. All the results were found consistent as CR of all factors with respective criteria's found below 0.10.

Table 3: Paired comparison matrix of factors (level 2) with respect to cost

	Technical	Organization	People	Project	Process	Priority Vector	λ	Results
Technical	1.00	0.33	0.33	0.14	5.00	0.09	5.36	λ_{max}= 5.36
Organization	3.00	1.00	3.00	0.33	5.00	0.24	5.37	CI = 0.09

People	3.00	0.33	1.00	0.33	3.00	0.14	5.48	RI = 1.12
Project	7.00	3.00	3.00	1.00	9.00	0.48	5.44	CR = 0.08
Process	0.20	0.20	0.33	0.11	1.00	0.04	5.14	(Acceptable)

Table 4: Paired comparison matrix of factors (level 2) with respect to time

	Technical	Organization	People	Project	Process	Priority Vector	λ	Results
Technical	1.00	0.50	3.00	0.14	5.00	0.16	5.48	λ_{max}= 5.41
Organization	2.00	1.00	3.00	0.33	3.00	0.20	5.73	CI = 0.10
People	0.33	0.33	1.00	0.33	5.00	0.12	4.93	RI = 1.12
Project	7.00	3.00	3.00	1.00	9.00	0.49	5.77	CR = 0.09
Process	0.20	0.20	0.20	0.11	1.00	0.04	5.14	(Acceptable)

Table 5: Paired comparison matrix of factors (level 2) with respect to scope

	Technical	Organization	People	Project	Process	Priority Vector	λ	Results
Technical	1.00	0.20	3.00	0.33	3.00	0.13	5.44	λ_{max}= 5.36
Organization	5.00	1.00	7.00	3.00	5.00	0.49	5.57	CI = 0.09
People	0.33	0.14	1.00	0.33	3.00	0.08	5.14	RI = 1.12
Project	3.00	0.33	3.00	1.00	5.00	0.24	5.51	CR = 0.08
Process	0.33	0.20	0.33	0.20	1.00	0.05	5.13	(Acceptable)

Table 6: Paired comparison matrix of factors (level 2) with respect to quality

	Technical	Organization	People	Project	Process	Priority Vector	λ	Results
Technical	1.00	0.20	3.00	0.33	3.00	0.13	5.48	λ_{max}= 5.40
Organization	5.00	1.00	5.00	3.00	5.00	0.46	5.66	CI = 0.10
People	0.33	0.20	1.00	0.20	3.00	0.09	5.07	RI = 1.12
Project	3.00	0.33	5.00	1.00	5.00	0.27	5.63	CR = 0.09
Process	0.33	0.20	0.33	0.20	1.00	0.05	5.16	(Acceptable)

After performing pair comparison matrix of factors separately, the most important was to find out the composite weight for the factors with overall objective. After receiving composite weight,rank factors according to the highest composite weight. Project factor has the highest importance as its composite weight and process factor

has the least importance among all five factors. Project factor were related with the aspects of project like project size, project complexity. The process factors were related with process tools and techniques required for project management, planning and monitoring. The results were shown in Table 7.

Table 7: Overall composite weights for the factors

Criteria		Cost	Time	Scope	Quality	Composite Weight	Rank
Factor ↓	Criteria Weight →	0.1	0.37	0.17	0.37		
Technical		0.09	0.16	0.13	0.13	0.14	3
Organization		0.24	0.2	0.49	0.46	0.35	2
People		0.14	0.12	0.08	0.09	0.11	4
Project		0.48	0.49	0.24	0.27	0.37	1
Process		0.04	0.04	0.05	0.05	0.05	5

Combined CR= $\sum w_i CI_i / \sum w_i RI_i$ **(3)**

Combined CR = (1 * 0.05 + 0.10 * 0.09 + 0.37 *0.10 + 0.17 * 0.09 + 0.37 * 0.10)/ (1* 0.9 + 0.10 * 1.12 + 0.37 *1.12 + 0.17 * 1.12 + 0.37 * 1.12)

Combined CR = 0.07 which is less then < 0.10 and results were consistent with evaluations.

VI. CONCLUSION

AHP method was used to evaluate the importance of agile factors. AHP was used when number of criteria's and alternatives were less than 7 unless it was not as much effective technique. AHP was a choice making method and used to evaluate the alternatives and choose the best alternative. An adapted scale was used in the study to know the important factor for agile projects. In this study, survey was collected from experts and priority vector, CI, RI, highest eigen valuewere calculated after making paired comparison matrix tables and results were checked to know the consistency of evaluations by looking at values of CRs.The factors were ranked according to their composite weight. On the top of list project factor followed by organization, technical, people and process factor respectively. The composite weight lied in the range of 0.05 to 0.37 and its CR was also found to be appropriate. This ranking will help project managers to concentrate on the most important factors first, so that project success can be achieved.

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