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Fuzzy Multi Attribute Assessment Model for Software Outsourcing Partnership Formation

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ABSTRACT Building on the preceding studies, this paper aims to extend the latest capability maturity model integration (CMMI)-based organization assessment model to the fuzzy environment. Our approach has overcome the limitations of the preceding CMMI-based models. Our proposed model is based on the multi-attribute decision-making (MADM) approach incorporating the capability of group decision making. The rating of qualitative factors based on crisp values may be insufficient to model the real-world MADM industrial problem. For controlling human subjective vagueness, linguistic variables are translated using the triangular fuzzy number. The proposed model is generalized in order to be easy to adopt by other organizational assessment practitioner and researcher. Other researcher and practitioner can adopt the proposed model procedure and methodology in order to develop their own organizational assessment, capability improvement, and decision-making framework for companies, enterprises, or organization. The proposed model has two working parts. The ranking part of the framework model can be used for ranking the importance of influential factors, while the assessment part of the model can be used as an assessment tool in the SDO organization. Collectively, it might be utilized as a decision support system. A running numerical example of software outsourcing partnership (SOP) formation is presented to validate the proposed model. The ranking part is demonstrated with the help of empirical survey conducted with 35 experts, while the assessment part is demonstrated by conducting two case studies in SDO organization. SDO vendor organization can benefit from the model to gauge their capability toward SOP formation.

INDEX TERMS Triangular fuzzy numbers, Fuzzy multi-criteria decision making, group decision making, Motorola assessment tool, client-vendor relationship, software outsourcing partnership.

I. INTRODUCTION

In the literature, two perspectives exist for the design and development of an assessment (maturity) model i.e potential performance perspective and life cycle perspective [1], [2]. The early models like Nolan's model [3] belong to the life cycle perspectives. In this perspective, an organization progresses has to pass all the stages automatically, due to learning effects and improvements with the passage of time. These models have a designated "final" stage, which can be reached while progressing over time. Nowadays, most of the published assessment models are based on the potential performance perspective [1], [2]. In this perspective, an organization may achieve higher stage based on their performance while the "final" stage of maturity is the stage where no further improvement is needed [2]. Crosby's Quality Management Maturity Grid (QMMG) fits into the potential performance perspective [4]. Assessment models differ in their structure. However, every assessment model has two components in common [2].

1. A defined set of levels, representing the development of object in streamlined ways. These levels should be based on organizational activities and structure, representing a hierarchical development and must be executed sequentially [2].
2. A defined set of criteria in the form of application targets, process, or condition. These criteria represent the capability of the measure objects and affect the organizational process, units or problem domain [1], [2].

Nowadays, most of the models are design and developed through potential performance perspective [1] and are based on the classic staged maturity framework introduced by Humphrey in 1988 [5].

A. APPROACHES TO MATURITY ASSESSMENT MODEL DEVELOPMENT

According to Wendler [2] in the majority of maturity assessment models, the authors follow some unknown models developed in results of the outcomes of other researcher or their own developed model. Others follow some widely adopted approach developed by standard organization like, COBIT by CioIndex, QMMG by Crosby's [4], BPMM (Business Process Maturity Model) [6] developed by OMG (Object Management Group), SPICE (Software Process Improvement and Capability dEtermination) [7] by SQI (Software Quality Institute), ISO/IEC 15504 [8] and ISO-33000 family of standards by ISO, and CMMI(Capability Maturity Model Integration) by SEI (Software Engineering Institute) [9]. There are also some other widely adopted approaches like COPC,[1] PMMM,[2] LEAN,[3] and OPM3[4] but these are not relevant to our domain. A summarized view of the approaches is given below.

1) COBIT BY CIOINDEX[5]

COBIT maturity model was rarely addressed in the research contributions. Therefore, we did not find any reference from published literature.

2) QMMG BY CROSBY'S

This approach focuses on six features of the quality management using five maturity levels. The levels of QMMG range from certainty (L5), wisdom (L4), enlightenment (L3), awakening (L2), and uncertainty (L1) [4]. Maturity models based on this approach are [10] and [11].

3) BPMM BY OMG[6]

This approach was used as a process improvement framework. It provides a roadmap for process improvement and guide manager to monitor business process efficiency. Innovating (L5), predictable (L4), standardized (L3), managed (L2), and initial (L1) are the five levels of BPMM. Maturity models based on this approach are [6] and [12].

4) SPICE (SOFTWARE) BY SQI[7]

It contains nine parted documents that is used to support software process assessment and improvement [7]. Its first version was released in 1995. Its six capability levels are continuously improving (L5), quantitatively controlled (L4), well defined (L3), planned and tracked (L2), performed informally (L1), not performed (L0). Maturity models based on this approach are [13] and [14].

5) ISO/IEC 15504 AND ISO-33000 FAMILY OF STANDARDS[8]

The SPICE evolved into ISO/IEC 15504 with six maturity levels. After CMMI, ISO/IEC 15504 is an emerging international standard for software process assessment [8]. ISO/IEC 15504 has also introduced assessment levels. Its six assessments levels are optimizing (L5), predictable (L4), established (L3), Managed (L2), performed (L1), and incomplete (L0). The ISO/IEC 15504 standard has evolved into a more advanced set of process assessment, the ISO/IEC 33000 family. Maturity models based on this approach are [15] and [16].

6) CMM/CMMI BY SEI[9]

CMMI is an established and mostly adopted organization capability assessment model [17]. Its first version was released in 1993 in the form of CMM while the last version CMMI for Development 1.3 was released in 2010. CMMI model contains five capability maturity levels (CMLs) [18]. The highest CML is level 5 that represents an outstanding capability (a quality production) while the lowest CML is 1, which denotes an ailing controlled software engineering process [9]. The first CML contains no key process areas (KPAs) while the other four contain 22 KPAs. Each KPA has their own related practices that would be used to accomplish a set of well-defined objectives [19]. Attainment of a certain CML for a software development organization is subject to the achievement of all the listed objectives of the KPAs in that particular CML plus in all the lower order CML [17]–[19].

However, for the design and development of the customized maturity models, the researchers have many choices. It is motivating that CMMI has the only widely accepted assessment framework model profoundly adopted by the researcher within the academic community [2], [18], [20]. The other mentioned assessment models, even though widespread in practice, look to be barely adopted for research [2], [18], [20].

B. MINI ASSESSMENT MODEL AS AN ALTERNATIVE TO CMMI

Many software development organization inaugurate software process improvement (SPI) in the form of widespread assessment using software CMMI [9]. However, CMMI based assessments are costly and time-consuming; which looks beyond the reach of the vast majority of small software development companies [16]. Therefore, many organizations find it challenging to do it regularly. Staples *et al.* [21] carried out the study on this very issue and concludes that numerous organizations do not adopt CMMI because of its substantial costs. As a solution, numerous organizations have developed mini assessment instruments to get the process pulsation of

[1] https://www.copc.com/
[2] http://www.pmsolutions.com/
[3] https://www.lean.org/
[4] https://www.pmi.org/
[5] https://www.cioindex.com/article/articleid/950/
[6] https://www.omg.org/spec/BPMM/About-BPMM/
[7] http://www.sqi.gu.edu.au/spice/
[8] https://www.iso.org/standard/50519.html
[9] https://www.sei.cmu.edu/search.cfm?q=CMMI

an organization between full assessments [22]. Furthermore, in some area CMMI based assessment is not applicable [21].

Motorola assessment instrument [23] was the first mini assessment instrument for organizational progress evaluation. This instrument evaluates the software development capability of the organization and announced the current status of the organization relative to CMM [23]. Other similar approaches are mini assessment [22], Dyba scale [24], Iskrate weighted system [25].

Many other models developer uses the structure of CMMI and develops an assessment model in the domain where CMMI is not directly applicable or it is time-consuming and costly. Since the first version of the CMMI [9], more than 150 assessment models have been published to be used in several fields [20]. Following the structure and concepts of CMMI like, CML, KPAs, and practices, a number of researchers have developed various other capability maturity assessments models (CMAMs) for assessing the capability of the organization in various phenomenon's like SPI implementation [19], [26], outsourcing partnership [17], requirements engineering [18], [27], software testing [28], [29], software outsourcing [30], [31], software usability [32], software process maturity [33], cloud computing [34], software quality [35], software measurement [36], software workforce [37], software maintenance [38], software security [39], and organizational learning during the software development [40].

Some authors adapted the structure of CMMI and transferred its contents (tasks and practices) to the new study domains such as knowledge sharing management [41], medical security [42], digital investigations [43], digital game [44], energy efficiency [45], and analytic maturity [46].

In the development of the assessment model most of the aforementioned studies like [27]–[29], [33]–[43], [45], [46], directly adopt the entire CMMI structure. However, in some studies such as [17]–[19], [26], [30], [31], [34], [44], and [47] the KPAs was replaced by critical success factors (CSFs). The available CMAMs [17]–[19], [26]–[47] have both theoretical and industrial contribution to the software community as a general and the model development for the assessment of a specific organization in the specified domain as a particular. Besides the significant contribution, there are some areas where these models can be improved. Some of the limitations common to the available CMAMs are discussed in section III.

In view of Wendler [2] the available maturity models currently lacking a proper structure, validation, and applicability of the adopted structure. Moreover, authors sometimes based their work on other models (mostly CMMI) and transferred their content(tasks and practices) and/or structure without testing its applicability in their problem domain [1], [2].

Generally speaking, to cope with the aforementioned issues, inspired by the referred work [48], [49], this study developed a general framework for the development of Fuzzy Multi-Attribute Assessment Model (FMAAM) for organization evaluation based on the structure of CMMI and fuzzy multi-attribute-decision making (MADM) approach [50], [51] taking various CSFs as main while its implementation practices as sub-criteria. To the best of our knowledge, this study is the first study to proposed an assessment model based on fuzzy MADM approach [48], [49] while still retaining the structure of CMMI [10].

Specifically, based on the knowledge of our previous SOP model [17] and data collected through SLR and questionnaire survey, this study develops a model based on CMMI and fuzzy MADM approach for forecasting the possibility of successful SOP formation. The model will work as an assessment tool for software development outsourcing (SDO) vendors and will indicate their weakness using a fuzzy version of the Motorola instrument [23] developed by SEI [9]. To the best of our knowledge, this study is also the first study to revise the Motorola assessment tool to a fuzzy environment by introducing triangular fuzzy number (TFN) score and updated guidelines to 7-point Likert scales.

In order to undertake corrective improvements to enhance the likelihood of effective SOP formation for future ventures, vendor organization may exercise the proposed model for their internal assessment.

The remainder of the article is arranged as follow: Section II presents a technical background related to the empirical case of SOP formation, CMMI based CMA models, and FMCDM approaches. Limitations of the existing CMA models along with the proposed solutions are listed in Section III. Section IV is the research methodology that presents the framework of the newly developed model. Subsequently, Section V presents the validation of the approach through an empirical case study. Section VI presents the assessment results with the proper recommendation for improvements. Section VII is the summary and discussion while section VIII concludes the paper.

II. BACKGROUND

This study developed an FMAAM for Software Outsourcing Partnership (SOP) formation using the structure of CMMI and FMCDM approach. Therefore, our background section is divided into three sub-sections i.e SOP as an empirical case, CMMI based CMAMs, and FMCDM approaches.

A. THE EMPIRICAL CASE OF SOP FORMATION

In order to remain competing in the market competition, recently global business partnerships have arisen as one of the key collaboration mechanism for growing organizations [17], [52], [53]. It is a bidirectional association between autonomous organizations based on mutual trust and shared goals. To overcome problems and to obtain greater benefits, organization like UPS (Universal Postal Service) and Motorola [54], IBM, Kodak and digital equipment corporation (DEC) [55], Hi Sun and SDB (Shenzhen development bank) [56], Xerox and Electronic Data Systems (EDS) [57], and IBM and United States Achievement Academy (USAA) [55], [57], established partnerships.

From the perspective of the present study, SOP is defined as "a strategic partnering relationship resulting from a process of transferring the software development responsibility for a specific business function from an employee group to a non-employee group including the transfer of assets such as personnel'' [17]. A partnership cannot be precipitously established, but rather it develops with the passage of time. Typically, an established and long-lasting outsourcing association may perhaps is a candidate to be converted to outsourcing partnership [52], [53].

Engaging in partnership with other firms might improve the firm's revenues and competences. Contrariwise, the partnership is not always risk-free. Agreeing to the authors [52], [58], outsourcing partnership has a high disappointment rate. The outcome of Piltan and Sowlati [52] mentioned that outsourcing partnerships were the core source of producing nearly 26% of the revenues for more than 80% organization in their survey. Cost reduction is an attractive factor, but what if you get a software with very ruthless quality [58]. Dyer *et al.* [58] and Piltan and Sowlati [52] reports the failure ratio of outsourcing partnerships from 30% to 70%.

The decisions on either to convert the existing contact based outsourcing relationship to partnership require a careful assessment of various influential factors. Form the client perspective the decision is important since wrong decisions can result in a loss in the form of both efforts and resources. The assessments on whether to proceeds or inhibit SOP formation from the client perspective is not a yes-no question, rather it is a cost-benefit analysis based on various factors [17].

Like other researchers [17]–[19], [26], [30], [31], [34], [44], [47], in this research, we also adopted the concepts of CSFs. We have the view that as compared to KPAs vendor's capability towards partnership formation can be relatively better observed in the forms of CSFs. The vendor capabilities (CSFs) are complementary to CMMI, KPAs. Our developed model is not a standard like ISO-33000 and CMMI neither CMMI nor it is SPI model. Therefore, it is not necessary that software development companies, which are ISO or CMMI, certified, may also be a good candidate for SOP formation. Since the main goal of ISO or CMMI is to advance the software development skills of the organization rather than improving their SOP formation capability.

Unlike the other researcher, we consider the problem as the MCDM problem. Since, several quantitative and qualitative factors impact the conversion/formation decision, signposts that the SOP formation problem is an MCDM problem. Additionally, we have incorporated the fuzzy set theory in order to handle uncertainty, vagueness, human biases, and expert heterogeneity. Piltan and Sowlati [52] considered partnership assessment as MCDM problem. Some author like Lopez and Ishizaka [59] and Rajaeian *et al.* [60] suggested the use of FMCDM to support different outsourcing decisions.

B. SUMMARY OF THE CMMI BASES MODELS

Daskalantonakis [23] was the first researcher who develops an instrument for organizational progress evaluation knows as Motorola assessment instrument. This method was initially developed to drive Motorola's to level 2. They evaluated the capability of the organization and announced the current status of the organization relative to CMM [23]. The assessment instrument has three dimensions in the form of columns in a table where all the key practices can be appraised based on the score from 0 to 10.

Mini-assessment method (MMA) was developed by Eastman Kodak Company as an official method to evaluate the company capability relative to CMM. Although different to Motorola's instrument MMA tool used a score between zeros to one, however they consider all key process area equally important. The lack of documents for reviews and focused interviews decreases the thoroughness and reliability of the mini-assessment [22].

Dyba [24] proposed a tool for evaluating the CSFs in SPI. In their instrument, the author designs an evaluation scale for rating the success factor by giving a score from 1 to 5 Frey-Pucko *et al.* [25], develop a method called SEPAM (Systems Engineering Progress Assessment Method) for Iskrate Telecommunications Systems Developing Company. They propose six choices weighted system using weights like 0, 0.2, 0.4, 0.6, 0.8 and 1.0.

In literature, a number of organizational CMMI based CMAMs build on CSF concepts can be found such as SPI-IF (implementation maturity model, Niazi, 2005) [19], R-CMM(requirements capability maturity model, Beecham, 2005) [27], CenPRA model(A test process evaluation model, Bueno, 2006) [28], REMMF(requirement engineering maturity measurement framework, Niazi, 2007) [47], SAMM(software assurance maturity model, Chandra, 2008) [39], vPMM(value based Process Maturity Model, Lee, 2009) [33], SOVRM(Software outsourcing vendors' readiness model, Khan, 2010) [31], MIS-PyME MCCM (measurement capability maturity model, Diaz-Ley, 2010) [36], OS-UMM(Open source usability maturity model, Raza, 2012) [32], TMMi(Test Maturity Model integration, Veenendaal, 2012) [29], AiOLoS (A model for assessing organizational learning in software development, Chouseinoglou, 2013) [40], DI-CMM(Digital investigations capability maturity model, Kerrigan, 2013) [43], SOPM (Software outsourcing partnership model, Ali, 2014) [17], SWAM(software workforce assessment model, Tanriover, 2015) [37], CCCMM (Coordination communication challenges mitigation model for offshore SDO Vendors, Khan, 2015) [30], UQIM(Unified quality improvement model, Rahmani, 2016) [35], DGMM(Digital game maturity model, Aleem, 2016) [44], SPIIM(Software process improvement implementation and management model, Khan, 2017) [26], EEM(Energy efficiency maturity, Prashar, 2017) [45], APMM(Analytic Processes Maturity Model, Grossmana, 2018) [46]. These models have a number of limitations; few of them are discussed in the next section, i.e section-III. A summarized view of the CMAMs is given in Table. 1. Discussion in section VIII is based on this table.

TABLE 1. Summary of the CMMI bases capability assessment models.

S.NO	Year	Name	Purpose	Data Collection	Design	No of levels	Contents		Analysis and Measurement			Validations	
							Type	No	Analysis	Instrument	Score	Method	No
01	2005	SPI-IF	SPI implementation	Interview +Literature	Staged	04	CSFs+CBs (Practices)	08+07 (34)	Statics	Motorola	Crisp	Case study	02
02	2005	R-CMM	Expert validation of the requirement process	Questionnaire Survey	Staged	05	Practices	20	Statics	Dyba Scale	Crisp	Expert panel review	27
03	2006	CenPRA	Improve artifact oriented test process evaluation	IEEE Std. 829 practices	Process	05	KPAs (Practices)	04 (37)	Statics	Own design	Crisp	Case study	-
04	2007	REMMF	To maturity of requirements engineering process	Interview	Staged	03	CSFs (Practice)	08(66)	Statistic	Motorola	Crisp	Case study	02
05	2008	SAMM	Assessment of software assurance maturity	OpenSAMM Project	Staged	03	KPAs (Practices)	04 (12)	Statistic	Own design	Fuzzy	Expert panel review	33
06	2009	vPMM	Evaluation of business process	Questionnaire Survey	Staged	05	KPAs (Activities)	23 (57)	Statistic	Value-based	Crisp	Case Study	01
07	2010	SOVRM	Evaluation of vendors' readiness for outsourcing	Questionnaire Survey +SLR	Staged	04	CSFs+CBs (Practices)	10+04 (147)	Statistic	Motorola	Crisp	Case Study	03
08	2010	MCMM	To improve company measurement maturity	Questionnaire Survey	Staged	05	KPAs (Activities)	05 (93)	Statistic	GQM	Crisp	Case study	01
09	2012	OS-UMM	To inspects the usability open source projects	Questionnaire Survey	Staged	04	Factors	11	Statistic	BOOTSTRAP	Fuzzy	Case study	02
10	2012	TMMi	A non-profit self-governing test maturity model	Case Study	Staged	05	KPAs (Activities)	16 (81)	Statistic	Own desin	Crisp	Case study	–
11	2013	AiOLoS	To assessing the level of organizational learning	Experimental Case Study	Process	03	KPAs (Activities)	12 (39)	Statistic	GQM	Fuzzy	Case-study	02
112	2013	DI-CMM	To evaluate an organization digital investigation ability	Q.Survey +Interview	Staged	05	KPAs (Activities)	15	Statistic	Own design	Crisp	Case Study	03
13	2014	SOPM	To evaluate the organization ability of outsourcing	Questionnaire Survey +SLR	Staged	05	CSFs (Practices)	14 (142)	Statistic	Motorola	Crisp	Case study	02
14	2015	SWAM	To perform role based workforce skill assessment	SW-CMM	Process	NA	KPAs (Activities)	07 (42)	Math	Bloom's scale	Crisp	Expert panel review	11
15	2015	CCCMM	Communication challenges Mitigation	Questionnaire Survey +SLR	Staged	04	Challenges (Practices)	18 (75)	Statistic	Motorola	Crisp	Case study	02
16	2016	CIP-UQIM	To improve software quality in SME's	Questionnaire Survey +LR	Staged	05	KPAs (Activities)	16 (62)	Statistic	Own design	Crisp	Expert panel review	17
17	2016	DGMM	To improve complex game development projects	LR+ Questionnaire	Staged	05	CSFs (Practices)	7 (18)	Statistic	BOOTSTRAP	Fuzzy	Case study	02
18	2017	SPIIMM	For SPI implementation and management	Questionnaire Survey +SLR	Staged	05	CSFs+CBs (Practices	06+05 (31)	Statistic	Motorola	Crisp	Case study	03
19	2017	EEM	Evaluation of the contemporary maturity	Literature survey	Process	05	KPAs (Activities)	07 (19)	Statistic	Zero Defect Zero effect	Crisp	Case study	
20	2017	RMSPIM	For requirements management practices implementation	Literature survey	Process	NA	CMMI Practices	02	Statistics	Own design	Crisp	Expert panel review	
21	2018	APMM	To evaluate the analytic maturity of an organization	Literature survey	Staged	05	KPAs (Practices)	06 (25)	Statistics	Own design	Crisp	Not validated	-

C. SUMMARY OF THE FMCDM APPROACHES

Grounded on the solution space of the studied issues, MCDM studies can be distributed into two broad classes, i.e. multi-objective decision making (MODM) and multi-attribute decision making (MADM) [50], [51]. In MODM (also called continuous MCDM) the decision variables are continuous and the number of alternatives are almost unlimited [50], [61]. While for MADM (also called discrete MCDM) the decision variables are discrete and expert has to choose from limited numbers of available alternatives [50], [61]. The MADM firstly weighs the available alternatives and lists the superior and inferior alternatives in order, and then selects the optimal one [50]. Since our attribute is discrete, therefore, our study is a kind of MADM. In the literature, the discrete MCDM (MADM) is commonly labeled as MCDM [50], [61]. Therefore, in this paper, we also use MCDM to represent MADM.

MCDM having more than one alternative or attribute in uncertain conditions among which the decision-maker has to choose, rank or rate a choice or asserting the weights of attributes based on the predetermined set of conditions [62]. The objective of the MCDM is to rank all the candidate choices and then choosing the ideal one by employing a certain approach and existing decision information with consideration of different criteria [50]. MCDM is a constituent part of modern decision support system (DSS) and is based on decision science, systems engineering, and management science.

MCDM has lots of applications in many fields such as software development [49], [63], business management [64], [65], civil engineering [66], economics and finance [67], operational research [68], [69], outsourcing and partnership [49], [70], information technology [71], information sciences [72], transportation [73], [74], tourism management [75], [76], gaming [77], supply chain management [78], online banking [79], and marine science [80].

Numerous methods for dealing with the MCDM problem have been proposed by researchers. The most notable are SWARA (step-wise weight assessment ratio analysis) [64], multiplicative exponential weighting (MEW) [65], VIKOR (Vlse Kriterijumska Optimizacija Kompromisno Resenje) [66], simple additive weighting (SAW) [81], ELECTRE (Elimination and Choice Expressing REality), GDM (grey decision-making) [82], technique for ordering preference by similarity to ideal solution (TOPSIS) [83], MEEM (matter-element extension model) [84], AHP (Analytic Hierarchy Process) [85], ANP (Analytic Network Process) [86], PCM (Pairwise Comparison Matrix) [87], and Group Decision Making (GDM) [62].

Zadeh [88] was the first author who used the multi-criteria model for subjective decision-making processes using 'fuzzy sets theory'. Following Bellman and Zadeh [89] framed the decision-making problem in the fuzzy environment. After this FMCDM, approach has widely been employed to cope with MCDM problems. Kou *et al.* [87] developed a fuzzy multi-attribute decision-making framework to provide the subjective decision on objective choices in an ambiguous environment. Xu and Chen [90] and Li *et al.* [62] suggested a fuzzy multiple attribute group decision-making method. Wang [91] proposed a novel FMCDM approach based on negative and positive maximum-minimum solutions. In another study [92] the author develops an FMCDM framework based on upper and lower boundaries. Shakouri and Tavassoli [80], combined AHP (analytic hierarchy process) method and fuzzy inference system (FIS) with FMCDM and proposed a hybrid approach. Wang [91], proposed a fuzzy math programming technique for mix multi-criteria group decision making with incomplete criteria weight information and hesitant fuzzy truth degrees.

Chou [68] applied FMCDM approach to transshipment field for best marine port selection problems. Wang [48] employed FMCDM approach, in order to assess the monetary performance of local airlines in Taiwan. Narukawa and Torra [77] evaluate approaches in games by making use of FMCDM techniques. Chou *et al.* [71] used FMCDM approach for forecasting return on investment in IS/IT field. Ding and Liang [78] employed FMCDM to partner selection problem for liner shipping. Chang and Wang [72] measure organization knowledge management capability using FMCDM taking Taiwan semiconductor manufacturing company as a case. Likewise, Hu and Liao [79] presented critical criteria for weighting electronic facility extent in online banking in Taiwan by means of FMCDM. Hu [75] assess service quality of travel websites using FMCDM. Akincilar and Dagdeviren [76], proposed a hybrid FMCDM to evaluate hotel websites. Vahdani *et al.* [74] proposed two new FMCDM approaches for alternative fuel buses selection. Dalalah *et al.* [69] adopted FMCDM for supplier selection problem. Subsequently, Kuo and Liang [73] proposed an FMCDM framework for assessing intercity public conveyance system. Buyukozkan [63] measure the performance of software development projects utilizing FMCDM. Samantra *et al.* [70] proposed a risk assessment framework in IT outsourcing using FMCDM approach. Sangaiah and Thangavelu [49], assess the offshore/on-site team's partnership quality using FMCDM.

The models developed through FMCDM approach have the ability to handle uncertainty and vagueness in the expert judgment but they do not have the ability to identify the weak and strong area of an organization. Further, these models can rank influential factors but they cannot be used for multiple organizations as an assessment tool because the ranking mechanisms are based on the judgment of an expert belongs to only one organization. In the case of our framework, our study adopted an online survey in order to ensure the representation of diverse geographic locations and working environments. Since these models are not based on the structure like CMMI, therefore, these models will not give a complete assessment; rather can only be used as a prediction model. Our study extends organization CMAMs to a fuzzy multi-attribute assessment tool based on FMCDM approach and fuzzy version of Motorola guidelines.

D. FUZZY SETS

A fuzzy set allocates the value of membership to objects within its universe of discourse in a range of zero and one. On the other hand, classical set (crisp set) allocates the value of membership to objects within its universe of discourse which either one or zero. Let X is a universal set whose elements are {x} then, a fuzzy set *A* defined by its membership function as follows:

$$\mu_A(\mathrm{x}):\ \mathrm{X} \rightarrow [0, 1] \tag{1}$$

which allocates to each {x} a grade of membership *A* in interval [0, 1]. A fuzzy set can also be represented by a continuous membership function $\mu_{\mathrm{A}}(x)$

$$\mu_A(\mathrm{x}) = \begin{Bmatrix} 0 \quad if\ x \leq 1 \\ \dfrac{x-1}{m-l} \quad if\ l \leq x \leq m \\ \dfrac{u-x}{u-m} \quad if\ m \leq x \leq u \\ 0 \quad if\ x \geq u \end{Bmatrix} \tag{2}$$

E. FUZZY NUMBERS

Two commonly used forms of fuzzy numbers are trapezoidal and triangular. Fig. 1(a), indicates the x coordinates of the 3 vertices (**l**; **m**; **u**) of $\mu_{\mathrm{A}}(\mathrm{x})$ in a fuzzy set A. In Fig 1(a) ***l*** means lower, ***m*** mean central and, ***u*** mean upper boundary. In ***l*** and ***m*** the membership degree is zero while in ***m*** it is 1.

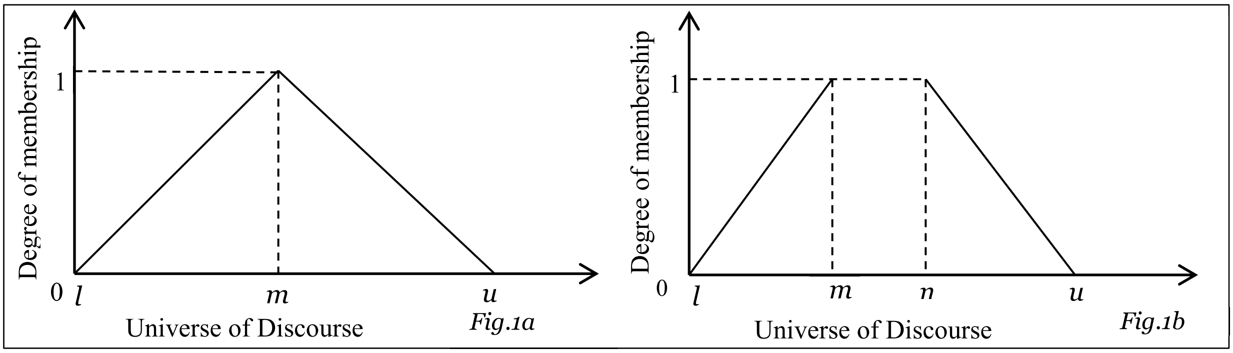

FIGURE 1. Triangular and trapezoidal fuzzy numbers.

F. LINGUISTIC SCALE

Several articles have mentioned that the subjective fuzziness of human thoughts can be dispensed by incorporating fuzzy set theory [48], [49], [72], [73]. As consequences, linguistic scale was recommended giving a practical means of unfolding such circumstances. In our study, we have incorporated seven points linguistic scale for assigning the importance weights of 130 practices respectively as shown in Table 2.

TABLE 2. Linguistic terms for weighting practices.

Linguistic terms	Corresponding weight of importance
Extremely contributing	(0.9, 1.0, 1.0)
Moderately contributing	(0.7,0.9,1.0)
Slightly contributing	(0.5, 0.7, 0.9)
Neutral	(0.3, 0.5, 0.7)
Slightly opposing	(0.1, 0.3, 0.5)
Moderately opposing	(0.0,0.1,0.5)
Strongly opposing	(0.0, 0.0, 0.1)

Similarly, seven linguistic variables as shown in Table 3 based on Motorola assessment tool are provided to the case organization to rate the implementation of practices across the three dimensions (approach, deployment, results) of Motorola assessment tool [23] as presented in Table 3.

TABLE 3. Linguistic term for rating of practices.

Linguistic term	Corresponding rate of implementation
Outstanding	(0.9, 1.0, 1.0)
Fully implemented	(0.7,0.9,1.0)
Marginally implemented	(0.5, 0.7, 0.9)
Fair	(0.3, 0.5, 0.7)
Weak	(0.1, 0.3, 0.5)
Poor	(0.0,0.1,0.5)
Very poor	(0.0, 0.0, 0.1)

III. LIMITATION OF THE EXISTING CMA MODEL AND OUR PROPOSED SOLUTION

Decision making is the selection of a satisfactory or optimal choice from a number of alternative choices [75], [86]. When multiple alternatives are considered, the decision making can be label as MCDM [69]. Several quantitative and qualitative factors impact the assessment decision, signposts that the assessment problem is an MCDM problem [62], [65].

Limitation #1: Most of the preceding models such as [17], [19], [26]–[36], [38], and [40]–[47] does not consider the problem as a multi-criteria decision making (MCDM) problem.

Software development vendors often inaugurate the SPI process using the guidelines of SEI in the form of software CMMI [9], with a widespread process assessment. Many other models developer such as [17]–[19] and [26]–[47] uses CMMI and develop an assessment model.

Need #1: Lack of capability assessment model for an organization based on Fuzzy MCDM.

Zadeh [88] was the first author who used the multi-criteria model for subjective decision-making. Following Zadeh, numerous authors used the method for different problems [64]–[70], [72], [73], [75], [80]. Some authors like Sangaiah and Thangavelu [49] and Buyukozkan [63] used the Fuzzy MCDM in software engineering, outsourcing [70], and partnership [52] domain but their methods are not based on CMMI nor they can provide a complete assessment.

Proposed Solution #1: Fuzzy Multi-Attribute Assessment Model (FMAAM).

Our Approach #1: This study develops a general template for capability assessment model based on FMCDM.

To the best of our knowledge, this study is the first study which proposed an assessment model based on FMCDM [48], [49] while retaining the structure of CMMI [9].

Limitation #2: The highest number of the preceding investigators such as [17]–[19], [26]–[36], [38], and [40]–[47] used statistics for the assessment and analysis.

The only exception found in [37] and [39]. In statistics, uncertainty is handled by randomness but in practice, not all uncertainties straightforwardly suitable for the probabilistic classification [88].

Need #2: There is a need for an assessment model to better deal with subjective vagueness, uncertainty, and human biases.

According to Kou *et al.* [67], real-world assessment making problems usually require subjective data provided by the expert evaluator. As each expert has a different knowledge level, complex judgment making experiences, and preference structures [48], [73]. For the stated reason, a good assessment model must tolerate ambiguity or vagueness [49], [73], [87].

Proposed Solution #2: Fuzzy mathematics has the ability to deals with such sorts of uncertainties better than statistics.

Several articles have mentioned that the subjective fuzziness of human thoughts can be dispensed by incorporating fuzzy set theory [48], [49], [72], [73], [93]. Fuzzy information in FMCDM method is denoted by fuzzy sets. Fuzzy set assign scores of association to object in the interior of their universe of discourse. A certain object in this technique can fit some higher class of objects with merely partial membership [88].

Our Approach #2: Our framework model is based on mathematics (fuzzy set theory).

Limitation #3: Most of the preceding organizational assessments models are based on survey or interview data, and their assessments are based on expert panel review or case study and still not incorporate a treatment to cope with human subjectivity, data uncertainty, and vagueness.

Some CMAMs try to handle subjectivity are [39], [40], and [44].

According to Prodanovic [93], in practice experts usually have to make a decision with incomplete, imprecise, or vague data. Uncertainty in data means vagueness or fuzziness due to poorly defined boundaries of scale [51]. Vagueness exists in the natural language terms, such as much smaller than, much better than, good or best, important, significant, considerable, fully implemented, partially implemented, not implement, achieved, achieving, qualified, marginally qualified or outstanding, etc. [49], [72].

Need #3: To express the situations that are hard to define with traditional techniques, there is a need for a new quantification technique.

According to Zadeh [88], the traditional quantification techniques face difficulties in expressing the situations that were hard to define or overly complicated.

Proposed Solution #3: Adopts computing with words technique in decision making [94].

Linguistic variables with a corresponding triangular fuzzy number (TFN) offered practical means of describing such situations. Several researchers [48], [49], [72], and [73] recommended linguistic scale, according to them linguistic scale giving a practical means of controlling incident of the subjective fuzziness of human thoughts.

Our Approach #3: In this study, the linguistic terms with corresponding values in TFN format are applied to reflect the attribute information.

Seven linguistic variables (term) were provided to the survey expert for ranking, as shown in Table 2. Later, we translated the linguistic term to corresponding TFN as shown in Table 2.

Limitation #4: Most of the preceding models such as [17], [19], [26], [30], [31], [34], and [47] used Motorola as an assessment instrument, which provides scores for the rating from three dimensions in the form of crisp numbers (0, 2, 4, 6, 8, 10).

According to Chang and Wang [72], it is impractical to give a single crisp value for an expert subjective opinion; specifically for an imprecise or vague data. In view of Prodanovic [93], the set of all real numbers >1 is a well-known example of classes of objects, where boundaries are poorly defined or not clear. According to Guo and Zhao [50], to handle the vagueness commonly expressed in decision data arising from the qualitative subjective judgment of the decision-makers, due to the ambiguity or lack of complete information the crisp values may be insufficient to model the real world MCDM problems.

Need #4: There is a need to revise the Motorola assessment tool to a fuzzy environment.

To the best of our knowledge, this study is the first study to revise the Motorola assessment tool to a fuzzy environment by introducing TFN score and revising guidelines to seven Likert scales. To validate this claim, we make a search with the string (maturity OR capability OR assessment) AND (model OR framework) on the ScienceDirect and IEEEXplore digital library.

Proposed Solution #4: Revise the Motorola scores (0, 2, 6, 8, and 10) to seven points Likert scale in TFN format.

Our Approach #4: In this paper, seven linguistic variables were provided to the expert participant of the case study for rating, as shown in Table 3. The guideline is also updated to seven points Likert scale.

Limitation #5: The earlier models considered all influential factors equally important.

According to Chang and Wang [72], not all the influential factors are equally important because the influential factors in the success contribution may have different meanings. Therefore, it is more practical, realistic, straightforward, and easy for evaluators to rank the factors like "factor F strongly contributes to the success of SOP formation" rather than to say factor F contributes 70% to the success of SOP formation."

Need #5: There is a need to rank the influential factors before using in the success or failure prediction.

According to Li *et al.* [62], transforming heterogeneous information into a single form results in loss of valuable information. To avoid information loss, the author proposed a method to integrate heterogeneous data using a method called weighted-power average operator.

Proposed Solution #5: A ranking mechanism with a heterogeneous technique for information integration.

Our Approach #5: Our mechanism is presented in the form of equations (4), (5), and (6) using the scale presented in Table 2.

For the above-stated purpose, this study presents the experts with self-effacing linguistic scale (easy to understand linguistic terms as shown in Table 2 column 1), parameterized by TFNs to give their judgment about the importance (weight) of listed influential factors, identified through SLR. The individual judgments were then integrated using (4). The aggregated outcomes are then used to obtain best non-fuzzy performance using (5) and finally, it was normalized by (6) to find the rank in crisp number format.

Limitation #6: For ranking of the influential factors in the preceding models, no attention is given to the expert heterogeneity (except [37]). Further, for rating in the vendor organization, some of the models allow only one representative to rate the implementation of the practices in their particular organization in the case study (see these models [17], [19], [26], [30], [31], [47]).

According to Li *et al.* [62], heterogeneity may exist when there is different preference formats or different knowledge level background and expression of the expert. In many situations, decision problems involve many field experts called group decision-making (GDM) [62]. The only CMAM able to tolerate expert heterogeneity is [37].

Need #6: For universally acceptable results it is better to use a number of experts having representation from a diverse number of departments, and then to aggregate the judgment keeping heterogeneity in mind.

Prodanovic [93], suggest the presence of various field experts in the process of decision-making.

Proposed Solution #6: Adopt heterogeneous Group Decision Making Model(GDM) [62].

Our Approach #6: This study develops a model capable of aggregating the decision of multiple experts using multiple CSFs and practices as influential factors.

In our proposed framework, multiple experts can participate in both the ranking survey and rating assessment case study. In this study, we have aggregated the judgment of 35 experts participated in the ranking survey while rating is done by ten experts from each case organization. Further, rating experts were chosen from various departments in the same organization. Moreover, unlike the preceding studies ranking expert were chosen from diverse nationalities, as outsourcing is a global trading.

A. INTRODUCTION TO THE PROPOSED FRAMEWORK

To cope with the aforementioned issues, inspired by the referred work, this study developed a Fuzzy Multi-Attribute Assessment Model (FMAAM) for SOP formation based on CMMI and FMCDM. The model will work as an assessment tool for SDO vendors and will indicate their strengths and weakness using a fuzzy version of the Motorola instrument developed by SEI [58].

The proposed model has two working parts (1) ranking part and (2) assessment part. The advantage of dividing the model into two parts is that each part can also be used separately. The ranking part of the framework model can be used as a ranking mechanism for weighting the importance of influential factors, while the assessment part of the model can be used as an assessment tool in SDO vendor organization. For instance, in order to find which factors contribute more or less, we have to rank the factors using the ranking part of the proposed model. Similarly, in order, to assess the capability of the organization and put it into a particular level, we can use the assessment part to know about weak and strong factors. Collectively, it can be used as a DSS.

The ranking part is demonstrated with the help of empirical survey conducted with 35 experts while the assessment part of the model is demonstrated by conducting two case studies in the SDO vendor companies. Besides, checking the capability of the SDO for SOP, the model helps decision-maker with decision support about whether to inhibit or initiate the conversion/formation. Consequently, SDO can make use of the assessment framework to advance their decision making and use suitable corrective actions as suggested by the framework model to avoid any loss in the form of resources and time. The model also indicates the weakness of the organization in order to take helpful improvement review to enhance the possibility of SOP formation for future ventures.

In the ranking phase, similar to the model discussed in the section II.B, we divide the influential factors and their respective practices into different levels. Then conduct a case study in a specific organization using Motorola instrument as an assessment tool but unlike to them the score given by the expert is translated into a fuzzy format using rating scale given in Table.2 and 3. We have translated the expert opinion into TFN and used a similar method as used by the FMCDM authors discuss in section II.B specifically [48], [49]. Only in the ranking phase of the proposed framework model, we follow the model [48], [49], but unlike them the expert not belongs to a specific country or organization. Furthermore, similar to the FMCDM [48], [49] studies, the model will give a quantitative measurement for decision support but unlike to them, our model will provide further assessment in both success and failure state. In case of success, it will provide the level of implementation of SOP while in case of failure it will indicate weak factors and practices. Similar to the assessment models [17]–[19], [26]–[47], our model will announce the level that organization stand. However, unlike these models, our framework will give success and failure percentage in order to guide the decision maker precisely.

B. STUDY CONTRIBUTION

The industrial and theoretical contribution of the present research is the design and development of a general framework for the improvement of multi-attribute assessment models. The model will do an organization assessment based on various influential factors and practices as an evaluation criterion. The industrial contribution of the model is that it can be used as an assessment tool for SDO vendors and will indicate their weakness using a fuzzy version of the Motorola instrument developed by SEI [23]. In order to undertake corrective improvements to enhance the likelihood of effective SOP formation for future ventures, vendor organization may exercise the proposed model for their internal assessment. The proposed model is primarily developed for use in the

SDO vendor organizations. However, it is also beneficial to software outsourcing client organizations as client organizations can identify the capacities in which SDO vendors can be evaluated based on their individual priorities. Moreover, clients can make a better informed-decision of their choice of SDO vendors. The framework model will help SDO client organization in the conversion of their existing contract based outsourcing relationship to outsourcing partnership. The model can be used in the client organization as DSS for deciding whether to inhibit or initiate the conversion. This model will not only work as a decision support tool but will also work as an assessment tool, for scrutinizing organizational capability in SOP formation by taking CSFs and practice as an input.

Theoretical contribution of the study is the general structure of the model. Other researcher and practitioner can adopt the proposed model procedure and methodology in order to develop their own organizational assessment, capability improvement, and decision-making framework for companies, enterprises, or organization. Moreover, the ranking part of the model can be used to design a ranking tool, to rank the success or failure contribution of different success factors or risk factor while the assessment part of the framework can be used to develop mini assessment instrument. Collectively, it can be used as a DSS. Other researchers may also incorporate the proposed model structure in order to develop a group decision making systems in the other relevant fields. The sub contributions of the study are:

- The study extended the Motorola assessment instrument to a fuzzy environment by suggesting the TFN scale for its dimension. Our specific contribution is the introduction of TFN scores and the updated guidelines for a 7-point Likert scale. The existing Motorola guidelines are suitable for a 5-point Likert scale only; we have added two more rows, one at the start and the other it the end to make it convenient for measurement on a 7-point Likert scale.
- The study demonstrates the potential of FMCDM based approach in guiding and evaluating SDO towards software outsourcing partnership formation.
- The study demonstrates the capability of the Group Decision Making (GDM) process for SOP formation.
- The study develops a model capable of aggregating the decision of multiple experts using multiple critical success factors (CSFs) and practices.
- The study develops a mechanism for ranking individual CSF and level.
- The study develops a mechanism for finding the rank of practice inside level and CFS.
- The study develops FMAAM for SOP based on CMMI and FMCDM approach.

IV. METHODOLOGY AND FRAMEWORK

Methodology for the proposed model development is pictorialized in Fig.2. We have utilized a mix of qualitative and quantitative approaches. Details are given as follow:

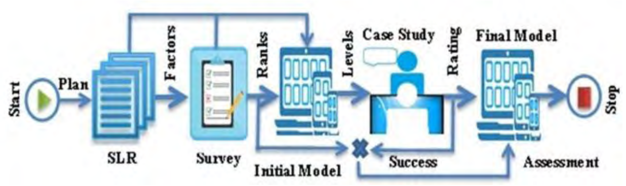

FIGURE 2. Methodology for proposed model development.

Phase #1: First of all the plan was design called SLR protocol, the literature was searched, and facts were collected according to the SLR protocol.

Phase #2: Secondly, a questionnaire survey was conducted for the validation and assessment of the SLR results.

Phase #3: Thirdly, an initial model was developed by distributing the factors and practices in five levels of the models.

Phase #4: In the fourth phase, case studies were conducted in order to check the practicality of the proposed model and to validate the model. In light of the recommendation of the case study, the initial model was revised into the final model.

A. FRAMEWORK FOR MODEL DEVELOPMENT FOR SOP FORMATION

In this study, we propose an analytical model for outsourcing stakeholder, using FMCDM approach, to evaluate their ability towards SOP formation. The proposed model is shown in Fig.3. Our proposed FMAAM framework consists of five main stages.

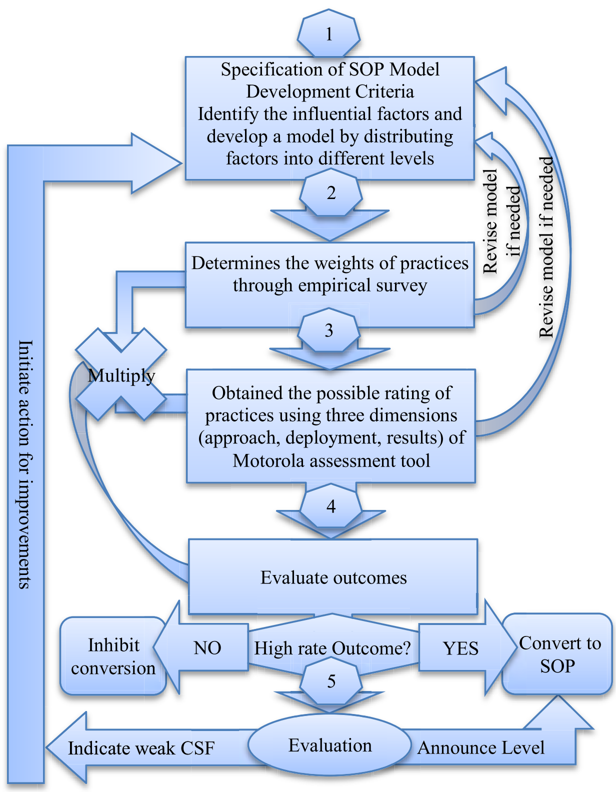

FIGURE 3. FMAAM Framework for evaluating SOP formation.

TABLE 4. Key evaluation dimensions of Motorola assessment tool.

Score	Approach	Deployment	Results
Very poor	• Practice not evident OR • No organizational ability OR • No management appreciation of need	• No part of the company uses the practice OR • No part of the company express interest	✓ No change
Poor	• Poor organizational ability OR • poor management recognition of need OR • poor organizational commitment	• Some part of the company uses the practice OR • Some part of the company express interest	✓ Ineffective
Weak	• Supportive items for the practice start to be created OR • Little parts of the company are able to implement the practice OR • Management starts to recognize needs	• Fragmented or inconsistent use of practice OR • Implemented in some parts of the company OR • Use subject to verification/ monitoring in some parts of company	✓ Inconsistent results OR ✓ Spotty results OR ✓ Indication of effectiveness only for some parts of the company
Fair	• Procedure for practice implementation defined OR • Numerous supportive items for the practice in place OR • Widespread but not full commitment by management	• Use subject to verification/ monitoring in several parts of company OR • Less fragmented use or uniformity in use OR • Used in some major parts of the company	✓ Unpredictable results for other parts of the company OR ✓ Reliable and positive results for some important parts of the company
Marginally Implemented	• Supportive items in place • Some management becomes preemptive and assure implementation • Practice implementation across every part of the company	• Use subject to verification/ monitoring in all of the company • Practice used in many parts of the company • Practice mostly stable across various parts of the company	✓ Positive quantifiable results in maximum parts of the company OR ✓ Constantly positive results over time throughout the company
Implemented	• Practice established as an essential part of the procedure • Most of the administration is proactive • Supporting items facilitate and encourage the use of practice • Entire management is committed	• Verification/ monitoring of use for nearly every part of the company • Installed in nearly every part of the company • Constant use across nearly every part of the company	✓ Constantly positive outcomes with the passage of time across nearly every part of the company OR ✓ Positive measurable outcomes in nearly every part of the company
Outstanding	• Management provides OR enthusiastic leadership and commitment OR • Organizational excellence in the practice recognized even outdoor the firm	• Verification/ monitoring for every part of the company OR • Consistent use with the passage of time throughout the company OR • Universal and consistent set up in every part of the company	✓ Requirement exceeded OR ✓ Guidance sought by others OR ✓ Constantly world-class results

Stage-1 (Identification of Influential Factors and Framing Them Into Model Form): In stage-1, we have used SLR as a method for data collection. For the present study, we had identified 14 CSF and 130 practices from a sample composed of 152 papers. Furthermore, we have distributed the identified CSFs into five partnership levels based on the structure of the CMMI [9], IMM [19], SOVRM [31], CCCMM [30], SOPM [17], and SPIIM [26].

Stage-2 (Obtaining the Importance Weights of the Influential Factors): In stage-2, we steered a questionnaire based-survey with thirty-five experts in the SDO industry. The drive of the survey was twofold 1) to confirm the findings of SLR and 2) to find the importance weights of the practices. The outcomes of this phase are summarized in Table 6. In light of the outcomes of the survey, we have revised the model.

The survey also validates the initial grouping of the inflectional factors into different levels.

Stage-3 (Obtaining the Possible Implementation of the Influential Factors): In the third stage, we have conducted a case study with the SDO organization. The aim of the case study was twofold 1) to check the practicality of the proposed model and 2) to find the possible rating of the inflectional factors. For rating, we use the dimension and guidance of the Motorola assessment tool [23], as given in Table 4. The outcome of this phase is summarized in Table 8. In light of the case study results, we may revise the model if needed [17].

Stage-4 (Evaluate the Outcomes): In stage-4, we evaluate the outcomes of phase 3. If high rate outcomes are obtained, then the successful conversion will be announced, otherwise, failure will be announced. In either case, we will proceed to Stage 5.

Stage-5 (Assess the Organization Through Model): As results of the assessment, the model will indicate weak CSFs in case of a failure while in case of success the model will announce the level and further improvements direction.

B. IDENTIFICATION OF INFLUENTIAL FACTORS AND FRAMING THEM INTO MODEL FORM

In this study, we used the outcome of our preceding SLR study [17]. In which we find 26 success factor out of which 14 was ranked is CSFs. For the proper implementation of the factors, we have collected 130 practices. We have adapted CMMI [9], SPI-IF [19], SOVRM [31], CCCMM [30], SOPM [17], and SPIIMM [7] perspectives and developed the initial model as shown in Table 5. The CSFs are categorized into five partnerships levels as shown in Table 5. Practices for 14 CSFs are listed in Appendix-D (Table 13). The code C1P1 means practice 1 for CSF1.

TABLE 5. Software Outsourcing Partnership levels.

Level no	SOPM partnership level	CSFs and its practices
1	**CONTRACT** This Partnership level can be best described as one of the chaotic processes	Nill
2	**SUCCESS** The focus of this level lies on establishing success for SDO projects	Effective and timely communication(C1P1-C1P17) Quality production(C2P1-C2P13) Success stories of previous projects (C3P1-C3P5) Access to new technologies, markets and complementary skills (C14P1-C14P6)
3	**READINESS** Trust of clients has been gained	Cross-cultural understanding and sensitivity (C4P1-C4P6) Mutual interdependence and shared values (C5P1-C5P7) Mutual trust (6P1-C6P15) Organizational proximity (C7P1-C7P11) Bidirectional transfer of knowledge (C8P1-C8P10)
4	**CONVERSION** Conversion and implementation has been successfully done at this level	Coordination, cooperation, and collaboration(C9P1-C9P11) Flexible service level agreements (C10P1-C10P7) Joint management infrastructure (C11P1-C11P7)
5	**MATURITY** Maturing the relationship through continuous management	Long-term commitments (C12P1-C12P6) Governance and control (C13P1-C13P9)

Below are the 5 levels of our proposed model:

1. **Initial contract:** The first level can be defined as one of the chaotic processes. The relationship at level-1 is purely contractual.
2. **Successful contract:** Second level of our model focuses on continues success of SDO projects. In this phase, constant enhancement is made for making the contract based relationship successful. Level-2 has four CSFs as shown in Table 5. For putting into practice, the four CSFs forty-one practices were found as given in Appendix-D (Table 13, #1-35 and #125-130).
3. **Partnership readiness:** The focus of the third level of our model is to gain the trust of the client. At level-3, inclination for a partnership will be observed and readiness of the company will be evaluated. Level-3 has five CSFs as shown in Table 5. For the proper implementation of the five CSFs, forty-nine practices were found as given in Appendix-D (Table 13, #36-84).
4. **Conversion to partnership:** Conversion or formation takes places at fourth level. Level-4 has three CSFs as shown in Table 5. For the proper implementation of the three CSFs, twenty-five practices were found as given in Appendix-D (Table 13, #85-109).
5. **Maturing partnership:** It is the fifth and last level of our proposed model. This level focuses on maturing the relation through efficient and effective management. Level-5 has two CSFs as shown in Table 5. For putting into practice the two CSFs, fifteen practices were found as given in Appendix-D (Table 13, #110-124).

C. OBTAINING THE IMPORTANCE WEIGHTS OF THE PRACTICES AND FACTORS

This study presented the participant an easy to grasp linguistic term, parameterize using TFNs, to express subjective agreement or disagreement about the significance of different practices. We are interested in findings the importance weight because not all of the practices are equally important. The procedure for obtaining the significance weights of practices are explained in the following steps:

Step 1: Create a judgment matrix $\tilde{A}$ for the significance weights of practices ($\tilde{P}_j, 1, 2, 3, \ldots\ldots\ldots, n$). The respondent of the survey ($\tilde{R}^i, 1, 2, 3, \ldots\ldots\ldots, m$) are then requested to give their independent estimations about the significant weight of each practice ($\tilde{\alpha}_j^i$ $\substack{j\\i}$ where $\boldsymbol{p}$ represent practice $\boldsymbol{i}$ represents practice number and $\boldsymbol{j}$ represent an expert number) by incorporating the linguistic variable as shown in Table 2, for example

$$\tilde{A} = \begin{matrix} & R^1 & R^2 & R^3 & \cdots & R^m \\ \begin{matrix} P_1 \\ P_2 \\ P_3 \\ \vdots \\ P_n \end{matrix} & \multicolumn{5}{c}{\begin{bmatrix} \tilde{\alpha}_1^1 & \tilde{\alpha}_1^2 & \tilde{\alpha}_1^3 & \cdots & \tilde{\alpha}_1^m \\ \tilde{\alpha}_2^1 & \tilde{\alpha}_2^2 & \tilde{p}_2^3 & \cdots & \tilde{\alpha}_2^m \\ \tilde{\alpha}_3^1 & \tilde{\alpha}_3^2 & \tilde{\alpha}_3^3 & \cdots & \tilde{\alpha}_3^m \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \tilde{\alpha}_n^1 & \tilde{\alpha}_n^2 & \tilde{\alpha}_n^3 & \cdots & \tilde{\alpha}_n^m \end{bmatrix}} \end{matrix},$$

$$j = 1, 2, \ldots, n; \quad i = 1, 2, \ldots, m, \tag{3}$$

where n represent the total number of practices and m represent total number of respondent, $\tilde{\alpha}_j^i = (l\tilde{\alpha}_j^i, m\tilde{\alpha}_j^i, u\tilde{\alpha}_j^i)$ shows the fuzzy weight of the practices given by ith respondent for jth practice. One example, of the result, is given in Table.6.

Step 2: Since the subjective evaluation of each participant vary with respect to their experience, role, perception, and understanding of the subject matter. Therefore, we incorporated the mean score approach to aggregate the fuzzy importance of each practices by m respondent.

$$\tilde{\omega}_j = \frac{1}{m}\left[\sum_{i=1}^{m} \alpha_j^i\right] \tag{4}$$

Where $\tilde{\omega}_j = (l\tilde{\omega}_j, m\tilde{\omega}_j, u\tilde{\omega}_j)$ shows the aggregate fuzzy importance weight of the jth practice.

TABLE 6. Corresponding TFNs (Weighting) of CSF3: 'Success stories of the previous projects'.

Expert	C3P1	C3P2	C3P3	C3P4	C3P5
E1	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E2	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.7,0.9,1.0)
E3	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E4	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E5	(0.9,1.0,1.0)	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E6	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E7	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E8	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.7,0.9,1.0)
E9	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E10	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E11	(0.5,0.7,0.9)	(0.5,0.7,0.9)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E12	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E13	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E14	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E15	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E16	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E17	(0.5,0.7,0.9)	(0.5,0.7,0.9)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.7,0.9,1.0)
E18	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E19	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E20	(0.5,0.7,0.9)	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.7,0.9,1.0)
E21	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.7,0.9,1.0)
E22	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E23	(0.9,1.0,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E24	(0.9,1.0,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E25	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E26	(0.7,0.9,1.0)	(0.5,0.7,0.9)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E27	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E28	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.7,0.9,1.0)
E29	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E30	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.7,0.9,1.0)
E31	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E32	(0.9,1.0,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E33	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E34	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
E35	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
$\tilde{\omega}_j$	**(0.79,0.93,0.99)**	**(0.81,0.94,0.99)**	**(0.85,0.97,1.00)**	**(0.90,1.00,1.00)**	**(0.86,0.97,1.00)**

Step 3: The aggregated TFN $\tilde{\omega}_j$ is used to obtain the best non-fuzzy performance (BNF) value, BNP_{W_j}. BNP_{W_j} can be produced through (5)

$$BNP_{W_j} = \frac{[(uw_j - lw_j) + (mw_j - lw_j)]}{3} + lw_j \tag{5}$$

Here, $BNPw_j$ represents the BNP value for the TFN $\tilde{\omega}_j$ while Wj is the importance weight of the jth practice in classical (crisp) number format.

Step 4: After the defuzzifcation of TFN in step4, crisp numbers are obtained and normalized using (6)

$$R_j = \frac{W_j}{\sum_{j=1}^{n} W_j} \tag{6}$$

Where R_j shows the normalized significance weight of the jth practice such that $\sum_{j=1}^{n} R_j = 1$.

We also calculate and normalized the crisp number for each practice within CSFs R_{PC} and within level R_{PL} using (7) and respectively.

$$R_{PC} = \frac{W_{PC}}{\sum_{PC=1}^{k} W_{PC}} \tag{7}$$

Here W_{Pc} represent the BNP weight of the each individual practice in the respective CSF, k represent the total number of practices in that CSF while $\sum_{PC=1}^{k} W_{PC}$ (= sum of the BNP weight of the all practices in that CSF).

$$R_{PL} = \frac{W_{PL}}{\sum_{PL=1}^{h} W_{PL}} \tag{8}$$

Here W_{PL} represent the BNP weight of the each individual practice in the respective level, while h is the total number of practice in that level.

Using W_{Pc} (BNP weight of practice in CSF), we can calculate the W_C BNP weight of each CSF by (9) and W_L BNP weight of each Level by using (10).

$$W_C = \sum\nolimits_{PC=1}^{k} W_{PC} \tag{9}$$

$$W_L = \sum\nolimits_{PL=1}^{h} W_{PL} \tag{10}$$

D. OBTAINING THE EXTENT OF IMPLEMENTATION OF THE PRACTICES IN THE RESPECTIVE ORGANIZATION

The procedures for obtaining the extent implementation of the practices in the respective organization are explained in the following steps:

Step 1: Create three matrices $\tilde{B}_A$, $\tilde{B}_D$, and $\tilde{B}_R$ for the extent of implementation of practices ($\tilde{P}_j$, 1, 2, 3, ..., n). A, D and R represent the three dimensions of Motorola assessment tool as given in Table. 3. The respondent of the survey ($\tilde{R}^i$, 1, 2, 3, ..., m) are then questioned to give their subjective opinions about the extent of implementation of each practice in their respective organization the guidelines of Motorola assessment tool [23] as specified in Table.3, by choosing linguistic term as given in Table 2 for example,

$$\tilde{B}_A = \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \\ \vdots \\ P_n \end{array} \begin{array}{c} \begin{array}{ccccc} R^1 & R^2 & R^3 & \cdots & R^m \end{array} \\ \begin{bmatrix} \tilde{\beta}_1^1 & \tilde{\beta}_1^2 & \tilde{\beta}_1^3 & \cdots & \tilde{\beta}_1^m \\ \tilde{\beta}_2^1 & \tilde{\beta}_2^2 & \tilde{p}_2^3 & \cdots & \tilde{\beta}_2^m \\ \tilde{\beta}_3^1 & \tilde{\alpha}_3^2 & \tilde{\alpha}_3^3 & \cdots & \tilde{\beta}_3^m \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \tilde{\beta}_n^1 & \tilde{\beta}_n^2 & \tilde{\beta}_n^3 & \cdots & \tilde{\beta}_n^m \end{bmatrix} \end{array}, \quad j = 1, 2, \ldots, n; \quad i = 1, 2, \ldots, m, \tag{11}$$

$$\tilde{B}_D = \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \\ \vdots \\ P_n \end{array} \begin{array}{c} \begin{array}{ccccc} R^1 & R^2 & R^3 & \cdots & R^m \end{array} \\ \begin{bmatrix} \tilde{\beta}_1^1 & \tilde{\beta}_1^2 & \tilde{\beta}_1^3 & \cdots & \tilde{\beta}_1^m \\ \tilde{\beta}_2^1 & \tilde{\beta}_2^2 & \tilde{p}_2^3 & \cdots & \tilde{\beta}_2^m \\ \tilde{\beta}_3^1 & \tilde{\alpha}_3^2 & \tilde{\alpha}_3^3 & \cdots & \tilde{\beta}_3^m \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \tilde{\beta}_n^1 & \tilde{\beta}_n^2 & \tilde{\beta}_n^3 & \cdots & \tilde{\beta}_n^m \end{bmatrix} \end{array}, \quad j = 1, 2, \ldots, n; \quad i = 1, 2, \ldots, m, \tag{12}$$

$$\tilde{B}_R = \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \\ \vdots \\ P_n \end{array} \begin{array}{c} \begin{array}{ccccc} R^1 & R^2 & R^3 & \cdots & R^m \end{array} \\ \begin{bmatrix} \tilde{\beta}_1^1 & \tilde{\beta}_1^2 & \tilde{\beta}_1^3 & \cdots & \tilde{\beta}_1^m \\ \tilde{\beta}_2^1 & \tilde{\beta}_2^2 & \tilde{p}_2^3 & \cdots & \tilde{\beta}_2^m \\ \tilde{\beta}_3^1 & \tilde{\alpha}_3^2 & \tilde{\alpha}_3^3 & \cdots & \tilde{\beta}_3^m \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \tilde{\beta}_n^1 & \tilde{\beta}_n^2 & \tilde{\beta}_n^3 & \cdots & \tilde{\beta}_n^m \end{bmatrix} \end{array}, \quad j = 1, 2, \ldots, n; \quad i = 1, 2, \ldots, m, \tag{13}$$

where n represent the total number of practices, m represent total number of respondent and $\tilde{\beta}_j^i = (l\tilde{\beta}_j^i, m\tilde{\beta}_j^i, u\tilde{\beta}_j^i)$ shows the fuzzy implementation of the practices given by ith respondent for jth practice.

After getting the evaluation in three dimensions ($\tilde{B}_A$, $\tilde{B}_D$, $\tilde{B}_R$), we obtained mean evaluation, $\tilde{B}_M$ by (14).

$$\tilde{B}_M = \frac{\tilde{B}_A + \tilde{B}_D + \tilde{B}_R}{3} \tag{14}$$

where ***M***, represents mean or average. One example, of the result, is given in Table 8.

Step 2: Since the subjective evaluation of participants, vary with respect to their experience, role, perception, and understanding of the subject matter. Therefore, we incorporated the mean score approach to aggregate the fuzzy implementation of each practice by m respondent using (15).

$$\tilde{q}_j = \frac{1}{m}\left[\sum_{i=1}^{m} \tilde{\beta}_j^i\right] \tag{15}$$

Where $\tilde{q}_j = (l\tilde{q}_j, m\tilde{q}_j, u\tilde{q}_j)$ shows the aggregate fuzzy weight of the jth practice.

Step 3: The aggregated triangular fuzzy numbers (TFN) $\tilde{q}_j$ is used to obtain the best non-fuzzy performance (BNF) value. BNP_{Q_j} can be produced through (16)

$$BNP_{Q_j} = \frac{\left[\left(u\tilde{q}_j - l\tilde{q}_j\right) + \left(m\tilde{q}_j - l\tilde{q}_j\right)\right]}{3} + l\tilde{q}_j \tag{16}$$

Here, BNP_{Q_j} represents the BNP value for the TFN $\tilde{q}_j$ while Q_j is the crisp implementation of the jth practice in classical number format.

E. DETERMINING THE SUCCESS POSSIBILITY OF CONVERSION TO PARTNERSHIP

One we come up with R_j the weight of the practice and Q_j implementation of the practice in the organization, then it is easy to obtain the possible success P_{sucess} by Eq. (17)

$$P_{sucess} = R_j \times Q_j \tag{17}$$

If the possibility of success is known then it is easy to find the possibility of failure by Eq. (18)

$$P_{failure} = 1 - P_{sucess} \tag{18}$$

V. EMPIRICAL CASES FOR ASSESSING THE POSSIBILITY OF SUCCESSFULLY SOP FORMATION

We have administered an empirical investigation through an online investigation, incorporating the online survey tool i.e Google Drive, in SDO organization. We concentrate on obtaining the linguistic weight for the influential factors (practices) because not all the practices are equally important for the implementation of the SOP. Prior to the questionnaire distribution, we wrote an open invitation letter to give a short summary of the work. We have posted an open invitation on different social networking website listed below.

- Yahoo (https://groups.yahoo.com)
- Facebook (https://facebook.com)
- LinkedIn (https://linkedin.com) and
- Companies at (http://www.pseb.org.pk)

We also invited the writers of the industrial articles through email to take part in our survey. These industry-oriented articles were selected during the SLR conduction i.e phase-2. In response to these invitations, a sum of 101 industrial experts agreed for support. After getting their inclination the survey form web link was directed to these experts. During pre-decided time bound, we acknowledged 42 filled questionnaires. Upon applying the quality criteria seven surveys forms were rejected. After exclusion, only 35 survey forms left for further analysis. Out of 35 survey forms, 16 were filled by overseas experts while the rest 19 are filled by local experts from Pakistan. Our survey response rate was 34.65% [95].

A. WEIGHTING CALCULATION OF THE INFLUENTIAL FACTORS THROUGH EMPIRICAL SURVEY

One hundred and thirty practices (See Appendix D) found through SLR and validated through a questionnaire survey are used as an input in the weight calculating process.

1) WEIGHT CALCULATION OF PRACTICE

Thirty-five experts acknowledged through a questionnaire survey, participate in the weighting process. The process is explained below.

1. These experts are questioned to give their subjective judgment about the significance of each practice in SOP incorporating linguistic scale presented in Table 2.
2. The linguistic evaluations are then transcribed into corresponding TFN as shown in Table 6 while taking CSF3: 'success stories of the previous projects' is an example.
3. Because the perceptions of each expert are different due to their role, industrial experience, qualification etc. Equation (4) is used to get the synthesized aggregate TFN as listed in Table 11 column 2 (see Appendix B for Table 11).
4. Then defuzzification of the TFN is carried out to obtain BNP in a crisp format using (5). The outcomes are shown in Table 11 column 3 and 4. The BNP value is used for ranking and further calculation as shown in Table 11(see Appendix B for Table 11).
5. The crisp number obtained in step 4 is normalized and the normalized importance R_j of practices is obtained by using (6) which are further used to find an overall rank for each practice. The outcomes are presented in Table 11 column 8 and 9(see Appendix B for Table 11).
6. We also calculate the normalized importance of the practices within CSFs R_{PC} using (7) and normalized importance within level R_{PL} using (8) as shown in Table 11 column 4 and 6 (see Appendix B for Table.11). The rank within CSF and Level are shown in the same Table 11 in column 5 and 7. Consult Table 5 for the detail of CSFs and Level.

2) WEIGHT CALCULATION OF CSF

Referring to (9) and (10), BNP weight of the CSF, W_C is sum of the BNP weight of all the practices in that respective CSF while BNP weight of the level, W_L is the sum of the BNP weight of all the practices in that level. We first calculate W_C by using (9) and W_L by using (10). Then we find the normalized importance of CSF within level R_{CL} using (19). The overall rank R_C of CSF was obtained by dividing W_C by sum of the weight of all practices; $\sum_{j=1}^{n} W_j$ refer to (20), which are 106.818 in our study as given in Table 6.

$$R_{CL} = \frac{W_C}{W_L} \tag{19}$$

$$R_C = \frac{W_C}{\sum_{j=1}^{n} W_j} \tag{20}$$

normalized importance of each level was obtained by (21)

$$R_L = \frac{W_L}{\sum_{j=1}^{n} W_j} \tag{21}$$

Where R_L is weight of the level and $\sum_{j=1}^{n} W_j$ shows the total weight, W_T. The outcomes are accessible from Table 11 (see Appendix B for Table 11).

B. RATING OF THE INFLUENTIAL FACTORS IN THE CASE ORGANIZATION

For obtaining the actual level of implementation of the influential factors, using practices in the SDO organization a case study was carried out. The case study method is a suitable method for providing enough evidence in the real world industrial environment. To be more certain and confident in our assessment, two distinct case studies were carried out at two distinct SDO companies. Companies were chosen because they provide particularly rich descriptions of different SDO activities. For the selection of the software case companies (http://www.pseb.org.pk) was approached. Ten SDO companies were shortlisted based on the description provided on their website. An invitation letter was sent to all the shortlisted companies for participation in the case study. In response to our invitation, four SDO companies show the willingness to take part in the case study.

Those companies were selected for case study who agreed to disseminate the case study outcomes. Initially, we talked to the CEO of the companies head-on, explained what their company role will be in the case study, and gave them printed copies of the case study documents including consent form, summary document, evaluation document, and questionnaire like document called document for the feedback session.

The senior managers with consultation with the CEO notify an evaluation team of diverse role, including a member of HR, IT, design, testing, and development department. Ten participants from each company with different roles, who were the key fellow of their SDO team, took part in each individual case study. A few hours of introductory training was given to the evaluation team about different parts of the model and its evaluation process [17].

If a practice has a strong implementation in the company, then the likelihood of success in conversion to SOP for future projects increases. The possible implementation of practice for SOP with regard to each CSF is calculated as follows:

Step 1: The participants in the case study were requested to provide their independent views about the extent of implementation of each practice in their organization from the three dimensions of Motorola by choosing linguistic term as shown in Table 3 and incorporating the Motorola guidelines as given in Table. 4.

TABLE 7. Importance weight and possible ranking of the CSFs and level.

CSF	W_C	R_{CL}	Rank	R_C	Rank	Level	W_L	R_L	Rank
CSF1	13.7171	0.39363	1	0.12842	1	2	0.326232	0.326232	2
CSF2	11.4086	0.32738	2	0.10680	3				
CSF3	4.6667	0.13392	4	0.04369	13				
CSF14	5.0552	0.14507	3	0.04799	11				
CSF4	5.1261	0.12921	5	0.05450	9	3	0.371395	0.371395	1
CSF5	5.8219	0.14675	4	0.11978	2				
CSF6	12.7952	0.32253	1	0.08100	4				
CSF7	8.6524	0.21810	2	0.06812	7				
CSF8	7.2762	0.18341	3	0.07839	5				
CSF9	7.2762	0.41973	1	0.05881	8	4	0.186751	0.186751	3
CSF10	8.3730	0.31491	2	0.04956	10				
CSF11	6.2819	0.26536	3	0.04253	14				
CSF12	4.5429	0.36783	2	0.07309	6	5	0.115621	0.115621	4
CSF13	7.8076	0.63217	1	0.04733	12				

Step 2: The linguistic terms are then transcribed into corresponding TFN an example based on CSF3: 'success stories of the previous projects' are shown in Table 8.

Step 3: Three-dimensional scores in TFN format are then converted to an average score in the same TFN format using (14) as shown in Table 8.

Step 4: To aggregate the subjective judgments of the participants towards the implementation of practices (because the perception of each expert is different due to their role, experiences, and education level etc.). Equation (15) is used to get the synthesized TFN as listed in Table 12 column 2 (See appendix C for Table 12).

Step 5: Then defuzzification of the TFN is carried out to obtain BNP in the crisp format using (16) as shown in Table 12 column 3 and 4 (See appendix C for Table 12).

C. DETERMINING THE SUCCESS POSSIBILITY OF SOP CONVERSION/FORMATION

Once we have an importance weight R_j and possible implementation Q_j of practice then it is easy to calculate the possibility of success using (17). The possibility of success for company A is shown in the second last column of Table 12. The overall success is equal to the sum of the success of all practices. The success 0.5 indicates a 50% chance of both success and failure. Once we get value for the possibility of success then the possibility of failure can be calculated using (18).

D. ASSESSMENT BASED ON THE MOTOROLA ASSESSMENT TOOL AND MODELS LEVELS

In order to find the possible partnership Level and weak area for further improvements, the implementation score I_C for each CSF and each Level I_L was calculated using (22) and (23) respectively.

$$I_C = \frac{\sum_{j=1}^{k} Q_j}{k} \tag{22}$$

Here, $\sum_{j=1}^{k} Q_j$ represent the BNP weight Q_c of the each individual CSF, k represent the total number of practices in that CSF i.e $Q_C = \sum_{j=1}^{k} Q_j$.

I_C = sum of the implementation score of all practices in that CSF (Q_c)/ No of practices (k)

$$I_L = \frac{\sum_{j=1}^{h} Q_j}{h} \tag{23}$$

Here, $\sum_{j=1}^{h} Q_j$ represent the BNP weight Q_L of the each individual level, h represent the total number of practices in that level i.e $Q_L = \sum_{j=1}^{h} Q_j$.

I_L = sum of the implementation score of all practices in that level (Q_L)/No of practices (h).

VI. RESULTS, ASSESSMENT, AND RECOMMENDATIO

The importance weight and possible ranking of 130 practices for 14 CSFs in connection to SOP formation are summarized in Table 11 (see Appendix B) and Table 7 respectively. C3P4, C7P, C2P, C6P7, and C10P2 are the top five practices with respect to the overall weight of importance. These ranking results indicate that for a vendor in order to upgrade their existing outsourcing relationship towards partnership they must:

1. Learn from their previous experience (C3P4)
2. Carefully comprehend client's business e.g. core competencies, values, and work culture (C7P3)
3. Improve their organizational capability by employing SPI certification like CMMI and ISO/IEC 15504 etc. (C2P1)
4. Follow the approved time schedule strictly (C6P7)
5. Inaugurate a method for proper consultations and reciprocal consensus on SLA specifications (e.g. price, scope, schedule, security provisions, resource requirements, penalties and escalation processes, and intellectual property rights) (C10P2)

C3P4, C2P1, C2P11, C3P5, C1P6 are the top five practices in level two. In order to implement CSF1: effective and timely communication the vendors need to communicate project status on daily basis (C1P6) and set up ICT infrastructure and communication guidelines (C1P5). Similarly for implementing CSF2: quality production they should improve their software development capability by implementing SPI certification (C2P1) and must collect requirements by following

TABLE 8. Corresponding TFNs of implementation of CSF3: 'Success stories of the previous projects'.

Expert	Dimension	Practices				
		C3P1	C3P2	C3P3	C3P4	C3P5
E1	A	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.5,0.7,0.9)	(0.9,1.0,1.0)
	D	(0.7,0.9,1.0)	(0.5,0.7,0.9)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0
	R	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)
	M	**(0.7,0.9,1.0)**	**(0.7,0.9,1.0)**	**(0.8,1.0,1.0)**	**(0.7,0.9,1.0)**	**(0.9,1.0,1.0)**
E2	A	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
	D	(0.9,1.0,1.0)	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.7,0.9,1.0)
	R	(0.9,1.0,1.0)	(0.7,0.9,1.0)	(0.5,0.7,0.9)	(0.9,1.0,1.0)	(0.7,0.9,1.0)
	M	**(0.9,1.0,1.0)**	**(0.8,0.9,1.0)**	**(0.7,0.9,1.0)**	**(0.9,1.0,1.0)**	**(0.8,0.9,1.0)**
E3	A	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
	D	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
	R	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
	M	**(0.7,0.9,1.0)**	**(0.8,0.9,1.0)**	**(0.8,1.0,1.0)**	**(0.9,1.0,1.0)**	**(0.9,1.0,1.0)**
E4	A	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.8,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
	D	(0.9,1.0,1.0)	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
	R	(0.9,1.0,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
	M	**(0.9,1.0,1.0)**	**(0.8,0.9,1.0)**	**(0.8,1.0,1.0)**	**(0.9,1.0,1.0)**	**(0.9,1.0,1.0)**
E5	A	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.5,0.7,0.9)	(0.9,1.0,1.0)
	D	(0.7,0.9,1.0)	(0.5,0.7,0.9)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.7,0.9,1.0)
	R	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.5,0.7,0.9)	(0.7,0.9,1.0)	(0.7,0.9,1.0)
	M	**(0.7,0.9,1.0)**	**(0.7,0.9,1.0)**	**(0.7,0.9,1.0)**	**(0.7,0.9,1.0)**	**(0.8,0.9,1.0)**
E6	A	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.5,0.7,0.9)	(0.9,1.0,1.0)
	D	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.7,0.9,1.0)
	R	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.5,0.7,0.9)	(0.9,1.0,1.0)	(0.7,0.9,1.0)
	M	**(0.8,0.9,1.0)**	**(0.8,0.9,1.0)**	**(0.7,0.9,1.0)**	**(0.8,0.9,1.0)**	**(0.8,0.9,1.0)**
E7	A	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.7,0.9,1.0	(0.9,1.0,1.0)
	D	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
	R	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
	M	**(0.8,0.9,1.0)**	**(0.8,0.9,1.0)**	**(0.8,0.9,1.0)**	**(0.8,0.9,1.0)**	**(0.9,1.0,1.0)**
E8	A	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)
	D	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
	R	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.5,0.7,0.9)	(0.9,1.0,1.0)	(0.7,0.9,1.0)
	M	**(0.8,0.9,1.0)**	**(0.8,0.9,1.0)**	**(0.7,0.9,1.0)**	**(0.8,0.9,1.0)**	**(0.8,0.9,1.0)**
E9	A	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.5,0.7,0.9)
	D	(0.9,1.0,1.0)	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)
	R	(0.9,1.0,1.0)	(0.7,0.9,1.0	(0.7,0.9,1.0)	(0.5,0.7,0.9)	(0.9,1.0,1.0)
	M	**(0.9,1.0,1.0)**	**(0.8,0.9,1.0)**	**(0.8,0.9,1.0)**	**(0.7,0.9,1.0)**	**(0.8,0.9,1.0)**
E10	A	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
	D	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.7,0.9,1.0	(0.7,0.9,1.0	(0.9,1.0,1.0)
	R	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.7,0.9,1.0	(0.9,1.0,1.0)	(0.9,1.0,1.0)
	M	**(0.9,1.0,1.0)**	**(0.9,1.0,1.0)**	**(0.8,0.9,1.0)**	**(0.8,0.9,1.0)**	**(0.9,1.0,1.0)**
$\tilde{q}_j = (l\tilde{q}_j, m\tilde{q}_j, u\tilde{q}_j)$		**(0.75,0.95,1.00)**	**(0.70,0.92,0.99)**	**(0.75,0.91,0.98)**	**(0.80,0.94,0.98)**	**(0.85,0.97,1.00)**

the relevant requirement engineering models (C2P11). CSF3: success stories of previous projects can be implemented by following the practice learn from your experiences (C3P4) and hire skilled full staff with relevant domain-specific expertise (C3P5). It is clear from Table 11 that state of the art IT infrastructure (C14P1) and development of complementary skills and resources (C14P5) are mandatory for achieving access to new expertise, markets, technologies, and complementary skills (CSF14).

Top five practices in level three are C7P3, C6P7, C6P6, C8P10, and C6P5 respectively. Temporarily moving selected employees to client's site (C4P4) and arranging language skills training (C4P2) can help in cross-cultural understanding and sensitivity. For achieving mutual interdependence and shared values (CSF5), vendors need to set up common expectation, vision, goals, and ownership (C5P2) and must start collaboration in the form of sharing risks, rewards, and workload (C5P3). For gaining trust of the client (CSF6), vendor's organization must strictly follow their approved time schedule (C6P7), develop, and deliver up to the mark technical skills to client organization (C6P6). For organizational proximity (CSF7) vendor might offer different types of skills training such as formal domain-specific, client-specific, analytical, and logical reasoning (C7P3) and might avoid communication barriers and lapses through the development of formal communication protocol (C7P4). It is

TABLE 9. Assessment results at Company A.

CSF	Q_c	k	I_C	Level	Q_L	h	I_L	$P_{Success}$
CSF1	14.33412	17	0.84318	**2**	35.96919	41	0.87730	**0.85932 Approx 86%**
CSF2	11.75716	13	0.90440					
CSF3	4.49356	5	0.89871					
CSF14	5.38436	6	0.89739					
CSF4	5.39117	6	0.89853	3	42.64221	49	0.87025	
CSF5	6.10401	7	0.87200					
CSF6	13.35535	15	0.89036					
CSF7	9.13537	11	0.83049					
CSF8	8.65631	10	0.86563					
CSF9	9.20744	11	0.83704	4	21.02324	25	0.84093	
CSF10	6.17892	7	0.88270					
CSF11	5.63688	7	0.80527					
CSF12	3.79263	6	0.63211	5	11.41004	15	0.76067	
CSF13	7.61741	9	0.84638					

TABLE 10. Assessment results at company-B.

CSF	Q_c	# Practices	I_C	Level	Q_L	# CSF	I_L	$P_{Success}$
CSF1	12.6341	17	0.74318	**2**	29.92586	41	0.72990	**0.67611 Approx 68%**
CSF2	9.2338	13	0.71029					
CSF3	3.7936	5	0.75871					
CSF14	4.2644	6	0.71073					
CSF4	4.1912	6	0.69853	3	32.84221	49	0.67025	
CSF5	4.7040	7	0.67200					
CSF6	10.3553	15	0.69036					
CSF7	6.9354	11	0.63049					
CSF8	6.6563	10	0.66563					
CSF9	7.0074	11	0.63704	4	16.02324	25	0.64093	
CSF10	4.7789	7	0.68270					
CSF11	4.2369	7	0.60527					
CSF12	2.5926	6	0.43211	5	8.41004	15	0.56067	
CSF13	5.8174	9	0.64638					

also clear from Table 11 that variance analysis (C8P10), and face to face negotiation (C8P9) is the utmost efficient and effective methods of exchanging information (CSF8).

Referring to Table 11, coordination, cooperation and collaboration (CSF9) can be established by adjusting the working hour's b/w distributed sites, in a manner in order to achieve 24 hours development (C9P1) and make use of extraordinary collaborative (C9P3). For Flexible SLA (CSF10) our study recommends C10P2 (Inaugurate a method for proper consultations and reciprocal consensus on SLA specifications (e.g price, scope, schedule, security provisions, resource requirements, penalties and escalation processes, and intellectual property rights) and C10P1 (appoint contract manager who is responsible to aligned content of the SLA with the business requirements) as most important practices. For establishing joint management infrastructure (CSF11) vendor organization should update the present steering board by giving some memberships to the client's employee (C11P7) and must involve experienced outsourcing team member in the outsourcing process at the earliest possible phase and do not change them in the middle of the process (C11P1). The five high ranked practices in level four are C9P3, C10P2, C9P10, C10P4, and C10P6 respectively as shown in Table 6.

Concerning the last level i.e maturing the relationship through continuous management, the top five practices are C12P2, C13P2, C13P9, C13P3, and C13P5 respectively as given in Table 11. For reaching long-term commitments (CSF1), vendor organization should emphasis on forming a trustful association with the client (C12P2) by offering some additional services (C12P1). For better governance and control, an organization might make use of relation-based governance models for client administration such as mutual intergroup differentiation model (MIDM) and common ingroup identity model (CIIM) by following written, defined, approved, and well-understood governance principles.

Table 7 shows the ranks of CSFs, CSF1, CSF5, CSF2, CSF6, and CSF8 are top five CSF by weight of importance in connection to SOP establishment. For aching success in SDO relationship (level 2 of the framework) vendor organization should focus on implementing CSF1, CSF2, CSF14, and CSF3 (given in increasing order of importance). For being reading to the partnership (achieving level 3 of the framework), vendor organization should focus on implementing CSF6, CSF7, CSF8, CSF5, and CSF4 (sorted rank wise).Conversion and implementation will be successfully done (achieving level 4), if a vendor implements CSF9, CSF10, and CSF11 (given in increasing order of importance). An organization will stand at level 5 of the proposed framework if they can implement CSF13 and CSF12 (given in increasing order of importance). The order of the level against the weight of importance is two, one, three and four such that level 2 got rank first while level 5 got the last rank.

A. ASSESSMENT RESULTS AT COMPANY-A

For the assessment, we have considered the implementation of CSF only; the rating of practices Q_j is used as input. Incorporating the guidelines of Motorola assessment tool in our FMCDM based assessment framework, an average score of 0.7 or above for each CSF will show that the specific CSF have been successfully implemented. Any CSFs with an average score that falls below point seven will be considered a weakness. For a company to achieve any SOP level they need to implement all the listed CSFs at that level. For example for a company to achieve level 2, their implementation score (average rating) for the CSF1, CSF2, CSF3, and CSF must be $>= 0.7$.

It is clear from Table 9, that the implementation score I_C for CSF12 is $0.63211 < 0.7$, which show that company-A failed to implement level-5. Therefore company-A, stand at level 4 (conversion).

Our assessment results indicate that Company-A is a good candidate to be converted to a partnership with success rate of 86%. After conversion Company-A should focus on getting long-term commitments (CSF12) from the client side in order to mature SOP (move to level 5).

1) POSSIBLE RATING AT COMPANY-A

The possible rating and assessment at Company-A for 130 practices for 14 CSFs in connection to SOP formation are summarized in Table 12 (see Appendix C) and Table 9, respectively. The forecasting outcome shown in Table 9 for Company-A, indicates that the possibility of success is 86% (0.85932) while the possibility of failure is just 14% (0.14068) roughly. Consequently, this study makes the compromise suggestion based on assessment as shown in Table 9 and 12, that the company shall start conversion and at the same time take remedial enhancement action to improve the weak factors in order to increase the possibility of success in relation SOP formation.

For assessment, we again incorporating the guideline of Motorola assessment tool in our framework based on FMCDM. Any rating score of practices below 0.7 will be considered a weakness. Our study recommends that the case organization should improve the implementation of the following practices.

1. 'Stimulate everyday informal and formal communication among team members' (C1P15)
2. 'Create space for one on one interaction'(C1P16)
3. 'Achieve mutual understanding by conducting face-to-face meetings' (C7P1)
4. 'Use commonly known development tools and techniques in order to minimize ambiguity in understanding' (C7P2)
5. 'Draft a detailed SLA by giving details of authorities, ownership, roles and responsibilities' (C10P4)
6. 'Establish a joint configuration management infrastructure'(C11P2)
7. 'Focus on optimum utilization of skills and resources of each stakeholder' (C11P3)
8. 'Take joint mutually beneficial decisions with their client in most problematic circumstances'(C11P5)
9. 'Use joint and multi-level relationship management approach' (C11P6)
10. 'Emphasis on forming a trustful association with the client' (C12P2)

B. ASSESSMENT RESULTS AT COMPANY-B

The assessment results at Company-B are presented in Table 10; because of the space limitation of the journal paper, we have given the summarized Table only. Our assessment results do not recommend Company-B for SOP formation because the success rate as given in Table 10 is less than 70%. i.e 68%. It is clear from Table 10 that company-B have only implemented all the CSFs of the level 2; therefore company-B are at level two success of the proposed assessment model. However, implementation score of level-3 (0.67025) indicates that company-B can easily move to the next level-3. In order to be ready for SOP (in order to move to level 3), company-B needs to improve all the five CSFs in level 2. Company-B must focus on reducing organizational differences (CSF4) in order to increase proximity (CSF7) and bidirectional transfer of knowledge (CSF8) between organizations. That will ultimately develop mutual interdependence and shared values (CSF5), and will further help in gaining the trust of the client (CSF6).

VII. SUMMARY AND DISCUSSION

In order to remain competing in the market competition, organization often initiates improvements process in the form of model-based assessment. It is a widespread assessment in which the first course of action for an organization is to find its present level of capability (i.e. maturity level) using the standard capability assessment model. Afterward, the organization performs a gap analysis in order to find the deviation between the current capability and the desired capability. Once the gap is identified, the quest for process improvement takes the form of tasks performed to fill the gap. Model-based assessments have been widely used in the course of the last two decades.

The two most popular SPI models are ISO/IEC (15504/33000) [8] and CMMI [9]. Other models include Crosby's QMMG [4], OMG's BPMM [6] and SPICE [7]. Although for the design and development of the customized maturity models, the researchers have many choices. It is inspiring that CMMI has the only assessment framework profoundly adopted by the researcher within the academic community. The other mentioned assessment models, even though widespread in practice, look to be barely adopted for research. This is the reason like other researchers (see [17]–[19], [26], [27], [29]–[32], [35], [37], [38], [40]–[47]), in this research, we also adopted the staged structure of CMMI with a slight modification that CMMI, KPAs were replaced by CSFs.

Since CMMI based assessments are costly and time-consuming; which looks beyond the reach of the vast majority of small software development companies [16]. As a solution, numerous organizations have developed mini assessment instrument like Motorola [23], Kodak [22], Iskrate [25] to get the process pulsation of an organization between full assessments [22].

Furthermore, in some areas, CMMI is not directly applicable [21]. Outsourcing partnership [17], requirements engineering [27], software testing [28], [29], software outsourcing [30], [31], services outsourcing, software process maturity [33], cloud computing [34], software usability [32], software quality management [35], software workforce [37], software maintenance [38], organizational learning in software development [40], knowledge sharing management [41], medical security [42], digital investigations [43], digital game [44], energy efficiency [45], and analytic maturity [46] are some example. Our problem domain i.e SOP formation is the similar case. It is not necessary that software development companies, which are ISO/IEC or CMMI certified may also be a good candidate for SOP formation. Since the main goal of ISO/IEC and CMMI is to advance the software development skills of the organization rather than improving their SOP formation capability.

Besides the significant contribution, there are several areas where these models can be improved. Some of the limitations common to the available maturity assessment models are:

Most of the preceding models such as see [17], [19], [26]–[36], [38], [40]–[47] does not consider the assessment problem as a multi-criteria decision making (MCDM) problem.

Moreover, none of the preceding CMAMs specifically mentioned the MCDM approach. Some authors like Sangaiah and Thangavelu [49], Piltan and Sowlati [52], and Buyukozkan [63] used the FMCDM in software engineering and partnership domain but their methods are not based on CMMI nor they can provide a complete assessment. Our approach is based on MCDM and can provide complete assessment ‘as-is’ statues to ‘to-be’ as discussed in section VI.

Highest number of the preceding investigators (see [17]–[19], [26], [27], [29]–[32], [35], [37], [38], [40]–[46]) used statistics for the assessment and analysis.

The only exception found in [37] and [39]. The former study uses mathematics only for analysis but the assessment score was still in crisp format. In the later study the author updates the model and incorporate scores for assessments based on fuzzy values but the analysis was still done based on statistics. Our model is based on fuzzy set theory specifically known as FMCDM.

Most of the preceding models (see [17], [19], [26], [30], [31], [34], [47]) are suffering from a problem like human subjectivity, data uncertainty, and vagueness.

CMAMs try to handle subjectivity are [39], [40], and [44]. In this study, the linguistic terms with corresponding values in TFN format are applied to reflect the attribute information as shown in Table 2 and 3, column 1. The individual judgments were then integrated by using (4) and (15).

Most of the preceding models used the subjective measurement instrument in the assessment except [39], [40], [44].

Most of the preceding models such as [17]–[19], [26], [27], [29]–[32], [35], [37], [38], and [40]–[46] used Motorola assessment instrument as an evaluation tool, which provides scores for the rating in the form of crisp numbers from three dimensions. The second majority used their own scale but except [39] (only in the revised version they used fuzzy score) the remaining design scores based on crisp numbers (see [28], [29], [35], [38], [39], [43], [46]). Other assessment tools mentioned are GQM (Goal question metric) [36], [40], BOOTSTRAP algorithm [14] in [32] and [44], Zero Defect Zero effect [45], Dyba scale [24] in [27], Value-based scale [33], and Bloom’s scale [30]. Our study revised the Motorola instrument by changing scores to 7 points TFNs and updated the guidelines for a 7-points Likert scale. The changes are validated through a case study.

The preceding models considered all the influential factors equally important but in practices, some factors contribute more or less as compared to the rest.

Some of the CMAMs developer like Ali and Khan [17], Niazi *et al.* [19], Khan *et al.* [26], Khan [30], [31], Niazi *et al.* [47], rank CSFs but these ranks are not used in the assessment process to predict capability. Unlike to them our approach first rank all the influential factors and incorporates it in the prediction of capability assessment (maturity level). The ranking part is validated by 35 industrial experts’ across the globe.

For ranking of the influential factors in the preceding models, no attention is given to the expert heterogeneity. Further, for rating some models (see [17], [19], [26], [30], [31], [47]) allow only one representative to rate the implementation of the practices in their particular organization.

The only CMAM able to tolerate expert heterogeneity is [37]. In our proposed framework, multiple experts can participate in both the ranking survey and rating assessment case study. In this study, we have aggregated the judgment of 35 experts participated in the ranking survey while rating is done by ten experts from each case organization. Further, rating experts were chosen from various departments in the same organization. Moreover, unlike the preceding studies ranking expert were chosen from diverse nationalities, as outsourcing is a global trade.

To cope with the aforementioned issues, inspired by the referred work [48], [49], this study extends organization CMAMs [17]–[19], [26]–[47] to a fuzzy multi-attribute assessment tool based on FMCDM approach [48], [49] and fuzzy version of the Motorola guidelines [23]. To reduce human bias and better deal with qualitative success factors in subjective environments, linguistic variables are translated using TFN. Then taking the TFN score as input, FMCDM approach [48], [49] are used to rank the CSFs. Our approach not only handles uncertainty, vagueness, human biases, and expert heterogeneity but also has the capability of group decision making while still conforming to the structure of CMMI. To the best of our knowledge, this study is the first study to proposed an assessment model based on FMCDM [48], [49], while retaining the structure of CMMI [9]. This study is also the first study to revise the Motorola assessment tool to a fuzzy environment. To validate this claim, we make a search with the string (maturity OR capability OR assessment) AND (model OR framework) on the ScienceDirect and IEEE Xplore digital libraries.

Moreover, authors sometimes based their work on other models (mostly CMMI) and transferred their content(tasks and practices) and/or structure without testing its applicability in their problem domain [2]. In view of Wendler [2] the available maturity models currently lacking a proper structure, validation, and applicability of the adopted structure. The proposed model is generalized in order to be able to adapt by other organizational assessment practitioner and researcher. Generally speaking, the study design a generic framework for the development of fuzzy multi-attribute assessment model (FMAAM) for organization evaluation based on the structure of CMMI and FMCDM approach taking various CSFs as main while its implementation practices as sub-criteria.

Specifically, based on the knowledge of our previous software outsourcing partnership model (SOPM) [17] and data collected through SLR and questionnaire survey, this study develops a framework model based on CMMI and FMCDM approach for forecasting the possibility of successful SOP formation.

The proposed model has two main parts i.e 1) weighting or ranking, and 2) assessment or rating. In the ranking part of the proposed framework model, we follow the model [48], [49], but unlike them the expert not belongs to a specific country or organization. Furthermore, different to the preceding studies ranking experts were chosen from diverse nationalities. Moreover similar to the FMCDM [48], [49] studies the model will give a quantitative measurement for decision support but unlike to them, our model will give further assessments in both success and failure state. Some author like Sangaiah and Thangavelu [49] and Buyukozkan [63] used the Fuzzy MCDM in software engineering domain but their methods are not based on CMMI nor they can provide a complete assessment. Software development organization often inaugurate SPI using the guidelines of SEI in the form of software CMMI [9]. The ranking part is demonstrated with the help of empirical survey conducted with 35 experts [95].

In the assessment phase, similar to the model discuss in Section II.B, specifically [17], [19], [26]–[36], [38]–[47], we divide the influential factors and their respective practices into five levels. We have translated the expert opinion into TFN and use a similar method as used by the FMCDM authors discuss in section II.C specifically [48], [49]. In case of success, our model will give the level of implementation of SOP while in case of failure the model will indicate weak factors and practices. Similar to the assessment models [17], [19], [26]–[36], [38]–[47], our model will announce the level the organization stand but unlike to these models, our framework will give success and failure percentage in order to guide the decision maker precisely. Furthermore, the currently available CMAMs suffering from the limitation as discussed in Section III. Our model addressed the stated limitation by incorporating the fuzzy set theory. For validation, alike to these models, we conduct two case studies in the relevant organization using Motorola instrument as an assessment tool but unlike to them the score given by the expert is translated into a fuzzy format using the rating scale given in Table.3.

The framework model is demonstrated with a running example of SOP formation as an empirical case.

VIII. CONCLUSION, LIMITATION, AND FUTURE WORK

This study developed a general framework for the development of Fuzzy Multi-Attribute Assessment Model (FMAAM). The proposed model has two working parts (1) ranking part and (2) assessment part. Due to the independent nature of the two parts, each part can be utilized individually. The ranking (weighting) part of the framework might be used as a ranking mechanism for influential factors like success factors and risk factors. Additionally, researcher and practitioner can employ this phase for ranking factors that have a negative or positive impact in some organizational venture. While the assessment part of the framework can be utilized as an assessment tool for the assessment of SDO organization. Collectively, it can be used as a decision support system.

Besides checking the capability of the organization our model also provides decision makers with valuable statistics for decision-making regarding whether to initiate conversion, inhibit conversion or undertake remedial improvements to increase the success rates in the conversion from contract-based relationship to SOP i.e the relationship based on mutual trust. Furthermore, the model gives an evaluation result for further improvement as presented in Section-VI. The evaluation result is a useful insight for the organization in order to know about their weakness and strengths. When an

TABLE 11. Importance weight and possible ranking of the practices.

Practice #	$(l\tilde{\omega}_j, m\tilde{\omega}_j, u\tilde{\omega}_j)$	BNP_WJ	R_{CL}	Rank	R_{PL}	Rank	R_j	Rank
C1P1	(0.65,0.83,0.95)	0.813	0.05929	10	0.02334	31	0.0076	79
C1P2	(0.67,0.84,0.96)	0.823	0.05999	9	0.02361	29	0.0077	76
C1P3	(0.70,0.85,0.95)	0.834	0.06082	8	0.02394	28	0.0078	71
C1P4	(0.83,0.94,0.99)	0.918	0.06693	5	0.02635	17	0.0086	42
C1P5	(0.84,0.96,1.00)	0.932	0.06797	2	0.02676	10	0.0087	28
C1P6	(0.86,0.97,1.00)	0.945	0.06887	1	0.02711	5	0.0088	10
C1P7	(0.79,0.92,0.98)	0.896	0.06533	6	0.02572	23	0.0084	55
C1P8	(0.77,0.91,0.97)	0.885	0.06450	7	0.02539	24	0.0083	57
C1P9	(0.63,0.81,0.95)	0.796	0.05804	11	0.02285	32	0.0075	89
C1P10	(0.51,0.70,0.87)	0.693	0.05055	14	0.01990	36	0.0065	108
C1P11	(0.57,0.76,0.91)	0.745	0.05429	13	0.02137	34	0.0070	98
C1P12	(0.82,0.95,1.00)	0.925	0.06742	3	0.02654	12	0.0087	34
C1P13	(0.52,0.70,0.86)	0.690	0.05034	15	0.01981	37	0.0065	109
C1P14	(0.59,0.77,0.93)	0.762	0.05554	12	0.02186	33	0.0071	95
C1P15	(0.40,0.58,0.74)	0.571	0.04166	16	0.01640	39	0.0053	123
C1P16	(0.42,0.56,0.73)	0.569	0.04145	17	0.01632	40	0.0053	124
C1P17	(0.82,0.95,0.99)	0.919	0.06700	4	0.02637	16	0.0086	41
C2P1	(0.90,0.99,1.00)	0.965	0.08456	1	0.02769	2	0.0090	3
C2P2	(0.52,0.69,0.83)	0.680	0.05960	13	0.01951	38	0.0064	112
C2P3	(0.85,0.97,1.00)	0.942	0.08256	3	0.02703	7	0.0088	15
C2P4	(0.78,0.93,0.99)	0.898	0.07872	8	0.02577	21	0.0084	53
C2P5	(0.84,0.97,1.00)	0.936	0.08206	4	0.02687	9	0.0088	22
C2P6	(0.71,0.87,0.97)	0.851	0.07463	10	0.02443	27	0.0080	65
C2P7	(0.65,0.84,0.97)	0.822	0.07204	11	0.02359	30	0.0077	77
C2P8	(0.75,0.90,0.98)	0.877	0.07688	9	0.02517	25	0.0082	58
C2P9	(0.83,0.96,1.00)	0.927	0.08123	5	0.02659	11	0.0087	33
C2P10	(0.83,0.95,0.99)	0.920	0.08064	7	0.02640	14	0.0086	39
C2P11	(0.88,0.99,1.00)	0.957	0.08390	2	0.02747	3	0.0090	7
C2P12	(0.55,0.71,0.86)	0.710	0.06219	12	0.02036	35	0.0066	103
C2P13	(0.82,0.95,1.00)	0.924	0.08098	6	0.02651	13	0.0086	36
C3P1	(0.79,0.93,0.99)	0.902	0.19327	5	0.02588	20	0.0084	50
C3P2	(0.81,0.94,0.99)	0.912	0.19551	4	0.02618	18	0.0085	45
C3P3	(0.85,0.97,1.00)	0.942	0.20184	3	0.02703	6	0.0088	12
C3P4	(0.90,1.00,1.00)	0.966	0.20694	1	0.02771	1	0.0090	1
C3P5	(0.86,0.97,1.00)	0.945	0.20245	2	0.02711	4	0.0088	11
C14P1	(0.57,0.73,0.82)	0.707	0.18576	1	0.02695	8	0.0066	17
C14P2	(0.82,0.95,1.00)	0.925	0.10343	6	0.01500	41	0.0087	127
C14P3	(0.74,0.88,0.96)	0.858	0.17747	4	0.02574	22	0.0080	54
C14P4	(0.84,0.96,1.00)	0.933	0.17992	3	0.02610	19	0.0087	47
C14P5	(0.73,0.89,0.97)	0.866	0.18199	2	0.02640	15	0.0081	40
C14P6	(0.68,0.86,0.97)	0.837	0.17144	5	0.02487	26	0.0078	59
C4P1	(0.65,0.83,0.95)	0.810	0.13793	6	0.01782	42	0.0076	106
C4P2	(0.84,0.96,1.00)	0.933	0.18040	2	0.02331	13	0.0087	35
C4P3	(0.81,0.95,1.00)	0.918	0.16740	4	0.02163	19	0.0086	63
C4P4	(0.57,0.73,0.87)	0.725	0.18207	1	0.02353	9	0.0068	25
C4P5	(0.62,0.80,0.94)	0.787	0.16888	3	0.02182	18	0.0074	60
C4P6	(0.64,0.82,0.94)	0.800	0.16331	5	0.02110	23	0.0075	70
C5P1	(0.72,0.87,0.96)	0.849	0.13921	4	0.02043	27	0.0079	81
C5P2	(0.69,0.85,0.95)	0.827	0.16031	1	0.02353	10	0.0077	26
C5P3	(0.64,0.82,0.95)	0.804	0.15770	2	0.02314	14	0.0075	43
C5P4	(0.64,0.81,0.94)	0.795	0.12449	7	0.01827	39	0.0074	101
C5P5	(0.75,0.92,1.00)	0.890	0.13512	6	0.01983	35	0.0083	93
C5P6	(0.85,0.97,1.00)	0.942	0.13741	5	0.02017	31	0.0088	87
C5P7	(0.88,0.99,1.00)	0.957	0.14575	3	0.02139	21	0.0090	66
C6P1	(0.90,0.99,1.00)	0.965	0.06461	9	0.02084	26	0.0090	75
C6P2	(0.90,0.92,1.00)	0.940	0.06282	11	0.02026	29	0.0088	84
C6P3	(0.52,0.68,0.82)	0.673	0.06215	12	0.02005	33	0.0063	91
C6P4	(0.85,0.96,0.99)	0.934	0.06952	7	0.02242	17	0.0087	56
C6P5	(0.71,0.87,0.97)	0.853	0.07361	3	0.02374	5	0.0080	13
C6P6	(0.61,0.81,0.95)	0.791	0.07480	2	0.02413	3	0.0074	8
C6P7	(0.53,0.72,0.88)	0.710	0.07540	1	0.02432	2	0.0066	4
C6P8	(0.64,0.82,0.95)	0.806	0.07346	4	0.02369	6	0.0075	16
C6P9	(0.80,0.93,0.99)	0.909	0.05262	15	0.01697	44	0.0085	114
C6P10	(0.36,0.54,0.74)	0.549	0.07302	5	0.02355	8	0.0051	23

TABLE 11. *(Continued.)* Importance weight and possible ranking of the practices.

C6P11	(0.60,0.77,0.90)	0.759	0.06669	8	0.02151	20	0.0071	64
C6P12	(0.90,1.00,1.00)	0.966	0.06185	13	0.01995	34	0.0090	92
C6P13	(0.84,0.96,1.00)	0.933	0.05545	14	0.01788	41	0.0087	104
C6P14	(0.83,0.96,1.00)	0.930	0.06297	10	0.02031	28	0.0087	83
C6P15	(0.44,0.59,0.73)	0.588	0.07101	6	0.02290	15	0.0055	48
C7P1	(0.63,0.81,0.95)	0.796	0.06340	11	0.01383	47	0.0075	126
C7P2	(0.55,0.72,0.87)	0.713	0.08773	7	0.01913	36	0.0067	96
C7P3	(0.50,0.68,0.84)	0.674	0.11161	1	0.02434	1	0.0063	2
C7P4	(0.79,0.93,0.99)	0.901	0.10787	2	0.02353	11	0.0084	27
C7P5	(0.71,0.86,0.96)	0.844	0.10743	3	0.02343	12	0.0079	30
C7P6	(0.59,0.75,0.88)	0.741	0.06791	10	0.01481	45	0.0069	121
C7P7	(0.55,0.75,0.92)	0.739	0.09202	6	0.02007	32	0.0069	90
C7P8	(0.64,0.82,0.95)	0.804	0.08244	8	0.01798	40	0.0075	102
C7P9	(0.71,0.85,0.92)	0.830	0.07793	9	0.01700	43	0.0078	113
C7P10	(0.38,0.50,0.63)	0.502	0.10413	4	0.02271	16	0.0047	51
C7P11	(0.22,0.35,0.52)	0.361	0.09752	5	0.02127	22	0.0034	67
C8P1	(0.42,0.57,0.73)	0.574	0.10183	6	0.01868	37	0.0054	99
C8P2	(0.75,0.79,0.94)	0.830	0.10157	7	0.01863	38	0.0078	100
C8P3	(0.85,0.97,1.00)	0.939	0.11047	5	0.02026	30	0.0088	85
C8P4	(0.88,0.99,1.00)	0.957	0.11401	3	0.02091	24	0.0090	72
C8P5	(0.85,0.97,1.00)	0.942	0.06898	9	0.01265	48	0.0088	129
C8P6	(0.66,0.83,0.95)	0.814	0.04961	10	0.00910	49	0.0076	130
C8P7	(0.73,0.89,0.97)	0.865	0.07893	8	0.01448	46	0.0081	122
C8P8	(0.65,0.80,0.95)	0.799	0.11401	4	0.02091	25	0.0075	73
C8P9	(0.57,0.76,0.92)	0.750	0.12906	2	0.02367	7	0.0070	18
C8P10	(0.53,0.70,0.81)	0.681	0.13154	1	0.02413	4	0.0064	9
C9P1	(0.67,0.83,0.94)	0.811	0.11249	1	0.04722	13	0.0076	14
C9P2	(0.49,0.62,0.85)	0.653	0.09725	3	0.04082	25	0.0061	78
C9P3	(0.53,0.69,0.89)	0.705	0.10328	2	0.04335	1	0.0066	62
C9P4	(0.45,0.65,0.83)	0.646	0.09543	5	0.04006	19	0.0060	88
C9P5	(0.53,0.71,0.88)	0.708	0.08952	6	0.03757	12	0.0066	97
C9P6	(0.85,0.96,0.99)	0.934	0.08133	9	0.03414	14	0.0087	111
C9P7	(0.90,0.99,1.00)	0.965	0.09691	4	0.04068	18	0.0090	80
C9P8	(0.83,0.96,1.00)	0.929	0.07799	10	0.03274	15	0.0087	115
C9P9	(0.81,0.93,0.98)	0.904	0.08417	8	0.03533	24	0.0085	107
C9P10	(0.67,0.80,0.88)	0.784	0.07712	11	0.03237	3	0.0073	117
C9P11	(0.73,0.86,0.93)	0.838	0.08451	7	0.03547	17	0.0078	105
C10P1	(0.83,0.96,1.00)	0.929	0.14873	2	0.04683	20	0.0087	24
C10P2	(0.85,0.97,1.00)	0.939	0.15358	1	0.04836	2	0.0088	5
C10P3	(0.73,0.86,0.92)	0.838	0.14782	3	0.04655	7	0.0078	31
C10P4	(0.55,0.62,0.67)	0.612	0.14388	5	0.04531	4	0.0057	49
C10P5	(0.37,0.55,0.73)	0.553	0.12477	7	0.03929	16	0.0052	94
C10P6	(0.37,0.51,0.67)	0.521	0.13341	6	0.04201	5	0.0049	68
C10P7	(0.74,0.89,0.97)	0.866	0.14782	4	0.04655	11	0.0081	32
C11P1	(0.90,0.99,1.00)	0.965	0.17740	2	0.04707	9	0.0090	19
C11P2	(0.81,0.95,1.00)	0.918	0.15832	4	0.04201	6	0.0086	69
C11P3	(0.85,0.97,1.00)	0.939	0.11568	5	0.03070	8	0.0088	118
C11P4	(0.42,0.60,0.76)	0.592	0.10439	6	0.02770	10	0.0055	125
C11P5	(0.40,0.59,0.79)	0.595	0.09841	7	0.02611	21	0.0056	128
C11P6	(0.52,0.70,0.85)	0.690	0.16354	3	0.04340	22	0.0065	61
C11P7	(0.64,0.83,0.96)	0.809	0.18225	1	0.04836	23	0.0076	6
C12P1	(0.63,0.82,0.96)	0.803	0.20210	2	0.07434	6	0.0075	44
C12P2	(0.85,0.97,1.00)	0.939	0.20671	1	0.07603	1	0.0088	20
C12P3	(0.81,0.95,1.00)	0.921	0.13040	6	0.04796	15	0.0086	120
C12P4	(0.82,0.93,0.98)	0.911	0.13103	5	0.04820	14	0.0085	119
C12P5	(0.81,0.95,1.00)	0.921	0.15178	4	0.05583	12	0.0086	110
C12P6	(0.49,0.66,0.81)	0.652	0.17799	3	0.06547	10	0.0061	82
C13P1	(0.69,0.85,0.95)	0.830	0.10283	8	0.06501	11	0.0078	86
C13P2	(0.79,0.92,0.99)	0.898	0.12027	1	0.07603	2	0.0084	21
C13P3	(0.84,0.96,1.00)	0.932	0.11796	3	0.07457	4	0.0087	37
C13P4	(0.85,0.97,1.00)	0.939	0.11674	5	0.07380	7	0.0088	46
C13P5	(0.36,0.51,0.69)	0.523	0.11796	4	0.07457	5	0.0049	38
C13P6	(0.78,0.91,1.00)	0.897	0.08356	9	0.05282	13	0.0084	116
C13P7	(0.80,0.94,0.99)	0.910	0.10625	7	0.06717	9	0.0085	74
C13P8	(0.83,0.95,0.99)	0.920	0.11503	6	0.07272	8	0.0086	52
C13P9	(0.76,0.89,0.95)	0.813	0.11942	2	0.07549	3	0.0081	29
	$W_T = \sum_{j=1}^{n} W_j$	106.818						

TABLE 12. Implementation score and possibility of success of the practices.

CSF #	$\tilde{q}_j = (l\tilde{q}_j, m\tilde{q}_j, u\tilde{q}_j)$	Q_j	Rank	R_j	Rank	$P_{sucess} = R_j \times Q_j$	Rank
C1P1	(0.85,0.96,1.00)	**0.9352**	30	0.0076	79	0.00712	57
C1P2	(0.85,0.98,1.00)	**0.9410**	22	0.0077	76	0.00725	55
C1P3	(0.85,0.97,1.00)	**0.9378**	27	0.0078	71	0.00732	52
C1P4	(0.80,0.93,1.00)	**0.9097**	44	0.0086	42	0.00782	31
C1P5	(0.87,0.98,1.00)	**0.9494**	14	0.0087	28	0.00829	12
C1P6	(0.79,0.90,0.98)	**0.8878**	62	0.0088	10	0.00785	29
C1P7	(0.70,0.91,1.00)	**0.8711**	71	0.0084	55	0.00731	54
C1P8	(0.90,1.00,1.00)	**0.9667**	1	0.0083	57	0.00801	25
C1P9	(0.64,0.86,0.97)	**0.8236**	101	0.0075	89	0.00614	89
C1P10	(0.70,0.90,1.00)	**0.8667**	78	0.0065	108	0.00563	100
C1P11	(0.71,0.89,0.98)	**0.8574**	84	0.0070	98	0.00598	93
C1P12	(0.71,0.91,0.99)	**0.8692**	73	0.0087	34	0.00752	45
C1P13	(0.61,0.79,0.91)	**0.7687**	113	0.0065	109	0.00497	110
C1P14	(0.86,0.97,1.00)	**0.9425**	20	0.0071	95	0.00672	74
C1P15	(0.24,0.54,0.69)	**0.4898**	127	0.0053	123	0.00262	129
C1P16	(0.16,0.40,0.57)	**0.3756**	130	0.0053	124	0.00200	130
C1P17	(0.85,0.98,1.00)	**0.9421**	21	0.0086	41	0.00811	20
C2P1	(0.68,0.90,0.98)	**0.8507**	89	0.0090	3	0.00768	35
C2P2	(0.78,0.95,0.99)	**0.9037**	48	0.0064	112	0.00575	99
C2P3	(0.86,0.97,1.00)	**0.9433**	17	0.0088	15	0.00832	9
C2P4	(0.75,0.93,1.00)	**0.8954**	55	0.0084	53	0.00753	44
C2P5	(0.84,0.98,1.00)	**0.9386**	25	0.0088	22	0.00823	15
C2P6	(0.87,0.97,1.00)	**0.9462**	15	0.0080	65	0.00754	41
C2P7	(0.70,0.90,1.00)	**0.8667**	79	0.0077	77	0.00667	75
C2P8	(0.74,0.85,0.96)	**0.8493**	91	0.0082	58	0.00697	64
C2P9	(0.90,1.00,1.00)	**0.9667**	2	0.0087	33	0.00839	7
C2P10	(0.90,1.00,1.00)	**0.9667**	3	0.0086	39	0.00833	8
C2P11	(0.70,0.89,0.96)	**0.8522**	88	0.0090	7	0.00764	39
C2P12	(0.67,0.86,0.95)	**0.8252**	99	0.0066	103	0.00548	105
C2P13	(0.87,0.99,1.00)	**0.9526**	13	0.0086	36	0.00824	14
C3P1	(0.75,0.95,1.00)	**0.8976**	53	0.0084	50	0.00758	40
C3P2	(0.70,0.92,0.99)	**0.8690**	74	0.0085	45	0.00742	50
C3P3	(0.75,0.91,0.98)	**0.8821**	65	0.0088	12	0.00778	33
C3P4	(0.80,0.94,0.98)	**0.9070**	45	0.0090	1	0.00820	17
C3P5	(0.85,0.97,1.00)	**0.9378**	28	0.0088	11	0.00829	11
C14P1	(0.79,0.95,1.00)	**0.9154**	42	0.0066	17	0.00606	91
C14P2	(0.77,0.95,1.00)	**0.9065**	46	0.0087	127	0.00785	30
C14P3	(0.84,0.98,1.00)	**0.9386**	26	0.0080	54	0.00754	43
C14P4	(0.71,0.92,1.00)	**0.8761**	67	0.0087	47	0.00766	37
C14P5	(0.73,0.93,1.00)	**0.8875**	63	0.0081	40	0.00719	56
C14P6	(0.72,0.90,0.98)	**0.8671**	77	0.0078	59	0.00680	69
C4P1	(0.72,0.91,0.98)	**0.8688**	75	0.0076	106	0.00659	77
C4P2	(0.82,0.96,1.00)	**0.9257**	35	0.0087	35	0.00809	22
C4P3	(0.56,0.75,0.91)	**0.7388**	118	0.0086	63	0.00635	81
C4P4	(0.70,0.90,1.00)	**0.8667**	80	0.0068	25	0.00588	96
C4P5	(0.72,0.88,0.97)	**0.8577**	83	0.0074	60	0.00632	82
C4P6	(0.78,0.94,0.99)	**0.9030**	51	0.0075	70	0.00676	70
C5P1	(0.86,0.97,1.00)	**0.9433**	18	0.0079	81	0.00749	46
C5P2	(0.78,0.95,0.99)	**0.9037**	49	0.0077	26	0.00699	63
C5P3	(0.77,0.94,0.99)	**0.8975**	54	0.0075	43	0.00675	72
C5P4	(0.74,0.95,1.00)	**0.8954**	56	0.0074	101	0.00667	76
C5P5	(0.67,0.89,0.99)	**0.8464**	92	0.0083	93	0.00705	60
C5P6	(0.90,1.00,1.00)	**0.9667**	4	0.0088	87	0.00852	2
C5P7	(0.73,0.93,1.00)	**0.8881**	61	0.0090	66	0.00796	26
C6P1	(0.79,0.96,1.00)	**0.9169**	40	0.0090	75	0.00828	13
C6P2	(0.86,0.97,1.00)	**0.9433**	19	0.0088	84	0.00830	10
C6P3	(0.62,0.83,0.96)	**0.8013**	105	0.0063	91	0.00505	109
C6P4	(0.90,1.00,1.00)	**0.9667**	5	0.0087	56	0.00845	4
C6P5	(0.69,0.90,0.98)	**0.8567**	85	0.0080	13	0.00684	67
C6P6	(0.64,0.87,0.98)	**0.8297**	98	0.0074	8	0.00615	88
C6P7	(0.69,0.86,0.96)	**0.8368**	95	0.0066	4	0.00556	103
C6P8	(0.83,0.96,1.00)	**0.9300**	32	0.0075	16	0.00701	62
C6P9	(0.71,0.92,1.00)	**0.8761**	68	0.0085	114	0.00745	48
C6P10	(0.70,0.91,0.99)	**0.8675**	76	0.0051	23	0.00446	119

TABLE 12. ***(Continued.)*** **Implementation score and possibility of success of the practices.**

C6P11	(0.82,0.96,1.00)	**0.9257**	36	0.0071	64	0.00658	78
C6P12	(0.90,1.00,1.00)	**0.9667**	6	0.0090	92	0.00874	1
C6P13	(0.75,0.93,1.00)	**0.8935**	59	0.0087	104	0.00781	32
C6P14	(0.70,0.90,1.00)	**0.8667**	81	0.0087	83	0.00754	42
C6P15	(0.70,0.89,0.98)	**0.8553**	86	0.0055	48	0.00471	114
C7P1	(0.47,0.74,0.86)	**0.6893**	121	0.0075	126	0.00514	108
C7P2	(0.22,0.39,0.61)	**0.4084**	129	0.0067	96	0.00273	128
C7P3	(0.56,0.78,0.93)	**0.7579**	115	0.0063	2	0.00478	113
C7P4	(0.85,0.97,1.00)	**0.9378**	29	0.0084	27	0.00791	27
C7P5	(0.90,1.00,1.00)	**0.9667**	7	0.0079	30	0.00764	38
C7P6	(0.69,0.86,0.96)	**0.8345**	96	0.0069	121	0.00579	98
C7P7	(0.66,0.91,0.98)	**0.8505**	90	0.0069	90	0.00588	95
C7P8	(0.75,0.93,1.00)	**0.8954**	57	0.0075	102	0.00674	73
C7P9	(0.55,0.77,0.91)	**0.7460**	117	0.0078	113	0.00579	97
C7P10	(0.75,0.90,1.00)	**0.8832**	64	0.0047	51	0.00415	122
C7P11	(0.83,0.97,1.00)	**0.9328**	31	0.0034	67	0.00315	126
C8P1	(0.75,0.93,1.00)	**0.8954**	58	0.0054	99	0.00481	112
C8P2	(0.70,0.92,0.99)	**0.8700**	72	0.0078	100	0.00676	71
C8P3	(0.65,0.83,0.95)	**0.8092**	103	0.0088	85	0.00711	58
C8P4	(0.84,0.98,1.00)	**0.9393**	23	0.0090	72	0.00842	5
C8P5	(0.74,0.91,0.98)	**0.8757**	69	0.0088	129	0.00772	34
C8P6	(0.61,0.85,0.97)	**0.8106**	102	0.0076	130	0.00618	86
C8P7	(0.70,0.89,0.98)	**0.8553**	87	0.0081	122	0.00692	66
C8P8	(0.53,0.70,0.89)	**0.7063**	120	0.0075	73	0.00528	106
C8P9	(0.59,0.81,0.96)	**0.7858**	109	0.0070	18	0.00551	104
C8P10	(0.90,1.00,1.00)	**0.9667**	8	0.0064	9	0.00616	87
C9P1	(0.61,0.81,0.96)	**0.7938**	107	0.0076	14	0.00603	92
C9P2	(0.53,0.79,0.92)	**0.7465**	116	0.0061	78	0.00456	116
C9P3	(0.70,0.90,0.93)	**0.8433**	93	0.0066	62	0.00556	102
C9P4	(0.83,0.96,1.00)	**0.9300**	33	0.0060	88	0.00562	101
C9P5	(0.75,0.93,1.00)	**0.8935**	60	0.0066	97	0.00592	94
C9P6	(0.84,0.98,1.00)	**0.9391**	24	0.0087	111	0.00821	16
C9P7	(0.75,0.96,1.00)	**0.9035**	50	0.0090	80	0.00816	18
C9P8	(0.54,0.76,0.91)	**0.7377**	119	0.0087	115	0.00641	80
C9P9	(0.81,0.93,0.98)	**0.9061**	47	0.0085	107	0.00767	36
C9P10	(0.83,0.96,1.00)	**0.9300**	34	0.0073	117	0.00682	68
C9P11	(0.60,0.83,0.96)	**0.7959**	106	0.0078	105	0.00624	83
C10P1	(0.90,1.00,1.00)	**0.9667**	9	0.0087	24	0.00840	6
C10P2	(0.79,0.96,1.00)	**0.9169**	41	0.0088	5	0.00806	23
C10P3	(0.59,0.84,0.96)	**0.7933**	108	0.0078	31	0.00622	85
C10P4	(0.27,0.43,0.87)	**0.5218**	126	0.0057	49	0.00299	127
C10P5	(0.69,0.90,0.93)	**0.8417**	94	0.0052	94	0.00435	120
C10P6	(0.80,0.96,1.00)	**0.9198**	37	0.0049	68	0.00449	118
C10P7	(0.72,0.90,1.00)	**0.8742**	70	0.0081	32	0.00709	59
C11P1	(0.58,0.81,0.92)	**0.7691**	112	0.0090	19	0.00695	65
C11P2	(0.27,0.48,0.68)	**0.4752**	128	0.0086	69	0.00408	123
C11P3	(0.33,0.58,0.77)	**0.5629**	125	0.0088	118	0.00495	111
C11P4	(0.60,0.80,0.91)	**0.7704**	111	0.0055	125	0.00427	121
C11P5	(0.41,0.62,0.82)	**0.6154**	122	0.0056	128	0.00343	125
C11P6	(0.31,0.60,0.78)	**0.5655**	124	0.0065	61	0.00365	124
C11P7	(0.63,0.82,0.96)	**0.8033**	104	0.0076	6	0.00608	90
C12P1	(0.66,0.86,0.97	**0.8300**	97	0.0075	44	0.00624	84
C12P2	(0.37,0.61,0.78)	**0.5904**	123	0.0088	20	0.00519	107
C12P3	(0.78,0.96,0.99)	**0.9112**	43	0.0086	120	0.00786	28
C12P4	(0.64,0.87,0.97)	**0.8245**	100	0.0085	119	0.00704	61
C12P5	(0.70,0.90,0.99)	**0.8615**	82	0.0086	110	0.00743	49
C12P6	(0.54,0.81,0.95)	**0.7637**	114	0.0061	82	0.00466	115
C13P1	(0.88,0.99,1.00)	**0.9543**	12	0.0078	86	0.00741	51
C13P2	(0.90,0.99,1.00)	**0.9641**	11	0.0084	21	0.00811	21
C13P3	(0.81,0.95,1.00)	**0.9178**	39	0.0087	37	0.00801	24
C13P4	(0.90,1.00,1.00)	**0.9667**	10	0.0088	46	0.00850	3
C13P5	(0.81,0.94,1.00)	**0.9191**	38	0.0049	38	0.00450	117
C13P6	(0.60,0.80,0.92)	**0.7718**	110	0.0084	116	0.00648	79
C13P7	(0.73,0.92,0.98)	**0.8800**	66	0.0085	74	0.00749	47
C13P8	(0.85,0.98,1.00)	**0.9444**	16	0.0086	52	0.00813	19
C13P9	(0.80,0.91,1.00)	**0.9024**	52	0.0081	29	0.00732	53
					Success probability	**0.85932**	
					Failure probability	**0.14068**	

TABLE 13. List of practices.

#	Code	Name
1	C1P1	'Use language translation technology to make communication between the partner organizations easier'
2	C1P2	'Encourage both asynchronous and Asynchronous communication'
3	C1P3	'For synchronicity, negotiate teams working hours'
4	C1P4	'Create shared cyber space'
5	C1P5	'Establish ICT infrastructure and communication guidelines'
6	C1P6	'Communicate project status on daily basis'
7	C1P7	'Encourage frequent communication through latest technologies'
8	C1P8	'Arrange IT training for team members'
9	C1P9	'Establish open communication through face to face meeting and onsite visits'
10	C1P10	'For efficient communication adopt distributed scrum practices'
11	C1P11	'Encourage the use of real time communication channel in order to get real time feedback'
12	C1P12	'Design special interfaces such as EDI between client and offshore vendor employees'
13	C1P13	'Encourage use of middleman with efficient communication skills and domain knowledge'
14	C1P14	'Enable communication between employees of both firms at all levels'
15	C1P15	'Inspire everyday informal and formal communication among team members'
16	C1P16	'Create space for one on one interaction'
17	C1P17	'Use team calendar in order to communicate according to plan for who needs to know what and when'
18	C2P1	'Improve capability by implementing SPI certification such as CMMI, ISO, COPC-2000, and LEAN etc.'
19	C2P2	'Improve competitiveness in service provision and quality of product through proper monitoring'
20	C2P3	'Acquire employees with relevant qualification, knowledge, and skills'
21	C2P4	'Provide ways for sharing of tacit knowledge'
22	C2P5	'Strictly follow development schedule'
23	C2P6	'Define quality standards'
24	C2P7	'Provide good service design and execution'
25	C2P8	'Use scrum practices for quality improvement'
26	C2P9	'Achieve long term capability and competitive advantage by hiring full-time employees'
27	C2P10	'Arrange trainings related to quality management'
28	C2P11	'Conduct requirements engineering phase thoroughly by following standard requirement engineering models'
29	C2P12	'Ensure reliance on world class delivery models and availability of global innovative talent'
30	C2P13	'Ensure to high extent the project met the client requirements related to usability, flexibility , reliability and response time'
31	C3P1	'Maintain good track record and reputation of the previous projects'
32	C3P2	'Undertake a pilot project'
33	C3P3	'Acquire required certifications and licenses'
34	C3P4	'Learn from your previous experiences'
35	C3P5	'Hire skilled full staff with domain specific skills'
36	C4P1	'Appreciate social networking, informal meetings and joint celebration'
37	C4P2	'Arrange language skills training'
38	C4P3	'Understand differences in values and norms'
39	C4P4	'Temporarily move designated employees to client's site'
40	C4P5	'Build diversified teams with members from dissimilar cultural backgrounds in order to align your team with client team'
41	C4P6	'Face-to-face meetings are recommended especially at the start of the project and when a new colleague joins'
42	C5P1	'Deliver competitive quality of product and service, resources, and skills
43	C5P2	'Set up common expectation, vision, goals, and ownership'
44	C5P3	'Establish collaboration in the form of sharing workload, risks, and benefits'
45	C5P4	'Respect for recognition of dependence and mutual obligations'
46	C5P5	'Develop complimentary skills and assets'
47	C5P6	'Start regular communication in different modes like synchronous and asynchronous, site visits, and using online tools'
48	C5P7	'Work together with client in decision making process and involve client in the every development phase'
49	C6P1	'Properly define responsibilities and role'
50	C6P2	'Efficiently and effectively share knowledge amongst the team members'
51	C6P3	'Maintain good track records of the previous project'
52	C6P4	'Offer long term cooperation'
53	C6P5	'Fulfill the client expectation as stated in the SLA'
54	C6P6	'Develop and deliver up to the mark technical skills'
55	C6P7	'Strictly follow the approved time schedule'
56	C6P8	'Provide high quality products as per agreed requirements'
57	C6P9	'Arrange site visits'
58	C6P10	'Maintain security and confidentiality of client's information and provide protection for IPR'
59	C6P11	'Strictly follow professional ethics in dealings'
60	C6P12	'Collaborate with the client in the form of joint investments, execution, and management'
61	C6P13	'Regularly and effectively communicate with clients at all levels of the organizational hierarchy'
62	C6P14	'Demonstration long term commitment'
63	C6P15	'If lack of previous experience in the domain then undertake a pilot project first'
64	C7P1	'Achieve mutual understanding by conducting face-to-face meetings'
65	C7P2	'Use commonly known development tools and techniques in order to minimize ambiguity in understanding'

TABLE 13. *(Continued.)* **List of practices.**

66	C7P3	'Scrupulously understand client's business (e.g., values, core competencies, and work culture)'
67	C7P4	'Offer different types of skills trainings such as domain-specific, client-specific and analytical, and logical reasoning'
68	C7P5	'Avoid communication barriers and lapses through the development of formal communication protocol'
69	C7P6	'Use of common standard and shared repository for artifacts'
70	C7P7	'Obtain geographical proximity by choosing sites in culturally similar locations'
71	C7P8	'Meshing the processes in the two organizations and hiding the line between them'
72	C7P9	'Adjust communication barrier through the use of middlemen'
73	C7P10	'Understand and respect the differences in norms and values'
74	C7P11	'Use time management to mitigate time zone difference'
75	C8P1	'Explicitly share information of, expectations, and other work related anxieties during conference calls, site-visits, e-mail exchanges or teleconferencing by using specifications, blueprints and prototypes'
76	C8P2	'Use latest technology and processes like shared knowledge databases and repositories, electronic scheduling, groupware, intranets, collaborative technologies, social media, shared cyber space and TMS'
77	C8P3	'Use both offline and online storage for handling of business information ensuring availability and data protection'
78	C8P4	'Establish mechanism for knowledge creation and dissemination'
79	C8P5	'Properly monitor the timeliness, adequacy, accuracy, credibility, and quality of information exchanged'
80	C8P6	'Identify opportunities and threats to mitigate risks in knowledge transfer and management'
81	C8P7	'Conduct domain specific technical trainings and update skill profile and database accordingly'
82	C8P8	'Transform tacit knowledge to explicit knowledge by documentation and process description'
83	C8P9	'Use face to face dialogue as it is the most effective and efficient technique of sharing information'
84	C8P10	'Use variance analysis to plan which knowledge is required and where it is required'
85	C9P1	'Managing the working hours between distributed sites, in such a way that can lead towards 24 hours development'
86	C9P2	'Develop a more detailed understanding of the coordination and control requirements for the exchange'
87	C9P3	'Use software configuration management to manage different versions of the components of a software system'
88	C9P4	'Stimulate exchanges and visits among sites'
89	C9P5	'Use scrum practices to mitigate coordination challenges'
90	C9P6	'Involve client at early stage in new product design and development'
91	C9P7	'Develop a joint functional management committee to manage collaboration'
92	C9P8	'Increase both informal and formal coordination and cooperation through informal and formal meetings'
93	C9P9	'Develop a mutual agreement instead of formal procedures and rules'
94	C9P10	'Respect for mutual obligations and provide active cooperation at all stages'
95	C9P11	'On a regular basis share data about each phase of the development'
96	C10P1	'Appoint contract manager who is responsible to aligned content of the SLA with the business requirements'
97	C10P2	'Establish mechanism for proper negotiations and mutual consensus on SLA specifications (e.g price, scope, schedule, security provisions, resource requirements, penalties and escalation processes, and intellectual property rights)'
98	C10P3	'Establish informal contracting mechanisms, such as relationship specificity and trust'
99	C10P4	'Draft a detailed SLA by giving details of authorities, ownership, roles and responsibilities'
100	C10P5	'Effectively manage changes to ensure SLA flexibility'
101	C10P6	'Acquire the services of legal counsel in SLA development'
102	C10P7	'Keep IPR protection on highest priority in SLA'
103	C11P1	'Involved experienced outsourcing team member in the outsourcing process at the earliest possible phase'
104	C11P2	'Establish a joint configuration management infrastructure'
105	C11P3	'Focus on optimum utilization of skills and resources of each stakeholder'
106	C11P4	'Use of inter organizational systems such as EDI'
107	C11P5	'Take joint mutually beneficial decisions with client in most problematic circumstances'
108	C11P6	'Use joint and multi-level relationship management approach'
109	C11P7	'Add some members from the client's company to the existing steering boards'
110	C12P1	'Offer additional services that will contribute to the development of a mutually beneficial partnership'
111	C12P2	'Focus on developing trustful relationship with client'
112	C12P3	'Escalate informal and formal commitment by effective communication'
113	C12P4	'Always share and discuss long range plan with client and create future orientation'
114	C12P5	'Devote resources and exert effort in order to sustain in on-going relationship'
115	C12P6	'Use mechanisms for mutual adjustment processes'
116	C13P1	'Adopt proper mechanism for penalty rewards systems and performance monitoring'
117	C13P2	'Use relational-based governance models for client management such as MIDM and CIIM'
118	C13P3	'Collect performance data from all stakeholders through multiple sources and size employee performance holistically'
119	C13P4	'Obtain feedback from client on daily basis'
120	C13P5	'Use earned value management (EVM) system in weekly progress review meetings'
121	C13P6	'Use both informal and formal governance approaches'
122	C13P7	'Establish mechanism for intellectual property management'
123	C13P8	'Clearly define responsibilities, roles and power of the stakeholder as per their competencies'
124	C13P9	'Governance principles should be written, defined, approved and well understood by both parties'
125	C14P1	'Use state-of-the art IT infrastructure'
126	C14P2	'Smooth client's entry to new market'
127	C14P3	'Attain CMMI certification that helps you to compete better'
128	C14P4	'Use high levels of automation and 24/7 service providing infrastructure
129	C14P5	'Develop complementary skills and resources'
130	C14P6	'Experiment new and latest technology'

organization knows where it is, it can more effectively plan for improvement.

The ranking part is demonstrated with the help of empirical survey while the assessment part of the framework is demonstrated by conducting case studies in the SDO organization. The results show that our assessment framework is easy to understand, easy to use and can effectively judge the strengths and weakness of their outsourcing processes. Furthermore, case studies have proven that familiarity with CMMI is not mandatory for FMAAM to be applied effectively in the SDO organizations. However, applying FMAAM may be slightly calmer in organizations that are previously aware of CMMI structure.

Consequently, companies, enterprises, or organization can make use of the proposed assessment framework to improve their decision-making and take appropriate corrective actions as suggested by the framework model to avoid any loss in the form of resources and time. Other researcher and practitioner can adopt the proposed model procedure and methodology in order to develop their own organizational assessment, capability improvement, and decision-making framework for companies, enterprises, or organization. Moreover, the ranking part of the model can be used to design a ranking tool, to rank the success or failure contribution of different success factors or risk factor while the assessment part of the framework can be used to develop mini assessment instrument. The rating phase can also be used separately in order to get the extent of implementation or level of ability of an organization for a particular influential factors i.e practice or solution. The weighting and rating phase combined can be used as DSS by predicting the success of some organizational decision.

The only limitation of the study to criticize this research work is related to giving case specific empirical implication besides generalize one. In this paper, we have taken SOP as an empirical case; however, the decision support framework based on multi-attribute assessment can be adopted for any MCDM problems related to any field. Additional, we have generalized the framework development methodology to such an extent that other researcher can easily adopt the proposed assessment model procedure and methodology in order to develop their own framework for organization process improvements.

FMAAM is currently implemented in the form of a spreadsheet, which can process data received through Google form. In order to industrialize the model, in future, we plan to automate the FMAAM in the form of online assessment service. Companies will be able to generate different assessment reports automatically. Form the results of the current study; we have noted a number of further gaps in this area that we plan to do in future. These include:

1. Validation of the model by conducting more case studies in the large-sized organizations.
2. Comparison of FMAAM suitability for offshore, onshore, and nearshore partnership formation.
3. Identification of different activities and risk involved in each partnership level of the FMAAM.

APPENDIX A
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The complete judgment of survey expert and case study evaluator in TFN format can be found as an associated file. For weights of the practices of Table 13 (Appendix-D), see Table 14 while for rating at company-A, see Table 15.

APPENDIX B
RANKING OF THE PRACTICES

See Table 11.

APPENDIX C
RATING OF THE PRACTICES

See Table 12.

APPENDIX D
LIST OF PRACTICES

See Table 13.

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