An Integrated Fuzzy Multi-Criteria Decision-Making Approach for Assessment of Software Process Improvement with Reference to Global Software Development projects

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Abstract

The offshore/on-site teams' effectiveness of knowledge transfer (KT) has been major determinant for software process improvement (SPI) in global software development (GSD) projects. The main aim of this paper is to reveal the influence of GSD teams' (offshore/onsite) knowledge transfer (KT) effectiveness dimensions with respect to the software process improvement (SPI) with reference to the outcome of GSD projects. Moreover, this research investigates to incorporate the effectiveness of knowledge transfer and process improvement in GSD project outcome relationship from the service provider perspective in following dimensions: product success, successful collaboration, and personal satisfaction. Similarly, the process improvement has been measured via GSD team KT dimensions: knowledge, team, technology, and organization factors. Moreover, the measurement framework for the combination of knowledge, team, technology, and organization factors for deriving KT factors by GSD team and SPI in GSD projects has not been sufficiently investigated in the existing literature. Also, fuzzy evaluation framework for assessment of SPI is not addressed by the existing researchers. To address this research gaps, the purpose of this paper to integrate fuzzy Decision Making Trial and Evaluation Laboratory (DEMATEL), and TODIM (an acronym in Portuguese for Interactive and Multiple Attribute Decision Making) approaches for assessment of SPI from KT dimensions in the context of GSD project outcome.

Keywords: Software Process Improvement (SPI), Knowledge Transfer (KT), Global Software Development (GSD), Decision Making Trial and Evaluation Laboratory Model (DEMATEL), TODIM

1. Introduction

In today's world, Global Software Development teams' knowledge transfer effectiveness has been one of the key determinants for evaluating the software process improvement in GSD project in software service outsourcing context. The aim of this paper is to reveal the influence of GSD teams' knowledge transfer (KT) effectiveness dimensions with respect to the software process improvement (SPI) with relate to the outcome of GSD projects. Software process improvement plays an important role in helping project teams in software development organizations. Moreover, earlier studies (Sangaiah and thangavelu 2013; Alsalti and Hackney 2011; Mohamed et al. 2009; Nidhra et al. 2013; Aziati et al. 2014; Kumar and Ganesh 2009)have addressed the characteristics of knowledge and significance of knowledge transfer in IS outsourcing success. Many of our related works [1,2,3,4,5,6,7] have emphasized the significance of knowledge transfer success in the Information System (IS) outsourcing. Thus, our objective of this research is to address the knowledge transfer effectiveness dimensions in the context of GSD project outcome and SPI perceived by GSD teams. Recently, there is an interest to use the evidential reasoning approach on the basis of hybrid MCDM methodologies. In addition, MCDM approaches have been applied for evaluation of multiple attributes and especially helpful for decision makers to handle uncertainty and subjective vagueness during the decision making process. Moreover, the number of MCDM approaches include decision making trial and evaluation laboratory (DEMATEL), fuzzy analytic hierarchical process (FAHP), fuzzy analytic network process (FANP), Technique for Order Performance by Similarity to Ideal Solution (TOPSIS), Elimination EtChoixTraduisant la REaite (ELECTRE) and so on investigated in the literatures. In our earlier work [4], we have integrated fuzzy DEMATEL with TOPSIS approach for evaluation of GSD project outcome factors in organizational behavior research phenomenon of GSD teams. Similarly, we have combined Fuzzy MCDM and DEMATEL approach for evaluation KT effectiveness with reference to GSD project outcome illustrated in our earlier study [8]. In addition, group decision making under fuzzy environment for evaluating KT effectiveness in GSD projects has been very limited in the literature. Thus, addressing this research gaps inspired us to propose a hybrid approach based on fuzzy MCDM presented in this paper. Furthermore, this study focuses on a hybridfuzzy MCDM approach that integrates DEMATEL, and TODIM, under fuzzy environment has been proposed for assessment of KT effectiveness of GSD teams with relate to the SPI.

The comprehensive framework for considering GSD teams' knowledge, team, technology, and organization factors for assessing KT effectiveness with reference to SPI-GSD project outcome has not been reported in the literature. To address this gap, our earlier research have addressed thirty-five evaluation factors for evaluating KT effectiveness of GSD teams by the use of a combined fuzzy DEMATEL and fuzzy MCDM approach [8]. Based on the results of our earlier DEMATEL-FMCDMstudy [8], and interview with experts, we have identified the majority of fifteen factors perceived as significant for evaluating KT effectiveness in GSD projects. These factors are depicted in Table-1. Consistent with earlier works [3,8], to address the enhanced way for identifying KT effectiveness factors in GSD projects, we have adopted fuzzy DEMATEL and TODIM approaches with triangular fuzzy number (TFN) in a group decision making process.

Factors	Context	Description
F1	Knowledge	Gathering the information and experiences among teams.
F2	Knowledge	Sharing the knowledge and experiences among team members
F3	Knowledge	Knowledge incentive towards business process and project outcome
F4	Organization	Specialty and knowledge creation ability among teams.
F5	Knowledge	Team members ability to provide assistance to solving problems
F6	Team	Personal attachment and support towards the project.
F7	Team	Co-ordination of teams to achieve the project goals.
F8	Knowledge	Learning and sharing the technical information and work materials of teams
F9	Technology	Explicit and standard communication pattern for knowledge transfer effectiveness.

F10	Technology	Tools and technology to facilitate knowledge transfer within teams.
F11	Team	Suggestion and contribution of teams on project outcome
F12	Team	Persistent, conscientious responsiveness information of teams on project outcome
F13	Team	Feeling of togetherness or closeness within teams
F14	Knowledge	Team participation and communication relationship
F15	Organization	Specialty and knowledge creation ability of teams

Table 1: Summary of source of measurements and experts' opinion on evaluation criteria's of KT effectiveness for SPI in GSD projects.

Recently the number of studies has used MCDM approaches, either independently, or hybridization of two or more MCDM approaches. In the recent studies, we can find hybridization of MCDM approaches for example DEMATEL and TOPSIS [4,9], DEMATEL, TOPSIS and ANP [10,11], AHP and ELECTRE [12],ANP, TOPSIS, and ELECTRE [13]. However, the hybridization of fuzzy DEMATEL, TOPSIS, and ELECTRE has not been available in the existing literatures. Thus, addressing this research gaps inspired us to propose a hybrid approach based on fuzzy DEMATEL, and TODIM approaches to evaluate the offshore/onsite teams' KT effectiveness from the perspective of GSD project outcome has been presented in this research.

To address these research gaps, an empirical study has been carried out in Indian software companies to evaluate KT effectiveness of the GSD teams. The rest of this paper is organized as follows: Section 2 presents the theoretical foundations of fuzzy MCDM approaches (DEMATEL, and TODIM). Section 3and 4 present the assessment framework used in this research and empirical case of study data. Section 5 and 6 presents the results and discussion and conclusion of the study respectively to address the significance of KT effectiveness on GSD teams.

2. Theoretical Foundations

In this study, the fuzzy DEMATEL, TODIM approaches has been integrated for evaluation of KT effectiveness from the perspective of GSD teams' under a fuzzy environment is proposed. The proposed methodologies for KT effectiveness on GSD project outcome evaluation framework consists of two basic stages: [1] First, we have used the fuzzy DEMATEL approach for determining the priority weights of the criteria. [2] Then, these DEMATEL weights have been applied in TODIM to identify the rank and significance of the attributes The theoretical foundations of fuzzy DEMATEL and TODIM methods have been illustrated in the following sections.

2.1 Fuzzy set theory

Definition: For any fuzzy set, (let's say) A, the function μ_A represents the membership function for which $\mu_A(x)$ indicates the degree of membership that x, of the universal set X, belongs to set A and is, usually, expressed as a number between 0 and 1 that is,

$$\mu_A(x): X \rightarrow [0,1] \quad (1)$$

$$\mu_A(x) = \begin{cases} 0 & \text{if } x \leq l \\ \dfrac{x-l}{m-l} & \text{if } l \leq x \leq m \\ \dfrac{u-x}{u-m} & \text{if } m \leq x \leq u \\ 0 & \text{if } x \geq u \end{cases} \quad (2)$$

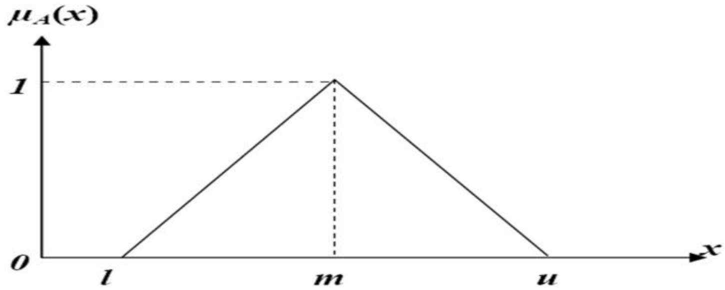

Figure 1: Membership Functions of the Triangular Fuzzy Numberμ_A.

In the Fig 1,**(*l, m, u*)** denotes the x coordinates of the three vertices of $\mu_A(x)$ in a fuzzy set A (l: lower boundary and u: upper boundary where membership degree is zero, m: the centre where membership degree is 1).

2.2 Fuzzy Linguistic Variables

Zadeh(1965) has stated that the uncertainty and subjective vagueness of human thoughts deals with fuzzy set theory. Furthermore, linguistic scales have been implied a practical means of relating such situations. For this reason, this research adopts the fuzzy set theory to measure the KT effectiveness of GSD teams in the relation to GSD project outcome by evaluating the subjective decisions of experts. Subsequently, this study has employed the five linguistic scales to assess the KT effectiveness factors with respect to SPI and GSD project outcome and their corresponding triangular fuzzy number (TFN) are listed in Table-2.

Linguistic scale	Corresponding TFN
Strongly agree	(0.9, 1.0, 1.0)
Agree	(0.7, 0.9, 1.0)
Neither agree nor disagree	(0.3, 0.5, 0.7)
Disagree	(0.0, 0.1, 0.3)
Strongly disagree	(0.0, 0.0, 0.1)

Table 2: Fuzzy membership with Triangular Fuzzy Numbers

2.3 Fuzzy DEMATEL Method

Recent studies [15,16] has successfully applied the DEMATEL approach to evaluate the factors with respect to the knowledge management practices in the context of MCDM problems. Consistent with earlier studies, this paper addresses the DEMATEL approach for evaluating KT effectiveness of GSD teams in the context of project outcome. The DEMATEL method is incorporated for analyzing the data in this study, and its computational procedure is summarized as follows:

Step 1: Set up Direct-Relation Matrix

The first step of the fuzzy DEMATEL analysis sets up a direct relation matrix Abased on the data collected from the experts.
Create a decision matrix A for the important weights of KT effectiveness factors$(C_j, j = 1,2,3, \dots, n)$. The respondents $(R^i, i = 1,2,3, \dots m)$ provided their subjective judgments about the importance weights of each KT factors by using linguistic scales (1-5) (as listed in Table 2).The direct relation matrix A is as follows:

$$\begin{array}{c} \\ \\ \end{array} \begin{array}{ccccc} R^1 & R^2 & R^3 & \dots & R^m \end{array}$$

$$A = \begin{array}{c} C_1 \\ C_2 \\ C_3 \\ \vdots \\ C_n \end{array} \begin{bmatrix} \tilde{a}_1^1 & \tilde{a}_1^2 & \tilde{a}_1^3 & \cdots & \tilde{a}_1^m \\ \tilde{a}_2^1 & \tilde{a}_2^2 & \tilde{a}_2^3 & \cdots & \tilde{a}_2^m \\ \tilde{a}_3^1 & \tilde{a}_3^2 & \tilde{a}_3^3 & \cdots & \tilde{a}_3^m \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_n^1 & \tilde{a}_n^2 & \tilde{a}_n^3 & \cdots & \tilde{a}_n^m \end{bmatrix}, i = 1,2, \cdots, m; j = 1,2, \cdots, n \quad (3)$$

In this decision matrix m, n denote the number of respondents and the number of criteria respectively. $\tilde{a}_j^i = (La_j^i, Ma_j^i, Ua_j^i)$ represents Lower-bound (L), Middle bound (M), Upper bound (U) of a Triangular Fuzzy Number (TFN) and fuzzy degree of impact as assessed by ith respondents for the jth influential factor.

Step 2: Design the fuzzy linguistic variables

The study addresses uncertainty and subjective vagueness of human assessments dealt with fuzzy linguistic variable [14]: strongly agree, agree, neither disagree nor agree, disagree, strongly disagree, and their corresponding triangular fuzzy numbers are listed in Table-2.

Step3: Transform triangular fuzzy numbers into the initial direct-relation matrix (M).

This study computes the subjective responses and their equivalent TFN are defuzzified into crisp values via CFCS(Convert Fuzzy Linguistic variable in to crisp scores) method suggested by earlier studies [9,17].

The logistic formula computes the direct-relation matrix M according to the CFCS method, thereby helping in obtaining the initial direct- relation matrix M as shown in Table-3

Step 4: Obtain average value.

This study obtains the average value of initial direct-relation matrix M from the total amount of all initial direct-relation matrixes M divided by 15 (the number of respondents (R1-R15).

Step 5: Set up the generalized direct-relation matrix (N).

We compute a generalized direct-relation matrix N through the Eqn. (4)-(5) in which all principal diagonal elements are between 1 to 0. The generalized direct-relation matrix is given as Table 4. Here, the initial direct relation matrix M is $n \times n$ matrix, set of elements (K) are determined through pair-wise comparison to find an importance of the criteria.

$$K = \frac{1}{max_{1 \le i \le n} \sum_{j=1}^{n} aij} \tag{4}$$

$$N = K \times M \tag{5}$$

Step 6: Set up the total-relation matrix (F)

The total-relation matrix F is acquired using Eqn. (6) from the generalized direct-relation matrix N. The total-relation matrix is shown in Table 5. The element f_{ij} denotes the indirect effects that factor i on j, So, F can represent the total relation matrix of each pair of system factors.

$$F = N(I - N)^{-1} \tag{6}$$

Step 7: Obtain the sum of rows and columns to compute prominence and relation of each criterion

The sum of rows and the sum of columns are separately denoted as r_i and c_i within the total-relation matrix F where the horizontal axis is denoted as ''Prominence'', and the vertical axis is named as ''Relation'' as shown in Eqn. (7)-(9). Here and r_i and c_i denote the degree of direct and indirect effect given by the factor i, j from all other factors.

$$F = f_{ij} | i, j = 1,2, \cdots, n \tag{7}$$

$$r_i = \square\, \mathcal{I}\ f_{ij} \quad i: s1:sn \tag{8}$$

$$c_i = \square\, \mathcal{I}\ f_{ij} \quad i: s1:sn \tag{9}$$

Step 8: Obtain the priority weight of the criteria's

The weight of the criteria's (W_j) is determined using Eqn. (10) for calculation of the overall weight of the constructs. Here $r_i + c_i$ indicates the degree of importance that factor in the respective criteria. Thus, this priority weight (W_j) is applied in the TOPSIS and ELECTRE methods to determine KT effectiveness with reference to GSD project outcome as shown in Eqn. (12). Table-6 shows the prominence, relation, and respective priority weight of the criteria.

$$W_j = \frac{\sum_{j=1}^{n} r_i + c_i}{\sum_{i=1}^{n} \sum_{j=1}^{n} (r_i + c_i)} \tag{10}$$

2.4 TODIM Approach

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The TODIM method is used to measure the dominance degree of each alternative over the others by establishing a multi-criteria value function based on the prospect theory (Zhang & Xu 2014; Fan et al., 2013). Recent study (Li et al., 2015) has incorporated Euclidean distance for defuzzification in TODIM and DEMATEL approaches. However, this paper employs CFCS method for defuzzification of fuzzy data into crisp score. The DEMATEL-FMCDM approach is initially used to determine the weights and rank of the risk criteria's. Then, the weights of criterion obtained through DEMATEL have been initially weighted in TODIM which represents the hybrid approach and use both to determine the final weights of the risk criterion. Furthermore, the operational procedures of TODIM method used in this study was adopted from earlier studies (Zhang & Xu 2014; Fan et al., 2013; Gomes 2008). This operational procedure and its data analysis approach as applied in this study has summarized as follows:

Step 1- *Defining and normalizing the decision matrix*: Identify the decision matrix $X = (x_{ij})_{m \times n}$ and normalize it to obtain $Y = (y_{ij})_{m \times n}$. Here x_{ij} and y_{ij} are the crisp numbers, $i \in M, j \in N$, where $M = \{1,2, \cdots, m\}$ and $N = \{1,2, \cdots, n\}$. For any fuzzy set, (let's say) A, in a

X (universe discourse) is characterized by a membership function $\mu_A(x)$ that assigns each element x in X a real number in the interval $[0,1]$, i.e., $\mu_A(x): X \rightarrow [0,1]$.

Step 2–*Computing the relative weights*: Obtain the relative weight W_{jr} of the criterion C_j to the reference criterion C_r based on the following definition:

$$W_{jr} = w_j / w_r, r \in N \text{ and } j \in N, \tag{13}$$

where w_j is the weight value of the criterion determined through DEMATEL approach, C_j *and* w_r $= ww_j|j \in N$ ∘∂∘. The weight factors $W = (w_1, w_2, \cdots, w_n)$ for each criterion C_j satisfying $\sum_{j=1}^{n} w_j = 1$.

Step 3 – *Computing the dominance degree*: Calculate the dominance of each alternative P_i over each alternative P_k using the following definition:

Here $\varnothing_j(P_i, P_k)$ represented as

$$\varnothing_j(P_i,P_k) = \begin{cases} \sqrt{\dfrac{w_{jr}(g_{ij} - g_{jk})}{(\sum_{j=1}^{n} w_{jr})}}, & \text{if } g_{ij} - g_{jk} > 0 \\ 0, & \text{if } g_{ij} - g_{jk} = 0 \\ -\dfrac{1}{\theta}\sqrt{\dfrac{(\sum_{j=1}^{n} w_{jr})(g_{ij} - g_{jk})}{w_{jr}}}, & \text{if } g_{ij} - g_{jk} < 0 \end{cases} \tag{14}$$

The term $\varnothing_j(P_i,P_k)$ represents the contribution of the criterion C_j to the function $o(P_i,P_k)$ when comparing the alternative P_i with the alternative P_k. A positive $(g_{ij} - g_{jk})$ represents a gain (i.e., most significance of the factors) or a negative $(g_{ij} - g_{jk})$ denotes a loss (i.e., least significance of the factors).

Step 4 - *Computing the overall dominance degree*: Calculate overall dominance degree of alternative P_i over P_k according to following computation:

$$o(P_i,P_k) = \sum_{j=1}^{n} \varnothing_j(P_i,P_k), \quad i, k \in M \tag{15}$$

Step 5– *Compute the overall prospect value:* To determine the overall prospect value of the alternative P_i, Eqn. (16) is used.

$$((P)_{i,} = \frac{\sum_{k=1}^{m} o(P_i,P_k) - min_i\, w\sum_{k=1}^{m} o(P_i,P_k)\circ\oslash\circ}{max_i w\sum_{k=1}^{m} o(P_i,P_k)\circ\oslash\circ - min_i w\sum_{k=1}^{m} o(P_i,P_k)\circ\oslash\circ}, i \in M \qquad (16)$$

Step 6– *Ranking the overall prospect values:* Sort out the alternatives by their overall prospect values$((P_{i,})$ $(i \in M)$. Ordering the values gives the rank of each alternative, and better alternative have a highest value of $($. Thus, this paper addresses the ranking alternatives or determine most desirable alternative from the finite set A using the decision matrix X and factor weight vector W.

3. Framework for evaluating KT effectiveness of SPI with reference GSD project outcome.

To the best of our knowledge, up to date research on evaluating GSD teams KT effectiveness with reference to SPI is very limited. Moreover, the assessment framework for the integration of knowledge, team characteristics, technology, and organizational elements for the effectiveness of KT perceived by SPI on GSD teams in relation to project outcome has not been adequately presented in the available literature.

Further, the hybridization of fuzzy DEMATEL and TODIM has not been addressed in the existing studies. Based on this context we have integrated fuzzy DEMATEL, TOPSIS, and ELECTRE approach for evaluating GSD teams' KT effectiveness from the perspective of project outcome in GSD projects. The schematic diagram of proposed framework and computation procedure of hybridization of DEMATEL and TODIM under a fuzzy environment is depicted in Fig.2.

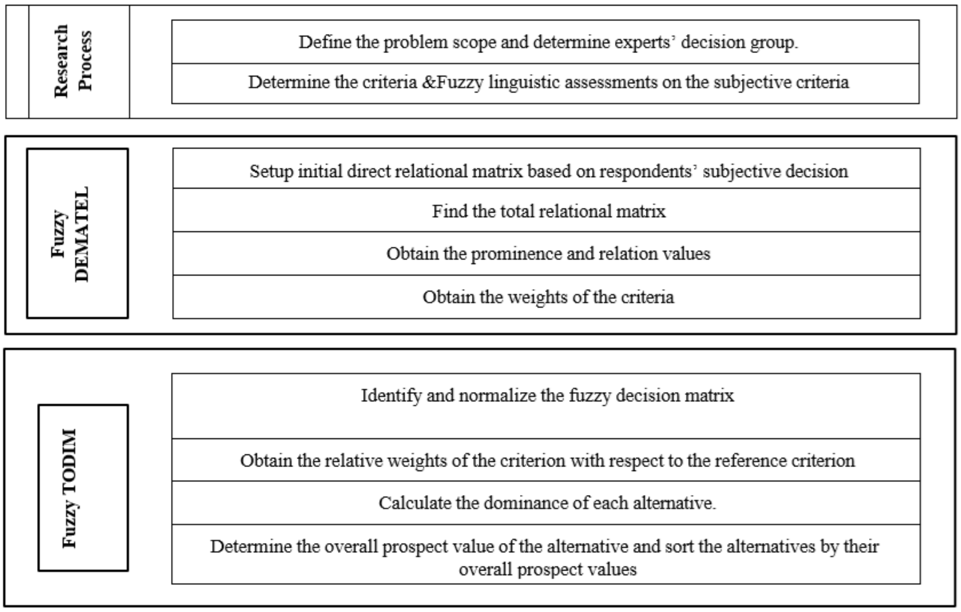

Figure 2: The proposed framework of hybrid Fuzzy DEMATEL-TODIM approach for evaluating KT effectiveness with reference to SPI by GSD teams

4. Empirical Case for Evaluating the KT effectiveness criteria's for SPI on GSD teams

The SPI dimensions as shown in Fig.3 (PSP, TSP, and CMM) investigated under GSD team knowledge transfer effectiveness with reference to GSD project outcome.

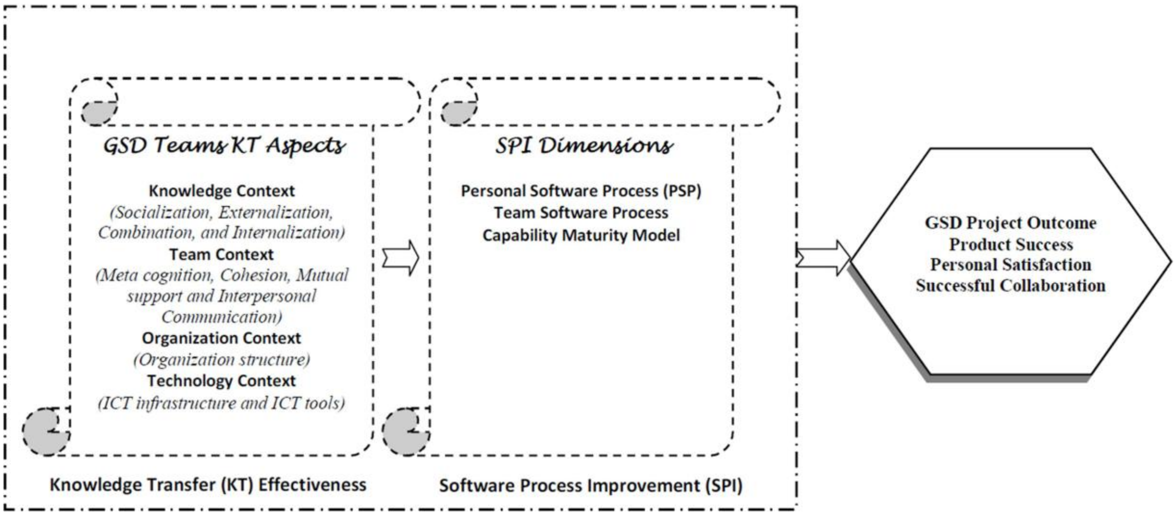

Figure 2.2: The GSD teams' KT effectiveness Dimensions: Significant Impact towards SPI and GSD project outcome.

To achieve this goal, an empirical study has been carried outin Inowits software organization located in India. The organization has more than 100 employees, reputation (ISO certification) and provides offshore outsourcing service support to various countries. The demographic details of the respondents of this study were executive committee, solution development team, and solution delivery team of this organization. Consequently, the empirical study has been tested among fifteen employees of this organization to validate the effectiveness of KT factors on SPI (see table 1) for GSD teams. The hybrid fuzzy DEMATEL-TODIME approaches were applied in this case study, as illustrated in the following sections.

4.1 Calculate importance weights of KT effectiveness measurement criteria's with reference to SPI on GSD project outcome by fuzzy DEMATEL

Step 1: Create a fuzzy decision matrix with respect to the subjective decisions of 15 experts through the use of likert scale [1 to 5] and their corresponding triangular fuzzy numbers (shown in Table-2) for the important weights to evaluate the significance each of the 15 criteria.

*Step 2:*Convert the fuzzy linguistic variables into crisp scores using CFCS (Convert Fuzzy Linguistic variable in to crisp scores) method suggested by prior studies [24,25] as shown in Table-3.

Step 3: Construct the generalized direct relational matrix and total relation matrix to obtain the weights of the criteria as shown in Table-4 and Table-5.

Step 4: Obtain Prominence and relation value and compute the importance of the criteria as shown in Table-6.

Step 5: The weights of the criteria (W_j) are determined via using Eqn.(10) to calculate priority weight of the constructs as shown in Table-6.

	F1	F2	F3	F4	F5	F6	F7	F8
R1	0.000	1.033	1.033	1.033	1.033	1.033	1.033	1.033
R2	1.067	0.000	1.033	1.033	1.033	1.033	1.033	1.033
R3	1.033	1.033	0.000	1.067	0.767	0.100	1.067	0.767
R4	0.333	1.067	1.067	0.000	1.067	1.033	1.033	1.033
R5	1.067	0.100	1.033	1.033	0.000	1.033	1.067	0.333
R6	1.033	1.033	1.033	0.333	1.033	0.000	1.067	1.033
R7	0.767	1.033	0.767	1.067	1.067	0.333	0.000	1.067
R8	1.033	0.333	1.033	0.100	1.033	1.067	1.033	0.000
R9	1.067	1.033	1.033	1.067	1.067	1.067	1.067	0.767
R10	1.067	0.333	0.333	0.767	1.033	1.067	1.033	0.100
R11	1.033	0.100	1.033	1.033	1.033	0.100	0.333	1.067
R12	0.100	1.067	1.067	1.033	0.333	1.033	1.067	1.033
R13	0.333	1.067	0.767	1.033	1.033	1.067	1.033	1.067
R14	1.033	1.033	1.033	1.033	0.100	0.767	1.033	0.333
R15	1.067	1.067	1.067	1.067	0.767	1.067	0.333	1.067

Table 3: Initial Direct Relation Matrix *(to be continued)*

	F9	F10	F11	F12	F13	F14	F15
R1	1.033	1.033	1.033	1.033	1.133	1.033	1.033
R2	1.033	1.033	1.033	0.767	1.133	1.033	1.033
R3	0.767	0.767	1.067	1.067	1.267	0.767	0.767
R4	1.033	1.033	1.033	1.033	0.100	1.033	1.033
R5	1.033	1.033	1.033	1.033	1.133	1.067	1.033
R6	1.067	1.067	0.100	1.067	1.267	1.033	1.033
R7	1.033	0.100	1.033	0.333	1.267	1.067	1.067
R8	1.033	1.033	0.767	1.033	0.433	1.033	0.333
R9	0.000	1.067	1.033	1.067	1.133	1.067	1.067
R10	1.033	0.000	1.067	1.067	1.133	1.067	0.100
R11	0.767	0.767	0.000	1.067	1.133	1.033	1.067
R12	1.033	1.033	1.067	0.000	1.133	1.033	0.333
R13	0.333	1.067	1.033	1.067	0.000	1.067	0.333
R14	1.067	1.067	1.033	1.033	1.133	0.000	1.033
R15	1.067	1.067	1.067	1.067	1.267	1.067	0.000

Table 3 (a): Initial Direct Relation Matrix

	F1	F2	F3	F4	F5	F6	F7	F8
R1	0.000	0.070	0.070	0.070	0.070	0.070	0.070	0.070
R2	0.073	0.000	0.070	0.070	0.070	0.070	0.070	0.070
R3	0.070	0.070	0.000	0.073	0.052	0.007	0.073	0.052
R4	0.023	0.073	0.073	0.000	0.073	0.070	0.070	0.070
R5	0.073	0.007	0.070	0.070	0.000	0.070	0.073	0.023
R6	0.070	0.070	0.070	0.023	0.070	0.000	0.073	0.070
R7	0.052	0.070	0.052	0.073	0.073	0.023	0.000	0.073
R8	0.070	0.023	0.070	0.007	0.070	0.073	0.070	0.000
R9	0.073	0.070	0.070	0.073	0.073	0.073	0.073	0.052
R10	0.073	0.023	0.023	0.052	0.070	0.073	0.070	0.007
R11	0.070	0.007	0.070	0.070	0.070	0.007	0.023	0.073
R12	0.007	0.073	0.073	0.070	0.023	0.070	0.073	0.070
R13	0.023	0.073	0.052	0.070	0.070	0.073	0.070	0.073
R14	0.070	0.070	0.070	0.070	0.007	0.052	0.070	0.023
R15	0.073	0.073	0.073	0.073	0.052	0.073	0.023	0.073

Table 4: Generalized Direct Relation Matrix*(to be continued)*

	F9	F10	F11	F12	F13	F14	F15
R1	0.070	0.070	0.070	0.070	0.077	0.070	0.070
R2	0.070	0.070	0.070	0.052	0.077	0.070	0.070
R3	0.052	0.052	0.073	0.073	0.086	0.052	0.052
R4	0.070	0.070	0.070	0.070	0.007	0.070	0.070
R5	0.070	0.070	0.070	0.070	0.077	0.073	0.070
R6	0.073	0.073	0.007	0.073	0.086	0.070	0.070
R7	0.070	0.007	0.070	0.023	0.086	0.073	0.073
R8	0.070	0.070	0.052	0.070	0.030	0.070	0.023
R9	0.000	0.073	0.070	0.073	0.077	0.073	0.073
R10	0.070	0.000	0.073	0.073	0.077	0.073	0.007
R11	0.052	0.052	0.000	0.073	0.077	0.070	0.073
R12	0.070	0.070	0.073	0.000	0.077	0.070	0.023
R13	0.023	0.073	0.070	0.073	0.000	0.073	0.023
R14	0.073	0.073	0.070	0.070	0.077	0.000	0.070
R15	0.073	0.073	0.073	0.073	0.086	0.073	0.000

Table 4 (a): Generalized Direct Relation Matrix

	F1	F2	F3	F4	F5	F6	F7	F8
R1	0.4242	0.4732	0.5366	0.5212	0.5038	0.4838	0.5366	0.4828
R2	0.4868	0.4013	0.5298	0.5147	0.4981	0.4777	0.5298	0.4767
R3	0.4244	0.4125	0.4004	0.4578	0.4224	0.3640	0.4679	0.4058
R4	0.4045	0.4299	0.4885	0.4059	0.4577	0.4374	0.4854	0.4366
R5	0.4481	0.3774	0.4888	0.4774	0.3930	0.4405	0.4908	0.3982
R6	0.4547	0.4411	0.4961	0.4406	0.4661	0.3851	0.5012	0.4466
R7	0.4062	0.4075	0.4465	0.4514	0.4358	0.3738	0.3937	0.4193
R8	0.4001	0.3415	0.4342	0.3657	0.4078	0.3938	0.4364	0.3243
R9	0.4935	0.4754	0.5384	0.5259	0.5073	0.4873	0.5404	0.4684
R10	0.3968	0.3416	0.3903	0.4069	0.4071	0.3936	0.4344	0.3338
R11	0.4035	0.3342	0.4429	0.4313	0.4142	0.3441	0.3996	0.4003
R12	0.3676	0.4130	0.4655	0.4502	0.3943	0.4175	0.4673	0.4189
R13	0.3789	0.4077	0.4446	0.4468	0.4330	0.4179	0.4623	0.4170
R14	0.4397	0.4297	0.4817	0.4711	0.3968	0.4184	0.4816	0.3942
R15	0.4796	0.4637	0.5253	0.5095	0.4747	0.4751	0.4813	0.4728

Table 5: Total Relation Matrix *(to be continued)*

	F9	F10	F11	F12	F13	F14	F15
R1	0.5347	0.5315	0.5436	0.5520	0.5895	0.5737	0.4664
R2	0.5280	0.5248	0.5367	0.5292	0.5821	0.5665	0.4613
R3	0.4476	0.4450	0.4772	0.4807	0.5191	0.4819	0.3901
R4	0.4865	0.4807	0.4919	0.4993	0.4723	0.5189	0.4247
R5	0.4871	0.4841	0.4960	0.5038	0.5388	0.5247	0.4267
R6	0.4974	0.4946	0.4474	0.5125	0.5563	0.5311	0.4309
R7	0.4583	0.4004	0.4682	0.4314	0.5124	0.4941	0.4068
R8	0.4342	0.4297	0.4234	0.4467	0.4386	0.4637	0.3371
R9	0.4708	0.5353	0.5457	0.5559	0.5922	0.5778	0.4706
R10	0.4312	0.3628	0.4404	0.4470	0.4774	0.4647	0.3231
R11	0.4241	0.4238	0.3847	0.4589	0.4840	0.4720	0.3862
R12	0.4619	0.4588	0.4716	0.4108	0.5089	0.4955	0.3613
R13	0.4178	0.4581	0.4662	0.4754	0.4337	0.4945	0.3588
R14	0.4820	0.4792	0.4897	0.4956	0.5307	0.4492	0.4204
R15	0.5227	0.5224	0.5315	0.5418	0.5819	0.5610	0.3878

Table 5 (a): Total Relation Matrix

	Row sum (r_i)	Column sum (c_i)	$r_i + c_i$	Priority weights	Rank
F1	7.754	6.408	14.162	0.0687	4
F2	7.644	6.150	13.794	0.0669	7
F3	6.597	7.110	13.707	0.0665	8
F4	6.920	6.876	13.707	0.0669	6
F5	7.102	6.612	13.588	0.0659	10
F6	6.976	6.310	13.412	0.0651	13
F7	6.506	7.109	13.615	0.0660	9
F8	6.077	6.296	12.373	0.0600	15
F9	7.785	7.084	14.869	0.0721	1
F10	6.051	7.031	13.082	0.0635	14
F11	6.204	7.214	13.418	0.0651	12
F12	6.563	7.341	13.904	0.0674	5
F13	6.513	7.818	14.331	0.0695	3
F14	6.860	7.669	14.529	0.0705	2
F15	7.531	6.052	13.583	0.0658	11

Table 6: DEMATEL -Calculation of Priority Weight on KT Criteria's

4.3 Applying TODIM

In order to determine the final rank of the alternatives, we apply TODIM as follows: *(i)* First, we obtain the weighted normalized decision matrix using DEMATEL and FMCDM approaches with respect to the criteria, as explained previously. The weights obtained from fuzzy DEMATEL are used to compute the weighted normalized matrix; *(ii)* Then, we determine the relative weights of the criterion on the basis of DEMATEL weights; *(iii)* After that, we calculate the dominance of each alternative by means of Eqns. (14-16); *(iv)* Finally, we compute the overall prospect value of the alternative, which allows us to obtain its rank according to the final indices. The overall prospect values of the alternatives determined through normalization of the corresponding dominance measurements is presented in Table 6which shows the results of the project ranking as obtained by integrating DEMATEL and TODIM. From Table 6, it can be realized that the

overall values, ranking order i.e., $P4 > P8 > P1 > P11 > P18$ of 20 projects is determined,

namely $((P_4) = 1$, $((P_B) = 0.9213$, $((P_1) = 0.8682$, $((P_{11}) = 0.7939$, $((P_{1B}) = 0.7844$ and $((P_2) = 0$.

Table 6: Overall prospect values and project ranking as obtained by integrating DEMATEL and TODIM

Factors	Overall prospect value *(f)*	Factors rank
F1	0.8682	03
F2	0.0000	20
F3	0.3792	18
F4	1.0000	01
F5	0.3208	19
F6	0.6449	10
F7	0.5069	15
F8	0.9213	02
F9	0.5105	14
F10	0.4292	17
F11	0.7939	04
F12	0.5109	13
F13	0.7808	06
F14	0.5497	12
F15	0.6306	11

Apparently, the greatest value is attributed to project (*P4)* and the lowest value to project*(P2*) for the dominance degree of each project in risk assessment. Similarly, Table 7 shows the overall relative weights and ranking of criteria among the projects.

Table 7: Overall relative weights and ranking of criteria among the projects, as obtained by applying TODIM

Risk factors	Overall prospect value *(f)*	Criteria rank
R1	0.7228	07
R2	0.9189	02
R3	0.3264	17
R4	0.7971	05
R5	0.8835	04
E1	0.4059	14
E2	0.7274	06
E3	0.9931	01
E4	0.9017	03
E5	0.2181	20
P1	0.5405	11
P2	0.5780	09
P3	0.2061	21
P4	0.6895	08
P5	0.4867	12
P6	0.3355	16
T1	0.4857	13

T2	0.2693	18
T3	0.1581	22
M1	0.5554	10
M2	0.2295	19
M3	0.3749	15

Based on the he weights of the 22 criteria (refer Table 5 and Table 7) drawn from Requirements (R), Estimations (E), Planning (P), Team Organization (T), and Project Management (M) with respect to Software project risks have been compared for DEMATEL, FMCDM, DEMATEL-FMCDM, and TODIM methods as shown in Figure 2 (a)-(e).

5. Results and Discussion

In the relation to the four main contexts and fifteen evaluation criteria for the possible ratings of KT effectiveness with reference to GSD projects has summarized in Table-1. The expert decision makers of this study, to assess the GSD teams KT effectiveness criteria through TFNs (see Table 2), were executive committee, solution development team, and solution delivery team of Inowitssoftware organization. As a result, initial direct relational matrixes have been computed with respectto fifteen factors as shown in Table 3. For finding the priority weights of the factors, we have computed initial direct relational matrix and direct relation matrix according to DEMATEL approach as shown in Table 4 and Table 5. Obtain Prominence and relation value and compute the importance of the criteria as shown in Table-6. The DEMATEL result shows that factors $F9 > F14 > F13 > F1 > F12$ are highest ranking factors to evaluate the KT

effectiveness on GSD project outcome. Subsequently, for ranking the alternatives TOPSIS approach has been applied. The three-expert group (executive committee, solution development team, and solution delivery team) decisions with respect to KT effectiveness criteria and its alternatives have been shown in Table-7. In addition, to compute the ideal positive, negative solution, closeness, and ranking alternative has been performed through TOPSIS approach their relevant results are shown in Tables 8 to Table-11. The highest rank alternative determined by

fuzzy TOPSIS, $A1 > A2 > A3$ as their results shown in Table 12. Further more in the ELECTRE

approach, the subjective decision of three experts group as normalized and determined through DEMATEL and TOPSIS approach. Subsequently, the weighted normalized decision matrix as shown in Table 13 has been applied in the ELECTRE approach. In the ELECTRE approach, the concordance and discordance values of alternative are computed through pair wise comparisons and its results are listed in Table 10 and Table 11. The final rankings are alternatives have been obtained through ELECTRE approach with respect to concordance and discordance values as shown in Table 12 and Table 13. The final ranking are determined if the concordance value is higher than the average and discordance value is lower than the average than first alternative is greater than the second alternative. Similarly, an ELECTRE result shows the final ranking of

alternative $A1 > A2 > A3 > A4 > A5$ and it shown in Table 14. What makes this research

stand out from other study in the field, in addition to proposed MCDM (DEMATEL-TOPSIS-ELECTRE) model, is an approach to solving the group decision making problems.

6. Conclusion

In the context of GSD projects research phenomenon, this study presents an integrated framework to evaluate the KT effectiveness with reference to GSD project outcome which integrates three approaches: (i) fuzzy DEMATEL and (ii) TOPSIS and (iii) ELECTRE. It is a clear indication that GSD teams' KT effectiveness reveals the key determinants of GSD outcome, while their relationship and measures across the fuzzy MCDM approaches is discussed. Consequently, the proposed framework to demonstrate the applicability of fuzzy DEMATEL-FMCDM model, the model has been validated based on the data gathered from the Indian software organization. As stated earlier the proposed framework of three MCDM approaches for evaluating KT effectiveness on GSD project outcome cases has been novelty of this study, which has till now not been addressed in the literature. Further, we are trying to focus on various kinds of MCDM approaches can be pay attention in our future studies regarding KT effectiveness on GSD project outcome.

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