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A Fuzzy DEMATEL Approach based on Intuitionistic Fuzzy Information for Evaluating Knowledge Transfer Effectiveness in GSD Projects

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Abstract

The offshore/onsite teams' effectiveness of knowledge transfer is significantly measured by a various kinds of factors. In this paper, we propose a Knowledge Transfer (KT) assessment framework which is integrates four criterions: knowledge, team, technology, and organization factors to evaluate KT effectiveness of GSD teams. In this context, we presents fuzzy DEMATEL approach for assessing GSD teams KT effectiveness based on intuitionistic fuzzy numbers (IFNs). In this approach, decision makers provided their subjective judgments on the criteria, characterized on the basis of intuitionistic fuzzy sets. Moreover, intuitionistic fuzzy sets are used in the fuzzy DEMATEL approach can be effectively assessing the KT effectiveness criteria, rank the alternatives. Subsequently, the complete process is illustrated with GSD teams' KT evaluation criteria samples, the factors are ranked using fuzzy linguistic variables which are mapped to IFNs. In that case, IFNs has been converted into their corresponding basic probability assignments (BPAs) and then Dempster-Shafer theory is used to combine the group decision making process. Besides, illustrate applicability and usefulness of proposed approach in group decision making process for evaluation of multiple criteria's under fuzzy environment has been tested by software professionals at Inowits software organization in India.

Keywords: *Knowledge Transfer (KT), Global Software Development (GSD), intuitionistic fuzzy sets, Fuzzy DEMATEL, Basic Probability Assignments, Dempster-Shafer theory.*

1. Introduction

In today's world, offshore/on-site teams' KT effectiveness has been one of the key determinants for evaluating GSD project outcome in the software service outsourcing context. GSD is primarily an outsourcing technique in which on-site teams' work involved in the client location, understanding and auditing the client requirements, whereas, offshore teams operating at

different regions, execute the requirements based on the inputs provided by the on-site teams [1]. Since, many of our related works [1,2,3,4,5,6,7,18] have emphasized the impact of knowledge transfer success in the Information System (IS) outsourcing. Consistent with earlier studies, this paper investigated the offshore/onsite teams KT effectiveness in GSD projects. Consequently, a comprehensive framework for considering GSD teams' knowledge, team, technology, and organization factors for assessing KT effectiveness in GSD projects has not been reported in the literature. Moreover, the number of studies [8,13,14,16] has adopted IFNs for multi-criteria decision making (MCDM) problems. In addition, fuzzy group decision making based on IFNs for evaluating KT effectiveness in GSD projects has been very limited in the literature. Thus, addressing this research gaps inspired us to employ a fuzzy DEMATEL approach based on intuitionistic fuzzy information has been presented in this paper. Subsequently, the proposed approach will helpful for decision makers to solve the uncertainty and subjective vagueness in MCDM problems.

In our prior research, we have investigated thirty-five evaluation criteria for effectiveness of knowledge transfer among GSD teams' on the basis of combined fuzzy DEMATEL and fuzzy MCDM approach [7]. Based on the results of our earlier study [7], above studied approaches (DEMATEL-FMCDM) and interview with experts we have identified the majority of ten factors perceived as significant for measuring KT effectiveness in GSD projects as listed in Table.1. Consistent with earlier works [6,7], to address the enhanced way for identifying KT effectiveness factors in GSD projects, we have adopted fuzzy DEMATEL approach with IFNs in a group decision making process. In our prior work [7], fuzzy DEMATEL approach has been addressed to evaluate the KT factors. Moreover, we have utilized triangular fuzzy numbers has converted in to crisp scores consisting of number of defuzzification steps. Since, the traditional methods in defuzzification of fuzzy numbers have time consuming and may lead to an error factors. To overcome this problem, the combination of BPA, Dempster-Shafer theory and fuzzy DEMATEL approach has been presented in this paper. Similarly, Dempster-Shafer theory associated with fuzzy DEMATEL approach has been addressed in recent studies [8,10] to avoid the need for defuzzification process in fuzzy DEMATEL approach. Likewise, this study integrated the Dempster-Shafer theory and fuzzy DEMATEL method for evaluating KT effectiveness in GSD projects.

In recent times, a number of studies [5,7,8,9] have adopted a fuzzy DEMATEL approach for evaluation of attributes, interrelationship among the criteria and especially handling the subjective judgments that are vague and imprecise. In this paper, the relative importance of ten KT effectiveness factors has been assessed by thirty experts with the use of linguistic assessments. Further, the linguistic values are represented by IFNs which are represented by their BPA values. Moreover, conversion of an IFN into BPA and fusing them saves the effort of defuzzifying the value set. In addition, when a large set of values are concerned, traditional ways of defuzzification approach becoming tedious and time consuming. As a result, Dempster-Shafer theory has been presented in this study to avoid the need of defuzzification and to fuse the BPA, and then fuzzy DEMATEL approach can be applied on each BPA. Consequently, the very few studies [8,10] have integrated that Dempster-Shafer theory and fuzzy DEMATEL method for group decision making process. Thus, addressing this research gaps inspired us to propose a combined approach based on fuzzy DEMATEL- Dempster-Shafer theory for evaluating KT effectiveness in GSD projects presented in this paper.

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.

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

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 Dempster-Shafer theory and fuzzy DEMATEL approach. Section 3 and 4 presents the empirical study and assessment framework

used in this research respectively. Section 5 and section 6 presents the findings of the study and concluding remarks of the study has presented to address the significance of KT effectiveness on GSD teams.

2. Theoretical Foundations

In this study, the fuzzy DEMATEL approach has been integrated with the Dempster-Shafer theory for evaluation of KT effectiveness from the perspective of GSD teams' via IFNs is proposed. The proposed methodologies for KT effectiveness on GSD project outcome evaluation framework consists of two aspects. First, the linguistic values are represented by IFNs which are represented by their BPA values before utilizing DEMATEL method. Finally, Dempster-Shafer theory has been utilized to avoid the need of defuzzification and to fuse the BPA, followed by fuzzy DEMATEL approach can be applied on each BPA. Despite the importance of defuzzification in fuzzy modeling and MCDM the number of earlier studies has utilized Dempster-Shafer in defuzzification process [12,17]. In Dempster-Shafer theory, the information from each source is seen as a piece of evidences which is represented by a basic probability assignment (BPA) [12]. This study processes the IFNs with help of BPAs in order to do away with a complex defuzzification process. The theoretical foundations of Dempster-Shafer theory and fuzzy DEMATEL have been illustrated in the following sections.

2.1 Intuitionistic fuzzy sets (IFS)

Intuitionistic fuzzy sets are sets whose elements have degrees of membership and non-membership. Intuitionistic fuzzy sets have been introduced by Krassimir Atanassov [15]. The IFS is formally defined as follows:

Definition: For any fuzzy set (let's say) X be fixed universe. Let A be the subset of X . An IFS A^* in X construct set have the form $A^* = \{\langle x, \mu_A(x), \vartheta_A(x) \rangle : x \in E\}$ where $\mu_A: X \rightarrow [0,1]$ and $\vartheta_A: X \rightarrow [0,1]$ satisfy the condition $0 \leq \mu_A(x) + \vartheta_A(x) \leq 1$. Here, A^* represents Intuitionistic fuzzy sets. The function $\mu_A: X \rightarrow [0,1]$ and $\vartheta_A: X \rightarrow [0,1]$ denotes degree of membership and non-membership respectively.

2.2 Dempster-Shafer theory

Currently, there is an interest to use the evidential reasoning approach on the basis of Dempster-Shafer theory in MCDM analysis. Moreover, the significance of Dempster-Shafer theory is greatly acknowledged in substantial measure of existing literature [11,20]. In addition, the earlier studies have incorporated Dempster-Shafer theory in MCDM for various kinds of applications [8,10,12]. Likewise, the Dempster-Shafer theory is incorporated for analyzing the data in this study, and its computational procedure which is summarized as follows:

Step 1: Set up intuitionistic fuzzy decision matrix

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 (as listed in Table 2). The direct relation matrix A is as follows:

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

In this decision matrix m, n denote the number of respondents and the number of criteria respectively. $\tilde{a}_j^i = (La_j^i, Ua_j^i)$ represents Lower-bound (L), Upper bound (U) of a IFNs and fuzzy degree of impact as assessed by i^{th} respondents for j^{th} influential factor.

Linguistic Variable	Corresponding IFNs
Extremely unimportant	(0.1,0.9)
Unimportant	(0.35,0.6)
Either important or unimportant	(0.5,0.45)
Important	(0.75,0.2)
Extremely Important	(0.9,0.1)

Table 2: Fuzzy membership with IFNs

Step 2: Design the fuzzy linguistic variables

The study addresses uncertainty and subjective vagueness of human assessments dealt with fuzzy linguistic variable: Extremely unimportant, unimportant, either important or unimportant, important, Extremely Important and their corresponding IFNs are listed in Table-2.

Step 3: Transform linguistic variables into IFN matrix.

Convert the linguistic assessment into IFN matrices to express the relations. Each linguistic variable is represented by an IFNs of the format (a_1, a_2) as shown in Table-2. The initial IFN matrices for three experts' group opinions are tabulated in Table-3 to Table-5.

Step 4: Conversion IFNs to BPA.

In this study, IFN matrices are converted into BPA matrixes. For example: if an IFN A is represented by (a_1, a_2) where a_1 is the degree of membership $m(y)$ and a_2 is the degree of non-membership $m(n)$, then the degree of uncertainty $m(\theta)$ would be calculated as $m(\theta) = 1 - m(y) - m(n)$. The corresponding BPA matrices for $m(y)$, $m(n)$, and $m(\theta)$ are represented in Table-6 to Table-11.

Step 5: Fuse BPAs by Dempster's rule of combination.

To apply Dempster's rule of combination in Eq.(1) to every element of the BPA matrixes, a comprehensive matrix which represents the initial relation can be constructed [8].

$$m(A) = \frac{1}{1-K} \sum_{B \cap C = A} m_1(B)m_2(C) \quad (1)$$

With

$$K = \sum_{B \cap C = \emptyset} m_1(B)m_2(C) \quad (2)$$

Where K is a normalization constant, applicable when $K < 1$. The fused matrices for $m(y)$ and $m(n)$ are given in Table-12 and Table -13.

Step 6: Apply fuzzy DEMATEL approach

Apply DEMATEL approach to calculate the overall relation with respect to the BPA of each proposition as shown Eqn.(3)-Eqn.(5). Then, the relative importance of factors can be identified from different aspects.

2.3 Fuzzy DEMATEL

The DEMATEL method is incorporated for analyzing the data in this study, and its computational procedure which is summarized as follows:

Step 1: Construct initial direct relational matrix D

On performing defuzzification of the given values through Dempster-Shafer theory, we have obtained the initial direct-relation matrix D. Each element d_{ij} is a positive integer that denotes the impact of criteria i on factor j . It is important to note that the diagonal elements d_{ij} are equal to 0.

Step 2: Obtain normalized decision matrix N

Normalized matrix is $N = [n_{ij}]$ obtained using Eq. (3) and (4) as shown:

$$m = \max_{1 \leq i \leq n} \sum_{j=1}^n d_{ij} \quad (3)$$

$$N = \frac{1}{m} D \quad (4)$$

Step 3: Compute the total relational matrix F

In order to calculate total relation matrix F, an identity matrix has to be constructed of the same size as the normalized matrix N. Total relation matrix F can be calculated using the formula given in Eq. (5)

$$F = N(I - N)^{-1} \quad (5)$$

Step 4: Obtain the sum of rows and columns to compute prominence and relation of each criterion

Identify most significant factors and least significant factors in widespread consideration of the indexes R-C on the BPA of each proposition. Considering the priority of each factor, the ones which are more significant and can greatly improve the efficiency of the KT effectiveness.

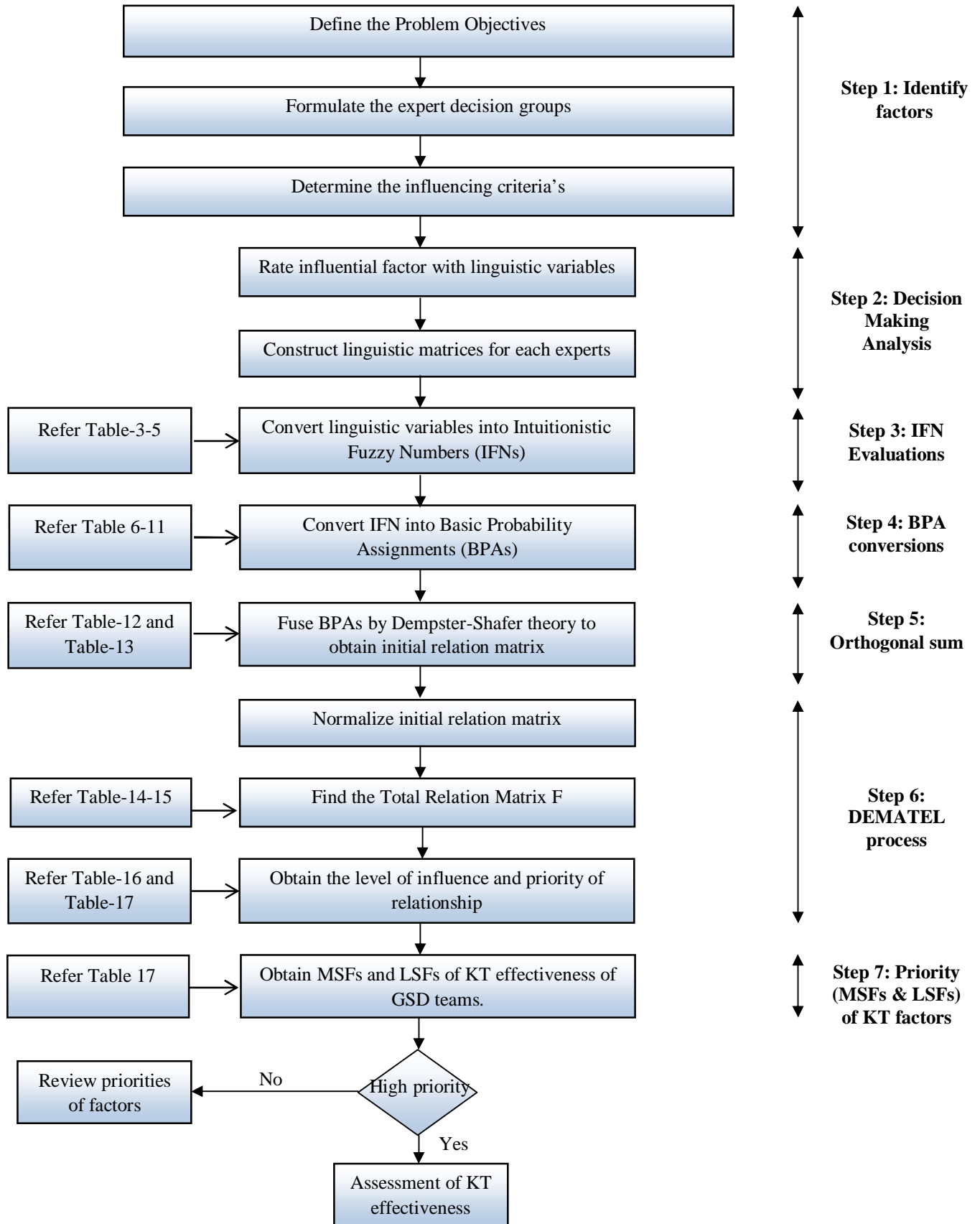


Figure.1: The flow diagram of the proposed Dempster Shafer theory - DEMATEL Framework for evaluating GSD teams KT effectiveness

3. Framework for evaluating KT effectiveness of GSD teams.

To the best of our knowledge, up to date research on evaluating GSD teams KT effectiveness 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 GSD teams has not been adequately presented in the available literature. Further, the hybridization of Dempster-Shafer theory and fuzzy DEMATEL method for group decision making has addressed only in very few studies. Based on this context, we have integrated Dempster-Shafer theory and DEMATEL approach for evaluating GSD teams' KT effectiveness via intuitionistic fuzzy numbers (IFNs). The construction of proposed framework and its computation procedure under a fuzzy environment is depicted in Fig.1.

4. Empirical case for evaluating the KT criteria's of GSD teams

The primary objective of this study is to investigate the influence of GSD teams' KT effectiveness at individual and organization levels in organizational behavior (OB) research phenomenon of GSD projects. To achieve this goal, an empirical study has been carried out in 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 three expert decision groups (executive committee, solution development team, and solution delivery team) of this organization. Consequently, the empirical study has been tested among thirty experts of this organization to validate the effectiveness of KT factors (see table 1) of GSD teams. The hybrid Dempster-Shafer theory and DEMATEL approaches were applied in this case study, as illustrated in the following sections.

5.1 Measurement of KT effectiveness criteria's by Dempster-Shafer theory

The basic computational procedure of Dempster-Shafer theory used in this study is as follows:

Step 1: KT effectiveness criteria were identified through related literature and our earlier study [7]. Then, create a fuzzy decision matrix with respect to the subjective decisions of 30 experts

use the linguistic assessments for the possible rating of ten KT effectiveness criteria and their corresponding IFNs as shown in Table-2.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)
F2	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)
F3	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)
F4	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.5,0.45)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)
F5	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)
F6	(0.9,0.1)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)
F7	(0.9,0.1)	(0.75,0.2)	(0.9,0.1)	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)
F8	(0.75,0.2)	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)	(0.75,0.2)	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)
F9	(0.9,0.1)	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)
F10	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.9,0.1)	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)

Table 3: Initial direct relational matrix and corresponding IFNs of the expert 1

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)	(0.75,0.2)	(0.9,0.1)	(0.75,0.2)	(0.75,0.2)
F2	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.75,0.2)	(0.9,0.1)	(0.75,0.2)	(0.75,0.2)	(0.9,0.1)	(0.75,0.2)	(0.75,0.2)
F3	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)
F4	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.5,0.45)	(0.75,0.2)	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)
F5	(0.9,0.1)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.9,0.1)	(0.5,0.45)	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)
F6	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.75,0.2)	(0.75,0.2)	(0.9,0.1)	(0.75,0.2)	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)
F7	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.75,0.2)	(0.5,0.45)	(0.5,0.45)
F8	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)
F9	(0.9,0.1)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)
F10	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.75,0.2)	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)	(0.5,0.45)	(0.5,0.45)

Table 4: Initial direct relational matrix and corresponding IFNs of the expert 2

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.50,0.45)	(0.75,0.2)	(0.75,0.2)
F2	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.75,0.2)	(0.75,0.2)	(0.50,0.45)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)
F3	(0.75,0.2)	(0.35,0.6)	(0.35,0.6)	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.75,0.2)	(0.1,0.9)	(0.9,0.1)	(0.9,0.1)
F4	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.50,0.45)	(0.9,0.1)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)
F5	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.35,0.6)	(0.50,0.45)	(0.75,0.2)	(0.9,0.1)	(0.75,0.2)	(0.50,0.45)	(0.50,0.45)
F6	(0.9,0.1)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.50,0.45)	(0.50,0.45)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)
F7	(0.9,0.1)	(0.9,0.1)	(0.9,0.1)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.50,0.45)	(0.50,0.45)	(0.50,0.45)
F8	(0.50,0.45)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.75,0.2)	(0.50,0.45)	(0.50,0.45)	(0.50,0.45)	(0.75,0.2)	(0.75,0.2)
F9	(0.75,0.2)	(0.50,0.45)	(0.50,0.45)	(0.50,0.45)	(0.75,0.2)	(0.9,0.1)	(0.75,0.2)	(0.35,0.6)	(0.35,0.6)	(0.35,0.6)
F10	(0.9,0.1)	(0.75,0.2)	(0.75,0.2)	(0.9,0.1)	(0.50,0.45)	(0.9,0.1)	(0.75,0.2)	(0.75,0.2)	(0.9,0.1)	(0.9,0.1)

Table 5: Initial direct relational matrix and corresponding IFNs of the expert 3

Step 2: Design the fuzzy linguistic variables. Convert the fuzzy linguistic variables into IFNs. The initial direct relational matrixes to express the relations on KT criteria and their corresponding IFNs of the experts as shown in Table-3 to Table-5

Step 3: For integrating experts' subjective decisions via IFN matrixes effectively, then IFN matrixes are converted to BPA matrixes as shown in Table-6 to Table-11.

	F1			F2			F3			F4			F5		
	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$
F1	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0
F2	0.75	0.2	0.05	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0
F3	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0
F4	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0
F5	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0
F6	0.9	0.1	0	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05
F7	0.9	0.1	0	0.75	0.2	0.05	0.9	0.1	0	0.75	0.2	0.05	0.9	0.1	0
F8	0.75	0.2	0.05	0.75	0.2	0.05	0.9	0.1	0	0.9	0.1	0	0.75	0.2	0.05
F9	0.9	0.1	0	0.75	0.2	0.05	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0
F10	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05	0.9	0.1	0	0.75	0.2	0.05

Table 6: The value of BPA for the expert group-1

	F6			F7			F8			F9			F10		
	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$
F1	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0.00
F2	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0.00
F3	0.9	0.1	0	0.75	0.2	0.05	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0.00
F4	0.9	0.1	0	0.50	0.45	0.05	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05
F5	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0.00
F6	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0.00
F7	0.9	0.1	0	0.75	0.2	0.05	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0.00
F8	0.75	0.2	0.05	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0.00
F9	0.9	0.1	0	0.75	0.2	0.05	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0.00
F10	0.9	0.1	0	0.9	0.1	0	0.75	0.2	0.05	0.9	0.1	0	0.9	0.1	0.00

Table 7: The value of BPA for the expert group-1 (contd.)

	F1			F2			F3			F4			F5		
	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$
F1	0.75	0.2	0.05	0.9	0.1	0	0.9	0.1	0	0.75	0.2	0.05	0.9	0.1	0
F2	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.75	0.2	0.05	0.9	0.1	0
F3	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05	0.9	0.1	0	0.9	0.1	0
F4	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0
F5	0.9	0.1	0	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05	0.9	0.1	0
F6	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.75	0.2	0.05	0.75	0.2	0.05
F7	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0
F8	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05	0.9	0.1	0	0.9	0.1	0
F9	0.9	0.1	0	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05
F10	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.75	0.2	0.05

Table 8 : The value of BPA for the expert group-2

	F6			F7			F8			F9			F10		
	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$
F1	0.9	0.1	0	0.75	0.2	0.05	0.9	0.1	0	0.75	0.2	0.05	0.75	0.2	0.05
F2	0.75	0.2	0.05	0.75	0.2	0.05	0.9	0.1	0	0.75	0.2	0.05	0.75	0.2	0.05
F3	0.9	0.1	0	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05
F4	0.50	0.45	0.05	0.75	0.2	0.05	0.75	0.2	0.05	0.9	0.1	0	0.9	0.1	0.00
F5	0.50	0.45	0.05	0.75	0.2	0.05	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0.00
F6	0.9	0.1	0	0.75	0.2	0.05	0.75	0.2	0.05	0.9	0.1	0	0.9	0.1	0.00
F7	0.9	0.1	0	0.9	0.1	0	0.75	0.2	0.05	0.50	0.45	0.05	0.50	0.45	0.05
F8	0.75	0.2	0.05	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0.00
F9	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05	0.9	0.1	0	0.9	0.1	0.00
F10	0.75	0.2	0.05	0.9	0.1	0	0.9	0.1	0	0.50	0.45	0.05	0.50	0.45	0.05

Table 9: The value of BPA for the expert group 2(contd.)

	F1			F2			F3			F4			F5		
	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$
F1	0.75	0.2	0.05	0.9	0.1	0	0.9	0.1	0	0.75	0.2	0.05	0.75	0.2	0.05
F2	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.75	0.2	0.05
F3	0.75	0.2	0.05	0.35	0.60	0.05	0.35	0.60	0.05	0.9	0.1	0	0.9	0.1	0
F4	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05	0.50	0.45	0.05
F5	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05	0.35	0.60	0.05	0.50	0.45	0.05
F6	0.9	0.1	0	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05
F7	0.9	0.1	0	0.9	0.1	0	0.9	0.1	0	0.75	0.2	0.05	0.75	0.2	0.05
F8	0.50	0.45	0.05	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05
F9	0.75	0.2	0.05	0.50	0.45	0.05	0.50	0.45	0.05	0.50	0.45	0.05	0.75	0.2	0.05
F10	0.9	0.1	0	0.75	0.2	0.05	0.75	0.2	0.05	0.9	0.1	0	0.50	0.45	0.05

Table 10: The value of BPA for the expert group-3

	F6			F7			F8			F9			F10		
	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$	$m(y)$	$m(n)$	$m(\theta)$
F1	0.75	0.2	0.05	0.75	0.2	0.05	0.50	0.45	0.05	0.75	0.2	0.05	0.75	0.2	0.05
F2	0.75	0.2	0.05	0.50	0.45	0.05	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05
F3	0.9	0.1	0	0.75	0.2	0.05	0.1	0.9	0	0.9	0.1	0	0.9	0.1	0.00
F4	0.9	0.1	0	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05
F5	0.75	0.2	0.05	0.9	0.1	0	0.75	0.2	0.05	0.50	0.45	0.05	0.50	0.45	0.05
F6	0.50	0.45	0.05	0.50	0.45	0.05	0.75	0.2	0.05	0.75	0.2	0.05	0.75	0.2	0.05
F7	0.75	0.2	0.05	0.75	0.2	0.05	0.50	0.45	0.05	0.50	0.45	0.05	0.50	0.45	0.05
F8	0.50	0.45	0.05	0.50	0.45	0.05	0.50	0.45	0.05	0.75	0.2	0.05	0.75	0.2	0.05
F9	0.9	0.1	0	0.75	0.2	0.05	0.35	0.60	0.05	0.35	0.60	0.05	0.35	0.60	0.05
F10	0.9	0.1	0	0.75	0.2	0.05	0.75	0.2	0.05	0.9	0.1	0	0.9	0.1	0.00

Table 11: The value of BPA for the expert group-3 (contd.)

Step 3: Fuse the BPA matrix by adopting Dempster's rule of combination as given in Eq.(1) and Table-12 and Table-13. The each element of the BPA matrixes, a comprehensive matrix which denotes the initial relation matrix can be constructed for applying fuzzy DEMATEL approach.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	0.000	0.729	0.729	0.576	0.648	0.648	0.576	0.446	0.576	0.576
F2	0.648	0.000	0.729	0.648	0.648	0.576	0.396	0.648	0.576	0.576
F3	0.576	0.288	0.000	0.729	0.729	0.729	0.512	0.072	0.648	0.648
F4	0.648	0.648	0.648	0.000	0.446	0.446	0.352	0.512	0.576	0.576
F5	0.648	0.576	0.576	0.288	0.000	0.396	0.648	0.648	0.446	0.446
F6	0.729	0.576	0.576	0.512	0.512	0.000	0.396	0.576	0.648	0.648
F7	0.729	0.648	0.729	0.576	0.648	0.648	0.000	0.396	0.272	0.272
F8	0.352	0.512	0.576	0.648	0.576	0.352	0.446	0.000	0.648	0.648
F9	0.648	0.352	0.396	0.396	0.576	0.648	0.512	0.288	0.000	0.324
F10	0.648	0.576	0.576	0.729	0.352	0.648	0.648	0.576	0.446	0.000

Table 12: Results of fused BPA's for $m(y)$

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	0.000	0.001	0.001	0.006	0.003	0.003	0.006	0.005	0.006	0.006
F2	0.003	0.000	0.001	0.003	0.003	0.006	0.013	0.003	0.006	0.006
F3	0.006	0.016	0.000	0.001	0.001	0.001	0.016	0.023	0.003	0.003
F4	0.003	0.003	0.003	0.000	0.005	0.005	0.031	0.016	0.006	0.006
F5	0.003	0.006	0.006	0.016	0.000	0.013	0.003	0.003	0.005	0.005
F6	0.001	0.006	0.006	0.016	0.016	0.000	0.013	0.006	0.003	0.003
F7	0.001	0.003	0.001	0.006	0.003	0.003	0.000	0.013	0.025	0.025
F8	0.031	0.016	0.006	0.003	0.006	0.031	0.005	0.000	0.003	0.003
F9	0.003	0.031	0.013	0.013	0.006	0.003	0.016	0.016	0.000	0.007
F10	0.003	0.006	0.006	0.001	0.031	0.003	0.003	0.006	0.005	0.000

Table 13: Results of fused BPA's for $m(n)$

5.2 Evaluation of KT effectiveness criteria's by Fuzzy DEMATEL

The basic steps of fuzzy DEMATEL approach used in this study are as follows:

Step 1: Convert the fuzzy linguistic assessments into crisp scores. Set up the initial direct relational matrix.

Step 2: Construct the generalized direct relational matrix and total relation matrix to obtain weights of the criteria as shown in Table 14 and Table-15.

Step 3: Obtain Prominence and relation value and compute the importance of the criteria as shown in Table-16 and Table-17.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	1.043	1.033	1.142	1.043	1.064	1.060	0.941	0.858	1.004	0.983
F2	1.133	0.903	1.128	1.042	1.052	1.036	0.903	0.878	0.993	0.973
F3	1.037	0.877	0.921	0.968	0.979	0.978	0.848	0.724	0.923	0.904
F4	1.034	0.922	1.019	0.847	0.930	0.927	0.815	0.783	0.907	0.888
F5	1.002	0.884	0.979	0.869	0.828	0.890	0.836	0.780	0.858	0.840
F6	1.101	0.960	1.061	0.981	0.990	0.901	0.867	0.834	0.965	0.945
F7	1.066	0.939	1.051	0.957	0.979	0.973	0.769	0.780	0.876	0.858
F8	0.964	0.878	0.981	0.927	0.924	0.888	0.809	0.679	0.893	0.875
F9	0.911	0.768	0.858	0.796	0.834	0.842	0.738	0.655	0.700	0.740
F10	1.098	0.969	1.072	1.023	0.974	1.015	0.910	0.841	0.941	0.847

Table 14: Total relation matrix according to $m(y)$

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	0.062	0.107	0.060	0.128	0.109	0.102	0.166	0.141	0.134	0.136
F2	0.084	0.106	0.065	0.106	0.120	0.137	0.227	0.129	0.151	0.153
F3	0.191	0.302	0.077	0.121	0.137	0.171	0.307	0.346	0.160	0.163
F4	0.159	0.217	0.122	0.146	0.212	0.216	0.476	0.331	0.239	0.243
F5	0.106	0.190	0.127	0.252	0.122	0.221	0.208	0.170	0.154	0.156
F6	0.112	0.209	0.137	0.265	0.267	0.140	0.308	0.223	0.163	0.165
F7	0.145	0.254	0.128	0.205	0.226	0.193	0.222	0.309	0.367	0.372
F8	0.392	0.317	0.156	0.199	0.233	0.431	0.285	0.192	0.182	0.185
F9	0.188	0.502	0.224	0.273	0.244	0.232	0.415	0.376	0.198	0.259
F10	0.112	0.197	0.133	0.137	0.386	0.155	0.173	0.185	0.149	0.106

Table 15: Total relation matrix according to $m(n)$

Priority	R	Priority	C	Priority	R-C
F1	10.17	F1	10.388	F10	-0.218
F2	10.04	F2	9.345	F8	0.696
F10	9.69	F3	8.212	F9	1.477
F6	9.61	F4	7.176	F7	2.430
F7	9.25	F5	6.203	F6	3.045
F3	9.16	F6	5.285	F5	3.874
F4	9.07	F7	4.375	F4	4.696
F8	8.82	F8	3.468	F3	5.350
F5	8.77	F9	2.610	F2	6.156
F9	7.84	F10	1.812	F1	6.031

Table 16: Level of influence of factors according to $m(y)$

Priority	R	Priority	C	Priority	R-C
F9	2.912	F1	1.551	F9	1.362
F8	2.572	F2	1.489	F8	1.083
F7	2.423	F3	1.405	F10	1.018
F4	2.362	F4	1.214	F7	1.147
F6	1.988	F5	1.055	F4	0.933
F3	1.976	F6	0.949	F6	1.027
F10	1.733	F7	0.837	F5	0.896

F5	1.706	F8	0.692	F3	1.014
F2	1.277	F9	0.300	F1	0.978
F1	1.144	F10	0.112	F2	1.032

Table 17: Level of influence of factors according to $m(n)$

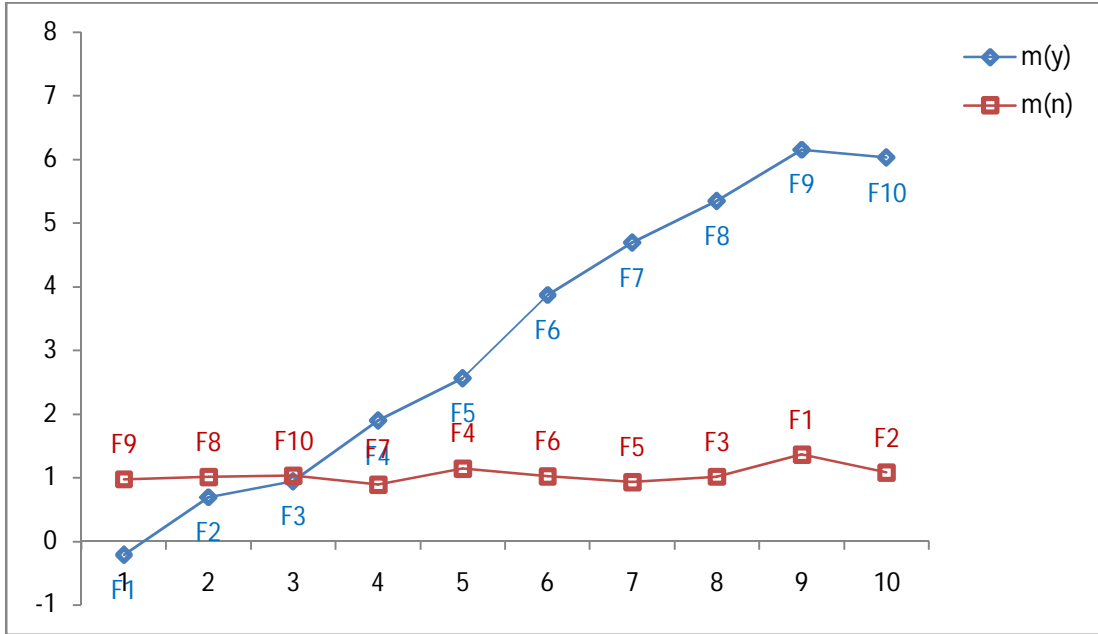


Figure 2: Prioritization of factors with respect to KT effectiveness of GSD teams

6. Results and Discussion

In relation to the four main contexts and ten evaluation criteria for the possible ratings of KT effectiveness with reference to GSD projects has summarized in Table-1. The expert decision groups of this study were executive committee, solution development team, and solution delivery team of Inowits software organization to evaluate the GSD teams KT effectiveness criteria using IFNs. As a result, three initial direct relational matrixes have been formed as shown in table-3 to table-5. In addition, table-6 to table-11 shows the IFNs to BPA matrixes conversion with respect to the criteria for each criterion. Subsequently, the Dempster-Shafer theory is used to fuse the BPA matrices of three expert matrices into a single comprehensive matrix in which elements are $\{m(y), m(n), m(\theta)\}$ as given in table-12 and table-13. The initial direct relation matrix constructed thus it is used in the fuzzy DEMATEL approach. Once the total relation matrix has been computed for the membership and non-membership functions as shown in table-14 and Table-15, the level of influence, and level of relationships have been obtained.

The indexes R, C, and R-C have been computed via table-14 and 15 respectively. Following the prioritization factors influencing KT effectiveness of GSD teams are figured out as depicted in Fig.2. In relation to the four main contexts and ten evaluation criteria for the possible ratings of KT effectiveness with reference to GSD projects has summarized in table-16 and table-17. For each factor R-C is calculated in which the results address that factors having greater values of $R - C$ have higher impact to another and it's assumed to have higher rank. So, $R - C$ is a good criterion for factors ranking. Therefore, factors having greater values of $R - C$ on $m(y)$ have higher influence compare to other factors and it denotes the higher priority. On other hand, factors having lower values of $R - C$ on $m(n)$ have higher influence compare to other factors and it denotes the higher priority. In summary the values of $R - C$ on $m(y)$ and $m(n)$, we can obtain a comprehensive final result in level of influential factors.

The results address that F8,F9,F10 have higher values of $m(y)$ and F3,F1,F2 have higher values of $m(n)$ when compare to other values. To aggregate the row values of total relational matrix in table-14, first row values are higher compare to other row values according to $m(y)$. similarly, to aggregate the row values of total relational matrix in Table-15, third row values are greater than other row values according to $m(n)$. while the highest values of Table-14 greater impact and lower value in Table-15. Thus, the factor F9 has highest influential factor compare to all other factors. In this context, F9 can be most influential factor to address the KT effectiveness of GSD teams. Likewise, factor F7, F6, F10 and F8 also reveals the significant impact on KT effectiveness. Based on this result, the factors are divided into two categories: Most Significant Factors (MSFs - F7, F9, F6, F10 and F8) and Least Significant Factors (LSFs - F1, F3, F4, F2 and F5). From the first row of Table 14, we aggregate the values among MSFs is lower values than the LSFs. The computation process is given below:

$$\text{MSF: } 0.738+0.700+0.842+0.740+0.655=3.675$$

$$\text{LSF: } 0.911+0.858+0.796+0.768+0.834=4.167$$

Sum of the values among MSFs is also lower than the values of LSFs. These results addressed that MSFs have higher impact than LSFs, which denotes that if the performance of MSFs is improved, the performance of LSFs can be greatly acknowledged for KT effectiveness in GSD projects.

6. Conclusion

In the context of GSD teams' organizational behavior research phenomenon, this research presents a framework to evaluate the KT effectiveness in GSD projects which integrates two aspects: (i) Dempster-Shafer theory and (ii) fuzzy DEMATEL. Moreover, this integrated approach has been investigated in Inowits software organization to explore the significance of the KT effectiveness of offshore/onsite teams in GSD projects. The results clearly indicates that GSD teams KT effectiveness factors reveals key determinant to achieve the GSD project outcome, while their priority relationship and its measures across the criteria under fuzzy environment presented in this paper.

Consequently, this study has presents two valuable contributions: (i) a comprehensive framework of the factors influencing KT effectiveness of GSD teams (ii) Dempster-Shafer theory – DEMATEL approach to find the relative importance of the criteria and to priority the criteria on the basis of intuitionistic fuzzy information. In addition, uncertainty and subjective vagueness within the decision making process, has been effectively handled through IFNs. The proposed approach can be more helpful industry for evaluating KT effectiveness of GSD teams. Similarly, the case study results of this research provide a vivid picture the significance of OB research on offshore/onsite teams' which addresses the significance of KT evaluation criteria's for the outcome of GSD projects. In future, we could include more criteria for KT effectiveness of GSD teams and integrating other fuzzy MCDM approaches to fuse in intuitionistic fuzzy information that is focused in subsequent studies.

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