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Assessment of the Endorsers of E-Business Practices for Food Supply Chain Performance Systems

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ABSTRACT

Globalisation and changing lifestyle of the people has escalated the demand for more product customisation, taste preferences, and awareness about the usage of quality food commodities. Recent developments in the field of information technology and its integration with the business practices has emerged as a new term named 'e-business' (EB). Increasing consumer base of the food supply chains (FSC) has escalated the demand of technological and operation advancements by mediating 'EB' activities. Such practices become extensively crucial when the world is suffering from the pandemic of COVID-19, leading to distressing of FSC linkages causing frequent market closures. To tackle the same, the work explores the various endorsers (EDR) of the 'EB' in FSC, which are contemplated by hybrid combinations of multi-criteria decision-making techniques. Outcomes of the present work aid managers to formulate the decision policies and develop a robust framework in the direction of 'EB' practices with FSC.

KEYWORDS

DEMATEL, E-Business, Food Industries, Food Supply Chains, Neutrosophic Sets

1. INTRODUCTION

Globally population is surging at very high rates, it being estimated that it's going to breach the mark of 15 billion at turn of century (Gharehgozli et al., 2017). To cater the masses, food production levels needs to be ramped up in effective and efficient manner. Although, programmes felicitating the agricultural production levels like green revolution, awareness about the usage of natural resources has resulted in the three-fold expansion of the production levels (FAO, 2017). But, share of the population suffering from the malnutrition and hunger is also significant (Keating et al. 2014). Rampantly increasing demand for the variety of food items, with in limited availability of the land, energy and water resources is burdening food producers to over produce (Schmidhuber & Tubiello, 2007).

Nowadays, dynamics of the FSC needs to be updated, operating protocols and practices governing procurement, storage, processing, retailing and distribution should be reinvestigated. In tradition practices of FSC, flow of the information, commodities and money was restricted up to a limited

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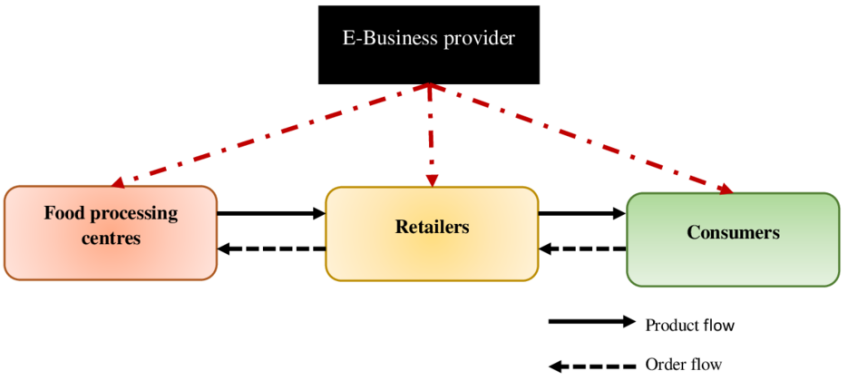
geographical regime. Such, FSC cannot feed the population globally as their potencies needs to be revamped. Current FSCs, needs to be transformed into ventures of global FSC, where its allied practices are being exercised in various geographical diversities and collaborative actions feed the consumers. Although, this will increase the distance between farm to fork, but FSC potencies will be diverged, in terms of enhanced rate of production and consumption of food commodities, strengthening the dimension of food safety and security.

Recent developments in the domain of information technology and increased accessibility to the internet services has revolution every walk of the life. Adoption of the new technologies having roots in the domain of information technology and data analytics have rendered solution to the multiple problems associated with the business practices (Kirs and Bagchi, 2012). Integration of the various internet based communication technologies and data monitoring modules with the business and management practices, has coined the new term called *'EB'* (Chatzoglou and Chatzoudes, 2016). '*EB*' help firms in assessment of the customer demand, monitor market conditions, evolving forecasting based solutions, governing of the product flow at various operational tiers of FSC. Furthermore, implication of the internet, uplift the performance of FSC, minimises operation cost and ensure prompt product deliveries. For better visualisation of the afore mentioned linkages between the '*EB*' and FSC, figure 1 is outlaid.

In developing economy of India, food industries and their supply chains (SCs) are establishing the venues of profitability and employment (Sharma et al. 2020). Indian FSCs have the responsibility to feed the consumer base of 130 crores and is backed up count of 39,700 food industries. As per the data compiled by the Ministry of Food Processing Industries of India (MOPFI, Government of India), Indian food industries whoops a healthy annual turnover of the US$258 Billion and spikes the annual growth rate of eight percent per annum (Sharma et al. 2020). FSC operations contribute a significant share of the 8.3 percent in gross domestic product of financial year 2017-18 (Annual reports, MOFPI).

FSC often deal with the perishability of the food items, its production and consumption are affected by the seasonal variabilities, regional boundaries, quality assurance etc. It demands for the round the clock monitoring of the product and chain processes, because end product is meant for the consumption purpose. Hence, *'EB'* plays a crucial role, in conduction of the transactional processes by embedding internet based monitoring and communication systems. *'EB'* practices help to establish the exchange of various real time information associated with the flow of food commodities, through the various channels of FSC, it also aids data logging, which strengthen the process of planning and controlling.

Figure 1. e-Business based FSC



Presented work is aimed to strengthen the FSC performance system by integrating it with the working spirits of *'EB'* environment. All the facts and figures highlighted above, depicts the importance of effective and efficient FSC and detail about the various benefits bundled with integration of *'EB'* practices. This study is sequenced to answer the following research queries:

RQ1: What are various Endorsers (Notated as 'EDRs'), assuring the success of the 'EB' based practices adoption in dynamics of FSC?
RQ2: How to establish the priority of these 'EDRs'?
RQ3: How these 'EDRs' endure the potencies of the real time FSC operations?

In continuation to the same, conceptual framework is outlaid and contemplated empirically. Firstly, conceptual framework is developed on the basis of insights gained from the core of research literature having roots in the domain of *'EB'* practices. Secondly, conceptual framework is analysed empirically by exercising the hybrid combination of Decision Making Trial Evolution Laboratory (DEMATEL) and Novel Neutrosophic Based Ranking Method (NBRM) methodologies to outrank the mutual importance of the *'EDRs'*.

This work is sequenced as section 2 portrays the insights of the relevant research literature. Section 3, outlays methodology of the DEMATEL and NBRM, whereas section 4 numerically illustrates them. Section 5 comprises of the results and discussions based upon the outcomes of this study. Section 6, extends the implications and provides conclusions which can be inferred from the study. Section 7 explores the future avenues associated with the current work.

2. LITERATURE REVIEW

Steering the *'EB'* practices with the FSC dynamics, renders solution to the variety problems linked with the perishability, seasonal fluctuation in the product demand and supply, analysis of the production and consumption trends, establishment of the contracts, shelf life of commodities. These unique attributes of the FSC embarks the era of aligning it with *'EB'* practices, to uplift the effectiveness of its operations. Nowadays, term *'EB'* and e-commerce are used interchangeably, but they mark the line of difference in terms of their scope *'EB'* encloses all the activities which are performed inter and as well as intra organisation, by utilising the IT enabled modes. Whereas, e-commerce handles only those activities which are supporting business activities (Cullen and Taylor, 2009). In nutshell e-commerce is the subset of the *'EB'*. Various definitions of the *'EB'* are compiled in the table 1 below to conceptualise the term.

From table 1 it can be inferred that current study conceptualises the e-business as the linkage which connects all the FSC stakeholders (from farm to fork) by the means of various internet based

Table 1. Definition of e-business

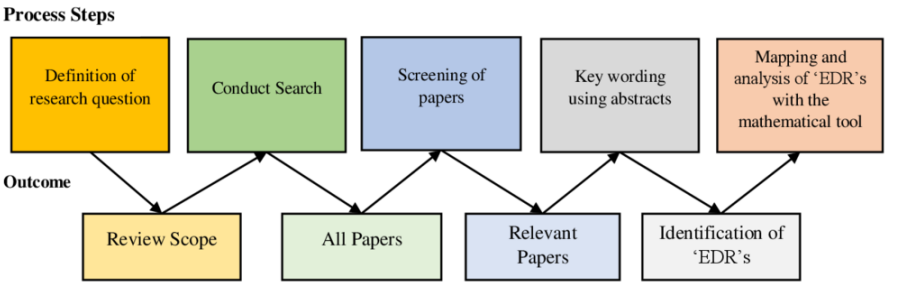
Reference	Definition
Kumar et al. (2013)	Cluster of the technologies which evolve effective and efficient solutions to the scenarios governing products availability, product support and service
Chatzoglou and Chatzoudes, 2016	Intermediating internet based services, for accomplishment of business transactions.
Chandak and Kumar (2020)	An organisation setup which connects business systems with its customer, vendors, suppliers and employees, through internet services.
Wiengarten et al. (2013)	Streamlining of the business procedurals by involving the internet technologies during the product flow in SC.

technologies to ensure effective and efficient product flow through the its numerous channels and tributaries. Based upon this conceptual framework, mathematical model is developed in the presented study. For the same, various research articles focusing on the mentioned concept were clustered and analysed thoroughly to cluster the various key findings in presented study. Accumulation of the various research articles from the core of research literature opted the protocols which have been clustered in the figure 2, to aid ease of visualisation.

Current, market scenarios and escalated product demands has provoked adoption of *'EB'* practices in SC performance system. Industries need to switch to modern technologies to ensure efficiency and effectiveness of their SCs. In FSC, real time- tracking of all operations, irrespective of their event of occurrences needs to executed, for tackling the perishability and ensuring prompt deliveries with better shelf life. *'EB'* in SCs sets the linkage between entire chain processes and operational entities along with product tracing and online processing of the consumer demand. This also empower the chain practitioners to detect the ambiguities in the system and processes under consideration. Kumar et al. (2013) detailed about the various key enablers of the e-application in the agri-product based FSCs. Kauremaa et al. (2010) revealed the potencies of the operational linkages based upon the fundamentals of *'EB'* and its impact on the SC performance system. Upadhyaya et al. (2017) assessed the various determinants of the e-marketplace adoption in B2B operation strategies. Kumar et al. (2016), highlighted the benefits associated with the e-retailing practices adoption and for the same developed mathematical model to assess its impact. Marimuthu et al. (2012) contemplated the performance of the *'EB'* enabled marketing practices. Raven et al. (2007) reviewed the status of *'EB'* practices in the developing nations. Sturiale and Scuderi (2016) overviewed the impact of the digitisation of the economy on the *'EB'* practices adoption in the dynamics of Italian agri-food SC. Ruan et al. (2019) extended *'EB'* initiatives to the vegetable processing FSCs to tackle the various operational issues and analysed the same with mathematical tools. Jing et al. (2020) assessed ***'EB'*** practices adoption in the agri-foods SC as the enabler of the quality, in comparison with the traditional SC practices, modelled supply quality by game theory. Ramasubramaniam (2018) explored the customer perspectives towards the quality of the product service rendered in the '*EB*' enabled SC by developing the mathematical models. Pramatari (2015) focused on aligning the FSC practices with the operating procedures and protocols of '*EB*' to improve the profitability and exercising better traceability of the operations.

Chandak and Kumar (2020) developed and evaluated the framework of SC performance by enabling sustainable *'EB'* practices. Sanders et al. (2007) exercised the empirical study to disseminate the impact of various *'EB'* based technologies on organisation SC performance. Daya et al. (2020) explained about the role of internet of things enabled FSC on the quality of food commodities and its impact on the food safety and security. Zeng and Lu (2020) explored the various capabilities of the information technology enabled FSC on the firm performance. Ruan et al. (2019) developed *'EB'* based model to assess the various issues associated with operation management in vegetable

Figure 2. Research protocols opted for this study



SC. Wang et al. (2017) evaluated the system investment associated with the *'EB'* practices in fresh agri-product SC. Zhu et al. (2015) analysed the three structure model to leveraging *'EB'* operations for development of business value model.

2.1 Research Gaps

After unearthing the relevant research literature associated with the field of *'EB'* and FSC, following gaps have prefunded:

1. Majority of the studies conducted in the past, encloses the frameworks, which focus on the enhancement of the SC performance (Fatorachian et al. 2021; Chandak and Kumar, 2020; Wu et al. 2016; Salam 2017). But, all these studies have a generalised attributes, hence there is strong need of the execution of the studies, which focus on the product/domain specific chains, to upscale its performance by aligning its dynamics with the new technological advancements.
2. A major section of the research literature focuses on the theoretical insights associated with the '*EB*' adoption by leveraging its after effects and consequences in the FSC performance system dynamics (Daya et al., 2020; Wang et al. 2019; Ranganathan et al. 2011). But its empirical analysis, highlighting the mathematical model based studies enduring adoption of *'EB'* needs to expedited by incorporating the various key advancements in the domain of soft computing techniques, so that results can be grounded more evidently and precisely.
3. Current times of the COVID-19 has pushed the world to search for the alternatives where person to person contact can be minimised and SC can be regulated to deliver its excellence. Hence such possibilities persist by enabling and strengthening the pace of 'EB practices' (Sharma et al. 2021).

To bridge the above mentioned research gaps, this study is executed, by following the methodology comprising of the three levels, detailed as below:

Level 1: Identification of the various *'EDRs'* of the *'EB'* in FSC, which are underpinned by the core of research literature as well as the valuable perceptions and views of field leaders.
Level 2: Mathematical analysis of the identified *'EDRs'*, to handle the mutual interrelationships by choosing the hybrid combination of DEMATEL and NRMB approach, to outrank them.
Level 3: Discussion of the outcomes, along with detailing of the diverse implications to strengthen the FSC network.

In continuation to the above, various *'EDRs'* are identified and explained in the table 2, based upon the key findings perceived from research literature.

3. RESEARCH METHODOLOGY

Presented work cluster sixteen *'EDRs'* were selected related to notion under consideration from the core of the research literature. These *'EDRs'* were further validated and reviewed by the field experts, with aim to align them with the practicalities of the FSC performance system. Assessments gathered from the experts, belongs to the various food industries situated in the vicinity of Ludhiana belonging to state of Punjab. For the same, questionnaire was developed on the seven point Likert rating scale (1- *Strongly Disagree* and 7 - *Strongly agree*) which evoked response from the 63 experts. All the experts chosen for this study belonged to the food processing industries and were enriched with working experience of more than eight years in the domain of food supply chain operations. Experts designated as Manager and above rank in the hierarchy were consulted for the gaining the assessments, handling the various FSC operations like procurement, production, distribution and

Table 2. 'EDRs' of the 'EB' in FSC

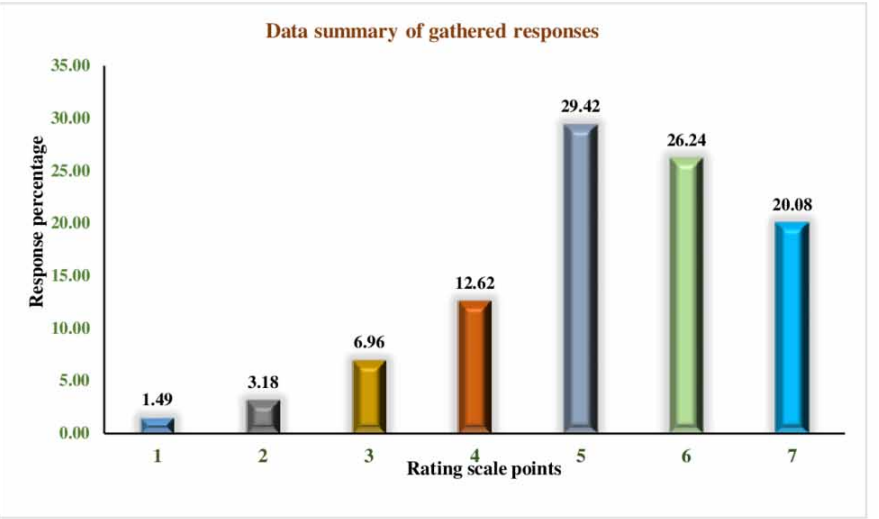
Notation	*'EDRs'*	References
E1	Hereness of skilled workforce	Lezoche et al. (2020); Ali et al. (2017); Balaji and Arshinder (2016); Leat et al. (2011)
E2	Prosperous Information Technology (IT) infrastructure	Ciccullo et al. (2021); Chen et al. (2020); Ganbold et al. (2020); Mahalik and Kim (2016)
E3	Adoption of digital payment platforms	Kayikci et al. (2020); Chang et al. (2019); Buyukozkan and Gocer (2018); Isakson (2014).
E4	Organisational and technological credibility	Ghadge et al. (2020); Talib et al. (2015); Cullen and Taylor (2009)
E5	Product traceability	Shao et al. (2021); Alfian et al. (2020); Mania et al. (2018); Dabbene et al. (2014)
E6	Concerns for food safety and security	Mkansi (2021); Imtiaz et al. (2020); Füzesi et al. (2016); Ghosh (2014)
E7	Changing lifestyle and growing awareness among consumers	Wang et al. (2019); Chatzoglou and Chatzoudes (2016); Bartikowski and Singh (2014).
E8	Accomplishment of contracts, strategic and tactical planning phases between the e-FSC partners	Nosratabadi et al. (2020); Wang et al. (2019); Zeng et al. (2017); Lin and Hsia (2011)
E9	Demand for the quality food products	Ekren,et al. (2021); Suhartanto et al. (2020); Lee et al. (2019); Huo et al. (2018)
E10	Highly competitive market conditions	Zhan et al. (2020), Rondović et al. (2019); Abdullah et al. (2018); Bi et al. (2017).
E11	Growing share of Foreign Direct Investment (FDI)	Aziz and Maliha (2020); Huo et al. (2018); Terzi (2016).
E12	Promising innovations in field of data analytics	Gao et al. (2021); Khanna (2020); Kafetzopoulos and Skalkos (2019); Tyagi et al. (2018);
E13	Adoption of smart packaging and logistics services in FSC operations.	Voldness et al. (2020); Majid et al. (2018), Yu et al. (2017).
E14	Accessibility to the Internet services	Lu et al. (2021); Varlese et al. (2020); Huo et al. (2018); Amoroso et al. (2013);
E15	Standardization of the FSC protocols	Chhetri et al.(2021), Musa et al. (2014); Nguyen (2013)
E16	Volatile consumer demand in terms of tastings, servings, customisation etc.	Calegari,et al. (2020); Verma (2020); Lee et al. (2019).

retailing, customer services and marketing. Furthermore, gained responses from the experts is summarised in graphical form (Refer figure 3) to aid visualisation of the percentage of responses relative to every rating value of the chosen scale.

3.1 Methodology of DEMATEL

DEMATEL aids decision making in the scenarios which showcase high level of the interrelationship between the indicators/entities under consideration (Tyagi et al. 2015a). This methodology critically examines the mutual interaction between the entities governing the decision, on the fundamentals of graph theory (Tyagi 2015b). Evaluation by the DEMATEL results in the classification of the decisional entities into the *'Causal'* and *'Effect'* group respectively, on basis of which outranking based decisions can be executed. Methodology of the DEMATEL implies the algorithm, which is begins

Figure 3. Summary of the collected data



with the development of relationship matrix. This matrix considers the impact of the one decisional element (p^{th})over the other element (q^{th}). It's being calculated to assess the mutual importance of the factors, based upon the assessment gained from the experts. For the diagonal elements ($p=q$) relative importance rates zero. A typical direct relation matrix is written as:

$$X^r = [x^r{}_{pq}]_{nxn} \tag{1}$$

For an instance assume 'r' number of respondents (where, 1 £ r £ m) and y_{pq} depicts the importance of p^{th} criterion over the q^{th} criterion. Based upon the compilation of the responses gained from 's' experts average direct relation matrix is formulated as shown in equation 2:

$$B = \left[b_{pq}\right] \tag{2}$$

where:

$$b_{pq} = \frac{1}{s}\sum_{r=1}^{m} x_{pq}{}^{r}$$

Gained assessment needs to be normalised for removing the extremities, this is also called as normalisation process. It leads to development of normalised *direct relation matrix* based upon the formulation mentioned in equation 3:

$$N_D = K \times B \tag{3}$$

where:

$$K = \frac{1}{\sum_{q=1}^{n} b_{pq1\le p\le n}^{max}} \; p,q = 1,2,3\ldots n$$

Normalised direct relation matrix seeds as input to evaluate the total relation matrix. It is being depicted by the notation *'G'* and is evaluated by the formula mentioned in the equation 4:

$$G = N_D\,(I\text{-}N_D)^{-1} \text{ where } I \text{ is identity matrix} \tag{4}$$

Sum of the rows and columns is evaluated in total relation matrix (Refer Equation 3) depicted by the S_R and S_c respectively. These value are utilised to evaluate the 'prominence'$[S_R + S_c]$ by involving sum of row and column, whereas $[S_R - S_c]$ represents 'relation value':

$$G = [g_{pq}]_{n\times n}$$

$$S_R = [\sum_{q=1}^{n} g_{pq}]_{qx1} = [g_p]_{nx1}\,;\; S_C = [\sum_{p=1}^{n} g_{pq}]_{1xq} = [g_j]_{1xn} \tag{5}$$

Calculated values of the relation group are used to classify them in to '*Cause*' and '*Effect*' group respectively. If $S_R - S_c > 0$ then decisional entities belongs to 'Cause group', for the same $S_R - S_c < 0$, entities belong to 'Effect group', aiding process of decision making.

3.2 Neutrosophic Set-Based Robust Ranking Approach

Real time scenarios, vagueness associated with the human perception and judgement based decisions becomes cumbersome to be quantified. It becomes imprecise to underpin the vagueness, uncertainty and indeterminacy simultaneously for a rating value gathered responses. In order to incorporate the same in the gained response values, Neutrosophic set (N_s)were introduced by Smarandache (Zhang et al. 2020). *'N_s'* is skimmed out from the intuitionistic fuzzy set theory, having the relative degree of membership value associated with the truth, indeterminacy and falsity function values (Baset et al. 2019). Although the fuzzy set theory answers the uncertainties in the decision making process, but it couldn't effectively handle the indeterminate and inconsistent information (Zhang et al. 2014).

Definition 1 (Gao et al. 2017): Consider *'X'* be a space comprising of the points where, $x \varepsilon X$. A neutrosophic set, *[D]* is defined by the truth-membership function $[TM_D(x)]$, its associated indeterminacy-membership function $[IM_D(x)]$ and allied value of falsity membership function value $[FM_D(x)]$ within the '*X*'.

Definition 2: Let *'X'* as the universe of discourse. A single valued 'N_s' lying in the *'X'* presumes the mathematical form as: $D = \{x, TM_D(x), IM_D(x), FM_D(x)\}$, where $TM_D(x)$: $X - [0,1]$, $IM_D(x)$: $X - [0,1]$ *and* $FM_D(x)$: $X - [0,1]$, implying the condition $0 \pounds TMD(x) + IM_D(x) + FM_D(x) \pounds 3$, where, $x \varepsilon X$.

Definition 3 (Baset et al. 2019): Assume $\beta_t, \theta_t, \gamma_t \in [0,1]$ and $t_1, t_2, t_3, t_4 \varepsilon R$, where, R refers to the real line set values of single valued 'N_s' depicted by '*t*'. Then, it is represented as, $t = (t_1, t_2, t_3, t_4); \beta_t, \theta_t, \gamma_t$, whose membership, indeterminacy and falsity membership function values are evaluated as the:

$$TM_t(x) = \begin{cases} \beta_t\left(\dfrac{x-t_1}{t_2-t_1}\right) & (t_1 \le x < t_2) \\ \beta_t & (t_2 \le x \le t_3) \\ \beta_t\left(\dfrac{t_4-x}{t_4-t_3}\right) & (t_3 \le x < t_4) \\ 0 & Otherwise \end{cases}$$

$$IM_t(x) = \begin{cases} \left(\dfrac{t_2-x+\theta_t(x-t_1)}{t_2-t_1}\right) & (t_1 \le x < t_2) \\ \beta_t & (t_2 \le x \le t_3) \\ \left(\dfrac{(x-t_3+\theta_t(t_4-x)}{t_4-t_3}\right) & (t_3 \le x < t_4) \\ 1 & Otherwise \end{cases} \tag{6}$$

$$FM_t(x) = \begin{cases} \left(\dfrac{t_2-x+\gamma_t(x-t_1)}{t_2-t_1}\right) & (t_1 \le x < t_2) \\ \beta_t & (t_2 \le x \le t_3) \\ \left(\dfrac{(x-t_3+\gamma_t(t_4-x)}{t_4-t_3}\right) & (t_3 \le x < t_4) \\ 1 & Otherwise \end{cases}$$

In the above set of equation 6, $\beta_t, \theta_t \, and \, \gamma_t$ indicates towards the maximum truth membership function value, minimum indeterminacy and minimum falsity membership degree values respectively.

Definition 4 (Mahdi et al. 2002): Assume $\tilde{p} \; and \; \tilde{q}$, be two single valued trapezoidal based neutrosophic numbers having elemental entries as: $\tilde{p} = (p_1, p_2, p_3, p_4); \beta_p, \theta_p, \gamma_p$ and $\tilde{q} = (q_1, q_2, q_3, q_4); \beta_q, \theta_q, \gamma_q$, their basic operations of addition, subtraction, multiplication and division is executed as:

Addition:

$$\tilde{p} + \tilde{q} = (p_1 + q_1, p_2 + q_2, p_3 + q_3, p_4 + q_4); \beta_p \wedge \beta_q, \theta_p V \theta_q, \gamma_p V \gamma_q \tag{7}$$

Subtraction:

$$\tilde{p} - \tilde{q} = (p_1 - q_4, p_2 - q_3, p_3 - q_2, p_4 - q_1); \beta_p \wedge \beta_q, \theta_p V \theta_q, \gamma_p V \gamma_q \tag{8}$$

Multiplication:

$$p \cdot q = \begin{cases} \left\langle \left(p_1 q_1, p_2 q_2, p_3 q_3, p_4 q_4\right); \beta_p \Lambda \beta_q, \theta_p \dot{\vee} \theta_q, \gamma_p \mathrm{V} \gamma_q \right\rangle & if \left(p_4 > 0, q_4 > 0\right) \\ \left\langle \left(p_1 q_4, p_2 q_3, p_3 q_2, p_4 q_1\right); \beta_p \Lambda \beta_q, \theta_p \dot{\vee} \theta_q, \gamma_p \mathrm{V} \gamma_q \right\rangle & if \left(p_4 < 0, q_4 > 0\right) \\ \left\langle \left(p_4 q_4, p_3 q_3, p_2 q_2, p_1 q_1\right); \beta_p \Lambda \beta_q, \theta_p \dot{\vee} \theta_q, \gamma_p \mathrm{V} \gamma_q \right\rangle & if \left(p_4 < 0, q_4 < 0\right) \end{cases} \tag{9}$$

Division:

$$p \cdot q = \begin{cases} \left\langle \frac{p_1}{q_4}, \frac{p_2}{q_3}, \frac{p_3}{q_2}, \frac{p_4}{q_1}; \beta_p \Lambda \beta_q, \theta_p \dot{\vee} \theta_q, \gamma_p \mathrm{V} \gamma_q \right\rangle & if \left(p_4 > 0, q_4 > 0\right) \\ \left\langle \frac{p_4}{q_4}, \frac{p_3}{q_3}, \frac{p_2}{q_2}, \frac{p_1}{q_1}; \beta_p \Lambda \beta_q, \theta_p \dot{\vee} \theta_q, \gamma_p \mathrm{V} \gamma_q \right\rangle & if \left(p_4 < 0, q_4 > 0\right) \\ \left\langle \frac{p_4}{q_1}, \frac{p_3}{q_2}, \frac{p_2}{q_3}, \frac{p_1}{q_4}; \beta_p \Lambda \beta_q, \theta_p \dot{\vee} \theta_q, \gamma_p \mathrm{V} \gamma_q \right\rangle & if \left(p_4 < 0, q_4 < 0\right) \end{cases} \tag{10}$$

This technique is used to establish the priority of the *'EDRs'* under consideration. Implied tool of DEMATEL, classifies the *'EDRs'* in to 'Causal' and 'Effect' group respectively by evaluating their prominence and relation values, but it couldn't handle the vagueness, uncertainty and level of indeterminacy in the clustered perception towards the notion. To overcome the aforementioned shortcomings and strengthen the reliability of results NBRM approach is exercised. It incorporates the human judgement in the form of membership, indeterminacy and falsity membership function values, enabling better control over the vagueness and uncertainty.

It follows the methodology beginning with the encapsulation of the assessments, involving pairwise comparison of the entities based upon the trapezoidal *'N_s'* (Baset et al. 2019):

$$\tilde{p} = (p_{1i}, p_{2j}, p_{3k}, p_{4l}); \beta_p, \theta_p, \gamma_p, \ where \ i, j, k \geq 0$$

This involves the linguistic rating values as depicted in the Table 3.

Based upon the rating values of various linguistic terms of trapezoidal *'N_s'* values pairwise comparison is made. Matrix comprising of the pairwise comparison of the entities is said to be decision matrix and is established in the equation 11:

$$\begin{bmatrix} 0 & \left(p_{12}, p_{12}, p_{13}, p_{14}; \beta_p, \theta_p, \gamma_p\right) & \cdots & \left(p_{1mi}, p_{1mj}, p_{1mk}, p_{1ml}; \beta_p, \theta_p, \gamma_p\right) \\ \left(p_{21}, p_{22}, p_{23}, p_{24}; \beta_p, \theta_p, \gamma_p\right) & 0 & \cdots & \vdots \\ \vdots & \vdots & \ddots & \vdots \\ \left(p_{n1i}, p_{n2j}, p_{n3k}, p_{n4l}; \beta_p, \theta_p, \gamma_p\right) & \left(p_{n2i}, p_{n2j}, p_{n3k}, p_{n4l}; \beta_p, \theta_p, \gamma_p\right) & \cdots & \left(p_{nmi}, p_{nmj}, p_{nmk}, p_{nml}; \beta_p, \theta_p, \gamma_p\right) \end{bmatrix} \tag{11}$$

Assessments gained on the trapezoidal *'N_s'* are converted in to the equivalent crisp number values $C\left(p_{nm}\right)$ by exercising formulation mentioned in the equation 12:

$$C\left(p_{nm}\right) = \frac{1}{16}\left[p_{1i} + p_{2j} + p_{3k} + p_{4l}\right] * \left(2 + \beta_p - \theta_p - \gamma_p\right) \tag{12}$$

Table 3. Linguistic rating terms based upon the trapezoidal 'N_s' values (Baset et al. 2019)

Linguistic term	'N_s' trapezoidal number
Highly low	$\left(0.1, 0.1, 0.1, 0.1\right); 0.5, 0.3, 0.3$
Slightly low	$\left(0.3, 0.4, 0.5, 0.6\right); 0.7, 0.1, 0.1$
Fairly low	$\left(0.4, 0.5, 0.6, 0.7\right); 0.8, 0.0, 0.1$
Neutral	$\left(0.5, 0.6, 0.7, 0.8\right); 0.7, 0.3, 0.3$
Fairly strong	$\left(0.7, 0.8, 0.9, 1.0\right); 0.9, 0.1, 0.1$
Highly strong	$\left(0.8, 0.9, 1.0, 1.0\right); 0.9, 0.0, 0.1$
Very strong	$\left(1.0, 1.0, 1.0, 1.0\right); 1.0, 0.0, 0.0$

Calculation of the average value from the crisp values of the expert's decision matrix. It follows the procedure by averaging the row values of asser1 decision matrix and subsequently repeating the procedure for the other assesser's individually. It follows the formulation mentioned in the equation 13:

$$Row_{nm} = \frac{Crisp_{1n} + Crisp_{2n} + Crisp_{3n} \ldots + Crisp_{mn}}{n} \tag{13}$$

Obtained average values are consolidated in the form $\left[Lower\ limit\left(\bar{L}\right), Upper\ Limit\left(\bar{U}\right)\right]$. Between these limits trapezoidal 'N_s' depicted by the 'g' and 'h' are substituted, to imply the robust ranking approach. Formulation for the same is clustered in the set of equation 14:

$$\tilde{B} = \left(\bar{L}, g, h, \bar{U}\right);\ using\ \overline{B_y} = \left[\left(\bar{L} + \left(g - \bar{L}\right)z\right), \left(\bar{U} - \left(\bar{U} - h\right)z\right)\right]$$

$$S\left(\overline{B}\right) = \frac{1}{2}\int_0^1 \left[\overline{B}_z^{-L}; \overline{B}_z^{-U}\right] dz$$

and:

$$\left(\overline{B}\right) = \frac{1}{2}\int_0^1 \left[\left(\overline{L} + \left(g - \overline{L}\right)z\right), \left(\overline{U} - \left(\overline{U} - h\right)z\right)\right] dz\ \ where\ z = \left[0,1\right]$$

Calculated values of the $S\left(\bar{B}\right)$ is used for outranking and aids decision execution process.

4. NUMERICAL ILLUSTRATION

Presented work identifies sixteen *'EDRs'* of the *'EB'* in FSC performance system. These sixteen *'EDRs'* are firstly, analysed by the methodology of the DEMATEL, which handles the mutual interrelationship effectively. DEMATEL results in the determination of *'EDRs'* which belongs to '*Causal*' and '*Effect*' group respectively. In second phase of the calculation, *'EDRs'* in the 'Causal group' are further analysed by the NBRM approach. This effectively handles the indeterminacy, inconsistency, vagueness and uncertainty associated with the human perception and leads to more accurate outranked results.

4.1 Illustration of DEMATEL

In lieu to the formulations mentioned in set of equations 1 – 5, methodology of the DEMATEL is exercised. Here, for the identified sixteen *'EDRs'*, relative importance ratings are gathered from the field experts, based upon which pairwise comparison of the *'EDRs'* (Refer equation 1) is made, constructing direct relation matrix. Averaged value of the direct relation matrix is normalised by implying the formulation mentioned in equation 3. Evaluated values are clustered in the table 4, depicted as normalised direct relation matrix.

Normalised value matrix leads to development of total relation matrix underpinning formulation mentioned in the equation 4. Its calculated values are depicted in the table 5.

Sum of the rows and columns of the previously developed total inter relationship matrix is used to determine the prominence and relation values. Relation values bifurcates the *'EDRs'* in to the cause and effect group respectively (Refer equation 5). Detailing of the same is consolidated in the table 6.

4.2 Methodology of NBRM

Results of the DEMATEL methodology has grounded the determination of *'EDRs'* belonging to '*Cause*' and '*Effect*' group respectively. Based upon the fundamentals of trapezoidal *'N_s'*, and formulation mentioned in set of equation 11-14, outranking of the *'EDRs'* is established. Nine *'EDRs'* belonging to the 'Causal' group are contemplated by developing its relation matrix. It

Table 4. Averaged Direct relation matrix

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16
E1	0.0000	0.0552	0.0613	0.0675	0.0552	0.0583	0.0429	0.0184	0.0552	0.0552	0.0491	0.0644	0.0675	0.0491	0.0675	0.0798
E2	0.0521	0.0000	0.0552	0.0337	0.0552	0.0613	0.0613	0.0675	0.0184	0.0307	0.0613	0.0552	0.0368	0.0429	0.0368	0.0736
E3	0.0368	0.0736	0.0000	0.0706	0.0675	0.0859	0.0736	0.0521	0.0613	0.0706	0.0736	0.0644	0.0675	0.0552	0.0859	0.0613
E4	0.0583	0.0491	0.0675	0.0000	0.0521	0.0552	0.0552	0.0675	0.0491	0.0736	0.0460	0.0337	0.0736	0.0521	0.0491	0.0368
E5	0.0368	0.0307	0.0491	0.0429	0.0000	0.0552	0.0429	0.0736	0.0245	0.0184	0.0368	0.0368	0.0491	0.0613	0.0552	0.0613
E6	0.0307	0.0368	0.0491	0.0245	0.0491	0.0000	0.0675	0.0736	0.0491	0.0552	0.0215	0.0307	0.0613	0.0429	0.0736	0.0429
E7	0.0521	0.0736	0.0429	0.0583	0.0706	0.0429	0.0000	0.0675	0.0491	0.0675	0.0337	0.0276	0.0613	0.0215	0.0521	0.0245
E8	0.0706	0.0613	0.0613	0.0429	0.0675	0.0675	0.0245	0.0000	0.0245	0.0859	0.0491	0.0337	0.0245	0.0552	0.0736	0.0368
E9	0.0337	0.0429	0.0491	0.0552	0.0552	0.0613	0.0644	0.0491	0.0000	0.0675	0.0429	0.0613	0.0337	0.0307	0.0368	0.0337
E10	0.0613	0.0521	0.0460	0.0429	0.0429	0.0613	0.0675	0.0460	0.0153	0.0000	0.0675	0.0613	0.0491	0.0368	0.0184	0.0429
E11	0.0613	0.0613	0.0552	0.0552	0.0429	0.0552	0.0613	0.0429	0.0736	0.0399	0.0000	0.0644	0.0429	0.0245	0.0368	0.0613
E12	0.0491	0.0245	0.0460	0.0460	0.0552	0.0429	0.0491	0.0491	0.0552	0.0491	0.0491	0.0000	0.0245	0.0491	0.0429	0.0675
E13	0.0491	0.0307	0.0552	0.0245	0.0675	0.0644	0.0675	0.0552	0.0552	0.0429	0.0675	0.0521	0.0000	0.0613	0.0429	0.0429
E14	0.0337	0.0552	0.0613	0.0399	0.0583	0.0583	0.0491	0.0736	0.0706	0.0613	0.0675	0.0491	0.0307	0.0000	0.0368	0.0337
E15	0.0245	0.0368	0.0337	0.0491	0.0675	0.0491	0.0552	0.0429	0.0613	0.0859	0.0368	0.0245	0.0245	0.0429	0.0000	0.0675
E16	0.0368	0.0245	0.0552	0.0368	0.0429	0.0736	0.0675	0.0675	0.0368	0.0613	0.0184	0.0307	0.0613	0.0307	0.0736	0.0000

Table 5. Total interrelation matrix

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16
E1	12.4980	17.1276	18.9687	17.7408	19.6466	20.6557	18.8843	17.0073	16.9497	19.9306	16.8341	17.4442	18.2627	15.8542	19.5182	20.0305
E2	15.2085	11.5188	16.9093	13.8174	17.9038	19.0303	18.2926	18.8633	12.7014	16.3280	16.1732	15.2582	14.4588	13.9983	15.7913	17.9765
E3	17.5644	20.7269	16.5819	20.0098	23.1289	25.2834	23.6289	22.1067	19.4291	23.6734	20.7790	19.4426	20.3165	18.2584	23.1860	20.8913
E4	16.8393	16.5870	19.1189	12.3005	19.1320	20.0854	19.3064	20.1975	16.0997	20.9688	16.4540	14.9438	18.3717	15.8517	17.8297	16.4321
E5	13.0458	12.9480	15.3803	13.4941	12.5251	17.3683	15.7392	18.1816	12.2463	14.3628	13.4020	12.8799	14.3059	14.5259	16.0519	15.9130
E6	13.0153	13.8640	15.7511	12.5574	16.8878	13.6015	18.0921	18.6285	14.3543	17.6098	12.7428	12.8607	15.5849	13.5052	17.7474	14.9500
E7	15.2796	17.1666	16.0047	15.6235	19.0838	17.6747	13.5912	18.8229	14.7850	19.0117	14.3054	13.3015	16.2559	12.5083	16.7096	14.3340
E8	17.0387	16.7888	17.9178	15.0376	19.3989	20.1515	16.2583	14.2306	13.6020	21.0287	15.9591	14.2960	14.0631	15.4702	18.9306	15.9354
E9	13.4629	14.4658	15.9483	15.0154	17.3963	18.4416	18.0733	17.0011	10.6759	18.5441	14.4679	15.3604	13.8004	12.6901	15.1116	14.4698
E10	15.5525	15.1710	15.7687	14.0918	16.4678	18.4384	18.2753	16.7115	12.0794	13.2556	16.2985	15.4079	14.9933	13.1325	13.8038	15.2442
E11	16.3856	16.7393	17.4786	15.9832	17.6192	19.2172	19.0146	17.6115	17.3031	17.6622	12.0178	16.5597	15.4747	13.0845	16.2423	17.6202
E12	14.2817	12.8118	15.4748	14.1320	17.0718	16.8253	16.6199	16.6617	14.7869	16.9439	14.6052	10.3917	12.8576	13.7965	15.3638	16.7213
E13	15.4154	14.4996	17.4244	13.6592	19.4294	19.8408	19.3674	18.5333	16.0093	17.8221	17.2048	15.6006	11.9911	15.8184	16.6561	16.1568
E14	14.3834	16.3869	17.9233	14.8193	18.7410	19.4577	18.0378	19.9103	17.0247	19.2356	17.2963	15.4501	14.4119	11.1109	16.1640	15.4985
E15	12.4102	13.6453	14.4583	14.2148	17.8727	17.1958	17.0531	16.2253	14.9956	19.5444	13.6269	12.2800	12.8025	13.2489	11.8131	16.5594
E16	13.6123	13.0974	16.3759	13.6068	16.6032	19.4224	18.3248	18.3644	13.6138	18.2916	12.6165	12.9718	15.8602	12.7484	18.0042	11.7544

Table 6. Prominence and Relation values calculation

	Row Sum (S_R)	**Column Sum** (S_C)	$S_R + S_C$ ***(Prominence)***	$S_R - S_C$ ***(Relation)***
E1	287.3532	235.9935	523.3467	51.3598
E2	254.2298	243.5449	497.7747	10.6849
E3	335.0072	267.4851	602.4923	67.5222
E4	280.5185	236.1036	516.6221	44.4150
E5	232.3700	288.9082	521.2782	-56.5382
E6	241.7528	302.6899	544.4427	-60.9371
E7	254.4584	288.5593	543.0177	-34.1009
E8	266.1073	289.0574	555.1647	-22.9501
E9	244.9248	236.6563	481.5811	8.2685
E10	244.6921	294.2134	538.9055	-49.5213
E11	266.0138	244.7836	510.7975	21.2302
E12	239.3459	234.4494	473.7953	4.8966
E13	265.4287	243.8110	509.2397	21.6177
E14	265.8518	225.6024	491.4542	40.2494
E15	237.9462	268.9235	506.8697	-30.9773
E16	245.2681	260.4874	505.7555	-15.2193

utilises the linguistic ratings of trapezoidal *'N_s'* (Refer Table 3) accumulated from the field experts, depicting the relative importance of the one *'EDRs'* over the other 'EDR'. Its outlaid in the table 7, (Refer equation 11).

Developed relation matrix (Refer, Table 8), comprises of the trapezoidal *'N_s'* based linguistic ratings, which are converted into its equivalent crisp number by using equation 12. Obtained crisp values are averaged by using the formula mentioned in equation 13, which aids calculation of lower and upper limit bound associated with the assessments. $\left[Lower\ \ limit\left(\bar{L}\right), Upper\ \ Limit\left(\bar{U}\right)\right]$, obtained values for the same are clustered in the table 8.

Implying the formulation clustered in the equation 14, lower and upper limit values are integrated, based upon which outranking decision are executed. Evaluated values are outlaid in the table 9.

5. RESULTS AND DISCUSSIONS

This study, involves the analysis of the *'EDRs'* of *'EB'* practices in FSC practices. In continuation of the same, sixteen *'EDRs'* were identified from the research literature and were validated by the field experts associated with this work. Firstly, to handle the mutual interrelationships between the *'EDRs'*, methodology of the DEMATEL was implied. It resulted in the determination of prominence and relation values of every 'EDR'. In the prominence group, *'EDRs'* are outranked in the sequence of E3> E8> E6> E7> E10> E1> E5> E4> E11> E13> E15> E16> E2> E14> E9> E12. Whereas, relation group bifurcates them into the broad category of causal and effect group respectively. To mark the line of difference between the causal and effect group *'EDRs'* graph is plotted in the figure 4, aiding better visualisation of the results.

Table 7. Relation matrix: Pairwise comparison of 'EDRs'

	E1	E2	E3	E4	E9	E11	E12	E13	E14
E1	(0.4 , 0.5 , 0.6 , 0.7 ; 0.8,0,1)	(0.3 , 0.4 , 0.5 , 0.6 ; 0.7,0.1,0.1)	(0.8 , 0.9 , 1 , 1 ; 0.9,0.1,0.1)	(0.5 , 0.6 , 0.7 , 0.8 ; 0.7,0.3,0.3)	(0.3 , 0.4 , 0.5 , 0.6 ; 0.7,0.1,0.1)	(0.4 , 0.5 , 0.6 , 0.7 ; 0.8,0,1)	(0.4 , 0.5 , 0.6 , 0.7 ; 0.8,0,1)	(0.3 , 0.4 , 0.5 , 0.6 ; 0.7,0.1,0.1)	(1 , 1 , 1 , 1 ; 1,0,0)
E2	(0.7 , 0.8 , 0.9 , 1 ; 0.9,0.1,0.1)	(0.5 , 0.5 , 0.5 , 0.5 ; 0.5,0.5,0.5)	(0.4 , 0.5 , 0.6 , 0.7 ; 0.8,0,1)	(0.5 , 0.6 , 0.7 , 0.8 ; 0.7,0.3,0.3)	(0.7 , 0.8 , 0.9 , 1 ; 0.9,0.1,0.1)	(0.3 , 0.4 , 0.5 , 0.6 ; 0.7,0.1,0.1)	(0.7 , 0.8 , 0.9 , 1 ; 0.9,0.1,0.1)	(0.7 , 0.8 , 0.9 , 1 ; 0.9,0.1,0.1)	(0.1 , 0.1 , 0.1 , 0.1 ; 0.5,0.3,0.3)
E3	(1 , 1 , 1 , 1 ; 1,0,0)	(0.1 , 0.1 , 0.1 , 0.1 ; 0.5,0.3,0.3)	(0.5 , 0.5 , 0.5 , 0.5 ; 0.5,0.5,0.5)	(0.7 , 0.8 , 0.9 , 1 ; 0.9,0.1,0.1)	(0.5 , 0.6 , 0.7 , 0.8 ; 0.7,0.3,0.3)	(0.5 , 0.6 , 0.7 , 0.8 ; 0.7,0.3,0.3)	(0.5 , 0.6 , 0.7 , 0.8 ; 0.7,0.3,0.3)	(0.3 , 0.4 , 0.5 , 0.6 ; 0.7,0.1,0.1)	(0.3 , 0.4 , 0.5 , 0.6 ; 0.7,0.1,0.1)
E4	(0.3 , 0.4 , 0.5 , 0.6 ; 0.7,0.1,0.1)	(0.5 , 0.5 , 0.5 , 0.5 ; 0.5,0.5,0.5)	(0.3 , 0.4 , 0.5 , 0.6 ; 0.7,0.1,0.1)	(0.4 , 0.5 , 0.6 , 0.7 ; 0.8,0,1)	(0.4 , 0.5 , 0.6 , 0.7 ; 0.8,0,1)	(0.3 , 0.4 , 0.5 , 0.6 ; 0.7,0.1,0.1)	(0.4 , 0.5 , 0.6 , 0.7 ; 0.8,0,1)	(0.1 , 0.1 , 0.1 , 0.1 ; 0.5,0.3,0.3)	(0.7 , 0.8 , 0.9 , 1 ; 0.9,0.1,0.1)
E9	(1 , 1 , 1 , 1 ; 1,0,0)	(0.3 , 0.4 , 0.5 , 0.6 ; 0.7,0.1,0.1)	(1 , 1 , 1 , 1 ; 1,0,0)	(0.3 , 0.4 , 0.5 , 0.6 ; 0.7,0.1,0.1)	(0.5 , 0.5 , 0.5 , 0.5 ; 0.5,0.5,0.5)	(0.7 , 0.8 , 0.9 , 1 ; 0.9,0.1,0.1)	(0.3 , 0.4 , 0.5 , 0.6 ; 0.7,0.1,0.1)	(1 , 1 , 1 , 1 ; 1,0,0)	(0.3 , 0.4 , 0.5 , 0.6 ; 0.7,0.1,0.1)
E11	(0.4 , 0.5 , 0.6 , 0.7 ; 0.8,0,0.1)	(0.4 , 0.5 , 0.6 , 0.7 ; 0.8,0,0.1)	(0.3 , 0.4 , 0.5 , 0.6 ; 0.7,0.1,0.1)	(0.5 , 0.6 , 0.7 , 0.8 ; 0.7,0.3,0.3)	(0.3 , 0.4 , 0.5 , 0.6 ; 0.7,0.1,0.1)	(0.8 , 0.9 , 1 , 0.9 ; 0.1,0.1,0.1)	(1 , 1 , 1 , 1 ; 1,0,0)	(0.4 , 0.5 , 0.6 , 0.7 ; 0.8,0,1)	(0.3 , 0.4 , 0.5 , 0.6 ; 0.7,0.1,0.1)
E12	(0.8 , 0.9 , 1 , 1 ; 0.9,0.1,0.1)	(0.7 , 0.8 , 0.9 , 1 ; 0.9,0.1,0.1)	(0.7 , 0.8 , 0.9 , 1 ; 0.9,0.1,0.1)	(0.8 , 0.9 , 1 , 0.9 ; 0.1,0.1,0.1)	(0.3 , 0.4 , 0.5 , 0.6 ; 0.7,0.1,0.1)	(0.4 , 0.5 , 0.6 , 0.7 ; 0.8,0,1)	(0.5 , 0.5 , 0.5 , 0.5 ; 0.5,0.5,0.5)	(0.8 , 0.9 , 1 , 1 ; 0.9,0.1,0.1)	(0.8 , 0.9 , 1 , 1 ; 0.9,0.1,0.1)
E13	(0.5 , 0.6 , 0.7 , 0.8 ; 0.7,0.3,0.3)	(0.8 , 0.9 , 1 , 1 ; 0.9,0.1,0.1)	(0.4 , 0.5 , 0.6 , 0.7 ; 0.8,0,1)	(0.4 , 0.5 , 0.6 , 0.7 ; 0.8,0,1)	(0.8 , 0.9 , 1 , 0.9 ; 0.1,0.1,0.1)	(0.5 , 0.6 , 0.7 , 0.8 ; 0.7,0.3,0.3)	(0.3 , 0.4 , 0.5 , 0.6 ; 0.7,0.1,0.1)	(0.5 , 0.5 , 0.5 , 0.5 ; 0.5,0.5,0.5)	(0.4 , 0.5 , 0.6 , 0.7 ; 0.8,0,1)
E14	(0.1 , 0.1 , 0.1 , 0.1 ; 0.5,0.3,0.3)	(0.1 , 0.1 , 0.1 , 0.1 ; 0.5,0.3,0.3)	(0.5 , 0.5 , 0.5 , 0.5 ; 0.5,0.5,0.5)	(0.1 , 0.1 , 0.1 , 0.1 ; 0.5,0.3,0.3)	(0.3 , 0.4 , 0.5 , 0.6 ; 0.7,0.1,0.1)	(1 , 1 , 1 , 1 ; 1,0,0)	(0.1 , 0.1 , 0.1 , 0.1 ; 0.5,0.3,0.3)	(0.7 , 0.8 , 0.9 , 1 ; 0.9,0.1,0.1)	(0.5 , 0.5 , 0.5 , 0.5 ; 0.5,0.5,0.5)

Table 8. Average values

	Lower limit $(\bar{L})$	*g*	*h*	Upper limit $(\bar{U})$	
E1	0.4033	0.3660	0.3770	0.3472	(0.4033, 0.3660, 0.3770, 0.3472)
E2	0.3257	0.3450	0.3500	0.3682	(0.3257, 0.3450, 0.3500, 0.3682)
E3	0.4587	0.3820	0.4120	0.3494	(0.4587, 0.3820, 0.4120, 0.3494)
E4	0.3433	0.3520	0.3640	0.3668	(0.3433, 0.3520, 0.3640, 0.3668)
E9	0.4130	0.3890	0.4070	0.3878	(0.4130, 0.3890, 0.4070, 0.3878)
E11	0.3879	0.3690	0.3820	0.3626	(0.3879, 0.3690, 0.3820, 0.3626)
E12	0.4808	0.4680	0.4780	0.4627	(0.4808, 0.4680, 0.4780, 0.4627)
E13	0.3192	0.3270	0.3310	0.3373	(0.3192, 0.3270, 0.3310, 0.3373)
E14	0.3960	0.3780	0.3880	0.3004	(0.3960, 0.3780, 0.3880, 0.3004)

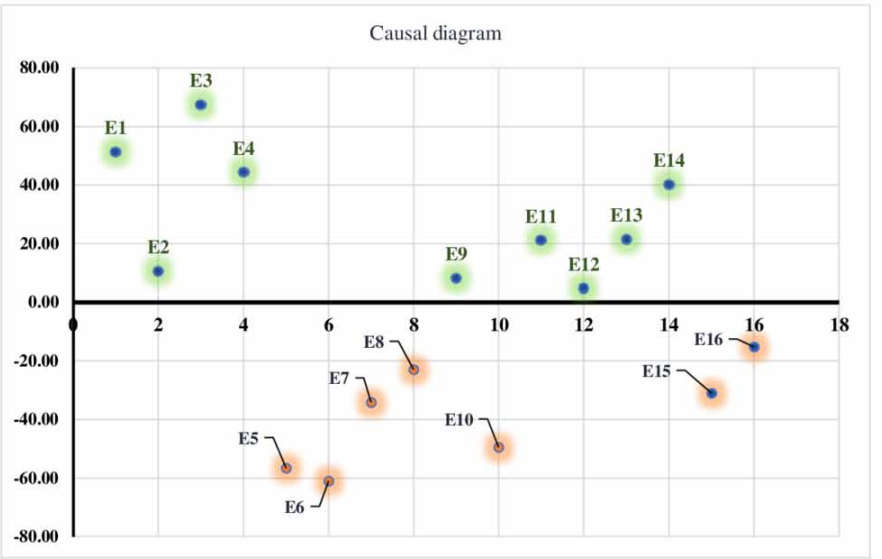
Table 9. Final outranking of 'EDRs'

	Lower Integral After Solved	Upper Integral After Solved	Sum Lower and Upper integral	Ranking
E1	0.2326	0.2397	0.4723	1
E2	0.1689	0.0391	0.208	9
E3	0.1829	0.2176	0.4005	2
E4	0.1942	0.2057	0.3999	3
E9	0.1739	0.1827	0.3566	6
E11	0.1829	0.1924	0.3753	4
E12	0.1803	0.155	0.3353	7
E13	0.1616	0.167	0.3286	8
E14	0.1696	0.196	0.3656	5

In the figure 4 all the data plots in first quadrant depicts the *'EDRs'* belonging to causal group, whereas in fourth quadrant only, effect group values are plotted. *'EDRs'* arranged as: *E3> E1 > E4> E14> E1)> E11> E2> E9> E12* belong to the cause group. Whereas *'EDRs' E16> E8> E15> E7> E10> E5)> E6* falls in the broad category of effect group. In the relation values of the implied methodology 'EDR' '*E3'* outranks highly among causal and effect group, respectively. Mathematically, it can be marked that 'EDR' '*E3*'is having the highest mutual interrelationship with the other *'EDRs'*, whereas, '*E6*' is having the least. It implies that *'EDRs'* of the causal have high level of the mutual interaction than the effect group ones.

Furthermore, to enrich the results and making them more reliable and robust, *'N_s'* theory is incorporated. This effectively handles the uncertainty along with the inconsistency, indeterminacy associated with the judgemental values. Although, DEMATEL handles the mutual interrelationship between the *'EDRs'*, but implying NBRM, imparts value by considering the various miniatures associated with mathematical functional values governing uncertainty, vagueness and indeterminacy level. Implication of the NBRM on the *'EDRs'* resulted in the establishment of the priority of *'EDRs'*

Figure 4. Causal and Effect Group Plots



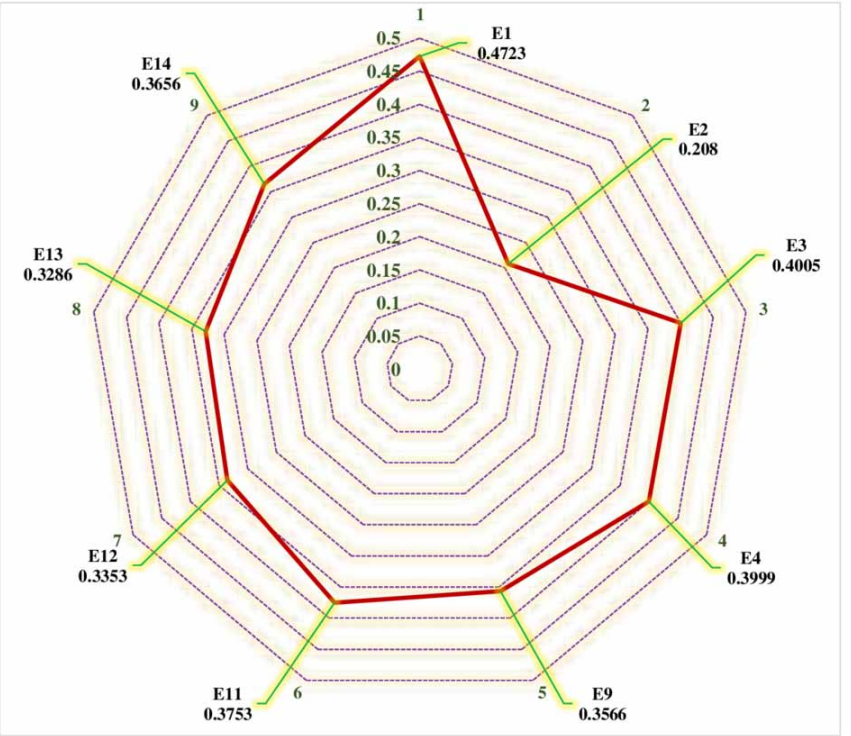
which is as: *E1> E3> E4> E11> E14> E9> E12> E13> E2*. Its data plots are made in the figure 5, aiding better visualisation of results.

Calculations of the NBRM, ranks 'EDR' *'Accessibility of skilled workforce' (E1)* highest among the others. It's very evident that workforce drives the system and working spirits of the employees upscale the operation potencies. In last few decades, there has been rapid increase in the education level and growing awareness about the information technology based systems. For the same skilled work force is required, having ability to handle the advanced communication and computing systems effectively and efficiently. Nowadays, accessibility to the skilled workforce has improved in the developed and wells as developing nation too. This marks thimbles that *'EB'* based activities have prosperous future endeavours too.

Skilled work force has potencies to handle the system dynamics, analyse the trends and curtailing the bottlenecks, hampering the FSC performance. Furthermore, skilled workforce has tendencies to consistently innovate the feasible and cost effective solution to a wide range of the operation and functioning issues. Extending FSC to the *'EB'* based ventures improves the flow of information between the operating tiers, ensures the real time condition monitoring, aids prompt financial and decision transactions, along with reliable database having better traceability. Profitability in the FSC is dependent upon the hassle free flow of commodities as wells as information and financial flow through its operating channels. Nowadays, development of the various digital payment modes *(E3)* has revolution the financial flow and unified the supplier buyer relation more effectively. In traditional SC practices, lack of awareness about digital payment modes often withheld the working capital of the industries and its allied partners, which ceases the product flow, leading to demand distress.

In India its being estimated that there is more than 150 percent increase in the digital transactions (RBI,2020). There is growing awareness among the masses about ease of digital payment modes and it is trending in the sub-urban and rural area too. This provides the favourable conditions when the *'EB'* activities can spawn their wings and cling with the dynamics of FSCs. Adoption of the *'EB'* also dependent upon the creditability of the organisation and technological support *(E4)* rendered by establishments. Globalisation, changing lifestyle of the people, growing taste preferences has prompted food industries to uplift their organisation working and opt for the technological advancement for withstanding the market competition. Increased share of the foreign direct investment *(E11)* has

Figure 5. Data plots of final outranking of the 'EDRs'



enabled transfer of the technology, support and people interchanging the ideas and thoughts related to implementation of effective and efficient strategies. In a report published by the Telecom Regulatory Authority of India (*TRAI*), India has 654 million active subscriber of the broadband based internet services in the year of 2020, whereas this count was 500 million in year of 2018. These figures indicate that internet users *(E14)* and its usage is increasing exponentially India, with this various giant of the *'EB'* have stepped in, which have provided access to the multiple product at competitive prices tags. Increased accessibility to the global markets have bought suppliers and consumer closer, which establishes the foundation of *'EB'* services and abled the SCs to operate irrespective of the geographical barriers.

Increasing awareness and usage of the internet services has opened up the new hotspots of the innovation in the field of data analytics and cloud based computing systems. Innovation in the area of cloud based computing system *(E12)* has revolution the *'EB'* system and bought the multiple stakeholder on a common platform prompting the ease of product flow, better traceability, financial flow, remote access to the market conditions. Furthermore, integrating it with the artificial intelligence based systems has reduced the human intervention, aiding faster product delivery rates, with better shelf life. Such advancements have find their way in the packaging of the food items, during phase of logistics and distribution *(E13)*. With increase in the information technology based infrastructure *(E2),* FSC profound the most suitable instances to align its practices with the *'EB'* strategies.

6. CONCLUSION AND IMPLICATIONS

Recent developments in the field of information technology has embarked the advancement in field of business operations. FSC activities are gaining pace and consumer base associated with it is surging.

To effectively and efficiently fulfil the consumers demand, FSC functioning needs to be allied with the various walks of *'EB'* practices. Presented work clusters the notion associated with the adoption of the *'EB'* practices in the dynamics of FSC. For the same sixteen *'EDRs'* were identified from the research literature, which were further brainstormed with the field experts to explore its feasibility with the real time operations, so that practical findings can be grounded. These sixteen *'EDRs'* where analysed in two stages, in first stage mutual interrelationship between the *'EDRs'* by was assessed by implying the methodology of DEMATEL. This analysis grouped *'EDRs'* into the 'Causal' and 'Effect' group respectively, based upon its evaluated prominence and relation value. *'EDRs'* in the 'Causal' group have higher level of mutual interaction, due to which they were further analysed, by *'N_s'*. In second stage, *'N_s'* based robust ranking methodology in exercised which, engages the trapezoidal linguistic rating values, effectively handling the vagueness, uncertainty associated with the indeterminacy, inconsistency associated with the human judgement. Final, priority of the *'EDRs'* was established based upon the outcomes of *'N_s'* based robust ranking methodology.

Implications of the presented study are bifurcated to the two broad categories based upon their nature of application in the field namely theoretical and practical respectively. Theoretically, presented work implications can be extended to the persons having both industry and academia background to deepen their thoughts and enhance their knowledge in the field of aligning the FSC practices with the fundamentals of e-business. Top official of the companies can utilise the insight of this work, to broaden their perspectives, conceptualise term *'EB'*, making familiar with its benefits, enabling it in FSC practices. They can revamp their operating capacities and can also review the new feasible and cost effective solutions to move with *'EB'* fundamentals, either in the phased manner or in a holistic action to escalate their profits and reduce risks of food safety and security. Budding researchers working in the domain of SC performance systems can overview the process of e-business practices and its scope in the allied domain to, come closer to the practicalities.

Practical implications of this study can be diversified to industry, academics and governmental bodies indulged in the FSC practices. People from the industrial background, can utilise this work outcomes, in their decision making processes, development of framework and polices, emphasising the adoption of *'EB'* based practices in FSC. Managers can develop the result promising strategies which focus on the aligning FSC with the *'EB'* practices, imparting pace to its functioning and escalating potencies. Authors have tried to detail the various procedures and attributes of the FSC network and covered the research work highlighting the methodologies and measures stepped up by developed nations to tune up the performance of their SC. This will help people from industry background to imply the decisions inculcating the *'EDRs'* of *'EB'* and promising better fortunes for the future avenues. Furthermore, governments can plan their polices, regulatory frameworks and ramp up the infrastructure needs for establishment of the *'EB'* based procedures in the FSC. Governmental bodies and its aides should ground the budget allocations, works plans and should collaborate with the industries and academicians to aware and train people and industrialist for the upgradations to the *'EB'* based protocols of FSC operations and functionalities.

Future avenues associated with the presented work can be extended by focusing on the more product specific processed FSC and considering various geographical regimes. This work can also be contemplated with more MCDM, modelling and simulation techniques to ground the concepts and validate the results. Furthermore, to walk with the advancements in the paradigm of Industry 4.0, technical integrations like artificial intelligence based system monitoring, cloud computing based product attributes storages and retrieval, IoT enabled food chain dynamics can be incorporated to yield the FSC potencies.

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