Partner Selection Factors for Successful CPFR Implementation Using Fuzzy DEMATEL

Farhad Panahifar, Cathal Heavey, P. J. Byrne, and M. Asif Salam

***Abstract*—In competitive global industries, the relationship between firms has changed from rivalry to collaboration using developed collaborative schemes like Collaborative Planning, Forecasting and Replenishment CPFR. Through partnerships, both parties should be mutually benefited. The key factor that maintains such relationships lies in addressing the question on how to select the right partner. In other words, lack of compatibility of partners' abilities and improper selection of partners will result in the failure of collaboration. While CPFR is a way that manufacturers and retailers mostly collaborate, there exists an important challenge for manufacturers to select proper retailers. The purpose of this study is to introduce and explore the key factors considered by manufacturers in retailer selection and the relationships between these factors. Based on a comprehensive literature review and applying experts' views the most important retailer selection factors are introduced. Fuzzy DEMATEL is applied to further analyse their interrelationships. Based on the empirical results, conclusions and suggestions are proposed as a reference for manufacturers and retailer.**

***Index Terms*—CPFR implementation, partnership, retailer selection factors, fuzzy DEMATEL.**

I. Introduction

CPFR is known as a most effective approach between collaborative innovations during the last decade. A broad impressive and promising result of CPFR implementation has been published in previous studies (Increase revenues and earnings, Reduce production and inventory costs [1]; Improvement of forecasting accuracy [2]. However, there exist different challenges and obstacles for successful CPFR implementation which lead to slower than expected implementation rate of CPFR [3]. Research conducted by [3] has comprehensively investigated CPFR implementation barriers in high-tech industries. The findings of this research which is the key motivation of this paper concludes that lack of compatibility of partners' abilities is one of the most important obstacles, which is caused by improper selection of partners. In other words, to successfully implement CPFR, there must be a certain degree of compatibly in abilities of supply chain trading partners [4]. Trading partners who wish to implement CPFR need to assess the potential relationship according to targeted and realistic objectives of CPFR implementation. For successful implementation of CPFR, firms require some indications from their trading partners to ensure that the potential capability exists to run a CPFR project. While CPFR is a means by which manufacturers and retailers collaborate, there exists an important challenge for manufacturers to select retailers for participation in CPFR. Once a manufacturer identifies several potential retailers to implement CPFR, they need to compare and contrast each partner against relevant selection criteria. This study selects high-tech industries as research subjects to explore the key retailer selection factors and relationships among these factors. High-tech industries such as semiconductor, computer and peripheral equipment, telecommunications, pharmaceutical and medical devices face constant difficulties with demand forecasting for high-tech products especially when introducing new products. To address this problem in high tech industries, [5] proposed two major solutions: i) excess capacity to buffer against demand variability and ii) develop high levels of collaboration with trading partners. When a new high tech product is introduced to the markets, different retailers/distributors are competing to sell this product. This gives power to manufacturer to select appropriate retailers to run CPFR. On the other hand, it is argued that retailers have better and accurate information about consumer demand and market than manufacturers [6]. Hence, manufacturers face a higher demand uncertainty than retailers [7]. This demand uncertainty has motivated manufacturers to innovate different uncertainty reduction strategies such as CPFR with retailers.

Following a comprehensive literature review, the significant factors in the retailer selection process are reported. Because of the gap of retailer selection factors in the relevant literature, experts' views are also used to identify other potential factors to provide a comprehensive list of factors, not incorporated within the previous literature. Fuzzy DEMATEL is then used to explore the key factors considered by manufacturers in retailer selection and develop the contextual relationships between those identified. The study presented here has been carried out in the high tech sector, where the importance of collective practices with trading partners, and in turn CPFR is highlighted [3], [8].

II. An Overview of Related Literature

In recent years, the high-tech industries are one of the most competitive in the world [9]. The term 'high-tech' used widely from the early 1970s to denote 'high technology'. High-Tech was often associated with the utilization of advanced technology. Since 1970 different classification and categorising of high-tech industries have been presented. In the 1990s, high-tech industries were defined to include 10 major areas: communication; information; consumer electronics; semi-conductor; precision machinery and automation; aviation; high-grade material; special chemical

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Farhad Panahifar is with the University of Limerick, Ireland (e-mail: farhad.panahifar@ul.ie).

and pharmaceutical; medical care; and pollution prevention [9].

High-tech industries are characterized by rapid changes of technology, high innovation, intense competition, long production lead time, short product lifecycles and a highly uncertain environment and market [3], [10]. The rapid technological change in high-tech industries can affect both inter and intra-company collaborations [10]. The dynamics and unpredictability of the high-tech business and market make optimizing performance on the supply chain difficult. The firms in this environment are struggling to find effective strategies to face such challenges. One well-known strategy is collaboration with other members of a supply chain by applying initiatives like CPFR.

CPFR is known as a most effective approach between collaborative innovations during the last decade with a broad impressive and promising result of CPFR implementation published in previous studies [1], [2], [11]. However, there exist different challenges and obstacles for successful implementing CPFR which lead to slower than expected implementation rate of CPFR [3], [12]. Lack of compatibility of partners' abilities and the lack of trust between partners are the most important obstacles that cause improper selection of partners. In other words, for successful implementation of CPFR, there must be a certain degree of compatibly in abilities and an appropriate level of trust between trading partners [4], [11]. As firms need to develop trust when adopting CPFR, they pay greater attention to partner selection. Partner selection is a complex and time consuming task in CPFR to ascertain whether a potential candidate has the abilities and resources in order to fulfil the agreed tasks.

During the last years, several techniques and methods have been proposed to solve the partner selection problems [13], [9], [14]-[16]. Reference [13] using survey methodology have emphasized the importance of quality performance, delivery reliability, cost efficiency, quantity flexibility and delivery speed as the most important factors in the selection of supply chain partners. Reference [14] proposed an integrated supplier selection and multi-echelon distribution inventory model (MEDIM) for an original equipment manufacturing company using fuzzy analytical hierarchy process (FAHP) and a genetic algorithm.

Reference [15] tried to understand the role of Fit, Trust and Strategic Expediency for partner selection. They summarized that strategic expediency and trust have a critical role in a partner selection process, and highlighting these roles can help decision makers to improve partner selection decisions. Reference [9] in their research focused on high-tech industries in Taiwan to understand a manufacturer's behaviours and then defined the relationships between the factors using structural equation modelling. They proposed eight supplier selection factors, comprising price response capability, quality management capability, technological capability, delivery capability, flexible capability, management capability, commercial image, and financial capability. Reference [16] contributed an alternative quantitative method to the partner selection literature by applying a mathematical method of formal concept analysis. The authors proposed a method to analyse available data regarding candidates, evaluating and comparing different candidates following several criteria when firms are involved in the partner selection process for horizontal collaboration.

Identification of the criteria influencing the selection activity is the most important step in partner evaluation and selection process. Most of the previous researches found in the literature have concentrated on studying this step. To our knowledge, many of the researches conducted in the supplier selection area have used multiple criteria decision making (MCDM) techniques. However, there are still gaps in the existing knowledge on partner selection for collaboration especially when a high-tech manufacturer selects a retailer or a set of retailers in order to launch a sustainable CPFR scheme. Although, the literature on partner selection topic is quite rich, only a very small portion of previous papers have studied the distributor or retailer selection. This paper tries to narrow this gap and intends to explore retailer selection problem in the context of collaborative plans.

III. Methodology

There is an increasing use of MCDM methods especially in the fuzzy area. Decision-making is the process of defining the decision objectives, gathering relevant information, and selecting the optimal alternatives [17]. MCDM methods are widely used in partner selection studies as partner selection is a multi-criteria decision problem [18]. DEMATEL which stands for Decision-making trial and evaluation laboratory method originally developed by the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva between 1972 and 1976. The DEMATEL method is a potent method that helps in gathering group knowledge for forming a structural model, as well as in visualizing the causal relationship of subsystems through a causal diagram. The DEMATEL model, was intended to study and resolve the complicated and intertwined problem group [19], has been successfully applied in many fields and areas, such as outsourcing providers, project management, marketing strategies, IC design service, green supply chain management practices [17], [20]-[25].

Fuzzy DEMATEL has been recently utilised in partner selection and evaluation studies [20], [26], [27]. Previous research applied DEMATEL because of its ability to confirm interdependence among considered factors, and also its capability in showing the interrelationships among factors [28]. According to [20] DEMATEL can be applied in supplier selection studies as it can find key criteria to improve performance and provide decision-making information and it does not need a large amount of data. The methodological framework in this study is based largely on expert opinion and perception and includes three supporting techniques: literature review, structural interviews and fuzzy techniques.

IV. Identifying Criteria for Retailer Selection Evaluation

Partner selection is a very prudent and challenging task. When companies plan for a long-term collaboration, partner selection needs intense precision. As pointed out earlier, there is an important gap in the literature of manufacturers' retailer selection and till the time of this paper there is no paper in the area of manufacturers' selection of retailer for adopting CPFR. There are only a small number of papers in the area of distributor selection which have been partially used in this paper. An earlier paper in the topic of selecting distributors was conducted by [29]. They introduced a computer-aided decision support tool for qualifying potential distributors. The authors applied in-depth interviews with experienced international business executives to propose five main dimensions affecting distributor selection. These elements consist of financial and company strengths, product factors, marketing skills, commitment and facilitating factors. Another paper originating from this area is [30]. They reviewed determinants of manufacturers' selection of distributors and put forward four major dimensions to cover 16 proposed factors influencing the selection of distributors. Four key constructs in their research, were derived from marketing, supply chain, and the logistics literature to investigate their influences on distributor selection, which are firm infrastructure, marketing capabilities, relationship intensity, and logistics capabilities.

TABLE I: RETAILER SELECTION CRITERIA

Dimension	Criteria	Tag
Organizational and Financial strengths	Management abilities and skills	C_1
	High internal alignment	C_2
	Flexible organization	C_3
	Organizational size	C_4
	Workforce skills and training	C_5
	Financial strength	C_6
	Physical facilities	C_7
	Reputation	C_8
Marketing abilities	Sales strength	C_9
	Market coverage	C_{10}
	Familiarity with the product(s)	C_{11}
	Customer service orientation and capability	C_{12}
	Product compatibility	C_{13}
	Footfall	C_{14}
Relationship strength	Retailers' commitment to agreed order	C_{15}
	Willingness to share information	C_{16}
	Retailers' initiative to build trust	C_{17}
	Enthusiasm to collaboration	C_{18}
	Manufacturer's familiarity with the retailer	C_{19}
Logistics capabilities	Inventory management	C_{20}
	On-time deliveries	C_{21}
Technological capabilities	Information security system	C_{22}
	Strong IT infrastructure	C_{23}
	Technology Compatibility	C_{24}

Due to the lack of existing scales for retailer evaluation or selection, the general structure for the main dimensions proposed by these two papers after incorporating the views of three members of an expert group are adopted in this research. These three experts were fully aware of the CPFR implementation in high-tech industry with more than 20 years of experiences in international marketplaces. Using a comprehensive literature review on CPFR implementations and incorporating high-tech experts' views and perceptions, the appropriate factors were initially identified to be 28 factors which after further discussion were reduced to an agreed total of 24 factors. It is argued that CPFR should not be seen as an approach to create a good relationship with new players; rather, it can help to enhance a good relationship with an existing trading partner [31]. Therefore, significant attention of the authors and the experts group involved has been to identify and introduce the factors which might play important roles in CPFR implementation rather than introducing retailer selection factors for a general collaboration.

To better categorize the factors, the dimensions proposed in the aforementioned papers have been examined in detail. Finally, three of the five dimensions have been adopted from these two papers including organizational and financial strengths [29] marketing abilities and logistics capabilities [30]. To comprehensively classify the identified factors, this study adds two more dimensions including relationship strength and technological capabilities based on discussions with the group of experts. Table I shows all dimensions and factors in more detail.

This study then surveys 12 experts with extensive knowledge and experiences of CPFR implementation to identify the most significant and effective retailer selection factors. All experts are either industrial practitioners with an average of 16 years of experiences in international high tech industries or academic scholars with research concentration in supply chain management area.

V. FUZZY DEMATEL

This study employs Fuzzy DEMATEL for achieving the objectives of the research which is to construct interrelations between criteria consisting of CPFR partner selection factors. The steps of Fuzzy DEMATEL are explained in details in the following paragraphs.

Step 1: Defining the evaluation criteria and design the fuzzy linguistic scale

To deal with the ambiguities of human assessments, the research will apply the fuzzy linguistic scale used in the group decision making proposed by [32] which expressed the different degrees of 'influence' with five linguistic terms as 'No influence', 'Very low influence', 'Low influence', 'High influence', 'Very high influence' and their corresponding positive triangular fuzzy numbers are shown in Table II.

TABLE II: THE LINGUISTIC VARIABLES AND THEIR CORRESPONDING FUZZY NUMBERS

Linguistic scale	Influence score	Triangular fuzzy scale
No influence (No)	0	(0, 0, 0.25)
Very low influence (VL)	1	(0, 0.25, 0.50)
Low influence (L)	2	(0.25, 0.50, 0.75)
High influence (H)	3	(0.50, 0.75, 1.00)
Very high influence (VH)	4	(0.75, 1.00, 1.00)

Step 2: Establishing the directed-relation matrix

To measure the relationship between criteria $C = \{C_i | i = 1, 2, ..., n\}$ a decision group of *p* experts were asked to make sets of pair-wise comparisons in terms of linguistic terms. Hence, *p* fuzzy matrices $\tilde{Z}^1, \tilde{Z}^2, \cdots \tilde{Z}^p$ each corresponding to an expert and with triangular fuzzy numbers as its elements, were obtained. Fuzzy matrix $\tilde{Z}$ is called the initial direct-relation fuzzy matrix where:

$$\tilde{Z} = \begin{matrix} C_1 \\ C_2 \\ \vdots \\ C_n \end{matrix} \begin{pmatrix} 0 & \tilde{z}_{12} \cdots & \tilde{z}_{1n} \\ \tilde{z}_{21} & 0 \cdots & \tilde{z}_{2n} \\ \vdots & \vdots & \vdots \\ \tilde{z}_{n1} & \tilde{z}_{n2} & 0 \end{pmatrix} \quad (1)$$

and $\tilde{z}_{ij} = \left(l_{ij}, m_{ij}, r_{ij}\right)$ are triangular fuzzy numbers.

where the following formulas are applicable to fuzzy numbers:

$$k.Z = (kl, km, kr) \quad (2)$$

$$N_1 \oplus N_2 = (l_1 + l_2, m_1 + m_2, r_1 + r_2) \quad (3)$$

$$Z = \frac{(Z^1 + Z^2 + \ldots + Z^P)}{P} \quad (4)$$

Step 3: Establishing and analysing the structural model

Equation (5) is used to transform the criteria scales into comparable scales.

$$\tilde{a}_{ij} = \sum_{j=1}^{n} \tilde{z}_{ij} = \left(\sum_{j=1}^{n} l_i, \sum_{j=1}^{n} m_i, \sum_{j=1}^{n} r_i\right)$$

and

$$u = \max_{1 \le i \le n} \left(\sum_{i=1}^{n} r_{ij}\right) \quad (5)$$

The normalized initial direction-relation fuzzy matrix is:

$$\tilde{X} = \begin{pmatrix} \tilde{x}_{11} & \tilde{x}_{12} \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \tilde{x}_{2n} \\ \vdots & \vdots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} \cdots & \tilde{x}_{mn} \end{pmatrix}$$

where

$$\tilde{x}_{ij} = \frac{\tilde{z}_{ij}}{u} = \left(\frac{l_{ij}}{u}, \frac{m_{ij}}{u}, \frac{r_{ij}}{u}\right) \quad (6)$$

Step 4: The total-relation matrix

To calculate the total-relation matrix ($\tilde{T}$) we assume $\lim_{k \to \infty} \tilde{x}^k = 0$

To calculate $\tilde{x}^k$ we use the equation 7 in order to multiple two fuzzy numbers

$$\tilde{N}_1 \otimes \tilde{N}_2 \cong \left(l_1.l_2, m_1.m_2, r_1.r_2\right)$$

$$\tilde{X}_{ij} = \left(l'_{ij}, m'_{ij}, r'_{ij}\right)$$

$$X_l = \begin{pmatrix} 0 & l'_{12} \cdots & l'_{1n} \\ l'_{21} & 0 \cdots & l'_{2n} \\ \vdots & \vdots & \vdots \\ l'_{n1} & l'_{n2} \cdots & 0 \end{pmatrix} \quad X_m = \begin{pmatrix} 0 & m'_{12} \cdots & m'_{1n} \\ m'_{21} & 0 \cdots & m'_{23} \\ \vdots & \vdots & \vdots \\ m'_{n1} & m'_{n2} \cdots & 0 \end{pmatrix}$$

$$X_r = \begin{pmatrix} 0 & r'_{12} \cdots & r'_{1n} \\ r'_{21} & 0 \cdots & r'_{2n} \\ \vdots & \vdots & \vdots \\ r'_{n1} & r'_{n2} \cdots & 0 \end{pmatrix} \quad (7)$$

Then the total-relation matrix is defined by the equation 8 as outlined here:

$$\tilde{T} = \tilde{X}^1 + \tilde{X}^2 + \cdots + \tilde{X}^k = \tilde{X}(I - \tilde{X})^{-1} \quad (8)$$

$\tilde{T} = \lim_{k \to \infty}\left(\tilde{X} + \tilde{X}^2 + \cdots + \tilde{X}^k\right)$ Then: $\tilde{t}_{ij} = \left(l''_{ij}, m''_{ij}, r''_{ij}\right)$

and

$$\tilde{T} = \begin{pmatrix} \tilde{t}_{11} & \tilde{t}_{12} \cdots & \tilde{t}_{1n} \\ \tilde{t}_{21} & \tilde{t}_{22} \cdots & \tilde{t}_{2n} \\ \vdots & \vdots & \vdots \\ \tilde{t}_{31} & \tilde{t}_{n2} \cdots & \tilde{t}_{nn} \end{pmatrix}$$

According the assumption in step 4 we have:

$$\lim_{k \to \infty} \tilde{X}^k = [0]_{n \times n} \text{ and} \left[l''_{ij}\right] = X_l \times \left(I - X_l\right) \quad (9)$$

$$\left[m''_{ij}\right] = X_m \times (\mathrm{I} - X_m)^{-1} \quad (10)$$

$$\left[r''_{ij}\right] = X_r \times (\mathrm{I} - X_r)^{-1} \quad (11)$$

Step 5: The sum of rows and columns

As we have calculated ($\tilde{T}$) in the last step, we can now calculate the relevant amounts of $\tilde{D}_i + \tilde{R}_i$ and $\tilde{D}_i - \tilde{R}_i$ whereas $\tilde{D}_i$ is the row sum and $\tilde{R}_i$ is the sum of columns in ($\tilde{T}$).

$$\tilde{T} = \left[\tilde{t}_{ij}\right], i, j \in \{1, 2, \cdots, n\} \; ; \tilde{D}_i = \left(\tilde{d}_i\right)_{n \times 1} = \left[\sum_{j=1}^{n} \tilde{t}_{ij}\right]_{n \times 1}$$

and

$$\tilde{R}_i = \left(\tilde{r}_j\right)_{1 \times n} = \left[\sum_{i=1}^{n} \tilde{t}_{ij}\right]_{1 \times n} \quad (12)$$

There are three methods to determine the best nonfuzzy performance (BNP) value in the literature of the multiple criteria decision making (MCDM) methods which including: (a) mean of maximal (MOM), (b) center of area (COA), and (c) -cut [33]. Utilizing the COA method to determine the BNP is simple and practical, and there is no need to introduce the preferences of any evaluators [34]. Thus, to defuzify the fuzzy weights in order to compare the alternatives in a nonfuzzy ranking method, the (COA) is applied in this paper using the following equation:

$$BNP = l + \frac{(r - l) + (m - l)}{3} \quad (13)$$

The values of $\left(D_i + R_i\right)^{def}$ and $\left(D_i - R_i\right)^{def}$ will be calculated using Equation 13.

Step 6: The cause and effect diagram

A causal and effect graph can be achieved by mapping the dataset of (D+R, D-R). The importance of each criterion is obtained by adding D to R which named 'Prominence' which forms the horizontal axis vector. Similarly, the vertical axis (D-R) named 'Relation' is made by subtracting D from R, which may group criteria into a cause group. Or, if the (D-R) is negative, the criterion is grouped into the effect group.

VI. Application of Proposed Method

The Fuzzy DEMATEL method is implemented with the following steps. First, a fuzzy linguistic scale (Table II) is used for making assessments. In step 2, the relations of interdependences among key factors in retailer selection are quantitatively analyzed through investigations of experts' perceptions.

Through twelve questionnaires, this study obtains their perceptions of various retailer selection criteria in CPFR implementation projects. Then, the initial direct-relation matrix was produced by Equation 4 which called Fuzzy matrix Z. In step 3, based on the initial direct-relation matrix, the normalized direct-relation matrix was obtained by equation 6. To produce the total-relation matrix, three matrices are constructed which are labeled X_l, X_m and X_r. The values of $\left[l''_{ij}\right]$, $\left[m''_{ij}\right]$ and $\left[r''_{ij}\right]$ will be then calculated with the help of Equations 9-11, respectively.

In the next step, the total-relation matrix (Table III) was acquired. In step 5, the values of R_i, D_i, $D_i + R_i$ and $D_i - R_i$ are obtained as shown in the Table IV. To complete Table IV, all calculated $D_i + R_i$ and $D_i - R_i$ are defuzified through a COA (center of area) defuzification method (Equation 13). In the final step, the cause and effect diagram are developed using Table IV. The results are the values of $\left(D_i + R_i\right)^{def}$ which shows the importance of all factors and $\left(D_i - R_i\right)^{def}$ which assign selection factors into cause and effect groups. Using this information obtained in Table IV, the cause and effect diagram (see Fig. 1) is achieved in step 6.

The values of X_l, X_m and X_r have been calculated using the matrix X as shown in the following matrices, respectively. The next matrix shows the values of matrix $\left[l''_{ij}\right]$ which is calculated using these three matrices. The matrices $\left[m''_{ij}\right]$ and $\left[r''_{ij}\right]$ will be calculated in a similar method.

VII. Findings and Discussion

In this paper, a fuzzy DEMATEL model is presented to deal with the influential relationship between the evaluation criteria in selecting retailers to CPFR implementation and to identify their casual relationships. Some of the major findings of this study are highlighted in the following paragraphs:

In Table IV, the values of show how significant a criterion is and the values of divide the criteria into cause and effect groups. If the value of is positive, the criterion belongs to the cause group and if its value is negative, the criterion is a member of the effect group. It is also shown in the causal diagram that the retailer selection factors for CPFR implementation extracted by using explanatory factor analysis were divided into the cause group including C_1, C_3, C_5, C_{12}, C_{13}, C_{16}, C_{19}, C_{21}, C_{22}, C_{23} and C_{24}. The effect group was composed of C_2, C_4, C_6, C_7, C_8, C_9, C_{10}, C_{11}, C_{14}, C_{15}, C_{17}, C_{18} and C_{20}. So, 'management abilities and skills', 'flexible organization', 'workforce skills and training', 'customer service orientation and capability', 'product compatibility', 'willingness to share information', 'manufacturer's familiarity with the retailer', 'on-time deliveries', 'information security system', 'strong IT infrastructure', 'technology compatibility' are cause factors whereas 'high internal alignment',' organizational size', 'financial strength', 'physical facilities', 'reputation', 'sales strength', 'market coverage', 'familiarity with the product(s)', 'footfall', 'retailers' commitment to agreed order', 'retailers' initiative to build trust', 'enthusiasm to collaboration' and 'inventory management' are identified as effect factors. Generally, the factors in the effect group tend to be easily impacted by others, which make effect factors unsuitable to be a critical success factor in a partner selection process.

The results show that C12 (customer service orientation and capability) with the greatest value of is identified as the most significant factor whereas C7 (physical facilities) is the least important criterion with the value of 3.793 for retailer selection to successful implement CPFR. C12 has also received a high Rank of Impact (ROI) which shows this element is a critical factor in retailer selection activities. On the other hand, physical facilities (C7) has received also the greatest negative score of with the value of -0.388 which shows this factor is not definitely a critical factor in selecting retailers from the viewpoint of manufacturers.

According to the results, the second greatest value of the index of significance belongs to C_1 (Management abilities and skills) with the value of 6.067. On the other hand, this factor is classified in the cause group with a relatively large value of 0.253. Therefore, it is introduced as a critical factor for the objective of partner selection. This indicates that for the purpose of supporting collaborative planning initiatives, like CPFR, management abilities and skills of the retailers have a strong influence on the firm and the whole chain.

Moreover, the results revealed that C_{19} (manufacturer's familiarity with the retailer) and C_5 (workforce skills and training) with the greatest value of $\left(D_i - R_i\right)^{def}$ (0.342 and 0.311, respectively) are confirmed to have a more influential effect on the other factors and will thus generate the competitive advantages. Workforce skills and training has been ranked also as the third greatest significant factor with the value of 5.412. This factor is thus introduced as a critical factor in the retailer selection process because it differentiates a firm from its competitors.

The results of this study indicate that all the three factors from technological dimension are identified as cause factors. This highlights that retailer' technological capabilities can simplify and enhance the speed and flexibility of CPFR. However, it is well documented in the CPFR literature that technology can play a role as key enabler, is no longer seen as a major barrier to success [3]-[31].

TABLE III: THE TOTAL RELATION FUZZY MATRIX T

	C1	C2	C3	...	C22	C23	C24
C1	(.019,.068, 0.24)	(.047, .105, .277)	(.039, .094, .276)		(.041, .091, .251)	(.042, .094, .260)	(.039, .079, .247)
C2	(.043,.090, .025)	(.012, .048, .198)	(.043, .087, .243)		(.029, .069, .214)	(.029, .070, .221)	(.028, .065, .211)
C3	(.034, .084, .026)	(.041, .090, .258)	(.012, .048, .211)		(.025, .065, .221)	(.024, .064, .227)	(.020, .057, .213)
C4	(.023, .060, .215)	(.033, .068, .215)	(.024, .058, .207)		(.015, .046, .180)	(.017, .050, .189)	(.013, .041, .176)
C5	(.048, .106, .283)	(.046, .102, .271)	(.046, .10, .271)		(.032, .076, .238)	(.029, .077, .246)	(.022, .063, .226)
C6	(.031, .079, .251)	(.023, .070, .237)	(.023, .067, .236)		(.030, .071, .220)	(.030, .073, .229)	(.022, .061, .214)
C7	(.011, .042, .177)	(.009, .037, .165)	(.010, .038, .169)		(.007, .032, .150)	(.009, .034, .157)	(.004, .027, .145)
C8	(.035, .085, .271)	(.035, .085, .260)	(.032, .075, .258)		(.026, .067, .225)	(.026, .069, .234)	(.025, .061, .224)
C9	(.041, .095, .265)	(.032, .084, .249)	(.032, .081, .247)		(.017, .058, .212)	(.020, .062, .227)	(.018, .057, .212)
C10	(.025, .071, .248)	(.025, .069, .235)	(.025, .066, .235)		(.026, .068, .219)	(.030, .072, .231)	(.025, .060, .216)
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
C19	(.032, .082, .251)	(.028, .077, .238)	(.028, .071, .235)		(.027, .068, .214)	(.017, .061, .218)	(.019, .059, .210)
C20	(.034, .083, .246)	(.033, .078, .235)	(.026, .071, .234)		(.027, .066, .208)	(.024, .065, .218)	(.017, .053, .201)
C21	(.042, .095, .264)	(.040, .091, .252)	(.034, .079, .249)		(.022, .066, .217)	(.026, .069, .228)	(.020, .061, .216)
C22	(.034, .082, .257)	(.025, .068, .233)	(.034, .079, .246)		(.009, .040, .181)	(.036, .078, .230)	(.024, .063, .213)
C23	(.034, .085, .245)	(.034, .081, .233)	(.027, .070, .229)		(.027, .066, .205)	(.008, .040, .179)	(.022, .060, .203)
C24	(.023, .067, .227)	(.027, .069, .221)	(.021, .059, .215)	...	(.020, .058, .198)	(.030, .069, .212)	(.006, .030, .160)

TABLE IV: THE VALUES OF R_i, D_i, $D_i + R_i$, $D_i - R_i$, $\left(D_i + R_i\right)^{def}$, $\left(D_i - R_i\right)^{def}$

	R_i	D_i	$\left(D_i + R_i\right)^{def}$	$\left(D_i - R_i\right)^{def}$	ROS	ROI
C1	(0.784, 1.952, 5.985)	(0.866, 2.229, 6.385)	6.067	0.253	2	4
C2	(0.726, 1.856, 5.685)	(0.591, 1.626, 5.386)	5.290	-0.221	11	21
C3	(0.685, 1.740, 5.667)	(0.639, 1.744, 5.761)	5.412	0.017	9	9
C4	(0.139, 1.437, 4.989)	(0.418, 1.249, 4.687)	4.307	-0.070	23	12
C5	(0.676, 1.798, 5.645)	(0.805, 2.099, 6.148)	5.724	0.311	3	2
C6	(0.205, 1.905, 5.930)	(0.568, 1.635, 5.528)	5.257	-0.103	13	17
C7	(0.434, 1.260, 4.578)	(0.241, 0.925, 3.942)	3.793	-0.388	24	23
C8	(0.740, 1.920, 5.879)	(0.695, 1.859, 5.967)	5.686	-0.006	5	11
C9	(0.771, 1.966, 5.979)	(0.729, 1.936, 5.779)	5.720	-0.091	4	14
C10	(0.735, 1.898, 5.769)	(0.664, 1.789, 5.668)	5.507	-0.094	6	15
C11	(0.671, 1.748, 5.562)	(0.582, 1.649, 5.313)	5.175	-0.146	15	18
C12	(0.806, 2.025, 6.001)	(0.852, 2.220, 6.485)	6.130	0.242	1	5
C13	(0.526, 1.466, 4.972)	(0.518, 1.591, 5.369)	4.814	0.171	20	6
C14	(0.553, 1.547, 5.177)	(0.469, 1.462, 5.042)	4.750	-0.101	21	16
C15	(0.705, 1.821, 5.726)	(0.528, 1.591, 5.382)	5.251	-0.250	14	22
C16	(0.682, 1.776, 5.661)	(0.704, 1.911, 5.767)	5.500	0.087	7	8
C17	(0.682, 1.804, 5.650)	(0.642, 1.722, 5.321)	5.274	-0.151	12	19
C18	(0.688, 1.794, 5.617)	(0.639, 1.742, 5.502)	5.327	-0.072	10	13
C19	(0.545, 1.488, 5.041)	(0.665, 1.838, 5.597)	5.058	0.342	17	1
C20	(0.640, 1.701, 5.619)	(0.516, 1.577, 5.320)	5.124	-0.183	16	20
C21	(0.656, 1.734, 5.585)	(0.720, 1.900, 5.742)	5.446	0.129	8	7
C22	(0.533, 1.475, 5.015)	(0.607, 1.709, 5.584)	4.974	0.292	18	3
C23	(0.567, 1.547, 5.247)	(0.534, 1.617, 5.262)	4.925	0.017	19	9
C24	(0.486, 1.358, 4.949)	(0.445, 1.395, 4.991)	4.541	0.013	22	10

Note: ROS=Rank of significance; ROI=Rank of impact.

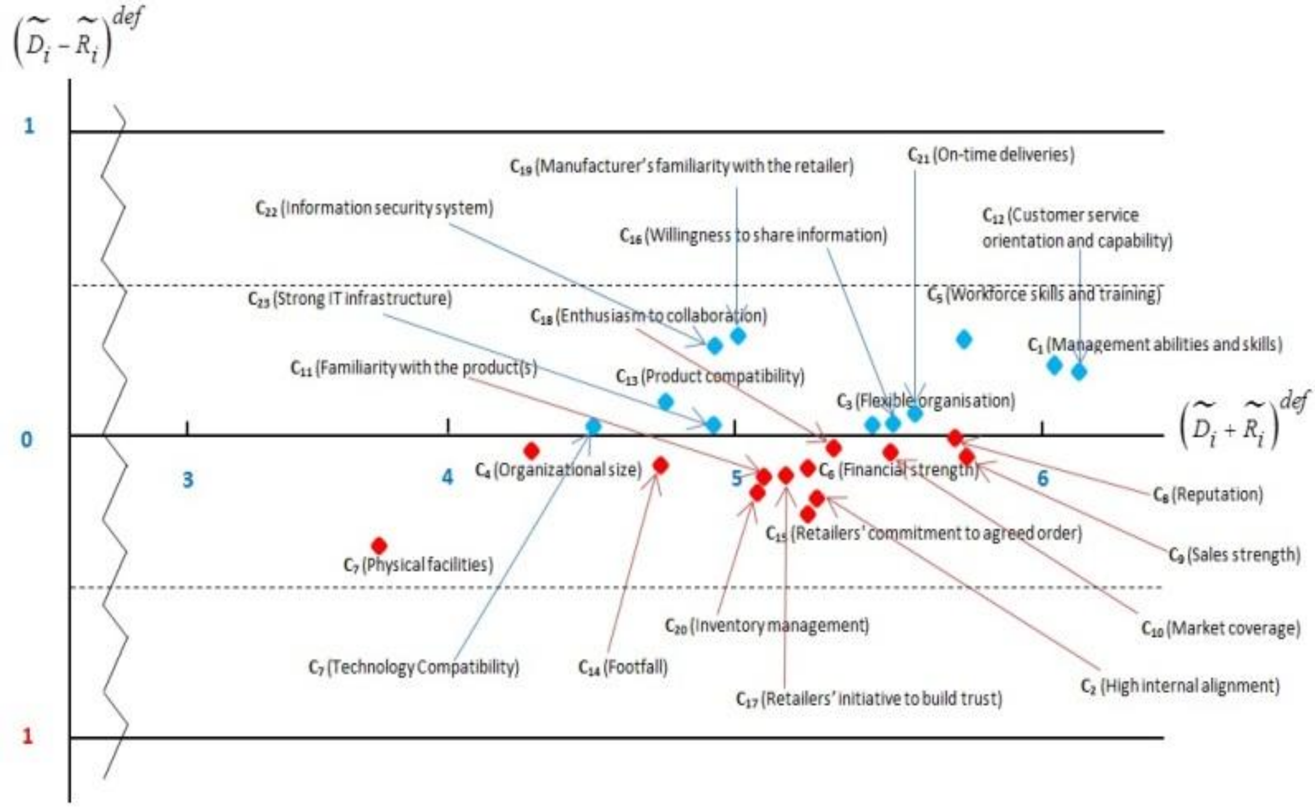

Fig. 1. The cause and effect diagram.

VIII. Concluding Remarks

Finding right partner with right capabilities is known to be the most strategic needs of any collaboration. Companies need to ensure the trading partner's potential to commit resources. To this end, it is imperative to companies have a clear understanding of effective partner selection factors in creating a successful collaboration. While CPFR is a way that manufacturers and retailers mostly collaborate, there arises an important challenge for manufacturers to select proper retailers. Hence, this study uses a literature review, expert views and the fuzzy DEMATEL technique to comprehensively find out, develop and analyze possible retailer selection factors for successful CPFR implementation. A new selection model is then formulated. The results of this study can help enterprises precisely recognize which retailers are suitable to run CPFR by focusing on crucial factors identified in this study. Discussion with experts helped us to classify the various criteria of decision-making into five dimensions: organizational and financial strengths, marketing abilities, relationship strength, logistics capabilities and technological capabilities. In other words, we suggest that the retailer selection problem to implement CPFR may be influenced by these five dimensions.

The proposed framework brings several contributions to a manufacturer's retailer selection to implement CPFR. First, a novel model for selecting retailer with emphasis on CPFR implementation has been developed. Second, with the proposed methodology, the complex interactions between retailer selection criteria can be transformed into a visible structural model, enabling firms to capture the most important anddominant factors. Third, the results show that the manufacturer should note that retailer's customer service orientation and capability (C_{12}) is the most important factor for CPFR implementation and its improvement can lead to the amelioration of the whole system. Customer service capabilities like 'delivery' and 'on-shelf availability' generate a better service to end users allowing manufacturer and retailer to enhance information visibility of the whole supply chain.

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Farhad Panahifar is a Ph.D. researcher and part-time lecturer at the Enterprise Research Centre in University of Limerick. Farhad has B.Sc. and M.Sc. degrees in Industrial Engineering with more than ten years industrial and academic experience.

His current research focus is in the area of supply chain management with emphasis on collaborative strategies (e.g. CPFR).

His research interests include supply chain management, simulation modelling, strategic planning, decision making techniques, business process reengineering (BPR) and productivity improvement.

Cathal Heavey is a professor of operations management in the Department of Design and Manufacturing Technology at the University of Limerick. He is an industrial engineering graduate of the National University of Ireland University College Galway and holds a M.Eng.Sc. and Ph.D. from the same University. He has published in the areas of queuing and simulation modelling.

His research interests include simulation modelling of discrete-event systems, modelling and analysis of supply chains and manufacturing systems, process modelling, component-based simulation and decision support systems.

P. J. Byrne is a senior lecturer of operations/supply chain management in Dublin City University Business School and is head of the management group in the school. Prior to this he worked as a senior research fellow in the Enterprise Research Centre in the University of Limerick.

P. J. has a B.Eng. degree in production engineering, from the Manufacturing and Operations Engineering Department in the University of Limerick. He has also received a Ph.D. from the same university in the area of supply chain simulation. His research interests include supply chain design, analysis and optimization, cloud based simulation, discrete event simulation, industrial applications of simulation modeling for the manufacturing and services sectors and business process optimization.

M. Asif Salam is as an associate professor of marketing and supply chain management in the Ted Rogers School of Management at the Ryerson University of Toronto. He is a doctorate in business administration in supply chain management from the Thammasat University, Thailand. His research interests include interdisciplinary issues in marketing and supply chain management, supply chain collaboration, supply chain integration, healthcare logistics, lean and agile logistics, and humanitarian disaster logistics.