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Analyzing of CPFR success factors using fuzzy cognitive maps in retail industry

Gülçin Büyüközkan *, Zeynep Vardaloğlu

Galatasaray University, Industrial Engineering Department, Çırağan Caddesi No: 36 Ortaköy, Istanbul 34357, Turkey

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ABSTRACT

The retail sector environment is characterized by intense pressure of competition, ever-changing portfolio of products, hundreds of different products, ever-changing customer requirements and be able to stand in a mass market. When considering that the giant retailers work together with their suppliers, each independent operation is seen as a comprehensive structure, consisting of thousands of sub-processes. In short, the retail industry dynamism and work in cooperation with the competitiveness of the sector is one of a rare combination. Of course in such a sector businesses of all sizes in many aspects of creating an efficient and low cost structure is in the effort. Collaborative planning, forecasting and replenishment (CPFR) model which is a scheme integrating trading partners' internal and external information systems is proposed to assist establishing a more effective supply chain structure in retail industry. Although CPFR can provide many benefits, there have been many failed implementations. The aim of this study is to determine the factors that will support better implementation of CPFR strategy in retail industry and analyze them using fuzzy cognitive map (FCM) approach. FCMs have proven particularly useful for solving problems in which a number of decision variable and uncontrollable variables are causality interrelated. A CPFR model made up of three sub-systems, namely information sharing, decision synchronization and incentive alignment, is proposed and "what–if" scenarios for proposed model are developed and interpreted. To our knowledge, this is the first study that uses FCMs for CPFR success factors assessment.

1. Introduction

The retail industry environment is characterized by intense pressure of competition, ever-changing portfolio of products, hundreds of different products, ever-changing customer requirements and be able to stand in a mass market. When considering that the giant retailers work together with their suppliers, each independent operation is seen as a comprehensive structure, consisting of thousands of sub-processes. In short, the retail industry dynamism and work in collaboration with the competitiveness of the sector is one of a rare combination. Of course in such a sector businesses of all sizes in many aspects of creating an efficient and low cost structure is in the effort. Retail industry has a complex and scattered structure. To manage the hundred stores which spread throughout the country, even thousands different stores on a world scale, and to create the same quality of service in each store is quite a though job. To achieve this, through a centralized information center to access all customer data, beyond geographical boundaries to ensure effective information sharing is required.

The management of the value chain of retail side is the most challenging. Retailers who are working with hundreds of different suppliers and who have to manage these relations in dozens of different areas are required to perform a full integration. Create a transparent structure between these retailer companies and suppliers, performing information sharing with each other effectively, and supporting each other's business processes are required.

Collaborative planning, forecasting and replenishment (CPFR) model which is a scheme integrating trading partners' internal and external information systems is proposed by Voluntary Inter-industry Commerce Standards Association (VICS) to assist establishing a collaborative supply chain structure in retail sector. As a result, by applying CPFR, companies can improve efficiencies across the supply chain, reduce inventories, improve service levels and increase sales (Aghazadeh, 2003; Aviv, 2007; Chan & Zhang, 2011; Chen, Yang, & Li, 2007; Dong & Xu, 2002; Holweg, Disney, Holmstrom, & Smaros, 2005; Kuk, 2004; Stedman, 1998; White, 2000). Though the collaborative initiatives apparently has positive effects on supply chain performance (Fliedner, 2003), it is hard to adopt and implement these kinds of structures and to reach the targeted goals.

There exist number of previous research focus on the reasons of failure in CPFR implementation and deciding the factors of success in retail sector. These researches used statistical methods such as analysis of variance (ANOVA) and multivariate analysis of variance (MANOVA) to determine crucial factors of success CPFR implementation in retail sector (Fu, Lin, & Chen, 2009). The weak side of these

* Corresponding author. Tel.: +90 212 227 4480; fax: +90 212 259 5557.
E-mail address: gulcin.buyukozkan@gmail.com (G. Büyüközkan).

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methods is they can not realize the importance of each factor. Thus, to step one further, there is a study on this topic that it offers using fuzzy analytical hierarchy process (AHP) to calculate the weights of each factor to understand the importance and priority of impact factors which influenced CPFR implementation (Fu et al., 2009).

In this study, it is offered to provide more accurate information as a valuable reference for retail sector. Hence, the aim of this paper is to analyze important factors of CPFR for three sub-systems to support its implementation effectiveness in retail sector. The strengths of all relationships were determined by experts. According to this expertise, we searched the dynamical of model.

To analyze the CPFR supporting factors, fuzzy cognitive map (FCM) approach is used. FCMs have proven particularly useful for solving problems in which a number of decision variable and uncontrollable variables are causality interrelated. FCMs are capable of modeling scenarios described in terms of significant events (or concepts) in the scenario and their cause-effect relationships. One of the most useful aspects of the FCM is its potential for use in decision support as a prediction tool (Kosko, 1986). Given an initial state of a system, represented by a set of values of its constituent concepts, a FCM can simulate its evolution over time to predict its future behavior. These features make FCM a very attractive tool for analyzing CPFR supporting factors. Moreover, FCM has successfully applied in a lot of areas such as strategic planning, information technology, electronic business and commerce, decision making, project management, investment analysis, medicine, environmental, ecological topics, airline service (Akgun, Kandakoglu, & Ozok, 2010; Hong & Han, 2002; Kang, Sangjae, & Choi, 2004; Lee & Han, 2000; Lee & Lee, 2003; Lee, Kim, & Lee, 2004; Papageorgiou, Markinos, & Gemptos, 2009; Rajaram & Das, 2010; Rodriguez-Repiso, Setchi, & Salmeron, 2007; Wei, Lu, & Yanchun, 2008; Xirogiannis & Glykas, 2007; Xirogiannis, Stefanou, & Glykas, 2004, 2008).

The paper is organized as follows. Firstly, the key concepts and definitions of the CPFR supporting factors are introduced. The FCM approach and its properties are then explained. In the following section, the methodology and the detailed description of our developed models for CPFR in retail industry are explained. The dynamical analysis of these proposed models are also given. Experimental results and dynamical behavior of the analyzed models are also presented in this section before the paper is concluded.

2. Research framework and background

2.1. Success factors of CPFR

The success factors of CPFR implementation are given into four groups.

2.1.1. Information sharing and system integration

Since CPFR initiatives are information intensive, information sharing is the basis of CPFR success (Hadaya & Cassivi, 2007; Li, 2002; Madberger, 2008; Simatupang & Sridharan, 2002, 2004; Yu, Ting, & Chen, 2010). It requires effective database linkages among SC members to sustain continuous information flows (Angulo, Nachtmann, & Waller, 2004; Bonde & Hvolby, 2004; Fliedner, 2003; Fu et al., 2009; Lambert & Cooper, 2000; Petersen, Handfield, & Ragatz, 2005; Yao, Dong, & Dresner, 2007; Yao, Evers, & Dresner, 2007). Information sharing between trading partners means that retailer and supplier exchange demand information and improves forecast accuracy while reducing demand and supply uncertainty and that makes the operational decisions such as production and logistics planning for both terms improved (Hadaya & Cassivi, 2007; Holweg et al., 2005; Yu et al., 2010). It makes the system able to have more visible and predictable demand in the system and allow collaborative forecasting (Holweg et al., 2005). Providing accurate and timely demand information results in decreasing in the bullwhip effect which causes excessive inventory, increased in costs and longer lead times in supply chain (SC) (Kumar & Kumar, 2003). Moreover, information sharing about common goals creates common understanding which augments SC decision making (VICS, 2002).

SCC is impossible unless the partners can get in touch with each others. Technological connectivity using information and communication technologies (ICT), is an important enabler which allows information sharing and coordination of SC initiatives (Aviv, 2007; Barratt & Oliveira, 2001; Chen et al., 2007; Dalton, 1998; Hvolby & Trienekens, 2010; Ireland & Bruce, 2000; Sanders & Premus, 2002; Simatupang & Sridharan, 2004; Su & Yang, 2010; Williams, Magee, & Suzuki, 1998). Firms which are operating in uncertain industry attend to adopt new technologies to be able to respond to the changing conditions (Williams et al., 1998). Technology can move collaboration on to a closer to real time for exchanging of shared information (Aviv, 2007; Barratt, 2004; Barratt & Oliveira, 2001; Dalton, 1998; Ellram & Edis, 1996; Hickey, 1999; Ireland & Bruce, 2000; Simatupang & Sridharan, 2004). Since system incompatibility is a barrier to be able to communicate (Basmaci, 2003; Parks, 2001), while selecting IT investment, it should be considered that how compatible the proposed technology is to industry standards and the firm's current IT infrastructure (Kuk, 2004). The more system compatibility with the manufacturers and their suppliers, the less development cost is required.

The use of electronic linkages such as EDI and the use of intranet to enhance collaboration of internal processes with enterprise resource planning (ERP) are getting important (Basmaci, 2003; Fliedner, 2003; Lambert & Cooper, 2000; Su & Yang, 2010). Using EDI technology and exchanging data under an EDI format result in allowing to for real time exchange in a easy way (Angulo et al., 2004; Bonde & Hvolby, 2004; Dong & Xu, 2002; Kuk, 2004; Lambert & Cooper, 2000; Li, 2002; Petersen et al., 2005; Selen, Deming, & Min, 2007; van Hoek, 1998; Yao et al., 2007).

Firms' size and structures, the decentralization of EDI adoption decisions are directly the effects of EDI adoption (Li, 2002; Yao et al., 2007). In addition, technological connectivity should be supported by policies that contribute a willingness to share relevant information timely (Fawcett, Magnan, & McCarter, 2008).

An effective formation of collaboration requires efficient communication between companies at all levels (Fu et al., 2009; Li, 2002; Madberger, 2008; van Hoek, 1998). Communicating frequently helps faster solving problem, trust and building relationship (Basmaci, 2003). Clear and broad lines of communication are required (Akkermans, Bogerd, & Doremalen, 2004; Frankel, Goldsby, & Whipple, 2002; Mohr & Spekman, 1994). Establishing regularly scheduled meetings with the purpose of discussing the forecast is also suggested (Danese, 2007; Hadaya & Cassivi, 2007). Open information sharing and continuous inter and intra improvements are another requirements for success collaboration (Li, 2002). Two aspects of communication behavior that address the extent to which the information exchanged is effective in an alliance include information sharing, and the level of information quality and participation assist greater transparency in the SC (Ellram & Edis, 1996) and play an important role in SCC (Lau & Lee, 2000; Patterson, Grimm, & Corsi, 2003; Stank, Daugherty, & Autry, 1999). Information quality means available, appropriate and accurate, able to move across the SC in a timely (Andraski, 1994; Hadaya & Cassivi, 2007; Whipple, Frankel, & Anselmi, 1999), being capable of using in making decision (Whipple et al., 1999) because of its adequacy (Andraski, 1994; Ellram & Edis, 1996), consistency and being easy to access (Andraski, 1994; Basmaci, 2003). Information participation refers to the extent to which partners engage jointly in planning and goal setting (Mohr

& Spekman, 1994). These two information attributes are closely related in a strategic supplier alliance and are critical in enabling both parties to coordinate their activities.

However, whereas information sharing aids in increasing efficiency and effectiveness, it can be costly to achieve (e.g. software design, development or purchase, human resource) (Chung & Leung, 2005; Fliedner, 2003; Yao et al., 2007). The high investment may make manufacturers discourage from using information exchange systems with suppliers. But it is known that to develop and maintain collaborative processes without jointed interfaces is also costly which constraints more trading partner relationship (Sherman, 1998). Thus, deciding how high level which companies would prefer to invest as information sharing cost is important. Due to a lack of trust and a fear that the information will be revealed to competitors, the chain members generally do not wish to share private information completely (Kuk, 2004) and make managers unwillingness to share information (Williams, 1994).

2.1.2. People management and development

Managers worry about being punished by short term financially oriented performance measures, unless the company's structure and culture can change quickly enough to support collaborative behavior (Fawcett et al., 2008). Thus, senior management support is crucial for implementing CPFR (Angulo et al., 2004; Chen et al., 2007; Ellram & Edis, 1996; Ireland & Bruce, 2000; McCharty & Golocic, 2002; Simatupang & Sridharan, 2004). They should be educated to the potential of CPFR and by the way, making the decision of "get on train or get left behind" can easily be done. Providing supply chain training throughout the organization and the supply chain is also important (Andrews, 2008; Fawcett et al., 2008; Li, 2002). By the way, understanding CPFR processes, the implications of change, potential benefits of CPFR and the importance of supporting such initiatives can be implemented easily in a company through the training and education of the personnel (Aastrup, Kotzab, Grant, Teller, & Bjerre, 2008; Andrews, 2008; Fu et al., 2009; Li, 2002; McCharty & Golocic, 2002). All employees should be informed about the implementation (Aastrup et al., 2008).

To capture all the benefits of CPFR, a cross functional support and inter organizational approach to planning and implementation must occur (Angulo et al., 2004; Dong, Xu, & Dresner, 2007; Ellram & Edis, 1996; Fu et al., 2009). Internally collaboration is not also about integrating processes between SC related functions (e.g. purchasing, manufacturing, logistics), but also needs to include marketing (Ireland & Bruce, 2000) and R&D activities (Schenck, 1998). Many companies use intranet to enhance collaboration of internal processes with various ERP planning systems (Dalton, 1998; Hickey, 1999). Cross functional team helps understanding of opportunities and challenges, strengthening the relationships (Basmaci, 2003).

Intra-organizational support in the shape of top management support (Aastrup et al., 2008; Dong & Xu, 2002; Ellram & Edis, 1996; Fu et al., 2009; Ireland & Bruce, 2000; Yao et al., 2007) and in terms of gaining the supports of other parts of the organization e.g. purchasing and manufacturing is needed for a process focus for collaboration (Hogarth-Scott, 1999; Ireland & Bruce, 2000). Where senior management commitment is lacking, directing CPFR process are generally unable to obtain the cross functional team commitment and information sharing which are needed (Angulo et al., 2004). Thus, the type of the managers is also important factor. Good managers make employees easier to be accustomed to sharing information with colleagues, customers and suppliers, or even making joint decision (Chen et al., 2007; Ireland & Bruce, 2000).

The other crucial factor is organizational readiness (Andrews, 2008; Fawcett et al., 2008). While the previous SC models used simple tools like spreadsheets in order to satisfy inventory levels and to manage replenishment planning, mature SC of today uses advanced planning software that employ cross-functional teams to serve for the same goal. Even latest organizations are characterized by robust process including consensus-based forecasting (Andrews, 2008). It is also important that organizational culture is suitable for collaboration, that is to say that it is open to share information and the employees of company do not resist the changing needed for collaboration (Chen et al., 2007).

Cultural differences between the partners are the hurdles of being collaborated (Chen et al., 2007). They become problem in planning, problem detection, situation, awareness, uncertainty management and decision making and create conflicts among the trading partners (He, 2009).

Organizational culture, the effect of trust, teamwork and reward systems etc. have positive effects on the exchange of information (Chen et al., 2007; Wu, Shih, & Chan, 2009). From both an internal and external viewpoint, a culture of openness and honesty is needed too (Fawcett et al., 2008; Hogarth-Scott, 1999; Mohr & Spekman, 1994; Spekman, Kamauff, & Myhr, 1998; Stank et al., 1999). By the way it is provided trust, respect and commitment as a result of improved certainty and reliability (Hoyt & Hug, 2000; Popp, 2000; Whipple & Frankel, 2000).

Level of employee involvement and organizational size are other crucial factors (Kuk, 2004). Organizations with high levels of employee involvement are more likely to accomplish the potential value while large organizations have more slack resources in technology adoption and implementation than small organizations (Kuk, 2004).

Organizations' readiness is the other supporting factor which refers having adequate technological capacity, educated employees, financial sufficiency and willingness and organizational culture to collaborate with trading partners (Andrews, 2008; Fawcett et al., 2008).

Beside of having their own technological capacity, firms also have partners which have technological capacity and connectivity between them. Thus, trading partners' readiness is also important (Madberger, 2008). If it exists, it means that there is trust between partners and organizations persuade to share information. Thus, the supplier selection is the most important step in creating a successful collaboration (Ireland, Hitt, & Vaidyanaht, 2002; Lee, 2009; Liao, Chang, & Lee, 2008; Wu et al., 2009).

2.1.3. Relationship management and trust building

A few suppliers or retailers may make deal with adversaries and share information that can give harm to a partner (Barratt & Oliveira, 2001; Kuk, 2004; Williams, 1994). Thus, long term supplier partnership is trustworthy and reduces the potential for collusive activities (Barratt & Oliveira, 2001; Fliedner, 2003). Long term relationships improve the strength between the partners and this is one of the factors that affect the success of CPFR (Fawcett et al., 2008). It provides confidence among the partners and thus, collaboration between organizations in the same supply chain will be sustained (Barratt & Oliveira, 2001; Fliedner, 2003). Long term objective for organizations is also supporter to develop trust (Dong et al., 2007). Trust is an important component of alliances, and several studies confirm the importance of trust and coordination in cooperative relationships (Aastrup et al., 2008; Angulo et al., 2004; Chen et al., 2007; Hvolby & Trienekens, 2010; Madberger, 2008; Monczka, Petersen, & Handfield, 1998; Stedman, 1998). Trust and commitment result in greater openness between trading partners and much information sharing and as a result greater knowledge for each other's contribution to the relationship (Dong et al., 2007; Fu et al., 2009; Li, 2002; Wu et al., 2009). SCM theory advocates that the use of one or few long-term collaborative suppliers selected on the basis of trust results in heightened

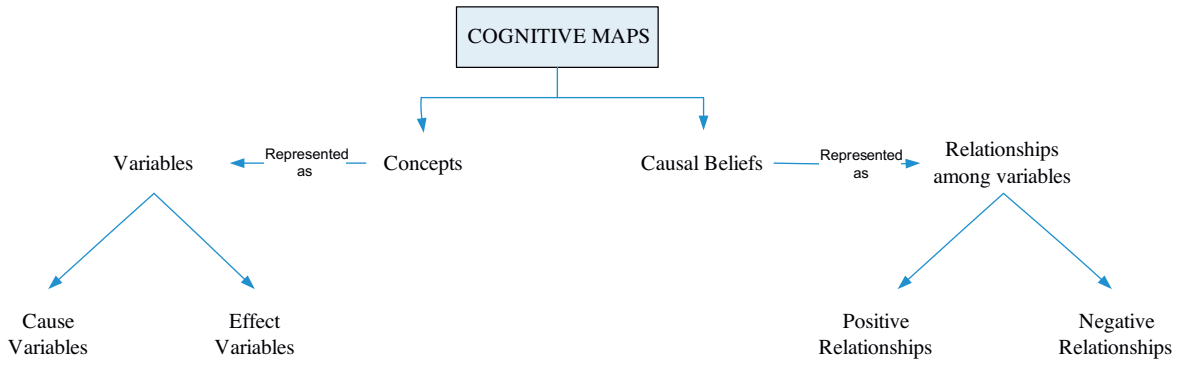

Fig. 1. The elements of the CM (Rodriguez-Repiso et al., 2007).

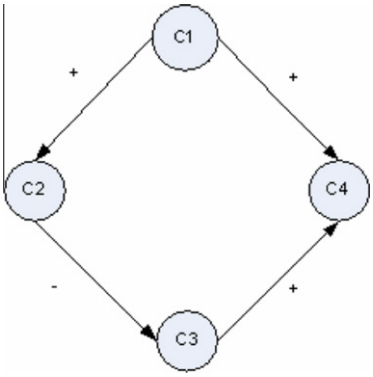

Fig. 2a. A simple example of a CM.

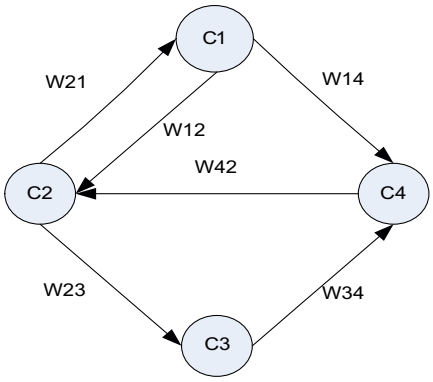

Fig. 2b. A simple example of FCM.

operational benefits for the firms involved (Lee, 2009; Lee & Whang, 2000; Spekman et al., 1998).

Collaboration requires a durable relationship and having a strong commitment among the partners to a common and transparent goal (Aastrup et al., 2008; Dong & Xu, 2002; Li, 2002; Wu et al., 2009; Yao et al., 2007). Selection for collaborative partner is also important and thus there are many researches which deal with this issue (He, 2009; Li, 2002; Mentzer, 2001). For that a possible approach is as follows (Barratt & Oliveira, 2001).

- Define single point of contract for each trading partner. By the way information is neither lost or nor deteriorates during its flow between the trading partners. The collaboration must be planned and maintained (Cassivi, 2006). Collaboration face to face between trading partners or electronically collaboration is used in order to develop the forecast successfully because the fact that most accurate information is occurred.
- Define agenda for collaboration in short-medium-long term. It helps stabilizing the collaborative goals across the time.
- Being able to have logistics/supply integration is also important (Kuk, 2004). Organizations should look for collaborative partners who can provide online SC visibility and connectivity to perform distribution and customer service functions (Kuk, 2004).

To initiate an effective CPFR relationship, a collaborative agreement between trading partners must ensure cost savings and revenue enhancements for both parties in order to name the agreement as a success (Andrews, 2008; Chen et al., 2007; Hvolby & Trienekens, 2010). However, it should be paid attention that the trading partners would perceive the equity which is related to the division of benefits and burdens (Dong et al., 2007). Unbalanced division of benefits and risks is the barrier to implementation. Be

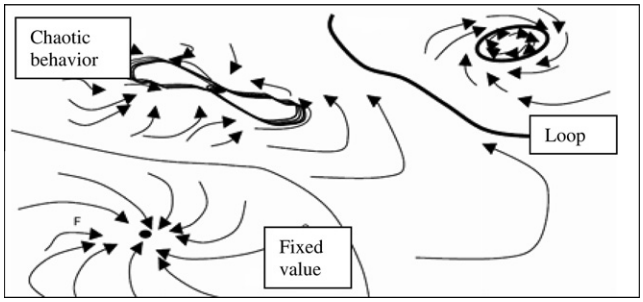

Fig. 3. Three possible situations (Yaman, 2006).

able to prevent this, conducting joint visioning, developing a mission statement, clearly defining roles, responsibilities and expectations, preparing detailed operating plans are necessary (Andrews, 2008; Chen et al., 2007; Khan & Mentzer, 1996). They all provides a picture of SCC and also opportunities for improvement at both the individual firm and the overall supply chain levels are highlighted (Basmaci, 2003). There have to be mutual agreed objectives aligned to corporate strategies (Barratt & Oliveira, 2001; Fu et al., 2009; Holweg et al., 2005; Mentzer, 2001; Wu et al., 2009), mutual benefits arising from the collaboration (Andrews, 2008; Fu et al., 2009; Naoum, 2003) and mutual risk sharing (Boddy, Cahill, Charles, Kraus, & Macbeth, 1998; Mclvor & McHugh, 2000).

For internal collaboration management reports, common goals and vision, shared resources are requires (Yoshino & Rangan, 1995). Strategic elements including intra-organizational support, the corporate focus, demonstrating the business case and the role of the technology are to sustain the collaboration (Yoshino &

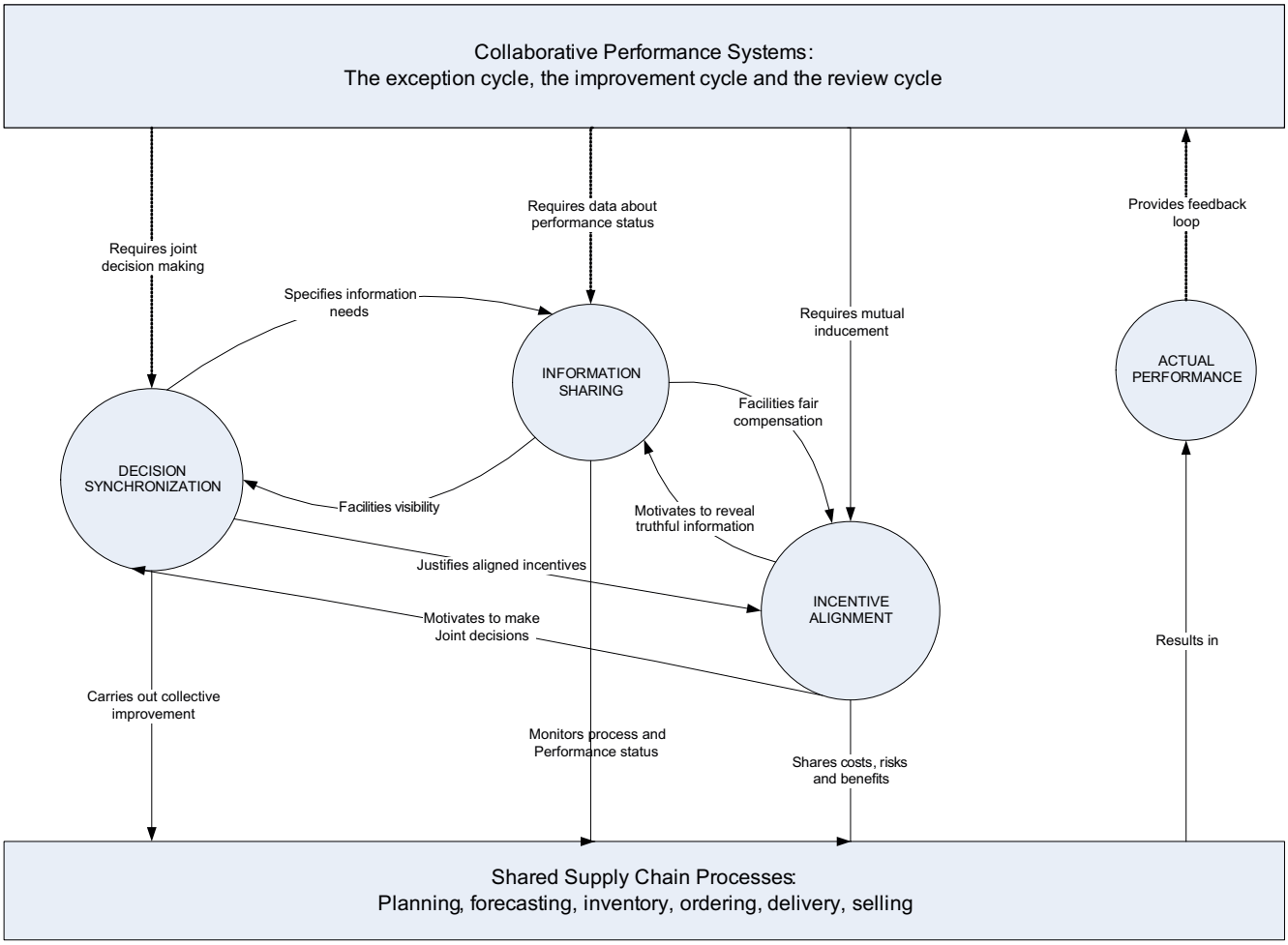

Fig. 4. A conceptual model for supply chain collaboration (Simatupang & Sridharan, 2004).

Rangan, 1995). Participants in the collaboration must commit resources. Commitment to a relationship is most frequently demonstrated by committing resources to the relationship, which may occur in the form of an organization's time, money, facilities, etc. (Monczka et al., 1998). Several studies have found a relationship between resource commitment and the joint action or continuity between parties within inter-organizational relationships (Monczka et al., 1998; Yoshino & Rangan, 1995). Good connectivity between customer and the supplier which the suppliers have direct access to consumption information to make better forecast and better respond to the customer's inventory needs in terms of quantities to ship and locations to replenish. The replenishment decisions made by supplier are then more likely to be accurate and the orders generated for the customers are more likely to meet the true demand in the marketplace (Kuk, 2004).

2.1.4. Other factors

For success collaborative forecasting, organizations must establish their own internal forecasting processes which are consistent, systematic and appropriate. Because it positively impact performance through decreased operations costs, improved customer service, increased sales and reductions inventory. However, joint decision making is also needed in the area of forecasting (Barratt, 2004; Ireland & Bruce, 2000). Most organizations develop forecasts based on orders receiving from their own customers and upon historical data. If this situation is considered in supply chain, there exists dramatic problems in demand that occurs in functionally oriented supply chains because of the fact that there are multiple forecasts developed trading partners and each with a small degree of error (Ireland & Bruce, 2000; Sabath & Fontanella, 2002).

Organizations in supply chain must have the same performance measures to be success in collaboration (Angulo et al., 2004; Ellram & Edis, 1996). If not, the performance measures in place produce conflicting both internally and externally. If has, it helps organizations to improve overall performance (Ireland & Bruce, 2000). By sharing performance metrics with customers and suppliers bottlenecks in the supply chain (inventory stockpiles and process gaps) can be identified.

System security and system complexity influence the implementation of CPFR model (Basmaci, 2003; Fawcett et al., 2008; Fu et al., 2009; Pohlen & Goldsby, 2003). Rationalization initiatives are required (Fawcett et al., 2008). Be able to do this, the suppliers and customers should be evaluated and classified through the form of ABC classification. Segmentation is needed to collaborate with a small number of strategically important customers and suppliers (Elvander, Sarpola, & Mattson, 2007; Mentzer, 2001; Selen et al., 2007).

2.2. Overview of FCMs

2.2.1. The concept of CM & FCM

The concept of CMs, which are the origin of FCMs, is first proposed by Tolman (1948). CMs have been used for representing the cause and effect relationships which are perceived to exist

Table 1
The success factors of information sharing sub-system in retail industry.

Factor number	Success factors of information sharing sub-system in retail industry
1	Good ICT infrastructure, like EDI
2	Trust among SC members
3	Continuous information sharing
4	Heterogeneity and hostility of industrial environment
5	Information quality
6	Partner communication
7	Unwillingness of managers to share information
8	Openness of communication
9	The leakage of information sharing
10	Firms' technological capacity
11	Information sharing cost
12	Cross department support
13	System security
14	Incentive alignment
15	Effectiveness of partner selection
16	System compatibility
17	Organizational readiness
18	Trading partners' readiness
19	Trading partners' technical readiness
20	Effective database linkages
21	Integration of systems
22	Intensity of communication
23	Information transparency
24	Clearly identified and broad, direct communication channels
25	Regularly scheduled meetings
26	Clarity about demand
27	Effectiveness of decision making to plan and control SC operations
28	Accurate forecasts
29	Increased of the bullwhip effect
30	Timely and relevant information
31	Differences in technologies and systems employed by partners
32	Intensive information
33	Personnel trainee
34	Culture of openness and honesty
35	Increased inventory
36	Level of SC/logistics integration
37	Lower employee involvement
38	Increased in organizational size
39	Information reliability
40	Increased in cost
41	Business performance

Table 2
The success factors of decision synchronization sub-system in retail industry.

Factor number	Success Factors of decision synchronization sub-system in retail industry
1	System complexity
2	Information quality
3	Intensity of communication
4	Effective database linkages
5	Effectiveness of partner selection
6	Trust among partners
7	Good ICT infrastructure
8	Differences in power
9	Unwillingness of managers to share information
10	Improved business performance
11	Improved customers' perception of fulfillment
12	The gap between delivery requirements and actual delivery
13	Heterogeneity and hostility of industrial environment
14	The uncertainty in management
15	Timely and relevant information
16	Cultural differences
17	Incentive alignment
18	Cross department support
19	Clarity about demand
20	Increased in bullwhip effect
21	Continuous information sharing
22	Effectiveness of joint decision making to plan and control of SC operations
23	Decision synchronization
24	The frequency of interactions between partners
25	Organizational readiness
26	Strength of relationships
27	Increased in cost
28	Openness of communication
29	Level of SC/logistics integration
30	Regularly scheduled meetings
31	Face to face communication
32	Clearly and identified broad line communication channels
33	Lower employee involvement
34	Making commitment
35	Long-term relationship
36	Buyer–supplier cooperation
37	Common performance metrics
38	Mutual benefits

among the elements of a given environment in political and social sciences (Lee, Kim, Chung, & Kwon, 2002; Tolman, 1948). Then, it is claimed by Axelrod (1976) that CM with causality value "+" and "−" is sufficient for replicating human cognition because of the fact that decision makers do not use more complicated set of relationships (Lee et al., 2002). CMs can be defined as a signed graph which are designed to represent the causal assertions and belief system of a person (or group of experts) with respect to a specific domain, and use that statement in order to analyze the effects of a certain choice on particular objectives (Asher, 1983; Bueno & Salmeron, 2008; Eden & Ackermann, 2004). CMs have two elements: concepts and causal belief. Concepts are the variables that represent the belief system of a person and the causal belief consists in the causal decencies between these variables (Axelrod, 1976). Such variables can be continuous, ordinal or dichotomous. The elements of the CM are shown in Fig. 1 (Rodriguez-Repiso et al., 2007).

In signed CMs, each relationship is linked to a sign that represents the sense of causal influence of the cause variable on the effect variable. Fig. 2a shows a graphical representation of weighted CMs in which the nodes are variable concepts and the edges are causal connections. If the edge from node C_1 to node C_2 is positive, an increase or decrease in C_1 causes a change in the same direction in C_2. If the relationship is negative, the change that the effect variable undergoes is in the opposite direction.

There are two rules that is used while determining the directions of the effect caused by changes in cause variables (Rodriguez-Repiso et al., 2007). The indirect effect of a path, $I\ (C_2, C_4)$, from a cause variable C_2 to an effect variable C_4 is positive if the path has an even number of negative arrows. On the other hand, it is negative if it has an odd number or negative arrows. As an example; the indirect effect of path $P\ (C_2, C_4)$ is therefore negative.

The total effect of a cause variable on an effect variable can be calculated with the summation of all the indirect effects from the cause variable to the effect variable. According to the Fig. 2a, the total effect of variable C_2 to variable C_4, $T\ (C_2, C_4)$ is the sum of the indirect effect of C_2 to C_4 through the path $P\ (C_2, C_3, C_4)$ which means that is negative.

However, with CMs, it can be only the centrality of concepts and the directions of the effect of one concept to another is analyzed (Feyzioglu, Buyukozkan, & Ersoy, 2007). The impossibility of quantifying relationships among variables is the main limitation of the CMs (Bueno & Salmeron, 2008; Feyzioglu et al., 2007). More specific and information rich, CMs should show not only the directions with signs, but also it should represent the magnitude of the change (Rodriguez-Repiso et al., 2007). Weighting the CMs with fuzzy weights offers a solution to this weakness (Lee et al., 2002; Bueno & Salmeron, 2008) and by eliminating the indeterminacy problem of signed maps where it is not possible to determine the total effect which is the result of negative or positive effects (Rodriguez-Repiso et al., 2007).

In this context, FCMs were introduced in 1986 by Kosko (1992) to extend the idea of the CMs which is proposed by Axelrod (1976) by

Table 3
The success factors of incentive alignment sub-system in retail industry.

Factor number	Success factors of incentive alignment sub-system in retail industry
1	Risk sharing
2	Sharing cost
3	Strength of relationship
4	Trading partners' readiness
5	Trust among partners
6	Uncertainty management
7	Information quality
8	Defining specific roles of individual SC members
9	Sharing resources
10	Unwillingness of managers to share information
11	Documented business principles/procedures/policies
12	The awareness of firms to competitor actions
13	Differences in power
14	Increased in conflict
15	Greater satisfaction
16	Making commitment
17	Mutual benefits
18	Long-term relationship
19	Unbalanced division of benefits and risks
20	Common SC vision and objectives
21	Availability of benefits for both parties
22	Information sharing cost
23	Increased in cost
24	Continuous information sharing
25	Cross department support
26	Effectiveness of partner selection
27	Rewarding system for project team
28	SC knowledge of the top management
29	Sponsorship
30	Good ICT infrastructure, like EDI
31	Informing all employee about CPFR implementation
32	Information transparency
33	High employee involvement
34	Transparency of SC
35	Incentive alignment
36	The frequency of integration between partners
37	Integration of systems
38	Personnel trainee
39	Faster mutual understanding
40	The leakage effect of information sharing
41	Common performance metrics
42	Quick adoption of innovative technology

allowing the concepts to be represented linguistically with an associated fuzzy set rather than requiring them to be precise (Kosko, 1986, 1992, 1997; Kosko & Dickerson, 1994). In order to describe the degree of the relationships between $[0,1]$ and $[-1,1]$ or use linguistic terms, such as "often", "always", "some", "a lot", etc. while in traditional CMs, the values of concepts take 0 or 1 (Kosko, 1986). It may be also described as a graphical representation that includes nodes indicating the most relevant factors of a decisional environment and links between these nodes representing the relationships between these factors (Lee et al., 2002; Williams et al., 1998) by using fuzzy numbers. Fig. 2b shows a simple example of FCM.

As it is mentioned in the CMs, each concepts stands for events, actions, inputs and outputs, goals, values, trends of the system that is modeled and these nodes (concepts) interact with each other showing the dynamics of the model. The connection edges between concepts whose weights have been inferred through a method based on fuzzy rules, are directed and they indicate the direction of causal relationships while each weighted edge includes information on the type and the degree of the relationship between the interconnected concepts. Because of all the values in the graph being fuzzy, concepts take values in the range between $[0,1]$ and the weights of the arcs are in the interval $[-1,1]$. Observing the graphical representation, it makes clear which concept influences other concepts showing the interconnections between concepts. Also, it permits updating in the construction of the graph, such as the adding or deleting of an interconnection or a concept.

There are three possible types of causal relationships that express the type of influence from one to other concepts. The weight has a positive number when the relationship between the concepts (or nodes) is directly related, zero when there is no correlation, and a negative number when the relationship is indirectly related.

Beyond the graphical representation of the FCM, there is its mathematical model. It consists of an $[1 \times n]$ state vector A which includes the values of the n concepts and an $[n \times n]$ weight matrix W which gathers the weights Wij of the interconnections between the n concepts of the FCM. The matrix W has n rows and n columns where n equals the total number of distinct concepts of the FCM and the matrix diagonal is zero since it is assumed that no concept causes itself.

Table 4
The terms of variable "Influence" and the membership values of these terms.

Negatively very strong (NVS)	μ_{nvs}	Negatively strong (NS)	μ_{ns}	Negatively medium (NM)	μ_{nm}
Negatively weak (NW)	μ_{nw}	Zero (Z)	μ_{z}	Positively weak (PW)	μ_{pw}
Positively medium (PM)	μ_{pm}	Positively strong (PS)	μ_{ps}	Positively very strong (PVS)	μ_{pws}

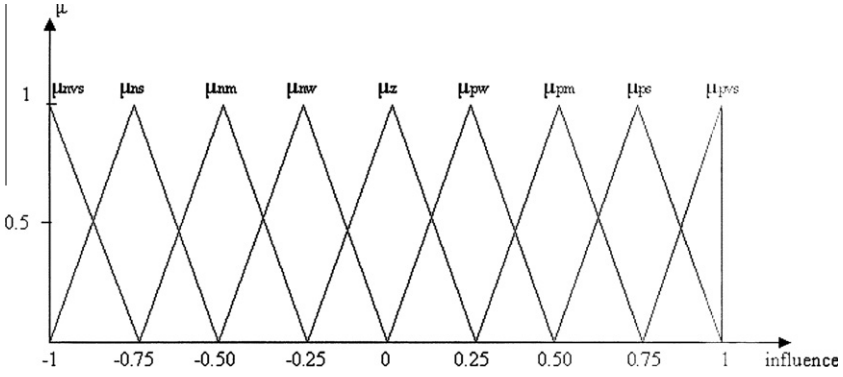

Fig. 5. The membership functions of the variable "Influence" (Stylios & Groumpos, 2004).

Table 5
The IMS matrix of information sharing sub-system via expert 1.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
1	Z	z	PVS	z	PS	PS	z	z	z	z	PM	z	PS	z	z	PS	z	z	z	PS	PVS	PS	PM	PVS	z	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z
2	Z	z	PVS	z	z	z	z	PVS	NS	z	z	z	PVS	z	z	z	PM	PS	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
3	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PM	PS	NM	PVS	z	z	z	z	z	z	z	z	z	z	z
4	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	NW	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
5	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	PS	z	z
6	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
7	z	z	NVS	z	z	z	z	z	z	z	z	z	z	NVS	z	z	z	z	z	z	z	z	z	z	NM	z	z	z	z	NS	z	z	z	z	z	PM	z	z	z	z	z
8	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
9	z	NVS	NVS	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	NM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
10	z	z	z	z	PM	z	z	z	z	z	NVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PM	z	z	z	z	z	z	PS	z	z
11	z	z	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z
12	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	PVS	z	z	z	z	z	z	z	NS	z	z	z	z
13	z	z	z	z	z	z	z	z	z	z	NVS	z	z	z	z	z	z	z	z	PW	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z
14	z	PVS	PS	NW	PS	z	z	z	NVS	z	z	z	z	z	z	z	z	PM	z	z	PM	z	z	z	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z
15	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PW	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
16	PW	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
17	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
18	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
19	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
20	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z
21	z	z	PS	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z
22	z	z	PM	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
23	z	z	z	z	PS	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z
24	z	z	z	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
25	z	PW	PW	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PM	z	z	z	z	z	z	z	PW	z	z	z	z	z	z	z	z	z	z	z
26	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	PVS	NS	z	z	z	z	z	z	z	z	z	z	z	z
27	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS
28	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	z	z	z	z	z	z	NVS	z	z	z	z	z	z
29	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	z	z	z	PVS	z
30	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
31	z	z	NM	z	z	z	z	z	NW	z	z	z	z	z	z	NVS	z	z	z	z	NS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
32	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
33	z	z	z	z	z	z	z	z	NW	z	z	z	z	z	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
34	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
35	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z
36	z	z	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	NVS	z	z
37	z	z	NS	z	NM	z	z	z	z	z	z	NS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
38	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	NW	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
39	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
40	z	z	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	NM
41	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	NW	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z

Table 6
The IMS matrix of information sharing sub-system via expert 2.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
1	Z	z	PS	z	PVS	PVS	z	z	z	z	z	z	PS	z	z	PS	z	z	z	PVS	PVS	PVS	PW	PVS	z	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z
2	Z	z	PVS	z	z	z	z	PVS	NVS	z	z	z	PVS	z	z	z	PM	PS	z	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
3	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	PVS	NS	PVS	z	z	z	z	z	z	z	z	z	z	z	z
4	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	NM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
5	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	PS	z	z
6	z	z	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
7	z	z	NVS	z	z	z	z	z	z	z	z	z	z	NVS	z	z	z	z	z	z	z	z	z	z	NM	z	z	z	z	NM	z	z	z	z	z	z	PM	z	z	z	z
8	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
9	z	NVS	NVS	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	NM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
10	z	z	z	z	PM	z	z	z	z	z	NVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PM	z	z	z	z	z	z	PS	z	z
11	z	z	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z
12	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	PVS	z	z	z	z	z	z	z	NS	z	z	z	z
13	z	z	z	z	z	z	z	z	z	z	NVS	z	z	z	z	z	z	z	z	PW	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z
14	z	PS	PS	NW	PS	z	z	z	NVS	z	z	z	z	z	z	z	z	PM	z	z	PW	z	z	z	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z
15	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	PW	z	PW	z	z	z	z	z	z	z	z	z	z	z	z	z	PM	z	z	z	z	z	z	z	z	z
16	PW	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
17	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
18	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
19	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
20	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z
21	z	z	PVS	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z
22	z	z	PM	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
23	z	z	z	z	PVS	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
24	z	z	z	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
25	z	PW	PW	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	z	z	z	z	z	z	PM	z	z	z	z	z	z	z	z	z	z	z
26	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	PVS	NS	z	z	z	z	z	z	z	z	z	z	z	z	z
27	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS
28	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z	z	z	z	z	z	NVS	z	z	z	z	z	z
29	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	z	z	z	PS	z
30	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
31	z	z	NM	z	NW	z	z	z	z	z	z	z	z	z	z	NS	z	z	z	z	NVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
32	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
33	z	z	z	z	z	z	z	z	NM	z	z	z	z	z	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
34	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
35	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z
36	z	z	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	NVS	z	z
37	z	z	NS	z	NM	z	z	z	z	z	z	NS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
38	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	NW	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
39	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
40	z	z	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	NM
41	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z

Table 7
The IMS matrix of information sharing sub-system via expert 3.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
1	Z	z	PVS	z	PS	PS	z	z	z	z	PM	z	PS	z	z	PS	z	z	z	PS	PVS	PS	PM	PVS	z	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z
2	Z	z	PVS	z	z	z	z	PVS	NS	z	z	z	PVS	z	z	z	PM	PS	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
3	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PM	PS	NM	PVS	z	z	z	z	z	z	z	z	z	z	z
4	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	NW	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
5	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	PS	z	z
6	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
7	z	z	NVS	z	z	z	z	z	z	z	z	z	z	NVS	z	z	z	z	z	z	z	z	z	z	NM	z	z	z	z	NS	z	z	z	z	z	z	PM	z	z	z	z
8	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
9	z	NVS	NVS	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	NM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
10	z	z	z	z	PM	z	z	z	z	z	NVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PM	z	z	z	z	z	z	PS	z	z
11	z	z	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z
12	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	PVS	z	z	z	z	z	z	z	NS	z	z	z	z
13	z	z	z	z	z	z	z	z	z	z	NVS	z	z	z	z	z	z	z	z	PW	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z
14	z	PVS	PS	NW	PS	z	z	z	NVS	z	z	z	z	z	z	z	z	PM	z	z	PM	z	z	z	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z
15	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PW	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
16	PW	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
17	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
18	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
19	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
20	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z
21	z	z	PS	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z
22	z	z	PM	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
23	z	z	z	z	PS	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z
24	z	z	z	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
25	z	PW	PW	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PM	z	z	z	z	z	z	z	PW	z	z	z	z	z	z	z	z	z	z	z
26	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	PVS	NS	z	z	z	z	z	z	z	z	z	z	z	z
27	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z
28	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	z	z	z	z	z	z	NVS	z	z	z	z	z	z
29	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	z	z	z	PVS	z
30	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
31	z	z	NM	z	z	z	z	z	NW	z	z	z	z	z	z	NVS	z	z	z	z	NS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
32	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
33	z	z	z	z	z	z	z	z	NW	z	z	z	z	z	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
34	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
35	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z
36	z	z	z	z	PM	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	NVS	z	z
37	z	z	NS	z	NM	z	z	z	z	z	z	NS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
38	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	NW	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
39	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	PVS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
40	z	z	z	z	z	z	PS	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	NM
41	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	NW	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z

Each concept has a number A_i that represents its value and it results from the transformation of the fuzzy real value of the system's variable. The weights of the arcs between concept C_i and concept C_j are represented with the symbol W_{ij}. The value A_i of concept C_i expresses the degree which corresponds to its physical value. At each simulation step, the value A_i of a concept C_i is calculated by computing the influence of the interconnected concepts C_j's on the specific concept C_i following the calculation rule (Kosko, 1986):

$$A_i^{(k+1)} = f\left(A_i^{(k)} + \sum_{\substack{j=1 \\ j \neq i}}^{N} A_j^{(k)} W_{ji}\right) \quad (1)$$

where $A_i^{(k+1)}$ is the value of concept C_i at simulation step $k+1$, $A_i^{(k)}$ is the value of concept C_j at simulation step k, f is the threshold function. The new vector shows the effect of the change in the value of one concept in the entire FCM. The type of f varies, but the most common choices are as bivalent, trivalent, logistics and sigmoid functions.

The logistics function; where $\lambda > 0$

$$f = \frac{1}{1+e^{-\lambda x}} \text{ is used.} \quad (2)$$

When concepts can be negative and their values belong to the interval $[-1,1]$ as in this article, the sigmoid function $f(x) = \tanh(x)$ is the most suitable to use (Kosko, 1986).

After the initial values of each of the concepts of the input vector and the weighted arcs are introduced by experts' belief, the system is free to interact till the model reaches the three possible situations (see Fig. 3) that are as follows (Yaman, 2006):

- A fixed equilibrium is reached, with the output values, being decimals in the interval, stabilizing at fixed numerical values.
- A limited cycle is reached with the output values falling in a loop of numerical values under a specific time period.
- A chaotic behavior is exhibited.

Starting the simulations with different initial vectors, it can be observed the dynamical behavior of system for different initial situations and FCMs are support "what–if" analysis (Lee et al., 2004).

3. Modeling of CPFR using FCM approach in retail industry

Based on the factors identified in the Section 2.1, some conceptual models for CPFR and sub-systems are developed. Fig. 4 represents a conceptual model for supply chain collaboration, in other words, a general model for CPFR (Simatupang & Sridharan, 2004). We focus on three sub-systems of CPFR: Information sharing, decision synchronization, incentive alignment. These systems are required to facilitate the chain members engaging in a cross-organizational cooperation that enables them to realize better overall performance (Simatupang & Sridharan, 2004).

This section is summarized in two sub-sections: Constructing the FCMs of CPFR sub systems and analyzing dynamical behavior of the developed FCMs.

3.1. Constructing the FCMs

Procedure for creating a targeted FCM requires three matrices which are Initial Matrix of Success Factors (IMS), Aggregated Matrix of Success Factors (AMS) and Weight Matrix of Success Factors (WMS). The graphical representation of WMS gives the FCM (Stylios & Groumpos, 2004).

3.1.1. Data acquisition

Data are collected from interviewing with three experts who are familiar to CPFR implementation of retail industry. The backgrounds of these experts are given as following.

One of them worked as a Customer Service Manager, Planning and Logistics Manager in P& G in the area of Turkey, Ukraine, Russia, Middle East, and Caucasian Region. From 2001 to 2008, he worked as a Supply Chain Director in L'Oréal Türkiye. Now he continues his career as a consultant on private logistics projects in his own consulting company. He has some studies about collaborative activities, EDI and score carding. The second one started his career in P& G as a Process Engineer. Then, he moved to Arthur Andersen Consulting and worked about supply chain topics. He served as Distribution Center Manager in L'Oréal Türkiye and after this experience; he worked in DHL Supply Chain Company as an Operation Manager. Other expert started working in L'Oréal Türkiye. After she had some experience in product planning, inventory management, demand forecasting, she has worked as a Customer Service Manager.

The success factors which are obtained from the literature survey were asked the experts to evaluate which are the important factors for implementing CPFR, for its three sub-system, in retail industry. To do this, the survey sent as e-mail to the experts. After specified the crucial supporting factors for all sub-systems given in Tables 1–3, the pair-wise questionnaire was designed and distributed to experts. Sequentially, the data obtained from the interviews were then used in constructing the IMS matrices for three sub-systems. Experts can know which concepts of the system influence other concepts and then, they determine whether the effect is negative or positive with a fuzzy degree of causation. The causal interrelationships among concepts are assigned using linguistic variable *Influence* according to expert views about success CPFR implementation in retail industry. This linguistic variable takes values in the Universe $U = [-1,1]$. Its term set which

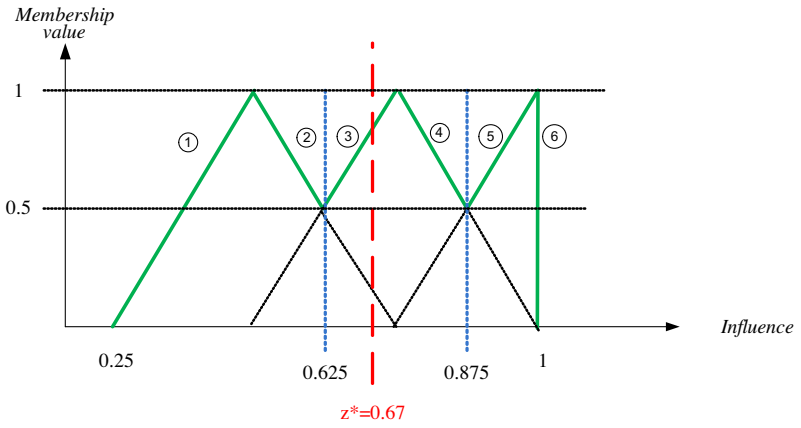

Fig. 6. The output of PM, PS and PVS.

Table 8
The WMS matrix of information sharing sub-system in retail industry.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
1	0	0	0.79	0	0.79	0.79	0	0	0	0	0.25	0	0.75	0	0	0.75	0	0	0	0.79	0.92	0.79	0.375	0.92	0	0	0	0	0	0.79	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0.92	0	0	0	0	0.92	−0.79	0	0	0	0.92	0	0	0	0.5	0.75	0	0	0	0.625	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.67	0.79	−0.625	0.92	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.375	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.92	0	0	0	0.92	0	0	0	0	0	0	0	0	0	0	0.75	0	0
6	0	0	0	0	0.625	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	−0.92	0	0	0	0	0	0	0	0	0	0	−0.92	0	0	0	0	0	0	0	0	0	0	−0.25	0	0	0	0	−0.625	0	0	0	0	0	0.5	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	−0.92	−0.92	0	0	0	0.79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0.5	0	0	0	0	0	−0.92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0.75	0	0
11	0	0	0	0	0	0	0.92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.92	0
12	0	0	0.92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.92	0	0.92	0	0	0	0	0	0	0	−0.75	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	−0.92	0	0	0	0	0	0	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.92	0	0
14	0	0.79	0.75	−0.25	0.75	0	0	0	−0.92	0	0	0	0	0	0	0	0	0.5	0	0	0.375	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0.79	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0	0	0	0	0
16	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.79	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.79	0	0	0	0	0	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0.79	0	0	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.79	0	0	0	0	0	0	0	0	0
22	0	0	0.5	0	0.92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0.79	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0.375	0.25	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.67	0	0	0	0	0	0	0	0.375	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.92	0.92	0.92	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.92
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.79	0	0	0	0	0	0	0	−0.92	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.79	0	0	0	0	0.79	0
30	0	0	0	0	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	−0.25	0	−0.125	0	0	0	−0.125	0	0.125	0	0	0	0	−0.79	0	0	0	0	−0.79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	−0.375	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.92	0
36	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−0.92	0
37	0	0	−0.75	0	−0.5	0	0	0	0	0	0	−0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−0.125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0.92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	−0.5
41	0	0.92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

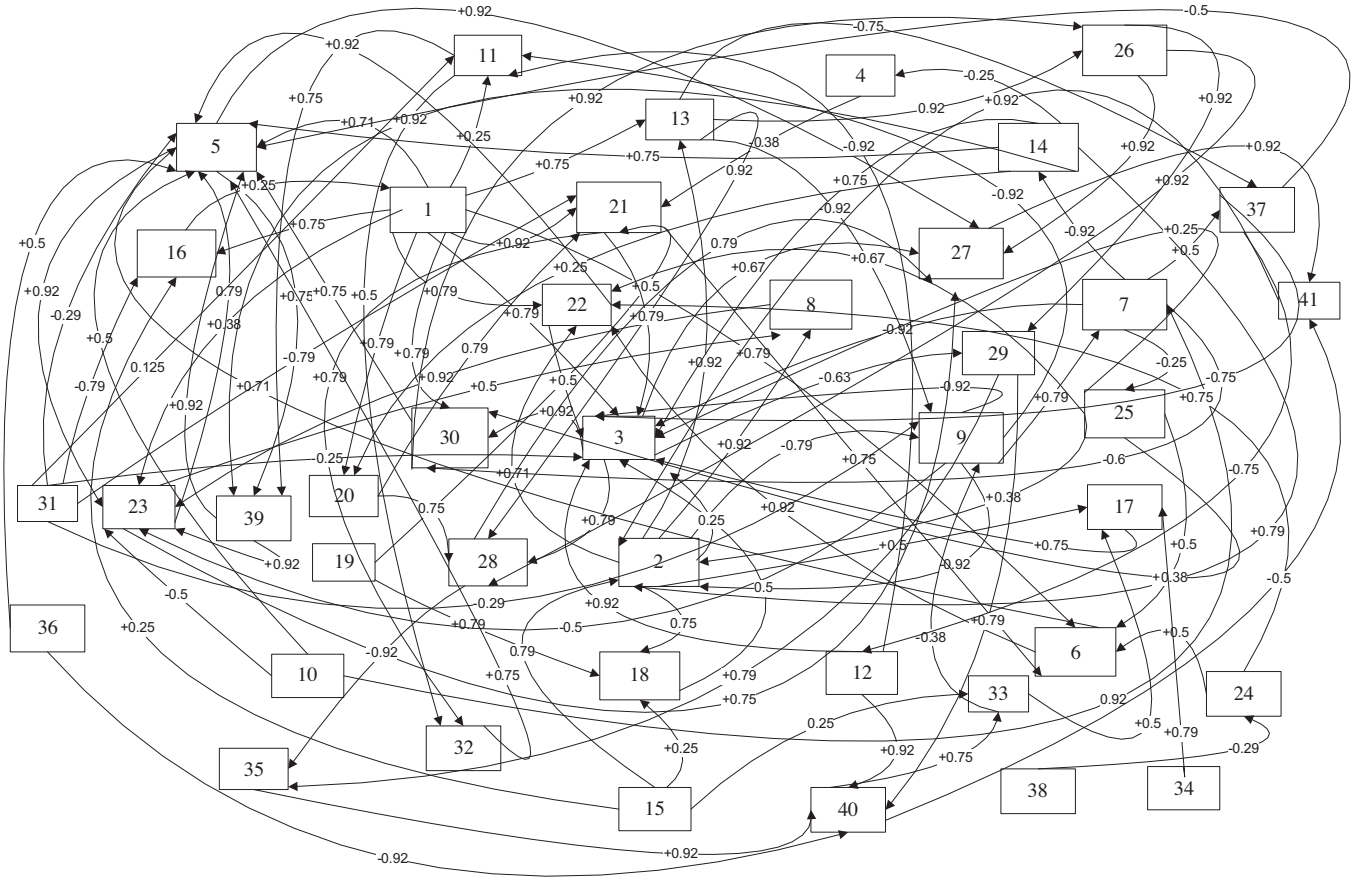

Fig. 7. The FCM of information sharing sub-system in retail sector.

includes 9 variables and the corresponding membership values for these terms are shown in the Table 4 while the membership functions are given in Fig. 5. These values are used for modeling the all sub-systems in this study.

To be an example, only the IMS of information sharing subsystems are given in Tables 5–7.

3.1.2. Aggregating the matrices and WMS

The suggested linguistic weights developed by experts individually are aggregated using the well-known fuzzy logic method of SUM and then the aggregated linguistic weights are produced. While doing this computation, the credibility weight for every expert is considered. In this study, experts have equal credibility in the beginning. For each interconnection there were 2M/3 suggested weights which belong to a neighborhood. Thus, there was no need to ask the experts to reassign this particular interconnection. The weights for each sub-system are aggregated by using COG method. While computing the line equations of membership functions, this formula is used.

$$\frac{y-y_1}{y_1-y_2}=\frac{x-x_1}{x_1-x_2} \tag{3}$$

For instance, if expert 1 evaluates that the factor has the influence on the other factor which is described using PM while the others thinks that it is PS, and PVS. This is calculated as given in Fig. 6.

The WMS matrix of information sharing sub-system is given in Table 8.

3.1.3. FCMs

The FCMs of success factors for three sub-systems in retail industry are developed representing the WMS matrices graphically as given in Figs. 7–9.

3.2. Dynamical behavior

Various "what–if" scenarios can be practice after inserting the necessary information to the simulating program. The proposed models of CPFR implementation in retail industry are investigated with six scenarios analysis. First two scenarios deal with the factors which are "trust among partners" and "unwillingness of managers" in information sharing sub-system. The next two are interested in "good ICT infrastructure" and "cross department support" in the models of decision synchronization sub-system. In the fifth and the sixth scenarios, the factors of "making commitment" and "availability of benefits for both parties" are investigated how the incentive alignment sub-system behaves when a slight positive change occurs.

Because of the page limitation, only one scenario is given to show the usefulness of the approach. In this scenario, we investigate the case where the "unwillingness of managers to share information"

$$z^*=\frac{\int_{0.25}^{0.5}\frac{(z-0.25)}{0.25}zdz+\int_{0.5}^{0.625}\frac{(z-0.75)}{-0.25}zdz+\int_{0.625}^{0.75}\frac{(z-0.5)}{0.25}zdz+\int_{0.75}^{0.875}\frac{(z-1)}{-0.25}zdz+\int_{0.875}^{1}\frac{(z-0.75)}{0.25}zdz}{\int_{0.25}^{0}\frac{(z-0.25)}{0.25}dz+\int_{0.5}^{0.625}\frac{(z-0.75)}{-0.25}dz+\int_{0.625}^{0.75}\frac{(z-0.5)}{0.25}dz+\int_{0.75}^{0.875}\frac{(z-1)}{-0.25}dz+\int_{0.875}^{1}\frac{(z-0.75)}{0.25}zdz}=0.67 \tag{4}$$

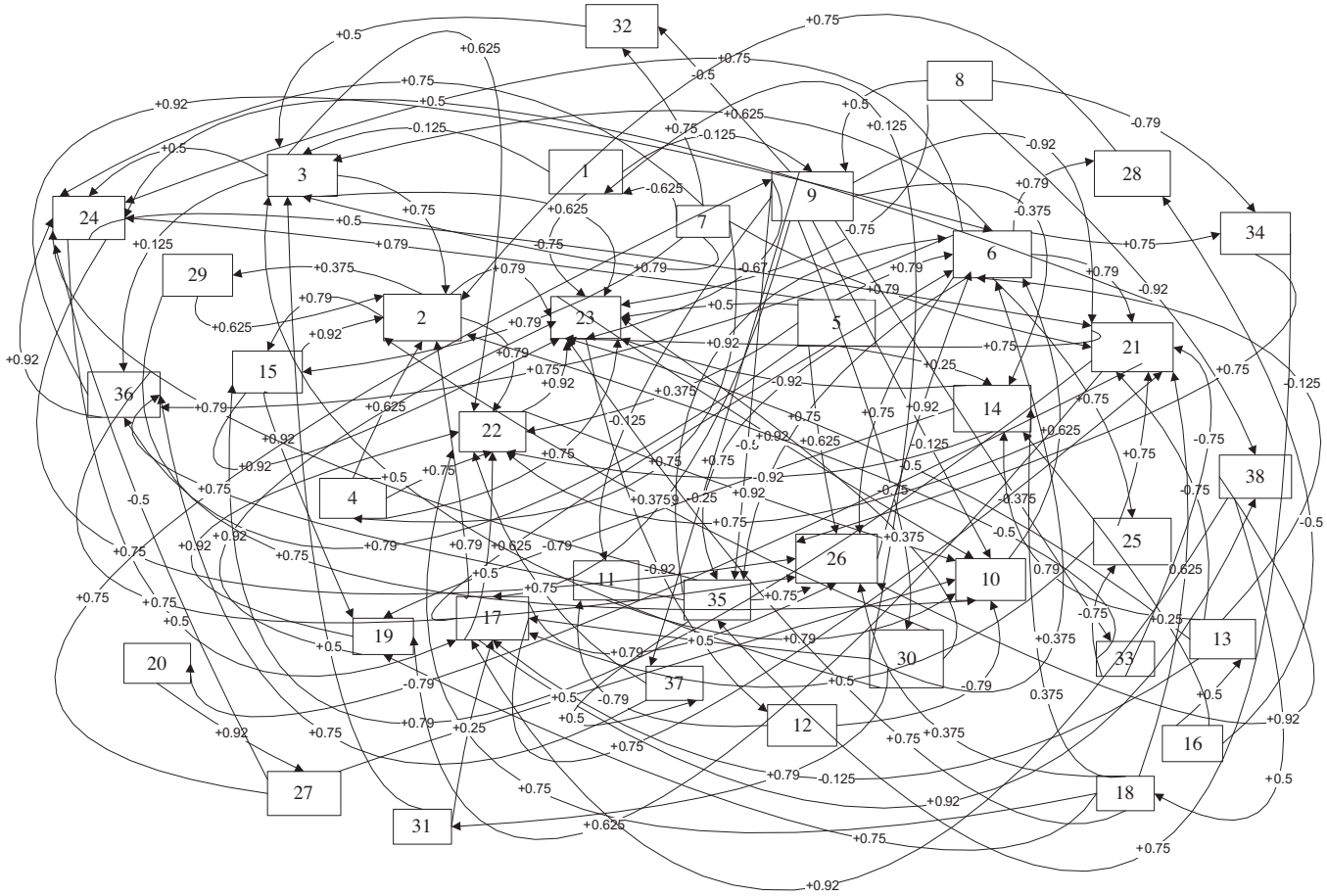

Fig. 8. The FCM of decision synchronization sub-system in retail sector.

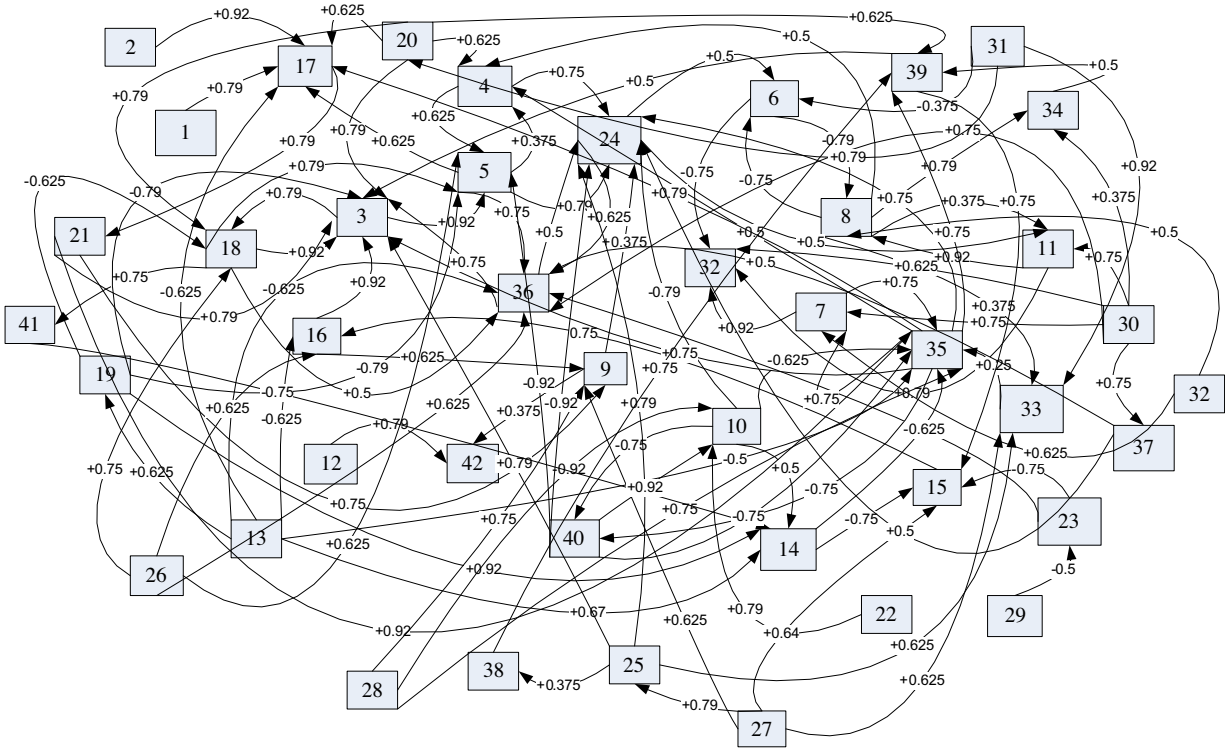

Fig. 9. The FCM of incentive alignment sub-system in retail sector.

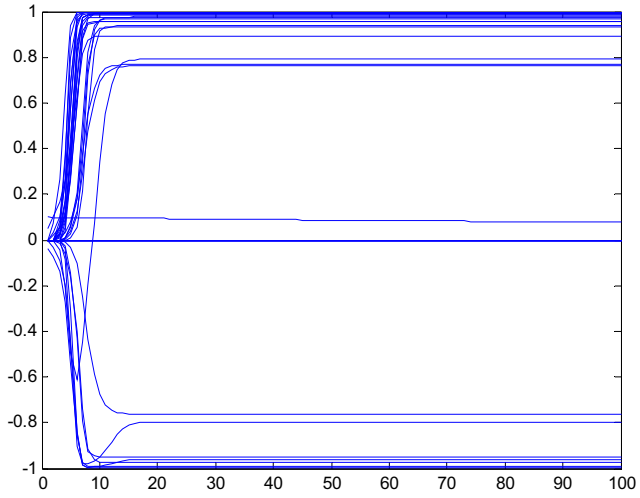

Fig. 10. The dynamical behavior of scenario "unwillingness of managers to share information".

Table 9
The obtained results of scenario "unwillingness of managers to share information".

	v_i	v_f		v_i	v_f		v_i	v_f		v_i	v_f
1	0	0	12	0	0.9304	23	0	0.9996	34	0	0
2	0	0.9991	13	0	0.9539	24	0	0	35	0	−0.7973
3	0	1	14	0	0.9537	25	0	0.7694	36	0	0
4	0	−0.7616	15	0	0	26	0	0.9920	37	0	−0.9743
5	0	1	16	0	0	27	0	1	38	0	0
6	0	0.9697	17	0	0.8817	28	0	0.9984	39	0	0.9894
7	0	−0.9977	18	0	0.9758	29	0	0.7908	40	0	−0.9597
8	0	0.9838	19	0	0	30	0	0.9931	41	0	0.9831
9	0	−0.9908	20	0	0.7616	31	0	0			
10	0	0	21	0	0.9768	32	0	0.9364			
11	0	−0.9495	22	0	0.9953	33	0.1	0.0774			

is high. We analyze how the information sharing sub-system behaves when a slight positively change (0.1) occurs. We set the activation level of this factor to 0.1 and we see the considerable effect on the other concepts. The dynamical behavior of the system is represented in Fig. 10 and the obtained results for this scenario are given in the Table 9.

To interpret the obtained scenario results more effectively, we summarize all the analysis results as given in Tables 10a, 10b, 10c and 10d.

The arrows show the strength of influence. Upward arrow means that when the concept investigated in the scenario changes, the success factor in the table given in the rows increases while the downward arrow indicates that it decreases. The double arrow is used to explain that this relationship is strong. The dash sign shows, there is no any change when the scenario is actualize. For example, as mentioned before in the second scenario, how the information sharing sub-system behaves when a slight negative change (0.1) of the concept "unwillingness of managers to share" occurs is investigated. After analyzing, it is observed that the concept "continuous information sharing" is affected strongly in a positive way. In the other word, if the unwillingness of managers to share information decrease, managers tend to share information, continuous information sharing within the SC highly increases. It also causes decrease in the inventory level and it force considerable decrease in cost.

Making commitment about sharing risks, benefits, resources strengthens the relationships among chain members and builds trust between the partners. This helps firms being ready to collaborate (trading partners' readiness) and the managers tend to share information. This assists in getting the qualified information which is used in decision making. By the way, the accurate demand, sales forecasts are ensured. This increase the performance of partners individually and the all chain. Having good ICT infrastructure gives an opportunity to partners be capable of communicate and share information intensively that are requirements for effective decision making. Cross department support is also crucial. Thus, we can say that system security, communication capability, building trust, information sharing, having SC vision and mutual objectives, making commitments are the most important success factors for CPFR implementation in retail industry.

4. Conclusions and implications

Many firms recognize the supply chain efficiencies and competitive advantage to be gained by implementing CPFR. Research shows that the adoption and utilization of CPFR in supply chain

Table 10a
The scenario results in retail industry.

Supporting factors	Scenarios					
	1	2	3	4	5	6
The frequency of interactions between partners	–	–	↗↗	↗↗	↗↗	↗↗
Continuous information sharing	↗↗	↗↗	↗↗	↗↗	↗	↗
Regularly scheduled meetings		↗↗	↗↗	–	–	–
Intensity of communication	↗↗	↗↗	↗↗	↗↗	–	–
Information transparency	↗↗	↗↗	–	–	↗↗	↗↗
Clearly and identified broad communication channels	–	–	↗	↗	–	–
Openness of communication	↗↗	↗↗	↗↗	–	–	–
Clarity about demand	↗↗	↗↗	↗↗	↗↗	–	–
Increased inventory	↗↗	↘	–	–	–	–
Improved business performance	↗↗	↗↗	↗↗	↗↗	–	–
Effectiveness of decision making to plan and control SC operations	↗↗	–	↗↗	↗↗	–	–
Accurate forecasts	↗↗	↗↗	–	–	–	–
Increased of the bullwhip effect	↗	↗↗	↘↘	↘↘	–	–
Timely and relevant information	↗↗	↗↗	↗↗	↗↗	–	–
Incentive alignment	↗↗	↗↗	↗↗	↗↗	↗↗	↗↗
Intensive information	↗↗	↗↗	–	–	–	–
Unwillingness of manager to share information	↘↘	↘↘	↘↘	↘↘	↘	↘
Partner communication	↗↗	↗↗	–	–	–	–
System security	↗↗	↗↗	–	–	–	–
Level of SC/logistics integration	–	–	↗	↗	–	–

Table 10b
The scenario results in retail industry.

Supporting factors	Scenarios					
	1	2	3	4	5	6
Cross department support	↗↗	↗↗	↗	↗	–	–
Lower employee involvement	↘↘	↘↘	↗	↘	↘	↘
Information sharing cost	↘↘	↘↘	–	–	–	–
Firms' technological capacity	↗	–	–	–	–	–
Information reliability	↗↗	↗↗	↗	–	–	–
Increased in cost	↘↘	↘↘	↘↘	↘↘	–	–
Risk sharing	–	–	–	–	–	–
Sharing cost	–	–	–	–	–	–
Strength of the relationship	–	–	↗↗	↗↗	↗↗	↗↗
The uncertainty in management	–	–	↗↗	↗↗	↘	↘
Defining specific roles of individual SC members	–	–	–	–	↗↗	↗↗
Sharing resources	–	–	–	–	↗↗	↗↗
Documented business/principles/policies/procedures	–	–	–	–	↗↗	↗↗
The awareness of firms to competitor actions	–	–	–	–	–	–
Differences in power	–	–	–	–	–	–
Increased in conflict	–	–	–	–	↘↘	–
Greater satisfaction	–	–	–	–	↗↗	↗↗
Making commitment	–	–	↗↗	–	↗↗	↗↗
Mutual benefits	–	–	↗↗	–	↗↗	↗↗
Long-term relationship	–	–	↗↗	–	↗↗	↗↗
Information quality	↗↗	↗↗	↗↗	↗↗	↗↗	↗↗
Common SC vision and objectives	–	–	–	–	–	–
Availability of benefits for both parties	–	–	–	–	↗↗	↗↗
Rewarding system for project team	–	–	–	–	–	–
SC knowledge of the top management	–	–	–	–	–	–
Sponsorship	–	–	–	–	–	–
Informing all employee about CPFR implementation	–	–	–	–	–	–
Transparency of SC	–	–	–	–	↗↗	↗
Faster mutual understanding	–	–	–	–	↗	–
Common performance metrics	–	–	↗↗	–	↗↗	–
Quick adoption of innovative technology	–	–	–	–	↗	–
System complexity	–	–	↗	↗	–	–
Improved business performance	–	–	–	–	–	–
Heterogeneity and hostility of industrial environment	↘↘	↘	–	–	–	–
Cultural differences	–	–	–	–	–	–
Decision synchronization	–	–	↗↗	↗↗	–	–
Face to face communication	–	–	↗↗	–	–	–
Increased in organizational size	–	–	–	–	–	–
Differences in technologies and systems employed by partners	–	-	↘	–	–	–
Good ICT infrastructure, like EDI	–	–	↗	–	–	–
System compatibility	–	–	–	–	–	–
Effectiveness of partner selection	–	–	–	–	–	–
Organizational readiness	↗	↗↗	↗↗	↗↗	–	–
Culture of openness and honesty	–	–	–	–	–	–
Personnel trainee	–	↗↗	–	–	–	–
The leakage of information sharing	↘↘	↘↘	–	–	↘	↘
Trust among SC members	↗↗	↗↗	↗↗	↗↗	↗↗	↗↗
Trading partner's readiness	↗↗	↗↗	–	–	↗↗	↗↗
Trading partners technical readiness	–	–	–	–	–	–
Effective database linkages	↗	↗↗	↗	–	–	–
Industry competitiveness	–	–	–	–	–	–
Uncertain environment	–	–	–	–	–	–
Integration of systems	↗	↗↗	–	–	–	–

are limited and inefficient. Given the impact and benefits of CPFR, it is essential to ensure their successful implementation and adoption by supply chain partners. The aim of this study has been to provide a rich insight into context of CPFR success in supply chain.

In order to do this, we have used the FCM approach to model the supporting factors for CPFR. The FCM approach has allowed us to identify and model both qualitative and quantitative factors and their complex causal relationships in the context of successful CPFR adoption, based on the perceptions of industrial experts.

Communication is found the most crucial factor, beside of its risks. They should trust in each other and business plans, forecasts, promotion plans should be shared. The sustainability of communication is valuable. Different from the communication capability, system complexity, trust among SC members, system security, good ICT infrastructure, like EDI, willingness of managers are also necessary for success CPFR implementation in retail industry. Cross department support increases intention to information sharing. This also helps improving the information quality and may provides effective decision making. It is considered that the key supporting factors for CPFR implementation in retail sector are such as cross department support, continuous information sharing, partner communication and trust and willingness of managers.

For the perspective of this study, the proposed models and developed approach could be implemented in other industries. In this way, industry differences could be identified and the requirements for more effective CPFR structures could be emphasized.

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