ISM analysis of CPFR implementation barriers

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Abstract

Collaborative Planning, Forecasting and Replenishment (CPFR) as an interconnection scheme between organizations has been shown to have significant benefits. Since its inception in the 1990s, its uptake has been lower than originally predicted. This paper identifies the major barriers and their interrelationships in CPFR implementations with a focus on high-tech industries. Interpretive Structural Modeling (ISM) is used with a group of CPFR experts from industry/academia and Matrice d'Impacts Croisés Multiplication Appliquée àun Classement (MICMAC) analysis to identify the driving and dependence powers. The paper identified 45 CPFR barriers and classifies them into four categories based on expert opinion, with only 13 of these determined to be significant. The results indicate that in terms of categories, managerial barriers are a significant root cause for both process and cultural barriers and CPFR implementation difficulties. It also indicates that although the importance of information technology to launch collaborative schemes has been addressed by many scholars, technology alone is not the complete solution for successful CPFR implementation. The paper has significant practical implications for organizations as it identifies the main CPFR barriers and their causal relationships. This will help firms in the process of CPFR strategy development particularly for mitigation strategies for dominant barriers.

Keyword CPFR implementation, barriers, ISM, MICMAC

Paper type Research paper

1. Introduction

In recent years there has been increased interest in supply chain collaboration, as a process that promotes inter-company co-operation (Danese 2011). In the last decade, the concept of information integration, especially in the area of planning and forecasting, has received significant attention from both scholars and practitioners. In recent years several kinds of collaboration schemes have been launched between companies. Vender–managed inventory (VMI), quick response (QR) and Continuous Replenishment program (CRP) were the initial techniques for collaborative practices between partners. The collaborative planning, forecasting and replenishment (CPFR) approach as a new initiative in this area, was developed by the Voluntary Inter-industry Commerce Standards (VICS) in 1998 (VICS 2013). According to VICS, CPFR is "a collection of new business practices that leverage the Internet and Electronic Data Interchange (EDI) in order to radically reduce inventories and expenses while improving customer service". Subsequently, there are a number of different definitions which have been derived from this original definition. For example, Barratt and Oliviera (2001) introduced CPFR as an evolution of Efficient Consumer Response (ECR) which covers the gaps left by previous business practices. Since the CPFR model concept was proposed in 1998, different studies have focused on understanding the issues related to its implementation (VICS 2008).

Despite a considerable body of research which has emphasized the positive results of adopting CPFR, the implementation rate is reported as being limited and has been slower than expected (Småros 2003, Danese 2007, Büyüközkan and Vardaloğlu, 2012). In other words, while the benefits of CPFR have been shown to be impressive, its implementation appears to have its own challenges because of the complex nature of the collaborative schemes. While it is generally recognised that CPFR has not yet lived up to its potential, few studies have addressed this gap and identified the reasons why its implementation rates are lower than expected. The motivation for this study is to address this gap, by identifying and analysing the main barriers to CPFR implementation. For the purpose of the analysis this paper focuses on the high tech sector, as this is a sector to which collaborative practice between partners is of significant importance as has been widely reflected in past studies (Akkermans et al, 2004; Washida, 2005; Sari, 2008; Yuan et al, 2010). 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 solve this problem researches have proposed two major solutions: (i) excess capacity to buffer against demand variability and (ii) develop high levels of collaboration with trading partners (Yuan et al. 2010).

Following a comprehensive literature review, the significant barriers reported in previous papers have been identified. Interpretive Structural Modelling (ISM) is then used, based on the opinion of a group of CPFR experts, to develop the contextual relationships between the identified barriers and MICMAC (Matrice d'Impacts Croisés Multiplication Appliquée à un Classement, which means Cross-Impact Matrix Multiplication Applied to Classification) for barrier classification based upon the driving and dependence powers. 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 of significant importance (Sari 2008; VICS 2008).

Based on this, the main objective of this paper is to better understand the poor uptake of CPFR and to identify pathways towards increased usage by 1) identifying, ranking and analysing the interactions among the main barriers to CPFR implementation and 2) from a practice led perspective to distil this to the most important and dominant barriers for the high-tech sector.

2. Literature review

CPFR has been acknowledged as one of the best collaborative schemes in business to business (B2B) commerce since its introduction by VICS in 1998 (VICS 2013). CPFR coordinates trading partners in order to decrease their differences in terms of supply chain visibility and decision making; the results of which lead to more demand driven supply chains. Many researchers have reported promising both short and longer term benefits from adopting CPFR between supply chain members. Past studies have reported numerous benefits from CPFR implementation, a sample of which includes: improved operational efficiency, reduced inventory variance, improvements in forecasting accuracy, enhanced responsiveness, reduced running costs, and the instigator for the development of new partnerships with customers or suppliers in the retailing and grocery section. (Boone and Ganeshan, 2000; McCarthy and Golicic, 2002; Småros, 2003; Danese, 2006; Chang et al., 2007; Poler et al., 2008; Du et al., 2009; Wei et al., 2010; Lin and Ho, 2012; Guorui and Ying, 2012). As has been described earlier, although the documented benefits of CPFR are significant if successful, the rate of implementation of CPFR has been much slower than expected (Småros 2003, Danese 2007, Büyüközkan and Vardaloğlu, 2012). One of the main reasons for this is the lack of detailed and comprehensive guidelines. In addition, one of the main challenges is the lack of understanding of CPFR implementation enablers and barriers. Some efforts have been made in previous studies to identify key factors or enablers for CPFR implementation (Lin et al., 2004;

Wang et al., 2005; Fu et al., 2010; Lin and Ho, 2012; Panahifar et al., 2013); however studies to fully understand its main barriers are still in their infancy.

Lin et al (2004) presented a methodology for adopting CPFR in the wood industry in Taiwan. Their study presented a structure based on Critical Success Factors (CSFs) obtained from previous studies. They found that well defined processes, high level of trust between partners, IT infrastructure and managers' commitment were identified as the most important CSFs in this industry. Wang et al (2005) applied and analyzed the CPFR concept for the Chinese retailer industry. They introduced a number of critical factors based on management concepts for successful implementation of CPFR in China. Fu et al (2010) analyzed critical factors for adopting CPFR in retailing using fuzzy AHP. According to this research, critical impact factors that resulted from retailers implementing CPFR are cross-department communication and collaboration capability, change management, organization innovation capability, system complexity, mutual objective, amalgamation capability of technology and culture, top management support, trust and communication, system security and electronic data interchange. Lin and Ho (2012) present the use of modeling and survey methods in analyzing critical factors for successful implementation of CPFR in hospital supply chains. More recently, Panahifar et al (2013) applied fuzzy AHP to select and rank the critical success factors for CPFR implementation for automotive spare part industry.

Barratt and Oliveira (2001) and Barratt (2004) present two comprehensive studies on CPFR implementation barriers. They reviewed the literature on the subject and presented several barriers in implementation such as, no shared targets; lack of demand variability; lack of budget for software; lack of partner trust; mutual benefit identification; executive support obstacles; lack of real time coordination of information exchange; lack of promotion; no adequate information technology and expertise.

Lack of visibility between partners in the supply chain is generally considered as a root cause of many barriers. Lack of partner trust has been presented as one of the biggest barriers to collaboration (Frantz, 1999; Seifert, 2003; Ireland and Bruce, 2000; Nesheim, 2001; Moberg et al, 2003). According to Seifert (2003), ineffective leadership, internally focused organizational silos, non-existent change management skills, lack of internal alignment, legacy systems, personal comfort zones, tunnel vision and lack of commitment to share information are the main barriers for adopting CPFR. Another significant challenge is lack of scalability of CPFR (Min and Yu, 2008; McCarthy and Golicic; 2002; Frantz, 1999). As pointed out by several researchers, fear of losing competitive information is an important obstacle for CPFR implementation (Frantz, 1999; Bowersox et al, 2000; Jacobs and Chase, 2008; Cassivi, 2006). Poor communication, difficulties with real time coordination of information exchange, technological reliability and dependencies, human resistance to change and training issues and internal restructuring are more barriers which have been reported in different papers (Cassivi, 2006; Min and Yu, 2008).

De Leeux and Fransoo (2009) found in a study on supply chain collaboration in high tech-companies that all the high-tech companies interviewed agreed that the criticality of incoming supply items is considered a key driver for supply chain collaboration in their sector. In terms of a 'critical item' they suggest that this can be defined as an item with limited availability of alternatives (or substitutes), which in combination with the technical capabilities required for manufacturing the product makes collaboration crucial. High-tech industries are characterized by rapid changes of technology, high innovation, intense competition, and a highly uncertain environment and market (Amabile, 1997; Washida, 2005). Chakrabarti (1991) defined the high-tech industry as sectors that that require appropriate research and development expenditure and employs a large number of engineers. From the early 1970s different classification and categories of high-tech industries have been defined. The most recent classifications were developed in the 1990s, and include 10 major areas: communication; information; consumer electronics; semi-conductor; precision machinery and automation; aviation; high-grade material; special chemical and pharmaceutical; medical care; and pollution prevention (Wu and Weng, 2010). In an earlier study on high-tech industries based solely on the Chinese market, Liu and Buck (2007) categorized Chinese firms using a larger set of details, dividing them into 21 sub-sectors.

What is common in each of these studies is that high-tech firms are faced with continual changes in the external environment and challenges in an uncertain market. To meet such challenges, high-tech firms are forced to continuously change and develop to advance and to sustain (Law, 2009). Based on this continual change and high investments, a high level of collaboration can be expressed as an appropriate strategy to meet these challenges (Sari, 2008; Yuan et al, 2010). CPFR is one such collaborative scheme. CPFR is based on confidence and transparency in which supply chain participants share information on forecasting, production plans including orders and inventories. While the benefits of CPFR have been acknowledged in various studies, its implementation has different challenges and obstacles.

3. Methodology – ISM and MICMAC

From the literature it can be seen that CPFR is regarded as having a positive impact on organisations when implemented correctly, but it is not utilised as often or as well as it could be. There are a number of papers that have attempted to identify key success factors for CPFR implementation. However, conversely, there is limited work presented which identifies the dominant barriers for adopting CPFR. In this paper, we begin to address this gap by identifying and introducing the main barriers for applying CPFR with a particular focus on high-tech supply chains. ISM is a methodology that has been widely used for studying and analysing the relationship between different variables, and has regularly been used in various research studies analysing the causal relationships for barriers to adaptation of a number of different initiatives. The main objective of a MICMAC analysis is to identify and analyze the driving power and the dependence power of attributes (Duperrin and Godet, 1973). MICMAC and ISM both apply the model of structural analysis matrix, analyzing the mutual relationship among factors (Lee, Y-C et al 2010). Based on this, the attributes are classified into four clusters – autonomous, dependent, linkage, and driver, based on driving and dependence power of each variable.

As described by Sage (1977), ISM is an advanced planning methodology applied to identify and summarize relationships among specific variables, which define a problem or an issue. The interactive learning process associated with the technique can transform unclear models of systems into clear and visible models (Sage, 1977). The ISM method provides a means by which order can be imposed on the complexity of different criteria (Mandal and Deshmukh 1994), where it can break this complexity down into comprehensible pieces of information enabling experts to better deal with it (Alawamleh and Popplewell, 2010). This methodology allows for a group of experts from a specific field, working as a team in a systematic manner to define the type of relationship desired (such as “aggravates”, “enhances”, “contributes to” and “precedes”) by answering simple questions (Bolanos et al., 2005). As a modelling technique ISM has been used extensively in many different domains for analyzing the influence of single factors in multi-factor systems thus making it particularly suited to the study presented in this paper.

Expert opinion is a fundamental cornerstone to ISM. Warfield (1982) suggest that there is a need for somewhere up to eight participating experts in an ISM approach. From the studies reviewed and presented in this paper, ISM models have been developed with as few as two experts (e.g. Ravi and Shankar (2005)). In addition the majority of these studies, groupings have both industrial and academic experts in the domain under review. The study presented in this paper was conducted using the input from nine CPFR/collaboration experts. These nine experts were divided into two separate groupings. For the purpose of the study, 6 experts were placed in the main ISM model development group, consisting of 3 industrial and 3 academic experts (Group 1) with the remaining 3 industrial experts assigned to Group 2 (ISM model validation). The details of the nine experts are presented in Table 1. The industrial experts in groups 1 and 2 all have experience working in an international marketplace including significant time spent working for and with multinational enterprises.

[Table I: Descriptions of experts' background will be placed here]

In other directly related studies ISM has been applied to the study of barriers in a number of different areas. Ravi and Shankar (2005) have used ISM to study the interaction among the major barriers of reverse logistics. McCormick and Kaberger (2007) used the ISM method to identify the major barriers hindering the application of bio-energy in the European Union (EU) and Wang et al (2008) and Saxena et al (1992) applied ISM to barriers in the case of energy saving in the Indian cement industry and China respectively. In two separate studies, Luthra et al (2011) and Mathiyazhagan et al (2013) have both applied ISM to the automobile industry and to the identification of barriers to the implementation of green supply chain management.

In other related domains ISM has also been applied to different studies in the area of trading partnerships and relationship. Mandal and Deshmukh (1994) applied ISM to vendor selection and in a similar study Thakkar et al (2008) proposed a methodology for identifying the dissimilarity that may exist in the buyer-supplier relationships in the automotive industry in India. In a further study carried out on a case in India, Raj et al (2008) used ISM to evaluate enablers for the successful implementation of Flexible Manufacturing Systems. Alawamleh and Popplewell (2010) applied ISM to study network risk sources and their relationships which may have negative effects on the time, cost, quality or total failure for the collaboration in a virtual organization. Govindan et al (2012) presented an ISM analysis of a third party reverse logistics provider in a tyre manufacturing industry and Diabat et al (2012) developed a model which analysed the various risks involved in a food supply chain with the help of ISM. Chang et al (2013) established a hybrid approach to analyse critical agility factors when launching a new product into mass production using ISM to identify the interactive causal relationships of the employed agility factors.

ISM is a methodology that has been used to identify the complex relationship among specific factors first introduced by Warfield (1974) and developed further by Sage (1977). ISM is applied by following a set of structured steps which is representative of the steps found in a wide range of ISM related journal publications. In this research, model development and validation has been conducted in three phases (Figure 1) with the main ISM development phase presented in Figure 2. Expert Group 1 was used for the original ISM steps and Expert Group 2 was used for ISM model validation at in phase III.

[Figure 1: *ISM model development and validations* will be placed around here]

[Figure 2: *Main ISM development phases* will be placed around here]

4. Model Development

In this paper, the process of identifying barriers to CPFR implementation in high-tech industries originates from an extensive literature review and is consolidated through the use of expert opinions. A group of nine experts from academia and industry fully aware of the implementation of collaborative schemes in high-tech industry and familiar with the concept of CPFR and its implementation process participated in the study. Phase I initially presents a literature review identifying barriers for successful implementation of CPFR, which is then reviewed and adapted if required by Expert Group 1. Phase II identifies the leading barriers by applying ISM, again incorporating the expert opinion of group 1. Phase III presents an extension to the traditional ISM where the model was presented to Expert Group 2 for validation of the findings. Phase I, II and III were conducted in three different sessions.

Phase I – A thorough initial evaluation of the literature was conducted by the authors, which was then followed by input from expert group 1. Following these steps a total of 45 barriers were identified and each of the barriers categorised into one of four developed headings (Table 2). These four classification headings were decided upon by expert group 1. In order to obtain a comprehensive classification of the barriers identified under these four headings, the original reference (examples as shown in Table 3) for each barrier is considered and a consensus position taken by Expert Group 1.

Phase II – in a second session on a different day, expert group 1 were provided with questionnaires to identify the most important variables in their opinion, from the 45 identified in Phase I. In this second phase a Nominal Group Technique (NGT) session was conducted to generate a consensus position in the selection of the most important barriers related to the CPFR implementation process. The NGT is a powerful learning and development tool developed by Delbecq et al (1975) to facilitate effective group decision-making. The purpose of the NGT technique is to generate information in response to an issue that can then be prioritised by a group of experts (Potter et al., 2004). In this session, the experts initially identified 15 of the most important barriers, which after further discussion were reduced to an agreed total of 13 (Table 3), which they selected as the most repeated variables. The second part of this workshop session was then used to study the relationship among the 13 selected barriers using the ISM/MICMAC methodology. In this, members of Expert Group 1 were questioned about the causal relationship between each of the barriers (e.g. does barrier i significantly lead to barrier j?). In this phase, more detailed definitions for each of the 13 barriers identified from the literature were presented to participants so as to ensure a definitive common understanding. The results of this phase are presented in detail in section 5.

Phase III – To conclude this study a third phase has been added to the traditional ISM process. In this stage the model findings were presented to an additional independent group (Expert Group 2) for the purpose of model and result validation and for identification of implications for practice. The results from this phase are presented as part of the discussions in section 6.

[Table 2: *Classification of barriers to CPFR implementation* will be placed around here]

[Table 3: *CPFR Barriers* will be placed around here]

5. Model Execution and Results

The contextual relationships among the 13 variables presented in Table 3 are identified by Expert Group 1. As part of the ISM process (Figure 2) four symbols (V, A, X, O) are used to denote the different types of contextual relationship that can exist between each of the barriers (i and j):

- V: Barrier i will lead to Barrier j;
- A: Barrier j will lead to Barrier i;
- X: Barrier i and j will lead to each other; and
- O: Barriers i and j are unrelated.

After evaluation of the resulting questionnaires and engagement in the NGT session, a full set of contextual relationships between all barriers are defined in the form of a Structural Self-Interaction Matrix (SSIM), the results of which are presented in Table 4. For example, from this table it was concluded that the barrier “lack of technical expertise” will lead to the barrier “difficulties with information sharing process and resource” thus obtaining an ‘A’ demarcation, or that the barrier “lack of partner trust” and the barrier “lack of commitment to share information” will lead to each other, thus obtaining an ‘X’ demarcation.

[Table 4: *Structural self-interaction matrix (SSIM)* will be placed around here]

Following the development of the SSIM, the next step in the ISM is the development of a reachability matrix. The conversion of the SSIM into the reachability matrix is completed by substituting V, A, X, O by 1 or 0, using the following rules, which are standard in ISM:

- If SSIM (i, j) is V, (i, j) then the reachability matrix will be 1 and (j, i) value will be 0.
- If SSIM (i, j) is A, (i, j) then the reachability matrix will be 0 and (j, i) value will be 1.
- If SSIM (i, j) is X, (i, j) then the reachability matrix will be 1 and (j, i) value will be 1.
- If SSIM (i, j) is O, (i, j) then the reachability matrix will be 0 and (j, i) value will be 0.

To convert the initial reachability matrix to the final reachability matrix a rule called transitivity is used, which states if variable ‘A’ is related to variable ’B’ and variable ‘B’ is related to ‘C’, then variable ‘A’ is necessarily related to ‘C’. For the purpose of completing the final reachability matrix directly from the SSIM, and completing the ISM analysis, the ISM software GMU (Broome, 1999), windows version, was used. This software eliminates the need for translations by hand. Based on the full set of contextual relationships in the SSIM, Table 5 presents the final reachability matrix.

[Table 5: *Final Reachability Matrix - Barriers to Implement CPFR in high-tech industries* will be placed around here]

As summarized by Warfield (1974), it is then necessary to develop the reachability and antecedent set for each barrier, which are determined from the final reachability matrix. These sets are used to determine the level of each variable and are completed in an iterative fashion. The antecedent set shows which barriers lead to other barriers, while the reachability set shows which barriers are affected by other barriers. This information is taken from the final reachability matrix (Table 5), with the 1’s in the rows representing the reachability sets and the 1’s in the columns representing the antecedent sets. For example the reachability set for ‘barrier 1’ is 1, 3, 6, 10, 11 and 12. The intersection is the common set of barriers in both the reachability and antecedent sets. When a reachability set is repeated in the intersection set, this barrier will be selected as the current top position in the ISM hierarchy model. (e.g. at the start-level I). These barriers are then eliminated from the current iteration and the next iteration begins. This process continues until all barriers have been eliminated. As Table 6 shows, the first barriers to be selected at level I are 10, 11 and 12. These barriers are then eliminated across the relevant rows, from the reachability and antecedent sets and also from the intersection column. This then becomes the next iteration of the model, so the second level can be found in the next step (Table 7). This process is continued until the level of each barrier is found and is presented by a further four iterations with a total of six levels in this study (see Tables 6 – 11).

[Table 6: *Iteration 1* will be placed around here]
[Table 7: *Iteration 2* will be placed around here]
[Table 8: *Iteration 3* will be placed around here]
[Table 9: *Iteration 4* will be placed around here]
[Table 10: *Iteration 5* will be placed around here]
[Table 11: *Iteration 6* will be placed around here]

The identified levels aids in building the digraph and the final model of ISM. From Table 6, it is seen that “lack of commitment to share information” (outcome variable 10); “lack of partner trust” (outcome variable 11) and “lack of internal alignment” (outcome variable 12) are found to be at Level I. Thus, these three variables would be positioned at the top of the ISM-based model Figure 3. To conclude the ISM model, the relationship between barriers is shown using a directed graph (or digraph) which identifies the contextual relationships between each of these factors and their hierarchies. According to the ISM methodology, the transitivities between these elements are removed in order to gain the anticipated digraph (Wang et al., 2008). The digraph is finally converted into the ISM model as shown in Figure 3. It is observed from this figure, that a lack of visible and effective leadership (barrier 2) is a very significant barrier for the CPFR implementation in high-tech industries as it appears at the base of the ISM hierarchy, with all other barriers emanating from it.

[Figure 3: *ISM-based model for barriers to implement CPFR in high-tech industry* will be placed around here]

Following on from the identification of the digraph a MICMAC analysis is used to identify and analyze the driving and dependence powers for each of the barriers. For a MICMAC analysis four clusters exist: autonomous, dependent, linkage and driver variables. The barriers are placed into one of the four quadrants using the information collated in the final reachability matrix (Table 5). From this table it can be seen that barrier 1 has a total 'driving power' across the row 1 of 6 and a total 'dependence power' from column 1 of 8. The full set of results from this analysis is presented in Figure 4.

[Figure 4: *Driving power and dependence diagram* will be placed around here]

The first cluster consists of the 'autonomous barriers' and have weak driving power and weak dependence. These variables will not have much influence on the studied system. In this study, there are no autonomous barriers in the first cluster. The second quadrant is called dependent variables and comprises of 1, 8, 10, 11, and 12. These have weak driver power and strong dependence. The third cluster includes barriers with a high dependence and driving power. They are called linkage barriers because they are unstable. In this study, the third cluster consist of barriers 3, 4, 5 and 6 where any action on one of these barriers will have an effect on other barriers. The fourth cluster has strong driving power and weak dependence power and is the independent variables. In our study, four barriers namely 2, 7, 9, and 13 are found to be in this cluster.

By reviewing the driving power and dependence diagram (Figure 4) and the final ISM model (Figure 3), a high level conceptual framework is extracted to better understand the relationship between four major criteria classified in Table 2. Figure 5 shows the conceptual framework of the observed internal relationships between different classifications of the barriers. This Figure reveals that managerial barriers are significant dominant barriers which lead to cultural and process barriers. However, it also shows that process barriers could be a main root negatively affecting cultural barriers. A glimpse into the figure 5 clearly reveals that technological aspect is not known as an important and dominant barrier to CPFR implementation.

[Figure 4: *Conceptual framework: Relationships between criteria* will be placed around here]

6. Finding and Discussion

While the documented benefits of CPFR are impressive, its uptake has not been as positive as had been originally anticipated. One of the main reasons for this is barriers to successful CPFR implementation, which have been classified in this study as managerial, technological, process and cultural issues. Based on a literature review and discussions with experts in the high-tech industry, an initial set of 45 barriers to successful CPFR implementation were identified, which were then distilled down to 13 most significant variables. To do this, an ISM model was developed, with the objective of developing a hierarchy of barriers. The model developed in this paper identifies the most important barriers and their causal relationships. This in turn, guides firms in the development of strategies to militate against the more dominant barriers. Some of the major findings and limitations of this study highlighted here are:

1) The results of this study indicate that of the 45 identified CPFR implementation barriers, 13 (Table 3) of these barriers are considered as very important and from a practice perspective should be given significant consideration prior to engaging in any CPFR implementation scheme.
2) Among these barriers, "lack of visible and effective leadership" is the most strategic and critical barrier which can intensify other issues. Leadership is a critical attribute in successful management teams as it can help to promote individuals and to support an internal and external collaborative atmosphere. Collaboration with others is a long journey which will fail without effective leadership. Following this "lack of technical expertise", "executive and management support obstacles", "difficulties with information sharing process" and "lack of compatibility of partners' abilities" are shown as the most important and dominant barriers which can lead to other barriers. This shows that the lack of technical expertise can also be exacerbated by the lack of visible and effective leadership.
3) Of the six barriers identified by Expert Group 1, from the managerial classification four of these have been shown to be highly important namely, "lack of visible and effective leadership", "lack of technical expertise", "lack of compatibility of partners' abilities" and "executive and management support obstacles". These barriers are all on the bottom three levels of the model and consist of four out of the five barriers identified as most powerful by the ISM procedure.
4) After the "lack of visible and effective leadership", the "lack of technical expertise" is a key and critical inhibitor which also has a high driving power as identified by the MICMAC analysis. From the ISM model the importance of this barrier can be seen as it indirectly lead to 11 other barriers.
5) The ISM model also shows that five of the important barriers belong to the process category with one of these "difficulties with information sharing process" identified as a powerful driving barrier. This barrier can intensify "fear of losing competitive information" and "lack of forecasting processes and resources". The final reachability matrix and the ISM model show that a "lack of forecasting process and resource" leads to seven other barriers. This corresponds with the findings of Småros (2003) where it was found that "retailers' lack of

forecasting process and resource" was the most important and the root cause of many CPFR implementation barriers. As a general rule, as the forecasting generation process is a time consuming task, CPFR implementers should develop this capability prior to starting any CPFR implementation initiatives with partners.

6) The final ISM model implies that a number of the identified barriers significantly intensify each other. For instance, the "lack of internal alignment" and the "lack of partner trust" are mutually correlated. In other words, trading partners find it difficult to trust each other when they realize that their partner suffers from a "lack of internal alignment" and vice versa. As a further example, it can also be noted in the "fear of losing competitive information" "lack of forecasting processes and resources" and "lack of partner trust" which intensify each other.
7) According to the results of this study, cultural barriers like "lack of commitment to share information" and "lack of trust between trading partners" are very significant issues which are affected and intensified by many of the other managerial and process barriers.
8) Danese (2007) suggests that the type of the technologies used for supporting CPFR can vary across implementation cases and plays a role in its success. In contrast the ISM model and driving power and dependence diagram in this study found that no barrier in the technological category has been identified as a "most important factor". This result is in line with the findings of Attaran and Attaran (2007) which state "CPFR process does not fundamentally depend upon technology" and Småros and Främling (2001) which concluded that technology is no longer seen as a major barrier to success and technological issues are only a small part of the challenge of CPFR implementation. This is not to say that technologies play "no role" but it is not a critical dimension.
9) As has been shown in the MICMAC analysis (Figure 4), there are no barriers in the first cluster (I). In other words there are no autonomous barriers, which mean that all 13 identified barriers considered in this study are considered influential in the CPFR implementation process. It also validates the barrier selections by the Expert Group 1, in addition to the validation exercise completed by Expert Group 2, thus the practical implication from this paper is that trading partners should pay attention to each of these barriers in any related CPFR implementation exercise.
10) It is observed that barriers located in the third cluster (III) seem to consist of executive and management support obstacles, and include a "lack of forecasting processes and resources", "difficulties with information sharing process" and "benefits difficult to calculate". These are unstable barriers and any action related to these barriers will have an effect on other barriers and in turn will also have more extended feedback onto themselves.
11) The ISM model also shows that a "lack of compatibility of partners' abilities" has a high driving power and an intensification relationship with nine other barriers (See Table 5 row labelled "9"). This implies that in order to run a successful CPFR implementation process, the right partner selection policy plays a critical rule. In other words, improper selection of partners will result in the failure of such collaboration. The key factor that maintains a successful collaboration lies in understanding how to select a right partner, a key area of research.

7. Managerial implications and concluding remarks

It is generally recognised that CPFR offers significant value for organisations that successfully implement it. However, as has been discussed earlier the uptake of CPFR has been significantly lower than what was originally expected. Although CPFR presents significant opportunities for organisations it also has a significant number of barriers. In this paper 45 distinct barriers have been identified. For organisations that are considering CPFR, knowledge of the most important implementation barriers and a strategy to overcome or reduce these is of critical importance. These implications and the potential ways to effectively deal with the identified barriers are briefly discussed in the next paragraphs.

Of the original 45 practical CPFR implementation barriers identified in this study this has been reduced to 13 of the most significant barriers through the use of ISM modelling, including expert opinion. As most organisations suffer from scarce resources, this identification of the most important barriers allows managers the ability to focus those scarce resources on the most important factors, while also being aware of the wider issues. In this study, a 'lack of visible and effective leadership' and a 'lack of technical expertise' were identified as the most dominant and second most dominant barriers to CPFR implementation respectively. For the purpose of enhancing effective and visible leadership it is recommended that practitioners begin with small scale CPFR projects and grow to full scale CPFR over time. CPFR is a complex task and full scale implementation in a single stage can often lead to frustrations and disconnects between management, implementers and front line staff. In a similar fashion, implementing small scale CPFR projects initially allows for the growth of technical expertise, which if not available in house can be provided through consultancy. However, what is also important is that the technical expertise is passed on to "in house" to create either an internal support or alternatively an internal implementation team for future CPFR activities.

The barrier a 'difficulty with information sharing process' is multidimensional in nature which can be intensified by technical, cultural and behavioral issues. In a practical sense, in combination with the 'lack of commitment to share information' barrier both parties may be reluctant to share promotional plans or new product launches for fear of losing commercial advantage. The development of a CPFR charter which defines and spells out issues of confidentiality and what information will be shared and how can significantly help to alleviate this barrier. In addition, 'lack of partner trust', which is a barrier itself plays a big role in this. Trust is something that can only be built over time but can be aided with the use of a CPFR charter and the initial development of small CPFR projects possibly using low cost and low risk collaboration tools to begin.

One of the key components of CPFR is forecasting, therefore the barrier a 'lack of forecasting processes and resources' can be described as a basic issue. Organisations can reduce the impact of this barrier by the creation of a forecasting protocol and forecasting team with representatives from all stakeholders. In addition the formal linking of multi-party information channels to share forecast related information in real time will greatly reduce this barrier. This also contributes to the reduction of the barrier 'difficulties with real time coordination of information exchange'. Difficulties with real time coordination of information exchange can be more easily addressed with modern information exchange systems. What is a more significant challenge is the development of an agreement between partners on how to use and interpret the prepared data, and how decisions should be made and implemented (i.e. agreeing the business process). For example, if a retailer was to provide real time links to Point of Sale (POS) data to a supplier, the supplier could in effect take control of all forecasting activities and the replenishment process. However to achieve this would require a change to traditional business practice (processes) and requires significant levels of trust.

It is noted that 'the difficulty in calculating the benefit' is also a barrier to successful CPFR implementation. In the first instance it is important to recognise that the literature has shown significant benefits in practical implications. However, the development of personal organisational benefit due to CPFR implementation is essential. From a practical perspective it is suggested that 'early-wins' are essential as a motivational tool in any long term CPFR plan. It is also essential that these wins are not one sided are shared across the stakeholders. Where wins are not naturally distributed in an even fashion – CPFR win sharing protocols should be developed prior to project execution. The development of such a protocol will also contribute to trust building. Trust permeates CPFR at all levels and it can be concluded that organisations need trust to embark on CPFR and CPFR will then enhance trust which creates a somewhat virtuous circle. From an organisational perspective, it is essential to align internal activities prior to engaging in CPFR with other parties.

A limitation to the current study is its focus on the high-tech sector. Although it expected that the findings may have wider general applicability further studies in different industrial domains should be undertaken to validate this assumption. Although a comprehensive list of barriers was identified, the classification of the same under four headings was completed using expert opinion. As with any individual judgement activity, these activities could be classified in a somewhat different fashion. This could have included for example reclassification of a barrier under an alternative heading, or the development of entirely different classification headings. In this particular study a second validation expert group were used to ensure consistency as much as was possible. However, further studies could be completed to evaluate alternate classification schemes and to test the robustness of the current expert consensus techniques used in this paper, including the evaluation of increased numbers of experts and/or the inclusion of experts from varying industrial sectors. In an extension of this, it could also include evaluation of the results using statistical validation of the ISM model.

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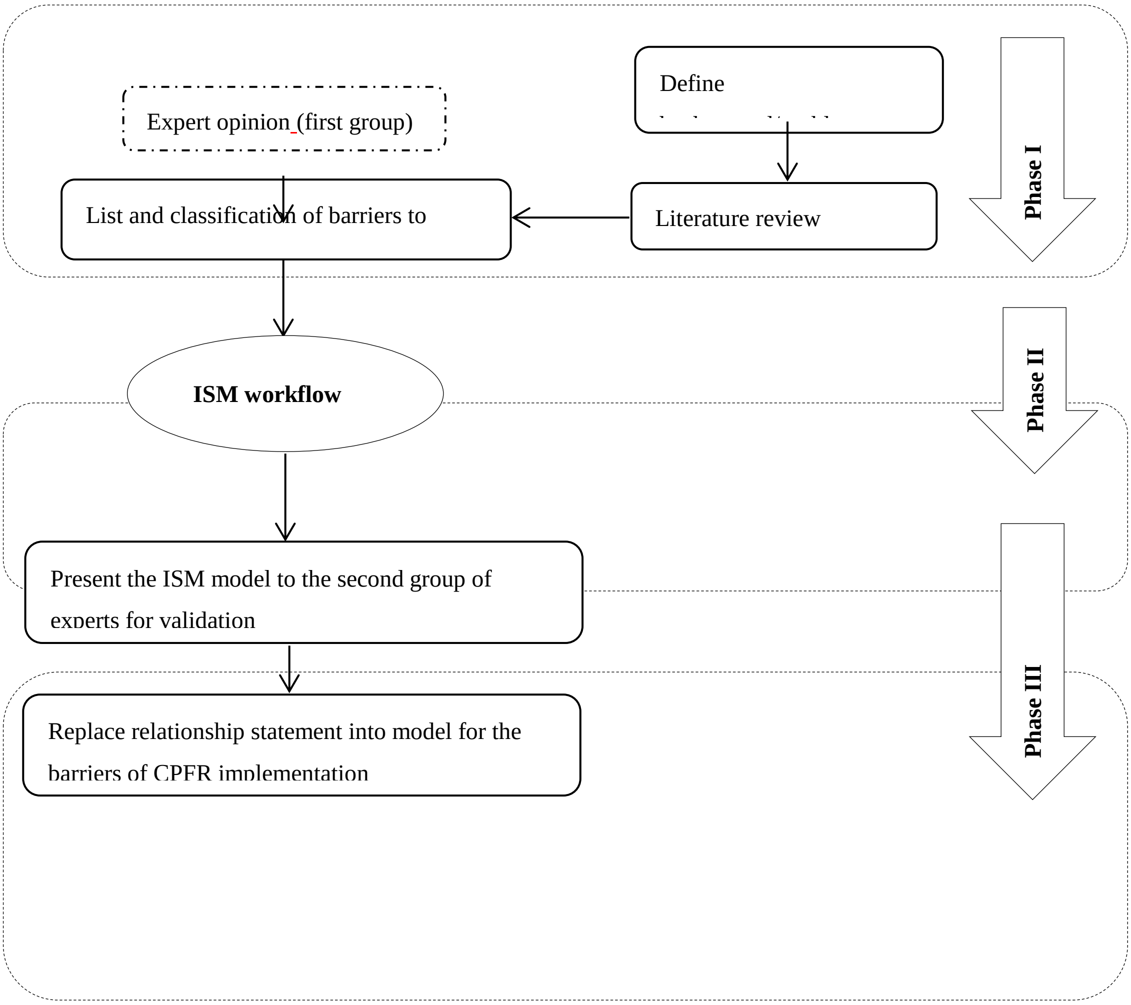
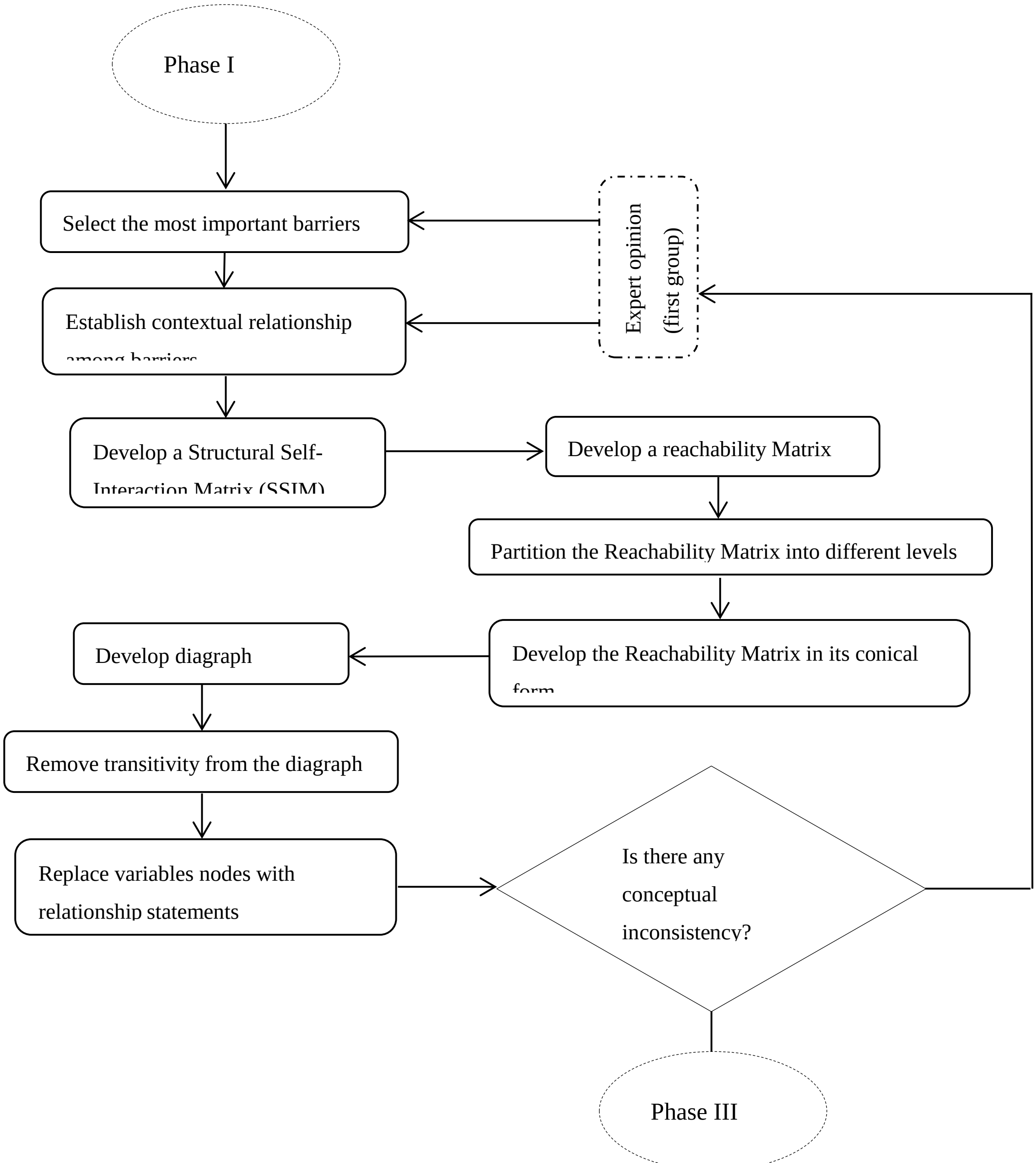


Figure 1. Methodology of the research



Phase I
Select the most important barriers
Establish contextual relationship among barriers
Expert opinion (first group)
Develop a Structural Self-Interaction Matrix (SSIM)
Develop a reachability Matrix
Partition the Reachability Matrix into different levels
Develop diagraph
Develop the Reachability Matrix in its conical form
Remove transitivity from the diagraph
Replace variables nodes with relationship statements
Is there any conceptual inconsistency?
Phase III

Yes

No

Figure 2. Main ISM development phases

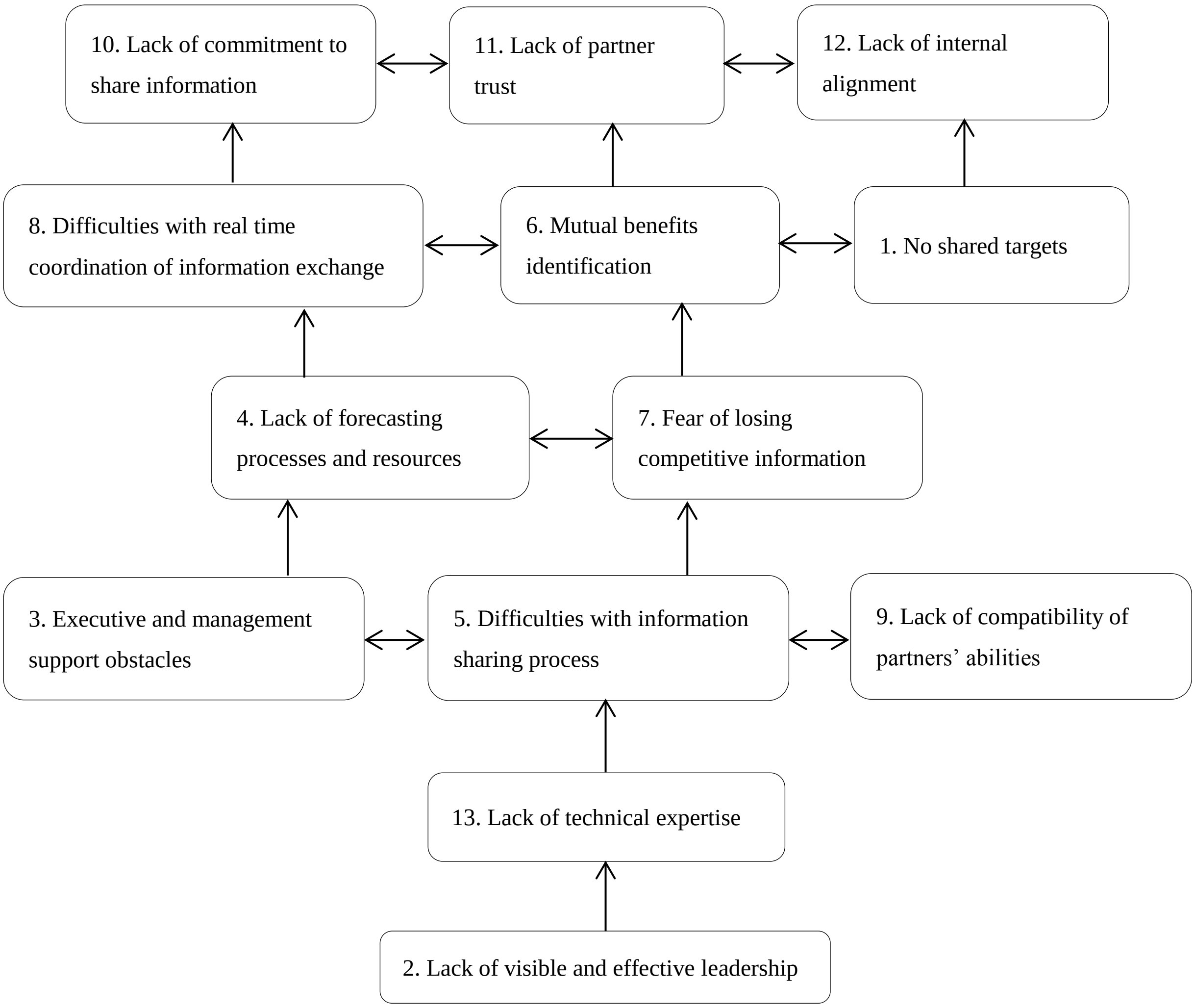


Figure 3. ISM-based model for barriers to implement CPFR in high-tech industry

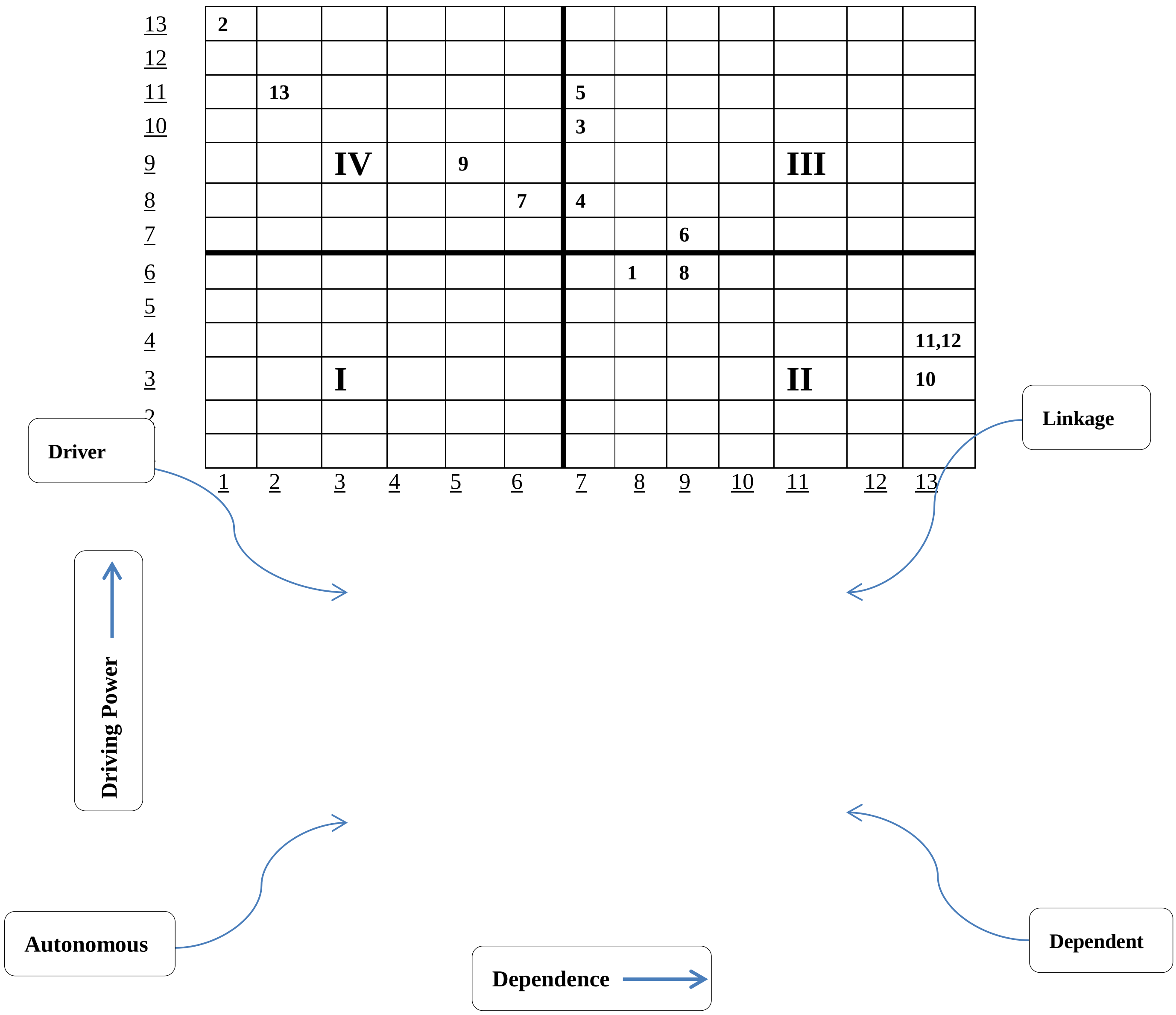


Figure 4. Driving power and dependence diagram.

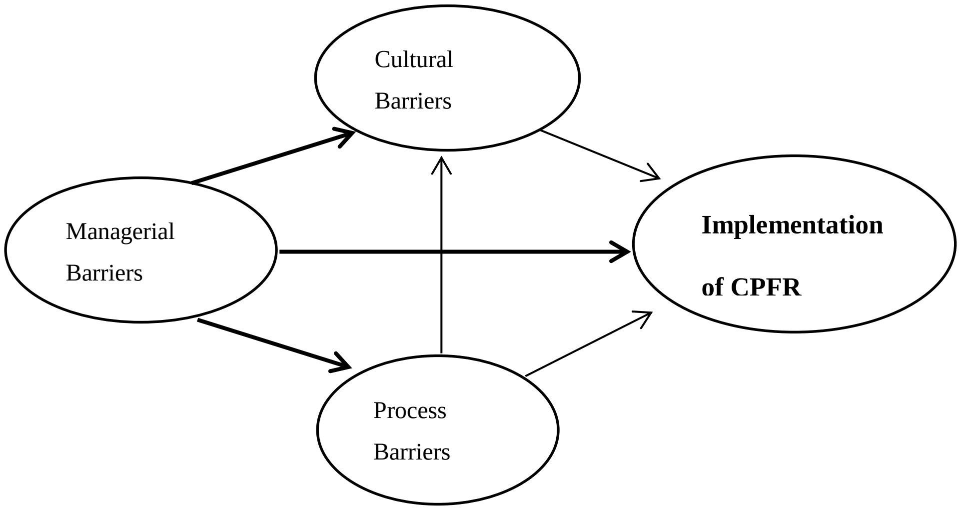


Figure 5. Conceptual framework: Relationships between criteria

Table 1. Descriptions of experts' background

	Experts	Academia/ Industry	Background/ current position	Years of experiences	High-tech sector
Group 1	E1	I	Supply chain Developer	18	Semiconductors
	E2	I	R & D manager (New Production Technologies)	21	Computer and peripheral equipment
	E3	I	Operations engineer	16	Mobile phone and Communications Equipment
	E4	A	Supply chain lecturer and researcher	20	Electronic component
	E5	A	Supply chain lecturer and researcher	10	Electronic component
	E6	A	Supply chain lecturer and researcher	10	Electronic Automotive
Group 2	E7	I	Senior Director of Operations	22	Semiconductors
	E8	I	Supply Chain Projects Leader	15	Medical Devices
	E9	I	Senior Executive of Supply Chain global programs	26	Computer and Digital equipment

Table 2. Classification of barriers to CPFR implementation

Criteria	Sub-criteria	Literature
Managerial	No shared targets	Barrat and Oliveira(2001)
	Lack of effective leadership	Seifert(2003)
	Unclear objectives	Cederlund et al(2007)
	Internally focused organizational silos	Seifert(2003)
	Lack of promotions	Barrat and Oliveira(2001)
	non-existent change management skills	Seifert(2003), Frantz(1999)
	Lack of financial resource	Cassivi(2006)
	Executive and management support obstacles	Barrat and Oliveira(2001), Cederlund et al(2007)
	No budget for software	Barrat and Oloveira(2001)
	Cost of technology	Fliedner(2003)
	Lack of internal alignment	Seifert(2003), Holweg, 2005, Fliedner(2003), Min and Yu(2008)
	Lack of compatibility of partners' abilities	Fliedner(2003)
	Lack of technical expertise	Fliedner(2003)
Process	Demand variability	Barrat and Oliveira(2001)
	Cost of systems	Cassivi(2006)
	Internal restructuring	Cassivi(2006)
	Lack of forecasting processes and resources	Småros(2003)
	Legacy systems	Seifert(2003)
	Difficulties with information sharing process	Småros and Främling(2001), Frantz (1999)
	Mutual benefit identification	Barrat (2004)
	Intensive nature of CPFR	McCarthy and Golicic(2002), Småros(2003)
	Lack of scalability of CPFR	Min and Yu(2008),McCarthy and Golicic(2002), Frantz(1999)
	Joint processes (Creating shared processes)	Småros and Främling(2001)
	Fear of losing competitive information	Frantz(1999), Bowersox et al(2000), Jacobs and Chase (2008), Cassivi(2006), Fliedner (2003)
	Difficulties with real time coordination of information exchange	Min and Yu(2008), McCarthy and Golicic(2002), Barratt and Oliveira(2001)
	Exception items in CPFR implementation process	Caridi et al(2006)
	Aggregation concerns (number of forecasts and frequency of generation)	Stedman(1998)
	Fragmented information sharing standards	Fliedner(2003)
	Conflicting objective between partners	Fliedner(2003)
	Potential loss of control	Fliedner(2003)
	Inconsistent forecasts	Fliedner(2003)
	Ineffective use of point-of-sales information	Barratt and Oliveira(2001)
Technological	Availability and cost of technology	Fliedner(2003)
	No adequate information technology	Barrat and Oliveira(2001)
	Inadequate collaborative software	Chung and Leung(2005), Min and Yu (2008)

	Technological reliability and dependencies	Cassivi(2006)
	Technology complexity	Tornatzky and Klein (1982)
	Incompatibility in IT structures	Seifert(2003)
Cultural	Lack of commitment to share information	Seifert(2003), Ke and Wei(2008)
	Poor communication	Cassivi(2006)
	Lack of partner trust	Hvolby & Trienekens(2010), Chen et al(2007), Seifert(2003), Frantz(1999), Ireland and Bruce(2000), Barrat and Oloveira (2001), Nesheim(2001), Moberg et al(2003)
	Fear of collusion leading to higher prices	Verity(1996)
	Personal comfort zones	Seifert(2003)
	Human resistance to change and training issues	Cassivi(2006)
	Tunnel vision	Seifert(2003)

Table 3. CPFR Barriers

Barrier	CPFR Descriptor/Effect
No shared targets *Lack of visible and effective leadership*	A significant barrier to the implementation of CPFR, lack of shared targets is a factor that limits trading partners' visibility about collaboration. Seifert (2003) suggests that to adopt a successful CPFR with partners, a company's leadership must preach the necessity for all employees to think in collaborative terms and act in real time. An effective leadership is a key factor to manage and control the entire collaboration project among trading partners.
Executive and management support obstacles	Top management support and commitment is necessary for any strategic programmes success such as collaboration as it is responsible for all activities at every level of collaboration (Zhu and Sarkis, 2007). On the other hand, many CPFR projects fail due to the lack of executive and top management support (Cederlund et al, 2007). Many experts are not willing to participate in serious collaborations with other companies, as they don't receive a high level of support from their own firms' top management.
Lack of forecasting processes and resources	Småros (2003) suggests that the lack of forecasting processes and resources is the single most important barrier and the root cause of many problems. The forecasting processes and resources have often been neglected in the implementation of CPFR process.
Difficulties with information sharing process	Information sharing is needed for communication and without information sharing, no collaborative processes can be developed. However even when firms are aware of its importance, there still exist fundamental technological issues concerning its process where the parties cannot trust each other (Småros and Främling, 2001). Van der Vaart et al., (2012) emphasized the importance of communication infrastructure which refers to the technical means in the information sharing process.
Mutual benefits identification	The benefits of CPFR vary with the trading partnership and suffer from some challenges like overcounting the benefits. There is the need to be clear about the mutual benefits for trading partners (Barrat, 2004). To truly gain the benefits from multiple collaborative relationships, the business community must trade and communicate via an open, interoperable, and global foundation of commerce (Seifert, 2003)
Fear of losing competitive information	Companies should be able to control what information is shared with whom and be able to rely on the security of the information sharing. These are fundamental issues concerning trust when companies are dealing with information sharing. However, when companies are faced with the necessity of sharing information, some supply chain parties are reluctant to share what they consider to be sensitive information because they fear that the information may leak, or that the information may be used against them (Småros and Främling, 2001).

Difficulties with real time coordination of information exchange	The studies on CPFR mostly emphasize the importance and performance potential of forecast information exchange, especially for the supplier in a dyadic supplier – customer relationship (Forslund and Jonsson, 2007). Researchers have also proposed that difficulties with real time coordination of information exchange is an important barrier to successful implementation of CPFR (Barratt and Oliveira, 2001; Min and Yu, 2008; McCarthy and Golicic, 2002). CPFR projects are only effective and successful if the information that fuels them is immediate, accurate and always available. Partners need real time information exchange to enhance their awareness and understanding of customers' requirements. For example, real time information exchange between sales and manufacturing allows for the setup of an efficient forecasting, production planning, and customer order fulfilment system.
Lack of compatibility of partners' abilities	Lack of compatibility of partners' abilities is one of the most important obstacles which can be attributed to improper selection of partners. In other words, to successfully implement CPFR, there must be a certain degree of compatibly in the abilities of supply chain trading partners (Fliedner, 2003). During the expert discussions it was agreed that the lack of compatibility of partners' abilities could also be the root cause of many of the other issues.
Lack of commitment to share information	A lack of commitment to share information between participants creates a critical barrier to success in CPFR initiatives (Seifert, 2003). Without a strong corporate commitment to timely share information, it is often difficult to exchange information about a firm's requirements and activities with other partners. Lack of information sharing is found to be the most critical factors causing the failure of supply chain collaborations (Ke and Wei, 2008).
Lack of partner trust	Trust indicates that a partner is willing to rely on exchange of information with other partner in whom it has trust. Heikkila (2002) stated that there is trust when a supply chain member believes that its partner is reliable and benevolent. Trust between partners in collaborative relationships is also important and thus there are many studies which deal with this issue (Frantz, 1999; Ireland and Bruce, 2000; Barrat and Oloveira, 2001; Nesheim, 2001; Seifert, 2003; Moberg et al, 2003; Chen et al., 2007; Hvolby and Trienekens, 2010). Barrat and Oliveira (2001) believe that developing trust between partners is a long-term objective for firms and a real trust based relationship will only be created after a relatively lengthy period, although it must start somewhere. Seifert, 2003 stated that 'lack of trust' is a major cultural issue which companies must address.
Lack of internal alignment	As a prerequisite and vital activity, internal operations need to be synchronized and then collaboration with external members may be pursued. Without internal alignment, the entire CPFR scheme will fail. (Fliedner, 2003; Holweg, 2005; Min and Yu, 2008)
Lack of technical expertise	Fliedner (2003) identified the lack of technical expertise as a barrier. Technical expertise is the capability to perform a particular professional task, with skill of an acceptable quality. It is apparent that without this, there will be no chance to run a successful collaboration plan. Against, a firm with higher quality of human resources such as better technical expertise will help in implementing CPFR. A lack of financial resources is a root cause of this issue.

Table 4. Structural self-interaction matrix (SSIM)

Barriers	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**
1. No shared targets	A	V	V	V	A	O	A	X	A	O	X	A
2. Lack of visible and effective Leadership	V	V	V	V	V	V	V	V	V	V	V	
3. Executive and management support obstacles	A	V	V	V	O	V	V	O	V	V		

4. Lack of forecasting processes and resources	A	V	V	V	X	V	X	O	A
5. Difficulties with information sharing process	A	X	V	V	X	X	V	V	
6. Benefits difficult to calculate	A	V	V	V	O	O	A		
7. Fear of losing competitive information	O	V	A	V	A	V			
8. Difficulties with real time coordination of information exchange	A	V	V	V	A				
9. Lack of compatibility of partners' abilities	A	V	V	V					
10. Lack of commitment to share information	A	X	X						
11. Lack of partner trust	A	V							
12. Lack of internal alignment	A								
13. Lack of technical expertise									

Table 5. Final Reachability Matrix - Barriers to Implement CPFR in high-tech industries

Barriers	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**Driving power**	**Ranks**
1	1	0	1	0	0	1	0	0	0	1	1	1	0	6	**7**
2	1	1	1	1	1	1	1	1	1	1	1	1	1	13	**1**
3	1	0	1	1	1	1	1	1	0	1	1	1	0	10	**3**
4	0	0	0	1	0	1	1	1	1	1	1	1	0	8	**5**
5	1	0	1	1	1	1	1	1	1	1	1	1	0	11	**2**
6	1	0	1	0	0	1	0	1	0	1	1	1	0	7	**6**
7	1	0	1	1	0	1	1	1	0	1	1	1	0	8	**5**
8	0	0	0	0	1	1	0	1	0	1	1	1	0	6	**7**
9	1	0	0	1	1	0	1	1	1	1	1	1	0	9	**4**
10	0	0	0	0	0	0	0	0	0	1	1	1	0	3	**9**
11	0	0	0	0	0	0	1	0	0	1	1	1	0	4	**8**
12	0	0	0	0	1	0	0	0	0	1	1	1	0	4	**8**
13	1	0	1	1	1	1	0	1	1	1	1	1	1	11	**2**
Dependence	8	1	7	7	7	9	6	9	5	13	13	13	2	**100**	
Ranks	**3**	**8**	**4**	**4**	**4**	**2**	**5**	**2**	**6**	**1**	**1**	**1**	**7**		

Table 6. Iteration 1

Barriers	**Reachability Set**	**Antecedent Set**	**Intersection**	**Level**
1	1,3,6,10,11,12	1,2,3,5,6,7,9,13	1,3,6	
2	1,2,3,4,5,6,7,8,9,10,11,12,13	2	2	
3	1,3,4,5,6,7,8,10,11,12	1,2,3,5,6,7,13	1,3,5,6,7	

4	4,6,7,8,9, 10,11,12	2,3,4,5,7,9,13	4,7,9	
5	1,3,4,5,6,7,8,9,10,11,12	2,3,4,5,8,9,12,13	3,4,5,8,9,12	
6	1,3,6,8,10,11,12	1,2,3,4,5,6,7,8,13	1,3,6,8	
7	1,3,4,6,7,8,10,11,12	2,3,4,5,7,9,11	3,4,7,11	
8	5,6,8,10,11,12	2,3,4,5,6,7,8,9,13	5,6,8	
9	1,4,5,7,8,9,10,11,12	2,4,5,9,13	4,5,9	
10	10,11,12	1,2,3,4,5,6,7,8,9,10,11,12,13	10,11,12	**I**
11	7,10,11,12	1,2,3,4,5,6,7,8,9,10,11,12,13	7,10,11,12	**I**
12	5,10,11,12	1,2,3,4,6,7,8,9,10,11,12,13	5,10,11,12	**I**
13	1,3,4,5,6,8,9,10,11,12,13	2,13	13	

Table 7. Iteration 2

Barriers	**Reachability Set**	**Antecedent Set**	**Intersection**	**Level**
1	1,3,6	1,2,3,5,6,7,9,13	1,3,6	**II**
2	1,2,3,4,5,6,7,8,9,13	2	2	
3	1,3,4,5,6,7,8	1,2,3,5,6,7,13	1,3,5,6,7	
4	4,6,7,8,9	2,3,4,5,7,9,13	4,7,9	
5	1,3,4,5,6,7,8,9	2,3,4,5,8,9,13	3,4,5,8,9	
6	1,3,6,8	1,2,3,4,5,6,7,8,13	1,3,6,8	**II**
7	1,3,4,6,7,8	2,3,4,5,7,9	3,4,7	
8	5,6,8	2,3,4,5,6,7,8,9,13	5,6,8	**II**
9	1,4,5,7,8,9	2,4,5,9,13	4,5,9	
13	1,3,4,5,6,8,9,13	2,13	13	

Table 8. Iteration 3

Barriers	**Reachability Set**	**Antecedent Set**	**Intersection**	**Level**
2	2,3,4,5,7,9,13	2	2	
3	3,4,5,7	2,3,5,7,13	3,5,7	
4	4,7,9	2,3,4,5,7,9,13	4,7,9	**III**
5	3,4,5,7,9	2,3,4,5,9,13	3,4,5,9	
7	3,4,7	2,3,4,5,7,9	3,4,7	**III**
9	4,5,7,9	2,4,5,9,13	4,5,9	
13	3,4,5,9,13	2,13	13	

Table 9 Iteration 4

Barriers	**Reachability Set**	**Antecedent Set**	**Intersection**	**Level**
2	2,3,5,9,13	2	2	

3	3,5	2,3,5,13	3,5	**IV**
5	3,5,9	2,3,5,9,13	3,5,9	**IV**
9	5,9	2,5,9,13	5,9	**IV**
13	3,5,9,13	2,13	13	

Table 10 Iteration 5

Barriers	Reachability Set	Antecedent Set	Intersection	Level
2	2,13	2	2	
13	13	2,13	13	**V**

Table 11 Iteration 6

Barriers	Reachability Set	Antecedent Set	Intersection	Level
2	2	2	2	**VI**