

# A Collaborative Planning Forecasting and Replenishment (CPFR) Maturity Model

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**Abstract:** This paper presents the development of a framework that organizations can use to assess their CPFR maturity. The proposed modeling framework identifies essential functional and structural aspects of CPFR processes and formulates a method for evaluation on a variety of characteristics of CPFR. This paper uses a multi-objective decision analysis variant to structure the framework into a hierarchical model for CPFR maturity assessment. Each area of the model was identified based on standardized, industry-accepted process definitions. Then, easy to answer questions were formulated to develop a multi-attribute assessment and scoring of capabilities. This model provides a structured representation of the CPFR process for maturity assessment and provides a path of progress for improving the state of CPFR within the underperforming areas. Engineering managers can use the developed model to assess an on-going CPFR program across several areas and communicate the identified high impact improvement areas with various organization segments.

**Keywords:** Collaborative Planning Forecasting and Replenishment (CPFR), Simple Multi-Attribute Rating Technique (SMART), Supply Chain Collaboration, Logistics

## 1. INTRODUCTION

Collaborative Planning Forecasting and Replenishment (CPFR) is an industry best practice that focuses on enhancing external Collaboration between suppliers and retailers by adopting time-phased forecasting and multilevel inventory planning to generate integrated supply chain plans across an extended planning horizon. CPFR requires collaborative information networks and real-time electronic data interchange (e.g., Point of sale data

(POS), stock level, demand forecasting, delivery schedules, and inventory cost). It also requires incentive alignment between the collaboration partners to ensure successful implementation and operation. The concept of CPFR grew out of the framework of Efficient Consumer Response (ECR), which has been further modified to reap the benefits of technology and become more versatile in better controlling and optimizing business processes [1].

CPFR evolved out of several efforts and collaborative operating models. The most prominently articulated CPFR model was developed by the Voluntary Interindustry Commerce Standards Association (VICS), which first described and publicized the concept of CPFR in the US [1]. Since its introduction, numerous studies (primarily case study-oriented) have examined the challenges of implementing and successfully operating collaborative partnerships based on CPFR principles and practices. Much of the academic literature associated with CPFR focuses on characterizing its principles and developing qualitative and quantitative models concerning its benefits and usage within practice. Section 2 will present further background on the literature associated with CPFR. CPFR has been recognized as a critical initiative that firms can utilize to leverage the generally accepted efficiencies to better coordination within a supply chain. Despite this recognition, the adoption of CPFR within various industries remains a challenge. Mainly, this is because that the benefits, which in many cases are anecdotal, the implementation processes and successful operating methods pose (in some cases) substantial risks of failure. Ref. [2, 3] addressed the issue of firm performance (benefits) within the context of CPFR. This paper addresses the issues related to the challenges of CPFR by proposing a maturity assessment model for the adoption of CPFR.

A maturity assessment model provides insight into a 'firm's ability to implement and operate a business practice successfully. This research develops a CPFR maturity assessment model that allows an organization to measure their ability to be successful along several essential dimensions within CPFR. Such a model should be useful to organizations considering CPFR implementations or diagnosing issues related to current implementations and monitoring best practice preparation.

This paper presents the CPFR maturity assessment model and illustrates its use via a case study and notional examples. Ref. [3] identified 22 best practices present in retail supply chains. Each practice was rated by supply chain experts on potential impact, the scope of applicability, difficulty, and cost of implementation. The rating results showed that CPFR was among the four best practices that supply chain experts and researchers believed would significantly impact the healthcare supply chain [3]. This result motivated us to select a case study context within the healthcare industry. We were quickly able to find willing collaborators due to the healthcare 'industry's interest in controlling costs and improving supply chain efficiencies. The proposed assessment model was developed in Collaboration with representatives with experiences within the retail, aerospace, trucking, and healthcare industries. Representatives were included in reviewing the assessment model questions and providing feedback on the tool's functioning and its results. While the case study assessment is applied within a healthcare supply chain context, the proposed model was designed to apply to any firm interested in applying CPFR.

The rest of this paper is structured as follows. Section 2 presents background on CPFR and categorizes the literature findings relative to its benefits and characteristics. In section 3, we present the framework behind the CPFR maturity model. Section 4 elaborates on the process of quantifying the CPFR maturity. Section 5 illustrates the use of model through a notional example. In section 6 the evaluation results of the model is presented. Finally, in section 7, we summarize the contributions and provide ideas for future work.

## 2. LITERATURE REVIEW

This section reviews literature pertinent to empirical and theoretical work done on CPFR to understand better the structure of CPFR, the level of business operations it encompasses, and factors affecting success in implementing CPFR.

Wal-Mart was the first to approach VICS to launch the CPFR program to improve its supply chain performance [4]. The Wal-Mart and Warner-Lambert CPFR business model was designed to share forecasts between the two partners and identify forecast discrepancies between the two organizations, to reduce inventory throughout the

supply chain and reduce stock-outs [1]. Wal-Mart is in a unique class within the retail industry and leads the adoption of best practices, so the adoption of CPFR by Wal-Mart can be considered one indication of its benefits.

During the 1990s, Quick Response (QR) leadership committee was established to meet the changing requirements of a competitive market continually [5]. At around the same time, the Efficient Consumer Response (ECR) movement was initiated by the grocery industry to meet consumer demands efficiently. With the need to communicate better between business partners, Collaboration was prioritized with ECR and QR practices. One method of solving the communication problem between supply chain partners was introducing the Vendor Managed Inventory (VMI), which is still a common inventory management strategy. More details about VMI can be found in [6]. Besides VMI's initiative, ECR embarked on modifying the VICS's CPFR guidelines to adapt to the European market. According to [7], an analysis of the VICS CPFR guidelines showed little to no changes necessary to adapt the guidelines to the European market. This conclusion is essential for this research and CPFR adoption in general; the benefits of CPFR and the maturity model developed in this research can be considered applicable regardless of the market and/or sector.

Understanding how CPFR is implemented in the industry was developed through empirical studies in [2]; this helps build the model's hierarchy. Ref. [8] summarized CPFR uses through a general industry survey. Analysis of the survey showed that industry implementation of CPFR could be as simple as using collaborative forecasting and automatic replenishment and as complicated as a complete installation of CPFR. This kind of analysis requires a categorization that tells the company where they should focus on improving CPFR implementation performance. Frameworks to facilitate the implementation of CPFR have been proposed in the literature. For example, [9] did a case study in an automotive supplier company and provided a holistic roadmap for implementing CPFR. Another model was proposed by [10] for CPFR implementation in healthcare supply chains. The organization may refer to these cases to learn about the implementation process and follow a suitable framework. However, an organization has no visibility on its current CPFR maturity and where to focus on improving. The purpose of the maturity model developed in this research is to provide organizations with a tool accompanied by a rubric to assess their CPFR maturity and readiness.

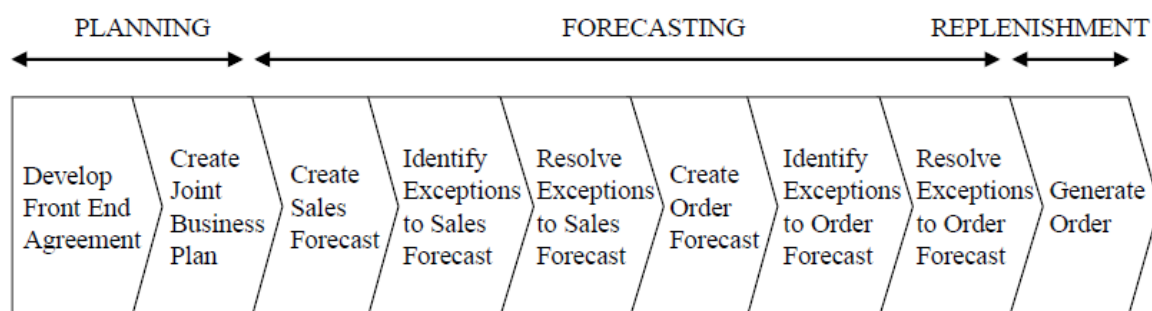
VICS's CPFR framework revolves around the concept of a 'buyer' and a 'seller.' Collaboration is the key in this framework, which incorporates replenishment, forecasting, and planning. CPFR is

about integrated Collaboration more than just a partnership [11]. This finding is not specific to any sector; for example, [12] stated that collaboration and building trust between SC partners is the key to reducing the immense cost faced by the healthcare sector. The collaboration model choice effect on inventory control and business outcomes was studied by [13]. Results showed that a strategic collaboration with suppliers and customers should be developed for the firms that focus on flexibility, quality, and delivery, while for firms focusing on cost and quality, operational Collaboration should be followed. Ref. [14] did a study on the coordination structures and their importance to supply chain managers. A literature review on the mechanisms of supply chain collaboration and their impact on performance was done by [15], through which the authors shed light on the most important area in CPFR, Collaboration. They also concluded that a maturity model on the supply chain collaboration is a must. Being crucial in CPFR, Collaboration has been investigated through questions and given weights that reflect its key role in our maturity assessment model. Our current research is to fill this gap by building a CPFR maturity model that can be used by engineer managers for evaluating the state of CPFR within their firms; this will help them in making decisions and redesigning weak elements in the SC to enhance the utility of CPFR.

An increasing number of studies present the benefits of CPFR and its positive potential impact on SC performance [16, 17]. The first significant benefit is reducing inventory; for example, see [11]. The second benefit is improving sales and financial operations performance; for example, see [18]. The studies mentioned above and most literature investigated the potential benefits of CPFR and the issues due to implementing CPFR. Ref. [2] provided systematic empirical evidence, using a survey methodology, on the impact of CPFR implementation on 'companies' operational and financial performance. They provided a benchmark for economic returns for companies to use when preparing for implementing CPFR. Another insight from [2] was that the benefits of CPFR tend to increase with time. All of the mentioned insights about CPFR benefits were used in our maturity CPFR model to build four tiers that will be used to classify supply chain systems based on their score results. Also, they were utilized in creating questions to assess maturity, which was indicated in the literature as a theme for CPFR as time of use advances. Our model will help companies evaluate this advance and learn where to focus on enhancing maturity.

The need to align common business goals must be realized between business partners, which will help dissipate business risk among the business partners and provide visibility into the complex operations of the SC. With an emphasis on the retail business process, VICS developed four collaborative activities that can improve performance: Strategy & Planning, Demand & Supply Management, Execution, and Analysis [19]. These steps are not necessarily sequential to one another. VICS separates the business partners between retailers and manufacturers and assigns a specific task to each group. The primary CPFR model breaks down the collaboration tasks into four different sectors, with two tasks per sector; details can be found in the next section. This organization facilitates identifying the most appropriate groups within the organization to assess each area.

There should be a collection of preparation steps and infrastructure for the successful implementation of the CPFR. According to [2], it takes a long time, possibly many years, to fully complete the installation process. Ref. [20] presented nine steps for implementing CPFR, as shown in Figure 1. Some fundamental technology needs are required for the successful implementation and operation of CPFR. The technology should facilitate these factors, including, but are not limited to, the capability to share forecasts and historical data between partners, automate the Collaboration and joint business plan, evaluate exception conditions, and enable revisions and commentary [19]. A newly published article [21] sheds light on Big Data analytics usage in managing supply chain resources. This area is expected to improve the demand forecasting quality, as well as communications capabilities. Data standardization may also play a crucial role in the accuracy of shared forecasts and logistics communications. Data standardization has been adopted by most sectors while missed in others like healthcare, [22] presented benefits and barriers of it in healthcare. Ref. [23] studied the effect of radio frequency identification (RFID) technology adoption on logistics service firm performance. They conducted a survey and analyzed the results from 131 valid responses and showed that RFID adoption positively affects business practices. Ref. [24, 25] developed a multicriteria decision-making framework based on multi-objective decision analysis and value analysis principles. The goal was to improve the performance of the SC by focusing on the physicians' preference items. All of this tells us how much effort we need to do to implement the CPFR, and it also justifies the need for a model to monitor CPFR progress after spending much effort and money.



**Figure 1:** Nine-Step CPFR Model [20]

Combining technology with business partnering, fast and accurate data exchange was possible, which led to more accurate forecasting. Adoption of collaboration forecasting resulted in improvements in the inventory, operational costs, profits, and product availability, as stated by [26], who studied this effect in a high technology product supply chain. A case study done by [27] in the European grocery sector showed that the lack of forecasting abilities is the most significant barrier to full Collaboration. Ref. [28] investigated the effect of forecasting errors on CPFR collaboration strategies using discrete-event simulation. He concluded from the simulation experiments that to gain maximum benefits from the CPFR, both the manufacturer and retailer should minimize random forecast error and avoid negative bias forecast error. A study of CPFR success factors in the retail industry using fuzzy cognitive mapping was done by [29]. The idea was to identify the factors that will facilitate better implementation of CPFR strategy in retail. Results showed that communication is the most crucial factor in implementation success. Such theoretical and simulation results show the importance of forecasting accuracy in CPFR performance; however, they do not tell where the company stands in terms of CPFR maturity overall and what to do to improve. This result will also be used in estimating the weights of questions targeting forecasting accuracy and technology. Weight estimation was done based on multicriteria concepts where the relative importance of indicators was implemented.

Unlike the retail, manufacturing, and consumer goods industry, healthcare has been relatively slow to adopt successful operations and logistics management practices. Only recently, the healthcare industry has started to focus on these topics [30]. Ref. [31] investigate more in the healthcare supply chain to focus on the reasons that cause complications in the supply chain because of physicians' preferences. Health spending is projected to grow at a steady rate of about 6.7 percent per year and is expected to reach an estimated \$4.3 trillion in 2017 [32]. In the report published on the Reuters website in February 2018,

Abutaleb [33] stated that United States health spending is projected to rise 5.3 percent in 2018, while it was 4.6% (\$3.5 trillion) in 2017. The supply costs of a hospital account for one-third of the total budget of a hospital on average. Forty percent of the supply chain (SC) cost is spent on supply distribution, which is more than five times the amount spent by major retailers such as Wal-Mart and Procter & Gamble in this functional area [34]. Thus, any opportunity to improve the supply chain in healthcare will have significant savings in healthcare spending. Implementing CPFR in healthcare supply chains is a potential improvement area, and with the maturity model proposed in this research, it should become more fruitful.

An example from manufacturing for the CPFR implementation can be found in work done by [35]. A reference model was proposed to draft measures for "the dimensions of strategy, processes, technology, and IT systems" to improve collaborative planning in the supply chain of the automotive and the semiconductor industry. Their work is oriented to a specific sector, and it provides a model (reference) but no indication for any progress monitoring of the collaborative supply planning. Ref. [36] investigated the benefits of Collaboration on supply chain performance using simulation. The study focused on pointing areas that need improvement before the initialization of Collaboration. It can be seen as readiness collaboration measurement using simulation, while our model can be seen as a maturity model that monitors all areas of CPFR.

The alignment between the maturity of performance measurement systems for a single organization and performance measurement systems for SCM was discussed based on the literature review by [37]. A model for assessing the maturity of a demand-driven supply chain was proposed by [38]. Their work has some similarities with our maturity model in terms of the methodology. They assessed the maturity of a supply chain to move toward a demand-driven supply chain, and we are assessing the maturity of a supply chain in terms of CPFR for full implementation. Very similar work to ours is the maturity model proposed by [39]. They followed the same methodology with the same

purpose, but their target was industry 4.0 maturity for manufacturing and enterprises. The way of defining dimensions and introducing items to assess each dimension is the basic methodology followed in our maturity model of CPFR.

Ref. [40] investigated and ranked the critical success factors (CSFs) necessary for implementing CPFR in the automotive industry. They used the Fuzzy Extent Analytical hierarchy Process (FEAHP) as their ranking methodology after collecting, classifying, and capturing expert opinions. The factors identified are divided into technological and non-technological and then further categorized into inter-company and intra-company indicators. The ranking of the factors helped us develop our maturity model, which will be discussed in section 4. In a similar work, [41] identified and ranked the most important criteria for efficiently implementing CPFR in the retail sector. They utilized a Fuzzy AHP in ranking the specified criteria. Both [40] and [41] are specific to the pre-implementation phase of CPFR. The present paper spans over a broader range of CPFR elements; it is also developed to enable organizations to measure maturity post CPFR implementation.

The literature reviewed in this research was divided into three main categories: Benefits of implementing CPFR, factors and their significance for implementing CPFR, case studies, and procedures for implementing CPFR. However, none has been found on the evaluation of CPFR maturity after implementation. In this research, we proposed a maturity assessment model for companies in any sector to evaluate their standing regarding the CPFR eight subsections. The evaluation will classify the company based on one of 4 tiers. Finally, the company will get suggestions on what to do to enhance its CPFR performance.

The next section presents the components modeled to assess CPFR readiness.

### 3. COMPONENTS OF CPFR MATURITY

This research models the maturity of an organization for implementing CPFR and presents a path of progress to achieve a higher level of maturity. This is achieved through (1) identifying the key activities in CPFR (2) Developing questions in order to rate each activity on a scale (3) understanding the

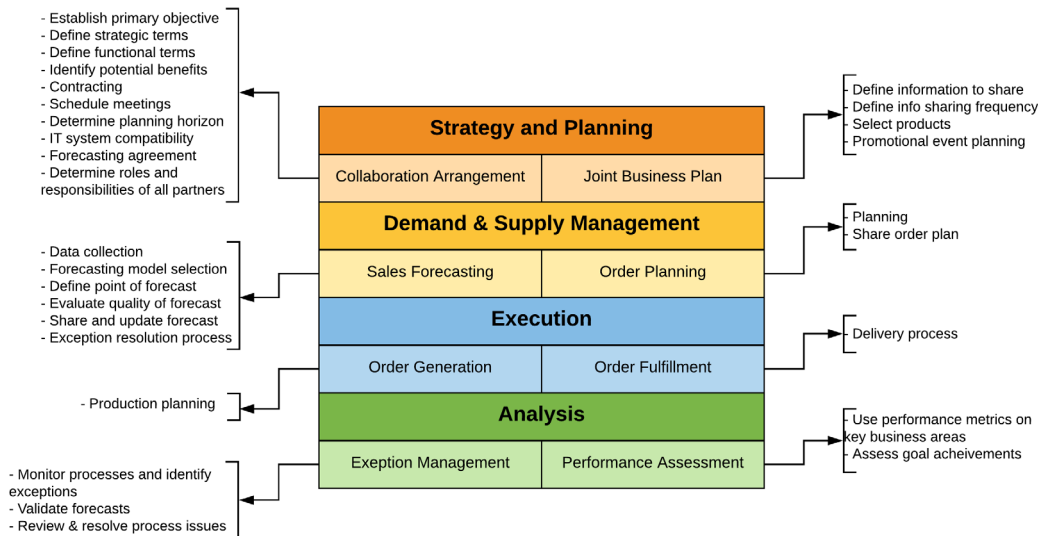
importance of each activity and (4) Developing a path of progress based on the obtained scores on activities. An understanding of these factors will help establish a maturity level. We will discuss how the model is developed and evaluated, as well as how the initial validation efforts are performed.

CPFR activities can vary significantly between different sectors of industry such as retail, healthcare etc. In order to compensate for those differences, measures are introduced in the model to provide an assessment of CPFR maturity within a wide range of industries. In addition to the review of literature and current practices, inputs from CPFR experts in industry were collected through interviews, extensive questionnaires and pilot studies. This combination established the required scope and depth for the maturity model. The following sections discuss the components of the model and how they fit into a comprehensive maturity model for CPFR.

#### 3.1 CPFR Activities Identification

Following the CPFR VICS model [19] this section categorizes the CPFR activities into four quadrants of (1) Strategy and Planning (2) Demand and Supply Management (3) Execution and (4) Analysis. These four *areas* represent a general framework that encompasses the requirements of CPFR and is applicable to most industries. Each quadrant is divided into two *sub-areas* that contain necessary *activities* to establish and maintain CPFR. *Areas*, *sub-areas*, and *activities* of the model are illustrated in Figure 2. The idea is to assess the maturity level using this hierarchical structure.

The *activities* will be defined throughout section 0 via examples and multiple questions per activity. The questions collect key information from different perspectives. The questions, which are developed through a process of discussing and analyzing the requirements of each activity, form the cornerstones of the CPFR maturity model. A company or 'organization's performance level, with respect to an activity, will be assessed by answering the questions pertaining to the activity. Answers will be collected in the form of scores on a scale of one to five. Further details will be discussed in section 4. We begin with the first quadrant of CPFR, Strategy and Planning, by defining the sub-areas and activities along with questions and examples



**Figure 2:** The structure of CPFR maturity model: areas, sub-areas, and activities

### 3.1.1 Strategy and Planning

Strategy and planning consists of developing collaborative arrangements and joint business plan development. This is the first section of the CPFR model that defines the establishment of ground rules for Collaboration between business partners to direct their operations and make strategic and tactical decisions. Strategy and planning binds the business partners in a commitment and ensures visibility in the business for all partners involved. As Figure 2 illustrates this area consists of two sub-areas of collaboration arrangement (Table 1) and joint business plan (Table 2).

**Collaboration Arrangement** is the phase where business partners form the guidelines for the collaboration effort. The guidelines include the assignment of tasks for each business partner, the required level of Collaboration, and the opportunities available to maximize the benefits of Collaboration. Partners should *establish the primary objective* of the Collaboration and develop a business plan that benefits all business partners. In order to keep consistency during Collaboration, partners should *define strategic terms* (e.g. forecast validation) clearly to exchange CPFR information effectively. In order for partners to communicate common understanding at the functional level, they should *define functional terms* (e.g. collect POS data) clearly. Partners need to be able to see the economic, operational or strategic gains of adopting CPFR; therefore they need to *identify the potential benefits* (e.g. reduced inventory or percent increase in expected sales) and determine the benefit sharing scheme.

In order for partners to come to common terms before establishing a CPFR relationship, a *contracting* agreement is needed to decide on resource allocation levels (e.g. allocating a new

division or department to CPFR operations), decision making protocols, commitments and accountability mechanisms. To maintain an effective level of communication, partners should *schedule monthly and quarterly meetings* to discuss relevant matters. Monthly meetings are typically 30 to 60 minutes to discuss issues such as vendor performance metrics, timelines, initiative progress report, changes to replenishment system, supply shortages, lead time, forecasts, etc. Quarterly meetings are to review previous business and supply chain initiatives, set milestones for each initiative, assess achievements, identify improvement opportunities, etc.

Setting new initiatives requires *planning horizon development*. A planning horizon essentially shows the capability of an organization to forecast demand and manage planning accordingly. For example, an organization might be able to forecast its demand over the next 6 months and schedule production and planning accordingly. *Compatibility of IT systems* plays a vital role in the success of CPFR. Information transfer, meetings and collaboration efforts are facilitated by an advanced IT system that can meet the needs of the effort, especially in large-scale implementations. For example, technology can be used to share forecasts between business partners.

It is important for partners to form a concrete forecasting process. A *forecasting agreement* has to be reached in determining the level of forecast, such as DC or store level forecast, the forecast update frequency, quality of data to be used, and the forecasting horizon. Often there are multiple forecasts within the same organization; the challenge is to reconcile all forecasting figures before any joint forecasting can proceed. All business partners should have a *defined role and responsibility* corresponding to supply chain

activities. Also specific tasks assigned to different departments need to be coordinated through formal or informal cooperation between departments. Effective internal Collaboration is the prerequisite of effective external Collaboration. The key success factor for external Collaboration is assigning a frontline collaborator to work with the 'partner's supply chain team. An example is a single point of contact from the customer to work with the 'supplier's planner on orders and forecasts. The list of evaluation questions used in RAM for collaboration arrangement is presented in Table 1.

**Joint Business Plan** primarily identifies events that will affect the supply chain in the long run. These events can be in the form of promotions and or product introduction. Joint business plans can also contribute towards defining the type of activities and collaboration efforts in the business plan. Partners should clearly *define a set of information* that they are willing to share (e.g. plans to release a new product to in the market). This information helps all business partners in preparing for possible changes in the demand pattern or the supply chain as a whole. In addition, *frequency of sharing strategic information* should be determined. Frequent sharing of future business plans and corporate strategy significantly help in building trust. Partners can also establish a rule for sharing key information a certain amount of time in advance (e.g. sharing the release time of a new product with retailer a year in advance).

Another important task for partners is to mutually *select the range of products* that should be managed with CPFR. Advanced CPFR can engage all items and products in the business, while basic CPFR efforts should start with a few items and products and expand later on as the process becomes more mature. The selection of products is important as some items are more difficult to manage through CPFR than others (e.g. products with volatile demand). As an example, a retail organization can plan on introducing only nonperishable items in the initial stages of CPFR to run a pilot and assess the situation.

Partners should utilize CPFR to maximize benefits from *promotional events*. Oftentimes, different manufacturers plan events to promote their product. These events generally take place at the store level with the retailer. Such events normally lead to sudden increase in demand which requires suppliers and retailers to hold sufficient amount inventory. Furthermore, promotional events from different business partners can be combined together. These promotions are called cross promotions that arise from the adjacent category, often involve items that help promote each 'item's sales. Such coordinated promotional planning helps all partners gain the benefit of increased sales. For example, promotional events of beef steak could influence the sales of charcoal and grills. Thus,

charcoal and grills manufacturer can collaborate with beef steak supplier on a cross promotional event. A certain amount of time has to be provided to all partners so that they can prepare and coordinate properly. The list of evaluation questions used in RAM for joint business plan is presented in Table 2.

### 3.1.2 Demand and Supply Management

This area primarily concerns with supply chain management where consumer demand is estimated with POS data. CPFR heavily depends on forecasting quality because forecasting is the beginning of order planning and fulfillment. It is a recommended practice to have a planning horizon over which the order and shipment requirements are planned. Thus, the process can be modified or adjusted over each planning horizon and repeated. A supply chain structure that provides visibility across the chain for all partners is a key factor for effective forecasting and order planning. As Figure 2 illustrates this area consists of two sub-areas of sales forecasting (Table 3) and order planning (Table 4).

**Sales Forecasting** is one the primary tasks of any CPFR arrangement. Because of the technical depth of this task, it is important for the assigned personnel to have the required technical skills. *Data collection* is the first step towards forecasting. Generally, in retail, the most useful data is the POS, which translates directly into consumer demand. However, DC level or manufacturer level consumption data can be used if necessary. To reduce manual work and human error, an automated data collection system that is accessible by all partners is necessary. An common example is multi-echelon supply chain system with end-to-end visibility through an EDI link with suppliers. The success of CPFR does not depend significantly on the type of *forecasting model* selected but on a model that all partners agree upon. The selection should be made considering the technical aspects as well as the level of sophistication of the business partners.

Partners should *define point of forecast* to be used for CPFR (e.g. POS, DC level, etc.). It is crucial to generate only one forecast for sales, shipping, and receipts. Multiple forecasts between departments or partners create complications and discrepancies that are hard to reconcile. The responsibility of creating the forecast should be negotiated during the collaboration arrangement phase. For example, in cases where the retailer or healthcare provider does not have an integrated system of data collection and forecasting, one of the partners with better qualifications can take up the responsibility. *Evaluating the quality of forecast* is an important activity for monitoring and improving the forecasts over time. Oftentimes the quality of data used for forecasting is a key contributor for quality. For example, forecasts made on POS data that is distorted due to significant amount of out of stock



items at the store level will give a wrong perception of the demand for a particular item. As a forecast is made and shared, the validation process should initiate with the confirmation that there is consistency in the data being used to validate the forecast. As the quality of forecast being evaluated and more recent demand data become available, the responsible partner should *update and share forecasts*. The ability to update the system on a weekly/daily/hourly frequency shows the level of maturity in CPFR. Advanced CPFR systems can generally provide forecasts on a daily basis. Even advanced forecasting processes involve issues that need to be jointly resolved on a case by case basis. Forecasts on SKUs that do not seem to be representative of the actual demand can be resolved through an *exception resolution process*. This process is ideally done through joint meetings, sharing real-time demand data, reassessing forecasts, and making changes. Often, exceptions can be identified by setting limits for unnormal behavior. Revised forecasts are oftentimes the output of the exception resolution activity. The list of evaluation questions used in RAM for sales forecasting is presented in Table 3.

**Order Planning** is the phase where future product ordering and delivery requirements are organized and set. This phase significantly depends upon the forecasting process and is supported by inventory positions, transit lead times, etc. At this point of supply chain planning, the process of production or purchase has not begun. In the *planning* phase, future product ordering is planned through the establishment of a replenishment system considering the required service levels, expected lead times and other requirements. Planning is important to translate the forecast into a plan based on which order fulfillment can be achieved. The planning phase needs to be a collaborative effort. Partners need to *share order plans* in order to create visibility into future shipments. Generally, in CPFR, the planning phase is initiated and executed by the manufacturer or supplier at the upstream of supply chain. However, the visibility of customers into the future order plans provides the opportunity to manage exceptions more efficiently and create a plan more in line with the overall business objective (e.g. inventory reduction, service level fulfillment). The list of evaluation questions used in RAM for order planning is presented in Table 4.

### 3.1.3 Execution

The execution phase generates and transports the order from the supplier to the customer. There are two primary functions associated with execution, *order generation* and *order fulfillment* (Figure 2). The overall objective of this phase is to transform the forecast into firm demand. Planning supports this phase by providing guidelines to follow.

**Order Generation** translates forecasts to demand. In general, the 'retailer's role with respect

to this task is buying/re-buying, and the manufacturer role is production and supply. However, there are other required collaborative activities that are common for all partners. The key activity to support order generation is *production planning*. This activity requires the time-phased generation of distribution and production orders. Customers who send Purchase Orders (PO) should have an auto PO generation process that will reduce manual work and thus errors. Web based ordering is the most preferred form of transaction, and for even more advanced levels, a web-based EDI transmission yields a higher cost to benefit ratio. Advanced Shipment Notification (ASN) is also essential in the CPFR process as it provides the customer with advance knowledge of future shipments and can help them to plan accordingly. In CPFR, suppliers expect to receive one consolidated PO per shipping point from the customer. Similarly, there needs to be a one-to-one match between the number of invoices and the number of 'PO's. These practices make the order processing task much more efficient. Table 5 lists the evaluation questions used in RAM for order generation.

**Order Fulfillment** is the process of delivering the product to the customer. This phase is related to logistics, including other general processes for receiving and verifying shipments and making payments. Both the supplier and the customer have key roles in the *delivery process* to enhance the CPFR experience. The very basic steps involve receiving and stocking products on retail shelves, recording sales transactions and making payments. Making payments through EDI is the fastest and the most secure method. Electronic based order receiving, such as bar codes on boxes to electronically match the invoice and the PO makes the fulfillment process efficient. EDI enables customers to know when and what is shipped, which in turn makes the receiving process easier. Table 6 lists the evaluation questions used in RAM for order fulfillment.

### 3.1.4 Analysis

The primary task of this area is assessment. This enables business partners to bring in necessary changes to their processes. In case of discrepancies and exceptional cases, the partners are supposed to share insights and adjust plans to resolve the issues. As Figure 2 illustrates, this area consists of two sub-areas of exception management (Table 7) and performance assessment (Table 8).

**Exception Management** involves constant monitoring of planning and operations to identify and manage exceptions in the process. Out-of-bounds conditions are identified and these conditions are then communicated with the business partners and adjusted to bring the situation back to the preferred or optimal condition. Partners should collaboratively *monitor processes and identify exceptions* to ensure that requirements are met. For



example, if there is a delay in shipping or an increase in the lead time, the condition should be first identified through the use of proper performance metrics and then communicated between partners. Another important activity is *validating forecasts*. The underlying principle is to compare the forecast with actual demand so adjustments should be made to future forecasts. This is a good practice since it keeps the forecasting process dynamic, reveal the exceptional demand behaviors, stays responsive to market change and allows for better inventory control policies. Once identified, partners should *review and resolve process issues* in a manner than benefit all business partners. This activity is primarily done through meetings during which out-of-bounds processes are reviewed and the correcting actions usually begin during these meetings. It is also important to note that all business partners use a common set of performance metrics as this will help standardize the review process.

**Performance Assessment** involves the assessment of system performance for all business partners. It is a joint effort where the contribution and commitments of the business partners are recognized and future development plans can be formulated and initiated. One of the most effective tools for performance assessment is to *use performance metrics*. The use of metrics on key business areas can help business partners identify areas of improvement and assess their current performance. However, it is important that proper performance metrics be used for each business area. Typical metrics used are market share, revenue, profitability, perfect order attainment, fill rate, inventory turnover etc. The continuous assessment of *achieving goals* is important to identify areas of improvement. During scheduled meetings, goals achieved should be highlighted while the operations falling behind their pre-set goals should be discussed. For example, forecast accuracy can be set to be greater than 85% as a goal. Evaluating forecast against the actual demand determines whether forecast accuracy has attained its goal.

**Table 1: Collaboration Arrangement (sub-area)**

Activity	Evaluation Questions
Establish Primary Objective	<ul style="list-style-type: none"> <li>• To what extent is your 'organization's business plan aligned with long term strategy?</li> <li>• To what extent is there a set of goals that drive business or collaboration effort?</li> <li>• To what extent are the goals viewed as a strategic imperative?</li> <li>• To what extent is the current business plan utilized to identify: 1) Future business opportunities? 2) Improve operational efficiency?</li> </ul>
Strategic Terms	<ul style="list-style-type: none"> <li>• To what extent are all the strategic terms in the organization standardized?</li> <li>• To what extent are all the strategic terms clearly defined?</li> </ul>
Functional Terms	<ul style="list-style-type: none"> <li>• To what extent are all the functional terms in the organization standardized?</li> <li>• To what extent are all the functional terms clearly defined?</li> </ul>
Potential Benefits	<ul style="list-style-type: none"> <li>• To what extent are potential benefits from business collaboration/arrangements with business partners identified?</li> <li>• To what extent does a business partner share the benefits of the business arrangement?</li> <li>• To what extent are business partners penalized for failing to meet business requirements?</li> </ul>
Contracting	<ul style="list-style-type: none"> <li>• To what extent are business agreements established through contracting?</li> <li>• To what extent is a formal rule maintained for operation and decision making processes?</li> <li>• To what extent does contracting clearly outline the key responsibilities of the supplier?</li> <li>• To what extent does contracting address resource allocation?</li> <li>• To what extent does contracting hold each party accountable for their commitments?</li> </ul>
Schedule Meetings	<ul style="list-style-type: none"> <li>• To what extent are the following means of communication utilized during Collaboration with general business partners: 1) Basic email and phone 2) Internally linked email 3) Internally linked email and spreadsheets 4) Enterprise class solutions</li> <li>• To what extent are the following discussed during the meeting: 1) Vendor performance metrics 2) Report on initiative progress, surface issues, establish new timelines 3) Identify and Resolve Future Supply Shortages 4) Communicate any changes to replenishment system</li> <li>• To what extent are quarterly meetings held between business partners?</li> <li>• To what extent are quarterly meeting used to address: 1) A review of all performance metrics to identify performance opportunities? 2) Assessment of the achievement of milestones set forth during the previous quarterly meeting? 3) Launch new initiatives?</li> </ul>
Planning Horizon	<ul style="list-style-type: none"> <li>• To what extent is the planning horizon taken into account during development of business initiatives?</li> <li>• What is the typical planning horizon for your organization? a) 0-3 weeks b) 0-3 months c) 3-6 months d) 6-12 months e) 18-24 months</li> </ul>
IT System Compatibility	<ul style="list-style-type: none"> <li>• To what extent does your organization have the ability to: 1) Share forecasts with business partners? 2) Allow business partners to access historical sales and/or order data?</li> <li>• To what extent is an enterprise class solution utilized in coordinating promotions, forecasts, orders and shipments?</li> </ul>
Planning Horizon	<ul style="list-style-type: none"> <li>• To what extent does your organization have the ability to: 1) Share forecasts with business partners? 2) Allow business partners to access historical sales and/or order data?</li> </ul>
Forecasting Agreement	<ul style="list-style-type: none"> <li>• To what extent does a forecasting agreement determines the level of forecast and the update frequency?</li> <li>• To what extent is the organization able to reconcile all forecasts into one primary forecast?</li> <li>• To what extent is there an agreement between business partners to maintain a quality and standard of data?</li> </ul>
Roles and Responsibilities	<ul style="list-style-type: none"> <li>• To what extent is there a defined set of responsibilities for all supply chain activities?</li> <li>• To what extent is internal Collaboration between departments present within the organization?</li> <li>• To what extent does your organization have assigned a frontline collaborator to work with your business partner?</li> </ul>

**Table 2: Joint Business Plan (sub area)**

Activity	Evaluation Questions
Define Information to Share	<ul style="list-style-type: none"> <li>To what extent is there an agreement between business partners to share information related to product introduction, changes to 'supplier's business plan, etc.?</li> <li>To what extent is there an agreement/understanding on the type of information to share between business partners?</li> </ul>
Define Information Sharing Frequency	<ul style="list-style-type: none"> <li>To what extent is the information shared in advance between business partners? For example, new product introduction.</li> <li>To what extent is information, which can affect supply chain planning, shared between business partners?</li> </ul>
Select Products	<ul style="list-style-type: none"> <li>To what extent are products identified for CPFR or other joint business initiatives?</li> <li>To what extent is the product selection formed in Collaboration with business partners?</li> </ul>
Promotional Event Planning	<ul style="list-style-type: none"> <li>To what extent are promotional events planned and coordinated in advance with the business partners?</li> <li>To what extent are adjacent category product promotion done during product promotion events?</li> <li>To what extent are all concerned business partners aware of an upcoming promotional event?</li> </ul>

**Table 3: Sales Forecasting (sub area)**

Activity	Evaluation Questions
Data Collection	<ul style="list-style-type: none"> <li>To what extent are sales or order data collected for forecasting and analysis purposes?</li> <li>To what extent is the data accessible by important business partners?</li> <li>To what extent is an integrated data collection system utilized?</li> <li>To what extent is the data collection process automated?</li> </ul>
Forecasting Model Selection	<ul style="list-style-type: none"> <li>To what extent is there a formal forecasting process available?</li> <li>To what extent does the forecasting process meet the requirements of important business partners?</li> </ul>
Define Point of Forecast	<ul style="list-style-type: none"> <li>To what extent is there a single forecast shared and adhered to by business partners?</li> <li>To what extent are different types of forecasts consolidated into one single forecast for business purposes?</li> </ul>
Share and Update Forecast	<ul style="list-style-type: none"> <li>To what extent are forecasts shared between business partners?</li> <li>To what extent is the data sharing process automated?</li> <li>To what extent is the forecast updated daily?</li> <li>To what extent are forecasts utilized to plan future supply chain initiatives</li> </ul>
Exception Resolution Process	<ul style="list-style-type: none"> <li>To what extent is real time data sharing between business partners available?</li> <li>To what extent is there an exception resolution process available to resolve issues such as forecast accuracy?</li> <li>To what extent are there meetings held between business partners to discuss exception issues?</li> </ul>

**Table 4: Order Planning (sub area)**

<b>Activity</b>	<b>Evaluation Questions</b>
Planning	<ul style="list-style-type: none"> <li>• To what extent are future orders or shipments planned through the use of Economic Order Quantity or other methods?</li> <li>• To what extent do future order requirements translate from forecasts made on demand?</li> <li>• To what extent is the frequency and quantity of items shipped based on economic order quantity or some other optimization method?</li> </ul>
Share Order Plan	<ul style="list-style-type: none"> <li>• To what extent are order plans shared between business partners in advance?</li> <li>• To what extent are order plans created in advance over a certain period of time?</li> </ul>

**Table 5: Order Generation (sub area)**

<b>Activity</b>	<b>Evaluation Questions</b>
Production Planning	<ul style="list-style-type: none"> <li>• To what extent is the purchase order (PO) generation process automated?</li> <li>• To what extent is the PO receiving and sending done thorough web-based EDI transmission?</li> <li>• To what extent is advanced shipment notification (ASN) used to notify future shipments?</li> <li>• To what extent is the invoice matched through EDI or other automated processes?</li> <li>• To what extent are the sent or received purchase orders consolidated by shipping point?</li> </ul>

**Table 6: Order Fulfillment (sub area)**

<b>Activity</b>	<b>Evaluation Questions</b>
Delivery Process	<ul style="list-style-type: none"> <li>• To what extent are order receiving electronic based?</li> <li>• To what extent is the invoice matched with the PO electronically using barcodes, etc.?</li> <li>• To what extent is EDI technology used in the order receiving/shipping process?</li> </ul>

**Table 7: Exception Management (sub area)**

Activity	Evaluation Questions
Monitor Processes and Identify Exceptions	<ul style="list-style-type: none"> <li>• To what extent are processes monitored through the use of metrics or other tools?</li> <li>• To what extent are exceptions in the process performance that might affect others in the supply chain communicated with business partners?</li> <li>• To what extent is the communication process between business partners, related to exceptions notifications, easy?</li> <li>• To what extent is a single point of contact from both sides used to discuss and resolve exceptions?</li> </ul>
Validate Forecasts	<ul style="list-style-type: none"> <li>• To what extent are the forecasts compared to the actual demand?</li> <li>• To what extent are future forecasts adjusted based on the knowledge gained from comparing the forecast to the actual demand?</li> </ul>
Review and Resolve Process Issues	<ul style="list-style-type: none"> <li>• To what extent are out-of-bound processes reviewed during meetings with business partners?</li> <li>• To what extent are performance metrics or other tools used to keep account of process performance?</li> <li>• To what extent are key supply chain operations kept under review to identify out-of-bound processes?</li> <li>• To what extent are face-to-face, phones, or live video meetings used during the review process?</li> <li>• To what extent do business partners use a common set of performance metrics to standardize the review process?</li> </ul>

**Table 8: Performance Assessment (sub area)**

Activity	Evaluation Questions
Use Performance Metrics on Key Business Areas	<ul style="list-style-type: none"> <li>• To what extent is the performance of key business areas assessed through the use of performance metrics or other tools?</li> </ul>
Asses Goal Achievements	<ul style="list-style-type: none"> <li>• To what extent are goals set for supply chain performance?</li> <li>• To what extent is goal achievement identified through the use of performance metrics or other tools?</li> </ul>

#### 4. CPFR MATURITY MODELING

The maturity model was developed to quantify the CPFR activities in order to assess the maturity of an organization. This section describes how the model was constructed, what assumptions were made, and how the model can be used.

The assessment is to be performed through rating the 'organization's performance on each of the activities identified in section 3. As discussed,

activities are defined by questions; therefore performance on each activity is determined through its questions. Answers to the questions are collected in the form of ratings on a scale of 1 to 5, with 5 being the best. Rating on a scale is selected primarily because it is a simple and powerful method of communication and data collection, especially with a wide range of people in different organizations. The combination of factual data and 'analyst's knowledge can be used for rating.

Let:

$n_j$  the number of questions in CPFR sub-area  $j$

$N$  the number of respondents

$X_{ijk}$  the rating score given to question  $k$  in CPFR sub-area  $j$  ( $j= 1,2, \dots, 8$ ) by respondent  $i$

$\bar{X}_{ij}$  the average rating score of questions in CPFR sub-area  $j$  given by respondent  $i$

$\bar{\bar{X}}_j$  The average of  $\bar{X}_{ij}$  values for sub-area  $j$

$W_j'$  the raw weight assigned to CPFR sub-area  $j$

$W_j$  the normalized weight assigned to CPFR sub-area  $j$

$P_j$  the maturity score of CPFR sub-area  $j$

$P$  The weighted CPFR maturity score of the organization

$$\bar{X}_{ij} = \frac{\sum_{k=1}^{n_j} X_{ijk}}{n_j} \quad (1)$$

$$\bar{\bar{X}}_j = \frac{\sum_{i=1}^N \bar{X}_{ij}}{N} \quad (2)$$

$$P_j = \frac{\bar{\bar{X}}_j}{5} \times 100 \quad (3)$$

$$W_j = \frac{W_j'}{\sum_{j=1}^8 W_j'} \times 100 \quad (4)$$

$$P = \frac{\sum_{j=1}^8 W_j P_j}{100} \quad (5)$$

The collected scores ( $X_{ijk}$ ) are transformed into average scores ( $\bar{X}_{ij}$ ) and then eventually to unweighted maturity scores ( $P_j$ ) by utilizing a linear additive model (Equation 3) and the Simple Multi-Attribute Rating Technique (SMART) [42]. The eight CPFR sub-areas have varying levels of importance towards the success of CPFR [19]. In order for SMART to capture the true difference between them, 'swing weights' ( $W_j'$ ) are used. They are designed to capture the range between the least and most important options. Once determined, they need to be normalized using Equation 4 and then be used for calculating the weighted CPFR maturity score (Equation 5). The decision maker can choose the values of swing weights depending on the specific requirements of each application. However, industry and academic experts, with long standing excellence in CPFR, were asked to assign a weight

to each of the eight CPFR sub-areas. After aggregating the responses from five experts, a set of recommended normalized weights ( $W_j$ ) was determined (Table 9)

**Table 9: Aggregating CPFR expert opinions on weights**

CPFR area	Raw Weight 1	Raw Weight 2	Raw Weight 3	Raw Weight 4	Raw Weight 5	Avg Raw Weight ( $W_j'$ )	Normalized Weight ( $W_j$ )
Collaboration Arrangement	100	99	100	85	95	95.80	<b>14.52</b>
Joint Business Plan	70	100	90	30	100	78.00	<b>11.83</b>
Sales Forecast	80	98	90	95	80	88.60	<b>13.43</b>
Order Planning/Forecasting	60	97	95	100	90	88.40	<b>13.40</b>
Order Generation	70	95	85	80	88	83.60	<b>12.67</b>
Order Fulfillment	80	96	80	75	89	84.00	<b>12.73</b>
Exception Management	40	94	75	50	70	65.80	<b>9.98</b>
Performance Assessment	90	93	80	45	69	75.40	<b>11.43</b>
					Total	659.60	100

Given the maturity scores ( $P_j$  for the eight CPFR sub-areas and  $P$  for the overall CPFR maturity

Table 10 illustrates the decision criteria for determining the maturity tiers. The Tiers are developed based on the findings from [43, 44]. The fourth level of maturity, Tier 4, represents the lowest level where independent organizations with minimal internal and external collaborative practices exist. The third level of maturity, Tier 3, describes organizations that have base level CPFR operations and have an initial effort to promote internal and external Collaboration. The second level of maturity

score), the maturity of an organization is divided into 4 'Tiers' with Tier 1 being the most advanced level and Tier 4 being the most basic level.

is Tier 2 which embodies organizations that have collaborative CPFR operations and can engage in significant level of internal and external collaborative practices. The highest level of maturity is Tier 1 which represents organizations with sophisticated and robust level of internal and external Collaboration. Table 11 categorizes and describes the characteristics of these four maturity tiers

**Table 10: Criteria of determining the maturity tiers**

Decision criteria	Tier
$80 \leq P_i \leq 100$	Tier 1
$60 \leq P_i < 80$	Tier 2
$40 \leq P_i < 60$	Tier 3
$P_i < 40$	Tier 4



Table 11: CPFR maturity Tiers

<b>Tiers</b>	<b>Collaboration Level</b>	<b>Collaboration areas</b>	<b>Planning Horizon</b>	<b>Information sharing level</b>	<b>Performance measurement level</b>	<b>IT proficiency</b>
<b>Tier 4</b>	Nothing to minimum internal Collaboration	Sales and order generation	Short (less than a month)	Minimal forecast sharing. Reactive to demand order generation	Activity or operational level only	No collaboration technology framework
<b>Tier 3</b>	Mostly Inter-organizational Collaboration between departments	Key activities to support sales and operations	Medium (few weeks to 2 months)	Point of sales, demand forecasts	Some organizational level but mostly operational	Inter-departmental links to support internal operations
<b>Tier 2</b>	Between business partners	Forecasts, order plans, future initiatives	Internally medium-long (2-12 months). Externally a few months	Routine forecasts and order plans, promotional plans	More sophisticated based on forecast accuracy and revenue plans	Begins to link business partners through sharing spreadsheets
<b>Tier 1</b>	Strategic partnership with integrated business plans and common goals	Daily forecasts, order plans, and future initiatives	18-24 months	Beyond information, personnel and physical resources are shared	Key indicators such as market share and profitability. Continuous improvement initiative	Enterprise level technology solutions

The other objective of the maturity model is to suggest a 'Path-of-Progress' for CPFR advancement. In the path of progress, any sub-area within tier 1 of the maturity tiers (i.e.  $P_j \geq 80$ ) will be categorized as "good standing" while sub-areas in lower tiers will be categorized as "improve". However, the defined CPFR sub-areas are not equally important, thus to maximize the impact and optimize resource allocation, it is instrumental to prioritize the improvements. Sub-areas with priority level 1 are recommended to be improved first, followed by the sub-areas in the remaining priority levels.

The eight sub-areas are divided into three levels of priority. Level 1 receives the highest importance while level 3 has the lowest. Table 12 lists the sub-

areas and their corresponding priority levels. The priority levels are determined primarily based on what has been found in the literature as well as the inputs we received from companies with a long standing of practicing CPFR. References [40] and [41] investigated and identified the top 10 critical success factors necessary for the implementation of the CPFR in the automotive and retail sectors. They used different variations of Analytical Hierarchy Process (AHP) as the ranking methodology after collecting, classifying and capturing expert opinions. Both studies concluded that factors related to collaboration management and IT play the most important roles. Therefore, we arranged the priority of our sub-areas consistent with the findings from their work.

**Table 12:** Mapping of priority levels of the CPFR sub-areas to the literature

CPFR sub-area	Priority level	CPFR success factors and their ranks [40]	CPFR success factors and their ranks [41]
Collaboration Arrangement	1	define mutual agreed objectives (1), clear communication plan (2), high-level of trust (3)	Cross department communication and collaboration capability (1),
Joint Business Plan	1	Information readiness (5) strong executive support (6)	Change management (2), Mutual objective (6)
Sales Forecasting	1	Developing IT infrastructure (4)	System complexity (4), innovation capability (6)
Order Planning/Forecasting	1	Developing IT infrastructure (4)	System complexity (4), innovation capability (6)
Order Generation	2		Electronic Data Interchange (10)
Order Fulfillment	2		
Exception Management	3		
Performance Assessment	3		

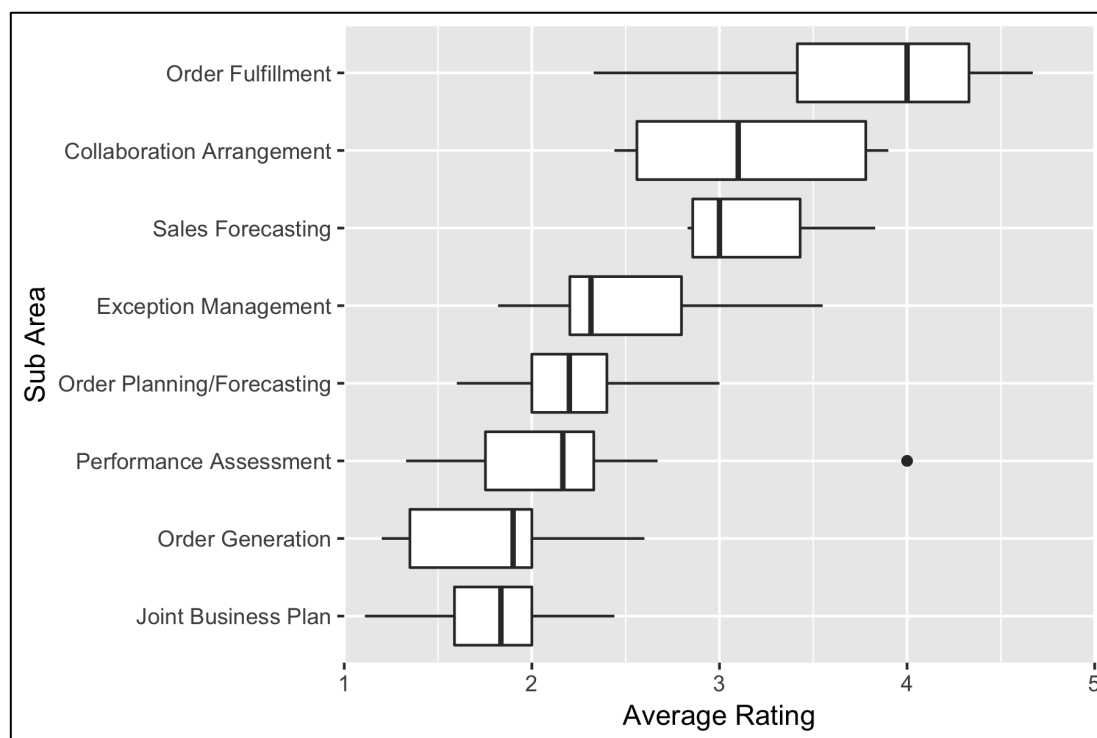
## 5. ILLUSTRATIVE CASE STUDY

The maturity model can be used within a company to evaluate the level of consensus among respondents about the CPFR maturity. Alternatively, it can be used across different companies to compare the maturity levels and determine high performers, medium performers and low performers. In this section, a notional example of multiple respondents within a company will be discussed.

The core of the maturity model is the answers given to the questions discussed in section 4. In other words,  $X_{ijk}$  values, ultimately determine the CPFR maturity level. Each of the 8 different sub-areas defined in section 4, evaluates the maturity from a unique perspective. There are a total of 95 questions within the 8 sub-areas and each question is answered on a scale of 1 to 5, with 5 being excellent maturity. Figure 3 illustrates a statistical summary of the collected responses (i.e.  $\bar{X}_{ij}$  values) from 10 respondents ( $N = 10$ ), sorted from largest to smallest by median values. This example resembles the application of the model within a company when the

objective is to evaluate the level of consensus among the respondents about the CPFR maturity.

The centrality and variability of the sub-areas in Figure 3 provides valuable insights to the stakeholders of the CPFR program within a company. The top-performer sub-area is order fulfillment with a median score of 4; however, it shows substantial variability. This indicates that even though this sub-area achieves the highest median maturity score, consensus does not exist among the respondents. The next two sub-areas, collaboration arrangement and sales forecasting, appear to be the middle performers, with median maturity score of approximately 3. The variability measures indicate that there is greater consensus about the maturity of sales forecasting. The performance of last five sub-areas is below 3, which shows a low performance level. The variability of these measures range between low to medium, which implies that a relative consensus exists among the respondents. See Table 14 for more information on the descriptive statistics of the sub-'areas' maturity scores.



**Figure 3:** Box-Plot summary of the average collected responses in each sub area ( $X_{ij}$ )

The next level of analysis is to determine the maturity score of each sub-area ( $P_j$ ). Table 14 lists the values and shows the tier levels determined using the decision criteria discussed earlier (Table 10 and Table 11). In order to evaluate the existing gap between the current maturity level and the ideal state, Figure 4 visualizes the maturity state of the organization across the eight sub-areas via a spider chart. It clearly

illustrates that while the three areas of collaboration arrangement, sales forecasting, and order fulfillment perform acceptably, the rest of the sub-areas need significant improvement. This provides an additional depth to the understanding of an 'organization's maturity and allows the decision makers to better understand the need for improvement and the process for improvement.

**Table 13: Summary of the collected responses, weights, tiers and performance values**

CPFR sub-area	$n_j$	$\bar{X}_j$	$\sigma_j$	$\tilde{X}_j$	$P_j$	Tier	Priority level
Collaboration Arrangement	41	3.15	0.620	3.10	63	2	1
Joint Business Plan	9	1.78	0.405	1.83	36	4	1
Sales Forecasting	18	3.16	0.364	3.00	63	2	1
Order Planning/Forecasting	5	2.22	0.404	2.20	44	3	1
Order Generation	5	1.82	0.493	1.90	36	4	2
Order Fulfillment	3	3.80	0.819	4.00	76	2	2
Exception Management	11	2.47	0.513	2.32	49	3	3
Performance Assessment	3	2.23	0.737	2.17	45	3	3



**Figure 4:** Spider chart of the maturity scores ( $P_j$ ) for the CPFR sub-areas

In the final step, the weighted CPFR maturity score is calculated. This metric is the overall indicator of the CPFR maturity level of an organization, considering the weights of the CPFR sub-areas. In this step, the normalized weights ( $W_j$ ), that were previously determined (Table 9), are used to combine the sub 'areas' maturity scores ( $P_j$ ) and calculate the weighted CPFR maturity score (Equation 5). Below is the final weighted CPFR maturity score of the organization.

$$P = \frac{\sum_{i=1}^8 W_j P_j}{100} = 52.17$$

The relatively low level of the weighted score puts this organization in Tier 3 of the CPFR maturity, where substantial improvements in different sub-areas need to be made to elevate the readiness of the

organization for successful implementation of CPFR. Additional implementation of the model in different industries with various levels of CPFR sophistication, will assist in understanding the achievable targets for each sub-area, which ultimately form an accurate benchmarking framework.

In order for the organization to plan for improvement, a rubric for improvement is provided in the 'Path of Progress' Rubric' shown in Table 16. It suggests the path that should be followed for a structured improvement to CPFR, based on the determined tier and priority levels. The next section discusses the evaluation and validation process of the model. In order to properly evaluate the model, it is necessary to investigate industry experts' opinion about the model as well as receiving feedback from different sectors.

**Table 14:** The path of progress rubric for CPFR excellence

Priority Level	Collaboration Arrangement	Joint Business Plan	Sales Forecasting	Order Planning / Forecasting	Order Generation	Order Fulfillment	Exception Management	Performance Assessment
1	Improve	Improve	Improve	Improve				
2					Improve	Good Standing		
3							Improve	Good Standing

## 6. EVALUATION AND VALIDATION

The evaluation process of the model is instrumental to establish its robustness and applicability. The primary objective of evaluation is to examine if the maturity model is able to capture all the CPFR factors that contribute towards its success. There are very few ways in which the model can be evaluated since

research into CPFR has thus far not yielded a significant amount of common understanding. CPFR carries different meaning in different industries, and even between suppliers and customers within the same supply chain. Some tasks and activities are more important to a certain group while that same set of tasks is less prioritized with another group of

experts. As such, the model allows the user to change the weights within the SMART calculation in order to accommodate this concept.

The evaluation process was performed by obtaining CPFR practicing industry opinions. A set of questions, focused on evaluating the key attributes of the model including usability, flexibility, usefulness, and effectiveness is developed. Table 17 summarizes

the collected responses from three respondents within the retail, manufacturing and the healthcare sector. The respondents are from companies that either have implemented CPFR with success or are currently engaged in some CPFR activities and looking to expand to full CPFR implementation. This establishes an initial evaluation of the model.

**Table 15: Model Assessment Summary**

Attributes	Average Score
Important CPFR activities addressed in the model	4.00
All terms are clearly defined	3.67
Proper use of weights to assign importance	4.50
Ease of taking the test	4.33
Model adequately assesses CPFR maturity	3.67
Model can be applied across industries	3.67
Usefulness of the model	4
Model accurately represents VICS CPFR	4.5

The average scores are promising concerning the performance of the model in different areas. It is however important to note that, the comparatively low score for the assessment capability of the model can be attributed to a low score for the definition of terms. Several terms were used in the model, which might be recognized in particular industries. It has been suggested by industry experts that CPFR is still not clearly understood by many organizations, and the terms used to define CPFR activities are thus unknown by many. Therefore, an overview on CPFR or a terms glossary can be a useful complement to the model. The model is planned to undergo continuous improvement through the collection of further feedback from industry experts. This would lead to the validation of the model which is a long-term process of data collection from implementation instances. Validation will shape the understanding about the effectiveness of the model in identifying improvement.

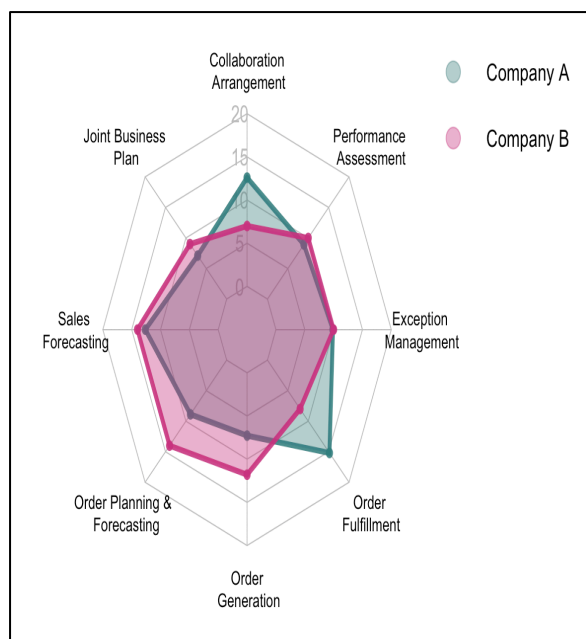
## 7. SUMMARY AND FUTURE WORK

This paper presents a model that organizations can utilize for assessing current and future implementations of CPFR program. The model offers a comprehensive framework and constitutes the four major areas of CPFR, strategy and planning, demand and supply management, execution, and analysis. The model allows organizations to self-assess their CPFR maturity by having multiple stakeholders within the organization evaluate all the aspects of CPFR competence. This would allow a comparison across the stakeholders to further understand the level of

consensus about the maturity level of the organization.

The model is also a useful tool for multiple CPFR partners to understand and communicate their strengths and weaknesses. Many of the failures in supply chain collaboration efforts have occurred due to factors such as operational complexity and lack of expertise [45]. Therefore, it is instrumental for CPFR partners to be aware of the each 'other's capabilities and views. When utilized by partners, this model can assist in determining the suitability of the CPFR partnership by showing how the maturity levels across the key areas stand out against each other. Figure 5 illustrates a notional case of partnership evaluation among two companies. We hypothesize that the maturity levels of cooperating organizations within a partnership may be an important factor in the success of the partnership. Future work can explore this hypothesis through the application of the CPFR maturity model to organizations involved in CPFR partnerships

One of the key areas of future work is utilizing the developed model for data collection from organizations in different sectors in order to study the state of CPFR excellence across companies and within different sectors. This will provide key insights on the differences that exist between industry sectors with respect to the CPFR areas introduced in the model (i.e. strategy and planning, demand and supply management, execution, and analysis). Finally, the modeling framework can be adapted to assess the maturity of other processes. For example, a similar approach could be applied to an organization interested in assessing its maturity for applying data analytics to its business processes.



**Figure 5:** Multi-company CPFR maturity comparison

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