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Opportunities and threats arising from expanding collaboration within supply chain distribution frameworks of SME manufacturers

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Opportunities and threats arising from expanding collaboration within supply chain distribution frameworks of SME manufacturers

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Abstract:

Supply chain collaboration research has traditionally focused on the ideal situation of a manufacturer engaging with all its downstream partners. In view of extensive cost, lack of trust or insufficient IT-systems this provides only limited support to actual problems of many companies. Investigating heterogeneous delivery frameworks is thus necessary to reveal possible advantages and drawbacks within the process of emerging with a varying number of customers from a traditional reorder-point (ROP) into a collaborative VMI/CPFR system. In this paper, discrete-event simulation is applied to model the distribution system of three SME manufacturers to show what impact increasing adoption of CPFR replenishment has on each market participant. A particular focus hereby lies on remaining non-collaborating customers. The analysis suggests that substantial benefits can arise from even a partial collaboration framework but non-participating customers may be severely disadvantaged as a result of it. Such issues need to be carefully considered before engaging in collaborative partnerships to avoid discontent amongst customers.

Keywords: Supply-chain management, Collaboration, Demand forecasting, Discrete-event simulation, CPFR

1 Introduction

Information sharing and collaboration within supply chains are widely popular topics in business and research nowadays. Most research agrees that increased visibility can vastly improve supply chain performance (Kulp 2002, Gavirneni et al. 1999, Lee et al. 2000, Lee and Whang 2000, Yu et al. 2001) as a lack of unflawed demand information is considered the major cause of inefficiencies and delays within production and delivery scheduling (Cachon and Fisher 2000; Chen 1998; Towill et al. 1992). Numerous investigations (Stank et al. 1999; Lambert and Cooper 2000; Lau and Lee 2000; Lin et al. 2002) come further to the conclusion that increasing demand visibility as to share information in between all echelons of a supply chain could remarkably diminish these inefficiencies and thus lead to smoother production, lower inventories, less delayed deliveries and reduced service level gaps. Despite of its early merits and obvious potential, many firms struggle to truly capitalise on the potential of collaboration (Barratt 2004; Crum and Palmatiers 2004). Common issues are difficult implementation (Sabath and Fontanella 2002), over-reliance on technology in trying to implement it (Mc Carthy and Golocic 2002), fear of relinquishing control (Moberg and Speh 2003) and a lack of trust between trading partners (Ireland and Bruce 2000; Nesheim 2001). In addition to the above mentioned a very often stated reason for disappointing results is the missing ability to differentiate between whom with and in what order to collaborate (Sabath and Fontanella 2002). Similar to this the involvement in too many supply chains, both horizontally and vertically, is an often criticised issue (Moberg et al. 2003). The actual problem arises from numerous manufacturing companies selling their products to multiple retail customers that directly compete with each other. The retailers on the other hand sell products from several competing manufacturers. If all these companies exchange vital information and work off common forecasts it will necessarily raise the threat of revealing crucial information. This is a core issue why collaborative initiatives fail due to a lack of trust and explains partly why most collaboration success stories only involve a limited number of engaged trading partners (VICS 1998; Foster 2000).

Furthermore, supply chain collaboration requires the input of significant resources to implement it. Hence organisations that attempt unilateral agreements with a vast number of customers or suppliers will usually not succeed since the cost of such wide-scale implementation would simply outweigh the achieved benefits (Barratt 2004).

The logical consequence would be a differentiation within trading partners as to engage in a collaborative replenishment only with a limited number of strategically important associates rather than a comprehensive approach that involves all suppliers and customers in a global collaborative system (Tang and Gattorna 2003; Christopher and Towill 2002).

A practical conclusion of above considerations is that manufacturing and retailing companies commonly prefer to involve only part of their customer base in collaborative replenishment systems. Thus manufacturers necessarily need to setup their operations in a way that both collaborating as well as non-collaborating customers can be served effectively and efficiently.

A further motivation for studying such heterogeneous setups is recent market developments within the group of small or medium sized enterprises. In the EU they generate nearly 60% of the private sector turnover and represent almost 70% of non-government employment (CBI 2000; Quayle 2003). Numerous small to medium sized suppliers nowadays face the decision to participate in some sort of joint business forecasting system of various large retail companies that offer the possibility to obtain demand data on distribution centre and store level. The very idea behind this being increased visibility for both retailer and supplier as to share demand and production data to optimise replenishment. Due to the number and diversity of customers a typical company has, the practical issue in most cases cannot be to totally switch planning and replenishment approaches from an isolated to a full collaborative replenishment framework since most often either financial considerations or simply non-availability of joint-data systems prevent a unique switch. Most companies are thus faced with the question to what extent their production and delivery planning process can benefit from a heterogeneous approach where some or even most customers still use a traditional order process whilst other customers share demand data and agree to collaborative delivery and replenishment approaches. Until very recently, collaborative SCM research has mainly focused on either the relationship between one vendor and one customer or the ideal situation of a manufacturer collaborating with all its downstream partners. This evidently provides only limited support to companies struggling with the aforementioned problems. A company that will only selectively chose trustworthy partners to engage in collaboration due to a fear of revealing vital information to too many market participants, will necessarily need a heterogeneous replenishment approach. The same accounts for a typical medium sized company that just cannot rely on either a pure traditional or a universal collaborative scenario. The purpose of this research is thus to emphasize on these conditions which constitute an intermediate approach in between traditional isolated echelons and fully transparent datasharing systems which is a field that has commonly been neglected by SCM research. In the rare cases where heterogeneous scenarios are evaluated the main focus of efficiency improvement is on inventory levels rather than order fulfilment or service level gaps. Waller, Johnson and Davis (1999) use simulation of a supply chain to examine the effect of VMI adoption rates strictly on inventory levels. The focus lies rather on increased replenishment frequencies and increased inventory review. The analysis is limited to vendor managed inventory (VMI) scenario considerations lacking any advanced collaboration (e.g. CPFR – collaborative planning forecasting and replenishment) related considerations. Småros, Lehtonen, Appelqvist, and Holmström (2003) use discrete event simulation to evaluate how to use increased demand visibility for production and inventory control. They focus on how the manufacturer benefits from reduced production load volatility as the number of VMI customers increases. They find that the value of visibility greatly depends on replenishment frequencies and length of production planning cycle employed by the manufacturer. The analysis has various interesting findings focusing more on flexible inventory and production metrics rather than order fulfilment and service level as performance measures. Moreover it centres on VMI scenario considerations with underlying stable demand not yet accounting for more complex non-stationary demand and CPFR related implementations.

The system simulation approach applied within this research expands previous undertakings and additionally addresses some of the typical problems within supply chain collaboration as it focuses on practically more relevant heterogeneous collaboration setups and applies actual sales, production and distribution data obtained from supply chain frameworks of three SME manufacturers. The choice of discrete event simulation as analysis method should consequently allow to integrate obtained data and market intelligence to a sufficient detail to obtain valid results that can give valuable insights into a widening collaboration framework. Furthermore, the investigation will - instead of focusing all the attention on global efficiency achievements - concentrate on scenario analyses for each individual market participant whether or not it is engaged in a collaborative process. This will allow evaluating the impact of collaborative replenishment from the point of view of a non-participating customer which is a new perspective within collaboration research.

In the following sections the methodology is outlined, a simulation model introduced and research background discussed. Thereafter, analysis structure is pointed out and performance measures established. Within the final part, investigation results are presented and implications discussed.

2 Methodology

The simulation model that is used in the investigation has been customised for the somewhat similar supply chain circumstances of the three food-manufacturers. It is based on actual sales, distribution and production data obtained in close corporation with major customers (grocery retailers). We chose to use discrete-event simulation as a well-accepted and somewhat matured methodology of Operational Research. For a summary of features, advantages and fields of application see Law and Kelton (2000), Pidd (2004) or Brooks and Robinson (2001). Simulation as a time-based modelling tool allows researchers to calculate time-based statistics and just as important, transferable model-code and animation provide an understandable representation of the system acceptable even to non-modellers. Maloni and Benton (1997) recommend using simulation models in particular to critically evaluate possible benefits of supply chain collaboration. One of the main advantages within that framework is the ability to evaluate interdependencies among random effects that may cause a serious degradation in performance even though average performance characteristics of a system appear to be reasonable (Shapiro, 2001). For that particular reason, discrete event simulation has most successfully been used to study flexibility in manufacturing systems (Gupta and Goyal 1992; Nandkeolyar and Christy 1992; Caprihan and Wadhwa 1997; Albino and Garavelli 1999; Borenstein 2000; Garg et al. 2001).
The facilitated simulation model was designed with the main goal in mind to evaluate possible benefits arising out of a widening collaboration and thus information sharing framework between manufacturer, retailers' distribution centres and retail outlets. Within this system the actual detail of information exchange as well as the number of participants of such a collaboration system can be individually defined. Some of the participants of the study were in the process of conducting a CPFR replenishment pilot study unveiling detailed order, sales, out of stock, demand, transportation and inventory data on a weekly basis on store level as well as on distribution centre level. Insights and data gained throughout this pilot study proved to be very valuable to validate the simulation model outcome for the particular manufacturer's distribution system and consequently also for the entire simulation framework. In addition to the above, further underlying data like weekly sales quantities, promotional activity schedules, promotional impact estimations, seasonal factor data, production scheduling, market trend/market share analyses, inventory dispatching or transportation setups have been obtained in close cooperation with the manufacturers, and additional support by their logistics partners and the involved retail companies. The actual simulation model has been laid out in a way to reflect the market conditions of the investigated supply frameworks. Although the model features an evident amount of customization, it should still be general and flexible enough to be representative for a wide variety of typical supply chain frameworks and market conditions of various enterprises of similar size and delivery structure. A graphical representation of the situation is shown in Figure 1.

2.1 The simulation model

The simulation model used for the investigation consists of three main suppliers serving the particular manufacturer which is then serving the distribution centres (DCs) of four customers. Moreover, these DCs serve several retail outlets each. The companies under investigation do business with more than four customers. Nevertheless, the selected retail-companies are key clients and together account for about 70% to 85% of total turnover. The developed model framework outlined below constitutes the basis of all three supply chain frameworks, nevertheless investigations are run on individually customised simulation setups since a vast amount of adjustments are needed and underlying data has to be changed to appropriately model each individual framework.

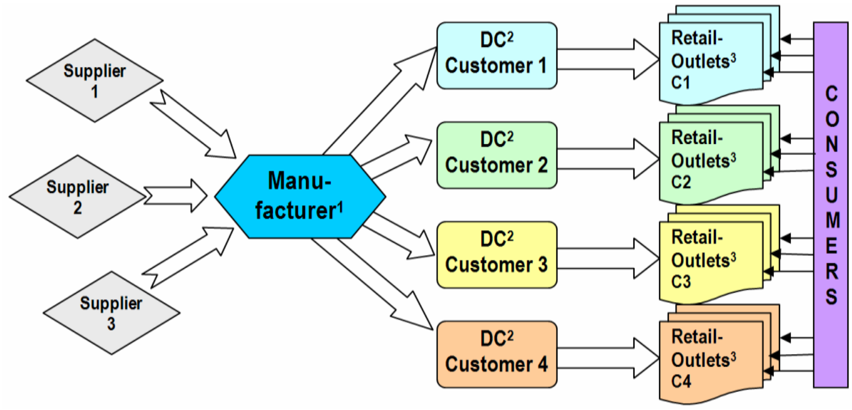

Figure 1: Outline of the modelled Supply Chain

Even though it is part of the simulation model, the investigation will not discuss any issues arising out of the relationship between manufacturers and their suppliers of raw material. Data that is used to run this part of the system is taken as a given. Within the distribution framework between manufacturer and retailers - deliveries for each particular customer are either scheduled via traditional reorder-point policies (ROP) or follow a CPFR approach.

The ROP case covers scenarios where order requests are either predetermined according to a fixed order interval (fixed order date ROP) or triggered by the retailer according to inventory level dropping below a particular lower bound (flexible order date ROP). Within the first case, the manufacturer has information about the target date of required delivery but does not know the requested quantity in advance, whilst in the second case neither time nor required quantity of incoming orders is known beforehand. Within these frameworks the manufacturer has to rely only on the standard demand or more particular average sales throughout the year with some seasonal adjustments as to face e.g. lower demand in summer and higher in winter. Production scheduling thus has to depend on past experience and a certain amount of estimation and does not involve recent sales or inventory information.

Within CPFR/VMI scenarios sales data on store level as well as inventory levels at retail outlets and distribution centres are available to the manufacturer on a weekly updated basis. Furthermore collaborative effort makes it possible to obtain detailed seasonal sales deviation factors as well as underlying long and mid-term market-trends. Another important component of a CPFR system is the collaborative setup and frequent updating of detailed promotion schedules combined with a promotion-impact estimation. This knowledge is finally used to create a sales, delivery and production forecast that is constantly supervised (exception handling) and adapts to recent market developments. Within this system replenishment is commonly arranged between manufacturer and retail-companies via a VMI approach. Thus the manufacturer supervises the inventory level of the retail-company's distribution centres and replenishment requests are triggered by DC-inventories reaching a particular reorder point that is determined by the aforementioned sales forecast based on past demand data, detailed promotion schedules, seasonal factors and most recent sales data. This system leads to a high level of demand transparency and makes it thus possible to deliver a scarce product to the location that it truly needs most urgent. The retail outlets within all three simulation frameworks are always connected with their DC via a CPFR/VMI replenishment system. Thus interaction between these two echelons is not affected by the general collaboration status. The delivery is on a daily request basis with average replenishment intervals approximately once a week. This can be considered as common practice for many kinds of products and within most major retail companies (VICS, 1999; Holmström et al., 2002). Thus the replenishment strategy between DC and outlets will not be further analysed. For further information Figure 2 gives a more detailed structural overview of the actual model layout.

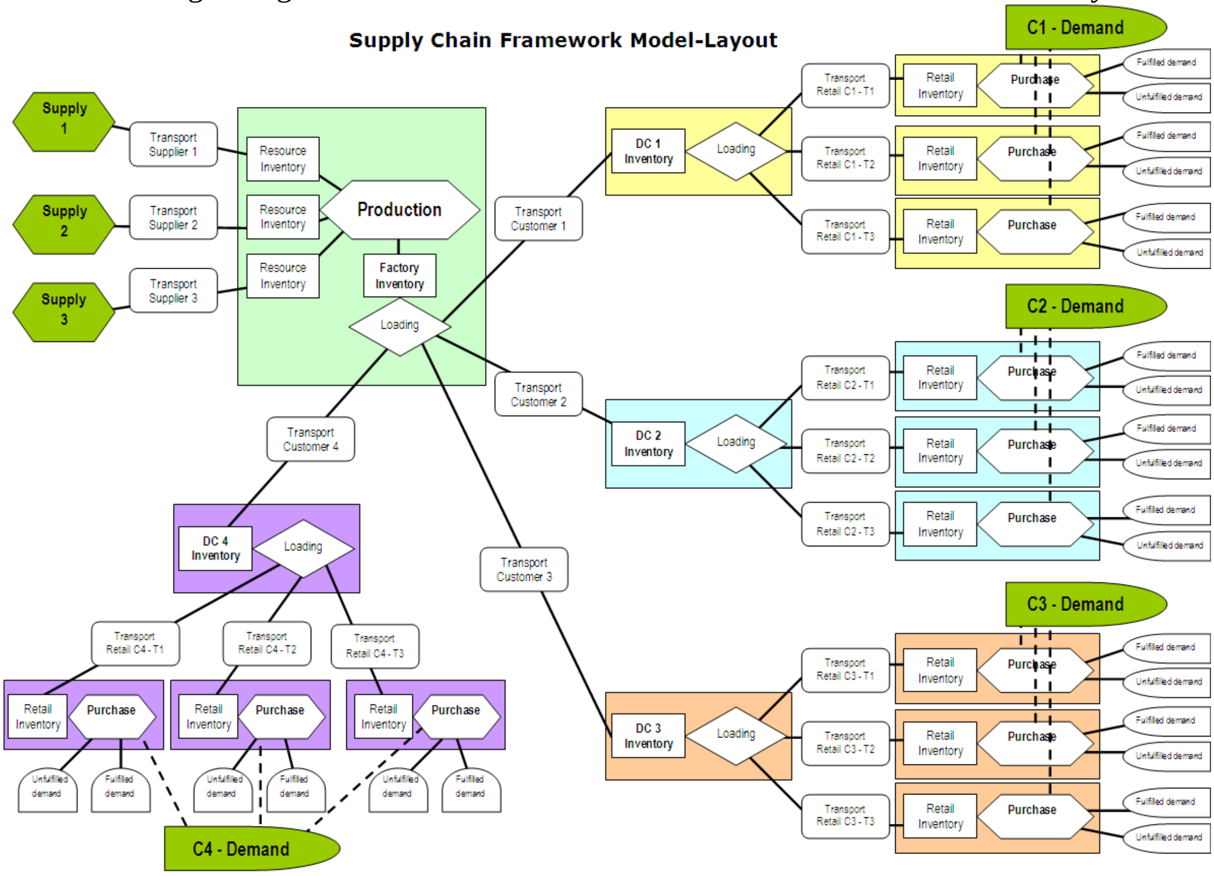

Figure 2: Structural overview of the simulation model

Additionally, Figure 3 gives a general overview of the modelled supply chain decision process distinguished after operational and strategic decision making. The upper half of the chart outlines operational information requirements (input and output variables) for each of the identified five decision echelons. These variables are constantly updated as the model runs. The lower part of the chart summarizes rather tactical and strategic framework definition policies, constraints and parameters that need to be defined before the simulation is run. Within both parts of the chart, variables marked with * are only needed in case of collaborative replenishment.

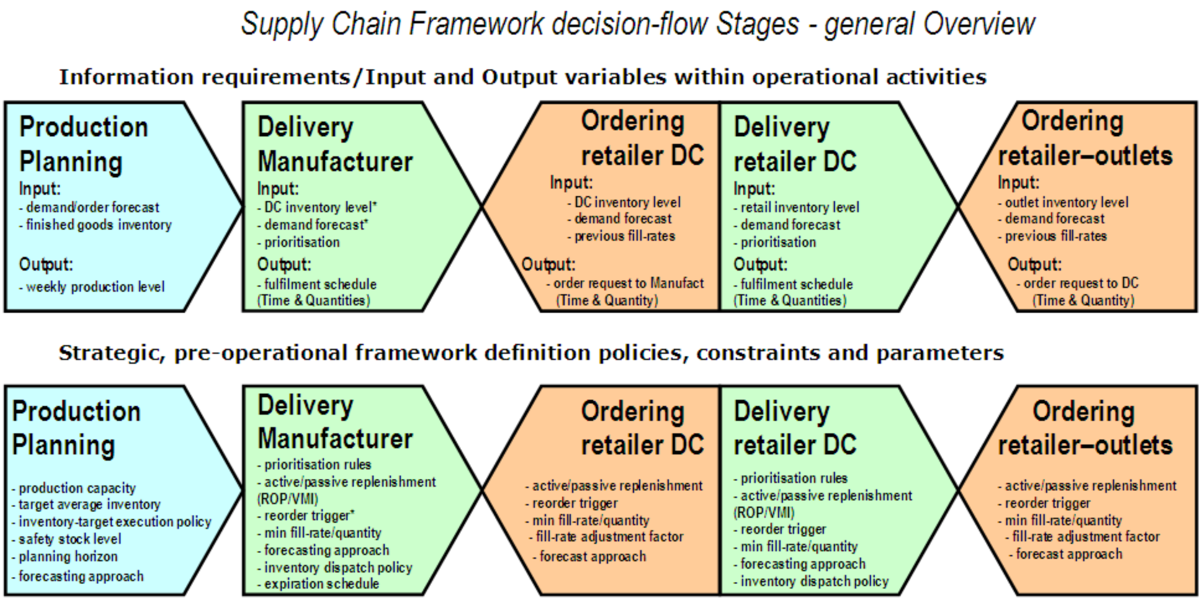

Figure 3: Overview of the modelled supply chain decision process

2.2 Modelling background information

The main contributors towards the investigation to provide the underlying data as well as necessary expertise are in fact the three food manufacturers as central stages within the investigated supply chain systems. All three are small or medium sized enterprises with annual turnover in between €30 to €160 million. They produce grocery items within distinct food categories. Each manufactures a variety of similar kinds of products in various forms and shapes and additionally in various sizes. The products that were chosen for the analysis were taken out of sets of data that contained detailed sales information about the best selling stock keeping units (SKUs). Altogether sales behaviour from all products within a particular product group was found to be almost identical. Replenishments are commonly made ordering the entire set in similar amounts and any kind of sales promotion always involves a whole set as well. Thus the analysis focuses on typical SKUs instead of a set since several test runs with each of the other products within a set resulted in a virtually identical outcome. The demand simulation part of the model is based on 170 weeks of actual sales data (sales in between 2001 and 2004) that account for sales of the four largest customers of each of the three manufacturers. The sales data under consideration is characterised by volatile demand behaviour, remarkable seasonalities and particularly intensive promotional activities. Market conditions for manufacturer 3 are characterised by a robust growth whilst manufacturers 1 and 2 operate in a matured fairly stable market. Based on this market intelligence a sales forecast system was implemented that serves the CPFR part as basis to determine production levels and estimate replenishment points and necessary quantities. The forecast is generated for each customer individually taking historic demand, price changes, promotional activity schedules and impact level estimations, competitor promotions and product introductions, weekly seasonal factors and long term market trends into account. These factors are then taken to decompose recent sales data supplied by various retail outlets which again serve to generate a short term trend forecast based on regression and exponential smoothing techniques. The final demand estimation is then obtained through reintegration of the underlying factors into the generated short term trend forecast. This forecasting procedure represents the actual practice within one of the involved companies. On the basis of this forecast, delivery requests are classified into several levels of urgency based on outlet and DC inventories/forecasted demand data which is then used to set delivery priorities in case of insufficient inventory to minimize overall loss of sales. Within heterogeneous scenarios ROP

orders will be preset to average urgency due to a lack of information about their real importance. If two incoming requests have the same priority one is chosen on a random basis. Within the delivery distribution system the minimum fill rate is set to 70%. Considering the above outline the investigation goes beyond most previous approaches that focused on products with stationary demand and did not include any collaborative forecasting system that includes retail outlets as well (e.g. Waller et al. 1999; Småros et al. 2003).
The companies predominantly use weekly production cycles which adjust production to expected forthcoming demand within the following three to six weeks. Production is capacity constrained according to individual conditions and actual production level is solely set up at the beginning of each week. The average inventory level held by each manufacturer is set on a fairly lean level as this goes along with the companies' restrictive inventory policy that average stock-level of each inventory class A SKU throughout the year must not exceed a certain period of demand due to product expiry or storage facility limitations. The simulation software used was Simul8 2006 Professional (Simul8 Corp, 2006). SIMUL8 is an object oriented, general purpose computer package for visual discrete event simulation. As such it is a powerful and flexible platform for visualizing and dynamically simulating nearly any kind of physical, financial or organizational system. Within recent years it is being widely used in industry and academia to simulate workflows in production, distribution and office environments to identify improvements in operations and processes.
The developed model contains 20 main entities as laid out in Figure 1. It incorporates overall more than 200 objects such as work-centres, resources, queues, item-entry and exit points. The actual model intelligence is implemented via Visual Basic code that controls the behaviour of all objects. The end-consumer demand that drives the supply chain system is implemented in form of three distinct demand behaviour categories among each of the four retail companies. Each of these represents demand behaviour of a certain group of retail outlets which have been categorised according to the obtained historic demand data. The actual customer inter-arrival times are then implemented via exponential distributions that have as a daily mean the obtained historic figures. The model is prior to each run set up with sufficient startup inventories to be able to fulfil replenishment and incoming orders respectively. To further reduce most of the initialization-bias and assure an unflawed observation, result-collection is initiated after a 13-week warm-up period. Overall the model runs over a timeframe of 170 weeks as this goes along with the range of sales data that was obtained from the involved companies. Due to a vast degree of complexity it takes about 3 to 4 minutes for a single full framework run on a Pentium 4 3.6GHz machine. Due to a substantial degree of incorporated variation regarding inter-arrival/processing distribution timings, each setting is run 10 times to achieve a sufficient confidence level for all output variables of interest.

3 Analysis overview and performance measures

As mentioned before, the investigation evolves around the impact of expanding demand visibility and improved supply chain collaboration. In addition to estimating possible benefits arising out of an advanced collaborative framework, a major focus will be on potential negative side-effects and strategic implications of particular performance results.
To be able to draw conclusions about these issues we will investigate various scenarios including individual homogeneous and heterogeneous framework settings starting from the default distribution setups of the three supply chain frameworks that serve as reference scenarios. Later on, distribution processes will be advanced to feature an increasing number of customers that engage in collaborative replenishment and thus abandon the initial ROP reorder policy. The investigation features several common performance measures to be able to evaluate particular achievements and possible drawbacks at a global level and for each

individual market participant. These performance metrics can be clustered into four groups: Global measures revealing overall achievements (mainly service level), inventory metrics, delivery accuracy metrics covering supply between manufacturer and retailers' distribution centres and finally delivery accuracy metrics covering replenishment between retailers' distribution centres and retail outlets.

Metrics accounting for the first group:

Overall Service Level Gap – this figure accumulates the individual service level gap figures of the four customers and is the most important performance metric within the entire analysis. This measure accounts for any occurring gap in supply on store level and thus lost sales and customer/consumer goodwill which has to be seen as the ultimate failure within a supply chain. The reason why service level is taken as a variable performance metric instead of inventory which is used in most other logistics research is due to the distribution frameworks of the involved companies. These are characterised by very tight inventory capacity restrictions which is mainly due to a wide assortment of products, threat of expiry and limited storage capacity. The predetermined storage space limit of about one average week's demand for each class A inventory item serves the investigation as a measuring fix point to set parameters accordingly that this target can be met. As a result of this manufacturers inventory can rather be seen as constant whilst service level will vary to meet the inventory target.
Typical Service Level Gap – expresses the average gap in supply at store level for just the weeks in which demand cannot be fully met by available inventory. This measure thus gives further insight as to how severe supply gaps are once they should occur.
Largest gap in supply – states the service level gap for the single worst week of supply from any one of the customers.
Weeks of perfect supply – states the percentage of weeks within the total investigation timeframe where demand could be fulfilled to 100%. This is taken as an average from individual figures from each of the four customers.
Production Forecast Accuracy is meant to give an impression as to what extent increased demand transparency helps improving forecast accuracy. This measure therefore captures the average gap in forecast that drives production planning. This metric is also a measure for the quality of the underlying forecast system that uses available promotion schedules, seasonal factors, long and short term market trends and of course recent sales data to provide a reasonably good estimate of forthcoming demand.

Metrics accounting for the second group:

Manufacturer inventory **–** states the level of inventory held on average by the manufacturer throughout the investigation period. As already outlined before, inventory is predominantly kept on a fixed level whilst service level varies.
Total distribution centres' inventory – denominates the average level of inventory held by all distribution centres combined.
Excessive Inventory – measures the percentage of time during which inventory held by manufacturer exceeded a critical upper limit which is set to 300% of the average level.

Metrics accounting for the third group:

Number of delivery tours needed **–** expresses the number of tours necessary to supply the distribution centres of the customers within each scenario. This figure is expressed as percentage compared to a theoretical level which is determined during distribution planning.
Uncritical delays by Manufacturer – this measure captures the overall percentage of deliveries that were for some reason delayed by the manufacturer and could not be carried out from stock straight away. Nevertheless fulfilment did not exceed the typical order lead time.

The delay can be because of unavailability of the particular item or due to certain delivery prioritization policies.

Critical delays by Manufacturer – stands for the percentage of deliveries that were postponed by the manufacturer and finally carried out with a substantial delay that made the delivery exceed critical order lead time. These cases must be seen as rather severe interruptions of order-delivery procedure and are thus the reason for major inconveniencies.

Manufacturer's fill rate – measures the load level (fill rate) that deliveries obtained on average. Thus it captures the proportion of the initially requested amount that was actually delivered. This measure should optimally be 100%.

Percentage of perfect deliveries – captures the proportion of deliveries that were not critically delayed and achieved a fill rate of 100%.

Metrics accounting for the fourth group:

Uncritical delays by Distribution Centres – this measure captures the overall percentage of deliveries that were delayed by the retail companies' distribution centres whilst actual fulfilment did not exceed the typical order lead time. The delay can once again be because of unavailability of the particular item or due to certain delivery prioritization policies.

Critical delays by Distribution Centres – stands for the percentage of deliveries that were postponed by the retail companies' distribution centres and finally carried out with a substantial delay that made the delivery exceed critical order lead time and thus most likely led to a gap in consumer supply.

The above measures can be seen as a selection of standard performance metrics for the analysis of the considered kind and segment of supply chains and should thus contribute to obtain a clearer picture about the investigated framework (Waller et al., 1999; Simchi-Levi and Kaminski, 2002; Hugos, 2003).

4 Investigation findings

In order to achieve reliable conclusions about the entire investigation framework numerous scenarios were investigated to point out the influence of each parameter-change towards the final outcome of the examined variables. Altogether 32 individual settings were analysed for each of the three supply chain frameworks covering a stepwise widening collaboration framework based on initial fixed or flexible date ROP delivery. The notation of every scenario will be in the form of four letters e.g. DDCC. These stand for the individual delivery approaches of customers 1 to 4. The particular letters used here include F, R and C where F stands for fixed date ordering, R for orders coming in on a flexible date basis and C for a VMI/CPFR replenishment setup. Following this outline RRRR i.e. stands for flexible date ROP delivery for all four customers whilst i.e. CFCC represents the case that customers 1,3 and 4 are replenished via VMI/CPFR whilst customer 2's orders come in on a fixed day within a certain order interval (e.g. on Friday of every even week). Within further proceedings we will first investigate the reference scenarios that constitute the actual state of delivery for each manufacturer before the engagement into collaborative replenishment. These will serve as basis to compare changes step by step whilst increasing the demand visibility by raising the number of customers that feature VMI/CPFR replenishment from 0 up to 4. The initial part of the analysis will focus on global achievements within a widening collaboration framework whilst the later part will evaluate various effects evolving demand transparency has on each individual customer.

4.1 Reference scenarios

Simulating the initial scenarios that represent the conditions prior to any VMI/CPFR implementation and thus base purely on ROP delivery (either fixed or flexible scheduled) resulted in the following global outcome of the certain performance measures:

Table 1: Performance outcome of reference non- and full collaboration scenarios

		FW1			FW2			FW3		
		fixed	flexible		fixed	flexible		fixed	flexible	
		FFFF	RRRR	CCCC	FFFF	RRRR	CCCC	FFFF	RRRR	CCCC
Global	**overall SL gap**	**6.8%**	**2.4%**	**0.7%**	**6.6%**	**3.7%**	**0.8%**	**8.2%**	**5.2%**	**1.7%**
	typical SL gap	28%	13%	7%	20%	12%	7%	20%	12%	7%
	largest overall SL gap	100%	49%	29%	87%	59%	31%	83%	65%	45%
	perfect weeks	78%	84%	91%	71%	74%	91%	69%	79%	86%
	FC accuracy gap	8.2%	8.2%	5.9%	7.6%	7.6%	5.5%	15.0%	15.0%	2.6%
inventory	**Manufacturer Inventory**	117%	100%	100%	115%	100%	100%	106%	100%	100%
	total DC inventory	100%	99%	96%	100%	118%	127%	100%	112%	115%
	Excessive Inventory	1.9%	1.0%	1.2%	7.4%	3.0%	2.0%	2.2%	1.5%	2.0%
Manufacturer to DC	tours needed	97%	121%	120%	100%	129%	130%	95%	116%	103%
	delivery delayed	51%	70%	51%	55%	88%	52%	61%	67%	42%
	critically delayed	**13%**	**32%**	**9%**	**40%**	**76%**	**18%**	**23%**	**30%**	**9%**
	delivery fill-rate	86%	81%	86%	80%	74%	84%	82%	81%	88%
	perfect deliveries	35%	22%	32%	16%	12%	33%	29%	29%	44%
DC to retail	delivery delayed	7.6%	4.5%	1.9%	10.3%	7.4%	1.7%	10.2%	5.1%	2.2%
	critically delayed	2.6%	1.6%	0.3%	3.3%	2.6%	0.4%	3.6%	1.4%	0.4%

The above table represents the outcomes of fixed/flexible ROP delivery as well as CPFR for each of the three supply chain frameworks (FW1, FW2, and FW3). The actual figures are grouped into four performance metrics categories that were outline before. The fixed/flexible date settings are based on slightly different average inventory levels held by the manufacturers but can sill be reasonably compared. The main conclusion from the presented results has to be the vast level of improvement that is possible due to introducing collaborative replenishment. Within all 6 scenarios overall service level gap diminishes remarkably whilst critical delivery delays are cut down extensively. The fixed date delivery scenarios profit even more from collaboration which does not come as a surprise. Framework 3 in particular shows enormously improved production forecast accuracy due to information exchange and demand visibility. The fact that distribution centre inventories increase after the introduction of collaborative replenishment should be rather due to substantial shortages within the old ROP system instead of shortcomings from collaboration.

To be able to estimate the actual improvements of each customer due to introduction of collaboration we chose four key-performance measures and generated a table that allows a more detailed analysis of collaboration impact on each individual customer.

The detailed figures reveal a better insight about what is the actual effect on each customer. Altogether collaboration with no doubt has a remarkably positive impact towards performance. Nevertheless, the level of improvement is certainly different amongst individual customers. As a result of this particular customers could be less or more inclined to encourage collaboration than others. For example introducing collaborative replenishment within the default fixed-date delivery setup of supply chain framework 1 improves performance outcome for customers 3 and 4 remarkably whilst customers 1 and 2 are barely affected by it. Similar outcome can be observed looking at the flexible date delivery scenario within supply chain framework 3. The introduction of collaborative replenishment leads here even to slightly reduced performance for customers 1 and 4 whilst the other two customers gain remarkably. Many of these individual effects are not visible if we only look at global supply chain wide

Table 2: Individual customers' performance for reference non- and full collaboration scenarios

		FW1			FW2			FW3		
		fixed	flexible		fixed	flexible		fixed	flexible	
		FFFF	RRRR	CCCC	FFFF	RRRR	CCCC	FFFF	RRRR	CCCC
SL Gap	C1	1.1%	2.5%	0.5%	7.2%	3.3%	0.5%	5.0%	0.1%	0.7%
	C2	1.1%	2.2%	0.9%	5.6%	3.7%	1.3%	10.7%	6.5%	2.5%
	C3	15.7%	2.3%	0.6%	7.5%	3.9%	0.4%	5.2%	8.1%	1.5%
	C4	11.8%	2.6%	0.8%	7.9%	4.1%	0.5%	11.8%	0.8%	1.2%
	Total	6.8%	2.4%	0.7%	6.6%	3.7%	0.8%	8.2%	5.2%	1.7%
Weeks of perfect supply	C1	93%	85%	93%	69%	77%	93%	81%	98%	95%
	C2	92%	83%	87%	71%	71%	84%	62%	62%	79%
	C3	59%	84%	92%	73%	74%	93%	74%	62%	81%
	C4	66%	83%	90%	71%	72%	93%	59%	92%	89%
	Total	78%	84%	91%	71%	74%	91%	69%	79%	86%
Critical delays Manuf-DC	C1	14%	31%	7%	28%	77%	16%	26%	40%	14%
	C2	3%	32%	12%	49%	78%	34%	23%	22%	7%
	C3	9%	34%	8%	41%	76%	13%	9%	25%	5%
	C4	31%	32%	7%	40%	74%	9%	46%	44%	13%
	Total	13%	32%	9%	40%	76%	18%	23%	30%	9%
Delays DC-Retail	C1	2.1%	4.7%	1.7%	11.3%	6.6%	1.2%	6.8%	1.0%	2.0%
	C2	2.0%	3.7%	2.2%	11.1%	7.1%	3.4%	12.0%	7.7%	2.5%
	C3	13.9%	4.9%	1.9%	10.5%	8.2%	1.4%	7.2%	10.3%	2.2%
	C4	13.4%	4.6%	2.0%	8.9%	7.8%	0.9%	15.0%	1.3%	2.0%
	Total	7.6%	4.5%	1.9%	10.3%	7.4%	1.7%	10.2%	5.1%	2.2%

achievements. Nevertheless such issues should be of major importance for particular customers to evaluate what level of benefit they can expect from collaboration initiatives.

4.2 The impact of collaboration on non-collaborating customers

After obtaining an overview about the overall potential collaborative replenishment can result in we will focus on how a widening collaboration framework affects the individual participants within such a system. We will therefore investigate all possible collaboration setups starting from the default pure ROP (flexible/fixed date) scenarios up to the full collaboration settings. Thus, we will investigate 16 individual settings for each of the 8 default scenarios. The actual impact on collaboration participants, remaining ROP customers or manufacturer is evaluated for each stage within the widening collaboration framework. The results will be presented in two tables for each collaboration stage. The first one includes the outcome for all three frameworks based on the flexible date ROP replenishment whilst the second table presents the results based on fixed-date delivery ROP. The tables are structured horizontally in a way to show each framework outcome next to each other for easy comparison to allow drafting general conclusions. Each framework is investigated for each possible combination of ROP and CPFR customers which includes 4 possible combinations with one CPFR and 3 ROP customers, 6 combinations of 2 CPFR and 2 ROP customers and 4 combinations of 3 CPFR and 1 ROP customers. Additionally each table states the default all ROP scenario outcome for reasons of comparison which serves as basis for the further adjusted settings. The actual presented numbers stated express the deviation from the default all ROP setting. Thus negative numbers stand for diminished outcome compared to the default all ROP setting which can be either positive or negative depending on the particular performance metric. Vertically the tables show the results for four chosen key performance measures for each individual customer (marked by C1, C2, C3, C4) and the combined global outcome. Each individual score is evaluated and highlighted green in case it constitutes a noticeable improvement above the initial case or highlighted red in case of declining performance. As long as there is no significant increase or decrease, score-fields are left unmarked. Within all following scenarios manufacturer inventory is set to a fixed level to allow a comprehensive investigation of resulting service levels and other key performance indicators.

One collaborative customer cases

The focus here is on the changes that strike each individual customer after one particular customer's replenishment is changed to CPFR whilst the others remain with ROP solutions. We will evaluate every possible combination of ROP and CPFR and compare the results with the default all ROP reference scenarios.

Flexible delivery-date framework

Table 3: Performance scores of flexible date delivery scenarios incl. one CPFR customer

flexible-date delivery - 1 CPFR customer 3 ROP

		FW 1					FW 2					FW 3				
		RRRR	CRRR	RCRR	RRCR	RRRC	RRRR	CRRR	RCRR	RRCR	RRRC	RRRR	CRRR	RCRR	RRCR	RRRC
SL Gap	C1	2.5%	-2.3%	-1.0%	-0.2%	-0.1%	3.3%	-3.2%	+0.2%	+0.6%	+0.4%	0.1%	0.0%	+0.4%	+0.3%	0.0%
	C2	2.2%	-0.1%	-1.7%	-0.4%	+0.4%	3.7%	+0.7%	-2.7%	+0.4%	+0.2%	6.5%	-0.7%	-4.9%	+0.7%	+0.6%
	C3	2.3%	-0.4%	-0.2%	-2.0%	+0.5%	3.9%	-0.2%	-0.8%	-3.8%	-0.1%	8.1%	-1.1%	0.0%	-6.9%	0.0%
	C4	2.6%	+0.2%	-0.5%	+0.2%	-2.4%	4.1%	-0.4%	-0.4%	-0.2%	-4.0%	0.8%	0.0%	+0.6%	+0.8%	-0.3%
	Total	2.4%	-0.7%	-0.9%	-0.6%	-0.2%	3.7%	-0.6%	-1.4%	-0.5%	-0.2%	5.2%	-0.6%	-1.6%	-1.9%	+0.2%
Weeks of perfect supply	C1	85%	+10%	+4%	+2%	+1%	77%	+19%	+5%	+2%	0%	98%	0%	-1%	-1%	0%
	C2	83%	+2%	+8%	+3%	0%	71%	-4%	+14%	+2%	+1%	62%	0%	+17%	+5%	0%
	C3	84%	+3%	+2%	+10%	-2%	74%	+4%	+9%	+23%	0%	62%	-2%	+5%	+20%	0%
	C4	83%	+4%	+4%	+2%	+10%	72%	+4%	+10%	+4%	+24%	92%	-1%	-2%	-2%	+1%
	Total	84%	+5%	+4%	+4%	+2%	74%	+6%	+10%	+8%	+6%	79%	-1%	+5%	+5%	0%
Critical delays Manuf-DC	C1	31%	-30%	-7%	-2%	+1%	77%	-75%	-22%	-8%	-3%	40%	-39%	-9%	-10%	-1%
	C2	32%	-2%	-28%	-2%	+2%	78%	+2%	-54%	-1%	-2%	22%	+1%	-21%	-2%	+1%
	C3	34%	-5%	-5%	-33%	0%	76%	-5%	-24%	-75%	-2%	25%	+2%	-1%	-23%	+2%
	C4	32%	-6%	-5%	-4%	-31%	74%	-7%	-25%	-11%	-73%	44%	-2%	-11%	-10%	-43%
	Total	32%	-11%	-12%	-11%	-8%	76%	-25%	-33%	-27%	-23%	30%	-6%	-11%	-12%	-6%
Delays DC-Retail	C1	4.7%	-3.1%	-1.8%	-0.5%	-0.5%	6.6%	-5.9%	-0.5%	+0.7%	+0.6%	1.0%	-0.3%	+0.7%	+0.5%	+0.3%
	C2	3.7%	+0.2%	-1.9%	+0.2%	+1.6%	7.1%	+1.4%	-5.2%	+0.9%	+0.2%	7.7%	-0.7%	-5.8%	-1.1%	+1.0%
	C3	4.9%	-1.1%	-0.4%	-3.4%	+0.4%	8.2%	-0.8%	-2.3%	-7.4%	-0.2%	10.3%	-0.7%	-1.7%	-8.2%	-0.3%
	C4	4.6%	-0.4%	-0.9%	-0.4%	-3.5%	7.8%	-0.8%	-2.2%	-0.1%	-7.4%	1.3%	-0.2%	+0.5%	+1.1%	-0.6%
	Total	4.5%	-1.1%	-1.3%	-1.0%	-0.5%	7.4%	-1.5%	-2.6%	-1.5%	-1.7%	5.1%	-0.5%	-1.6%	-1.9%	+0.1%

Within this first group of scenarios showing the scores of all possible settings with 1 single CPFR customer we can see the majority of cases revealing substantial improvements (green fields) or indifferent results (white) compared to the initial non-collaborative setting which does not come as a surprise. However, what is rather astonishing is the number of cases where individual and sometimes even global performance diminishes as a result of the increased collaborative framework (red fields). Looking at the scores we see that engaging in collaboration surely and commonly remarkably improves the performance of those customers who actually engage in CPFR. Very often this increase in collaboration additionally leads to improved results for the remaining customers as well resulting in a win-win situation. What is overall concerning nevertheless are the numerous obvious cases where one customer engaging in CPFR leads to significantly diminished outcome for one or more of the remaining ROP customers. It seems that frameworks 2 and 3 are more affected by these "collateral damages" than framework 1. This is certainly due to the dissimilar distribution setups for each framework and the different degree of importance (percentage of overall demand) that each customer has. Overall, each of the three frameworks includes at least one case where the improvements for the single CPFR customer are accompanied by shortcomings for at least two other customers. Framework 3 seems to be particularly problematic in this respect. For example, engaging customer 3 in CPFR would lead to significant service level improvements (SL gap diminishes from 8.1% to 1.2%) but has the side-effect of diminishing all remaining customers' service level. Altogether we can state that within all the above cases such "collateral damages" are not too much severe but are numerous and clearly noticeable. As a matter of fact, 11 out of 64 performance measure scores diminish as a result of a single customer engaging in CPFR in case of framework 1 which is equivalent to 17% of all cases. The figures for framework 2 and 3 are 20% and 34% respectively.

Fixed delivery-date framework

Table 4: Performance scores of fixed date delivery scenarios incl. one CPFR customer

fixed-date delivery - 1 CPFR customer 3 ROP

		FW 1					FW 2					FW 3				
		FFFF	CFFF	FCFF	FFCF	FFFC	FFFF	CFFF	FCFF	FFCF	FFFC	FFFF	CFFF	FCFF	FFCF	FFFC
SL Gap	C1	1.1%	-1.0%	-0.6%	2.1%	1.6%	7.2%	-7.0%	0.3%	-2.0%	-1.6%	5.0%	-4.9%	0.7%	-2.0%	1.2%
	C2	1.1%	0.5%	-0.9%	0.2%	0.4%	5.6%	2.0%	-4.9%	1.4%	0.2%	10.7%	-0.1%	-9.0%	-1.3%	1.4%
	C3	15.7%	-4.4%	1.2%	-15.5%	0.0%	7.5%	-3.0%	0.0%	-7.4%	-2.7%	5.2%	-0.4%	2.4%	-4.0%	1.5%
	C4	11.8%	-2.8%	2.4%	4.5%	-11.6%	7.9%	-2.9%	0.8%	-2.3%	-7.8%	11.8%	-1.4%	-4.1%	-1.5%	-11.2%
	Total	6.8%	-1.8%	0.4%	-2.4%	-1.8%	6.6%	-1.7%	-2.1%	-1.6%	-1.6%	8.2%	-1.1%	-3.0%	-2.4%	-0.5%
Weeks of perfect supply	C1	93%	5%	2%	-9%	-5%	69%	28%	3%	8%	7%	81%	17%	-1%	8%	-1%
	C2	92%	-3%	3%	-2%	-1%	71%	-5%	20%	-2%	1%	62%	0%	16%	3%	-5%
	C3	59%	6%	-3%	38%	4%	73%	5%	0%	25%	5%	74%	2%	-2%	7%	-2%
	C4	66%	4%	-2%	-4%	28%	71%	4%	-3%	4%	24%	59%	8%	13%	10%	33%
	Total	78%	3%	0%	6%	6%	71%	8%	5%	9%	9%	69%	7%	6%	7%	6%
Critical delays Manuf-DC	C1	14%	-12%	-7%	9%	7%	28%	-26%	-13%	4%	-2%	26%	-25%	-9%	-16%	6%
	C2	3%	1%	0%	1%	1%	49%	12%	-30%	3%	-7%	23%	0%	-21%	-6%	1%
	C3	9%	-4%	2%	-8%	9%	41%	-16%	-9%	-40%	-9%	9%	2%	2%	-8%	1%
	C4	31%	-14%	4%	-17%	-30%	40%	-10%	-1%	-12%	-39%	46%	-8%	-16%	-8%	-45%
	Total	13%	-7%	-1%	-4%	-4%	40%	-12%	-14%	-14%	-16%	23%	-6%	-11%	-9%	-6%
Delays DC-Retail	C1	2.1%	-1.3%	-0.8%	3.4%	2.5%	11.3%	-10.3%	-0.7%	-2.9%	-2.9%	6.8%	-6.2%	1.1%	-2.3%	1.3%
	C2	2.0%	1.8%	-1.0%	0.7%	1.1%	11.1%	2.5%	-9.2%	1.2%	0.0%	12.0%	0.0%	-10.3%	-1.9%	1.4%
	C3	13.9%	-1.6%	0.9%	-13.0%	0.3%	10.5%	-2.3%	-0.8%	-10.1%	-1.8%	7.2%	-0.8%	0.9%	-5.2%	1.0%
	C4	13.4%	-2.3%	-1.0%	0.2%	-12.3%	8.9%	-1.7%	1.0%	-0.7%	-8.6%	15.0%	-2.4%	-5.4%	-4.6%	-14.4%
	Total	7.6%	-0.7%	-0.6%	-2.2%	-2.1%	10.3%	-3.0%	-2.5%	-3.2%	-3.4%	10.2%	-2.4%	-3.4%	-3.6%	-2.6%

The results obtained based on the fixed-date delivery setting have to be considered somewhat conditionally since the actual improvement or declining performance figures very much depend on the underlying fixed-date order schedule which is set up reasonably to account for the investigated companies but is from a more general perspective somewhat arbitrary. Outcome from all three investigated frameworks should allow for some reasonably reliable conclusions but altogether findings cannot be generalised to such a wide extent as the results from the previous flexible date delivery scenarios. This is due to the fact that investigated settings represent only individual arbitrary choices out of a pool of hundreds of possible settings that are determined by specific setup of each manufacturer's delivery framework regarding number of customers, delivery intervals or days of order placements.

Having the above limitations in mind we can still draw some clear conclusions from the results obtained and visualised in the table above. In general the findings are very similar to the flexible-date replenishment cases above. However, the degree of individually possible improvements as well as actual "collateral damages" seem to be far more substantial within this framework. It seems that engaging one customer in CPFR can on one hand dramatically improve performance for that very customer but on the other hand can not just somewhat diminish performance of remaining customers but severely harm other's replenishment system. We can see within framework 1 for example customer 3 engaging in CPFR would lead to an almost perfect result for this customer (SL gap down from 15.7% to 0.2%) but at the same time increase service level gap of C1 from 1.1% to 3.3%, C2 from 1.1% to 1.3% and C3 from 11.8% to 16.3%. Similar effects can be found among other frameworks and performance measures. Overall framework 1 reveals 41% of scores being diminished due to introduction of as single collaborative customer whilst framework 2 and 3 account for 22% and 25% respectively. As a result of that, such side-effects of collaboration would have to be seriously taken into consideration before any decision about engaging a particular customer in CPFR is made.

Two collaborative customers cases

For the case that half of the customer base is engaged into CPFR the focus of attention lies on how far the increasing adoption of collaborative replenishment can help to close the gap between CPFR and remaining ROP customers. We have thus to consider the question as to what extent they too can possibly benefit from increased global demand transparency.

Flexible delivery-date framework

Table 5: Performance scores of flexible date delivery scenarios incl. two CPFR customers

flexible-date delivery - 2 CPFR customers and 2 ROP

FW 1

		RRRR	CCRR	CRCR	CRRC	RCCR	RCRC	RRCC
SL Gap	C1	2.5%	-2.2%	-2.2%	-2.2%	-0.8%	-0.4%	0.0%
	C2	2.2%	-1.4%	0.6%	1.0%	-1.3%	-1.4%	1.1%
	C3	2.3%	-0.4%	-1.8%	0.7%	-2.0%	0.0%	-1.8%
	C4	2.6%	-0.4%	0.4%	-2.1%	-0.5%	-2.0%	-2.3%
	Total	2.4%	-1.1%	-0.7%	-0.5%	-1.2%	-0.9%	-0.6%
perfect weeks	C1	85%	10%	9%	10%	5%	3%	2%
	C2	83%	5%	1%	-1%	4%	5%	1%
	C3	84%	4%	9%	-1%	10%	2%	9%
	C4	83%	6%	3%	10%	6%	8%	11%
	Total	84%	6%	6%	5%	7%	5%	5%
delays Manuf	C1	31%	-27%	-27%	-28%	-7%	-7%	-2%
	C2	32%	-25%	-4%	1%	-24%	-25%	-2%
	C3	34%	-11%	-30%	-3%	-31%	-7%	-31%
	C4	32%	-9%	-8%	-30%	-11%	-29%	-30%
	Total	32%	-19%	-18%	-16%	-19%	-18%	-17%
delays retail	C1	4.7%	-3.4%	-3.1%	-3.3%	-1.2%	-0.8%	-0.5%
	C2	3.7%	-1.6%	1.2%	1.8%	-1.4%	-1.8%	1.6%
	C3	4.9%	-1.6%	-3.3%	0.3%	-3.3%	-1.2%	-3.1%
	C4	4.6%	-1.2%	-0.8%	-2.9%	-1.5%	-2.8%	-3.2%
	Total	4.5%	-2.0%	-1.5%	-1.0%	-1.8%	-1.6%	-1.3%

FW 2

		RRRR	CCRR	CRCR	CRRC	RCCR	RCRC	RRCC
SL Gap	C1	3.3%	-3.0%	-3.2%	-3.1%	-0.3%	-0.8%	0.6%
	C2	3.7%	-3.0%	1.5%	1.5%	-2.6%	-2.9%	1.0%
	C3	3.9%	-2.2%	-3.7%	-0.9%	-3.8%	-1.7%	-3.7%
	C4	4.1%	-2.5%	-1.9%	-4.0%	-2.9%	-3.9%	-3.9%
	Total	3.7%	-2.8%	-1.1%	-0.7%	-2.3%	-2.2%	-0.5%
perfect weeks	C1	77%	18%	19%	18%	11%	12%	5%
	C2	71%	17%	-1%	-4%	14%	16%	1%
	C3	74%	17%	22%	7%	21%	15%	22%
	C4	72%	19%	14%	24%	20%	21%	24%
	Total	74%	18%	13%	11%	17%	16%	13%
delays Manuf	C1	77%	-68%	-73%	-74%	-41%	-35%	-11%
	C2	78%	-53%	-2%	1%	-52%	-59%	-5%
	C3	76%	-45%	-74%	-11%	-71%	-37%	-75%
	C4	74%	-49%	-25%	-73%	-48%	-70%	-73%
	Total	76%	-54%	-47%	-43%	-54%	-52%	-45%
delays retail	C1	6.6%	-6.0%	-5.8%	-5.8%	-3.0%	-2.1%	-0.5%
	C2	7.1%	-5.3%	2.4%	2.9%	-4.9%	-4.9%	1.6%
	C3	8.2%	-5.3%	-7.6%	-1.8%	-7.2%	-3.4%	-7.2%
	C4	7.8%	-5.3%	-3.9%	-7.3%	-6.2%	-7.0%	-7.3%
	Total	7.4%	-5.5%	-3.8%	-3.0%	-5.3%	-4.4%	-3.4%

FW 3

		RRRR	CCRR	CRCR	CRRC	RCCR	RCRC	RRCC
SL Gap	C1	0.1%	0.0%	0.0%	0.0%	1.8%	0.6%	0.5%
	C2	6.5%	-4.9%	-0.5%	0.5%	-4.1%	-4.7%	1.1%
	C3	8.1%	-0.9%	-6.9%	-1.0%	-6.7%	-0.6%	-6.8%
	C4	0.8%	1.2%	0.3%	-0.3%	1.1%	-0.2%	-0.3%
	Total	5.2%	-1.9%	-2.5%	-0.2%	-3.3%	-1.8%	-1.9%
perfect weeks	C1	98%	0%	0%	0%	-2%	-2%	-2%
	C2	62%	15%	11%	3%	18%	14%	8%
	C3	62%	10%	19%	2%	19%	10%	20%
	C4	92%	-1%	-1%	1%	-4%	0%	0%
	Total	79%	6%	7%	1%	8%	5%	6%
delays Manuf	C1	40%	-36%	-36%	-39%	-19%	-9%	-13%
	C2	22%	-20%	-3%	3%	-18%	-20%	-1%
	C3	25%	-3%	-23%	2%	-20%	-3%	-23%
	C4	44%	-11%	-18%	-42%	-17%	-38%	-39%
	Total	30%	-16%	-18%	-12%	-19%	-16%	-17%
delays retail	C1	1.0%	0.0%	-0.3%	-0.3%	0.4%	1.1%	0.9%
	C2	7.7%	-5.5%	-1.9%	0.6%	-5.0%	-5.5%	-0.5%
	C3	10.3%	-3.0%	-8.1%	-0.8%	-7.9%	-2.2%	-8.2%
	C4	1.3%	1.0%	0.0%	-0.5%	1.3%	-0.4%	-0.7%
	Total	5.1%	-1.9%	-2.6%	-0.2%	-2.8%	-1.8%	-2.1%

Within the above table all figures showing significant improved performance have once again been highlighted green whilst all declines have been highlighted red. Insignificant improvements have been left white. As we can see from a brief eyeball test, the percentage of cases showing significant improvements have surely increased compared to the single CPFR customer case. Especially within framework 2 this progress is clearly visible. Apart from a few exceptions it seems that not just the 2 customers engaged in collaborative replenishment improve their performance but also the remaining customers are better of as a result of increased collaboration. Among frameworks 1 and 3 it is nevertheless almost solely the customers engaged in CPFR that benefit from the increased level of demand transparency whilst remaining ROP customers are merely worse off or gain insignificantly compared to the reference scenarios. Nevertheless the gap is narrowing down and can in most cases almost be neglected. At this stage of overall collaboration global performance is improved to a remarkable extent no matter which customers engaged in CPFR. There is not one single scenario among any of the frameworks that reveals a globally diminished outcome. As a further sign that outcome is improving although struggling with various drawbacks we see that the majority of scores remarkably improve due to increased collaboration. The particular figures are 44% within FW1, 78% within FW2 and 46% within FW3.

Even though the situation for the remaining ROP customers seems to improve, there are still numerous cases that result in shortcomings for them. Overall framework 1 still has 13% of scores being diminished after introduction of two collaborative customers whilst framework 2 and 3 account for 10% and 23% respectively in that matter.

Fixed delivery-date framework

Table 6: performance scores of fixed date delivery scenarios incl. two CPFR customers

fixed-date delivery - 2 CPFR customers and 2 ROP

		FW 1							FW 2							FW 3						
		FFFF	CCFF	CFCF	CFFC	FCCF	FCFC	FFCC	FFFF	CCFF	CFCF	CFFC	FCCF	FCFC	FFCC	FFFF	CCFF	CFCF	CFFC	FCCF	FCFC	FFCC
SL Gap	C1	1.1%	-0.9%	-0.9%	-0.9%	0.4%	-0.1%	2.0%	7.2%	-7.0%	-7.0%	-6.9%	-1.0%	-0.7%	-3.7%	5.0%	-4.7%	-4.8%	-4.9%	-2.4%	0.8%	-1.0%
	C2	1.1%	-0.8%	0.8%	1.2%	-0.7%	-0.7%	1.2%	5.6%	-5.0%	3.6%	2.8%	-4.7%	-4.6%	1.8%	10.7%	-9.0%	-0.7%	1.4%	-8.9%	-9.1%	0.5%
	C3	15.7%	-3.7%	-15.5%	-3.8%	-15.4%	0.2%	-15.5%	7.5%	-3.7%	-7.4%	-5.8%	-7.3%	-1.0%	-7.3%	5.2%	3.1%	-4.1%	1.3%	-3.8%	2.9%	-4.0%
	C4	11.8%	-2.4%	2.9%	-11.6%	4.9%	-11.6%	-11.6%	7.9%	-3.3%	-6.3%	-7.8%	-1.4%	-7.7%	-7.8%	11.8%	-5.6%	-2.7%	-11.3%	-6.5%	-11.2%	-11.0%
	Total	6.8%	-1.9%	-3.3%	-3.2%	-3.0%	-2.5%	-5.3%	6.6%	-5.1%	-2.2%	-2.4%	-4.0%	-3.2%	-2.3%	8.2%	-3.7%	-2.8%	-1.5%	-5.8%	-3.9%	-3.0%
perfect weeks	C1	93%	3%	4%	4%	-1%	0%	-7%	69%	28%	28%	26%	8%	6%	13%	81%	16%	16%	17%	8%	0%	7%
	C2	92%	2%	-4%	-5%	1%	1%	-5%	71%	18%	-9%	-5%	16%	17%	0%	62%	16%	5%	-5%	16%	19%	5%
	C3	59%	5%	38%	13%	36%	4%	37%	73%	8%	24%	14%	23%	4%	23%	74%	-2%	10%	-3%	5%	-3%	7%
	C4	66%	5%	2%	28%	-4%	29%	28%	71%	8%	16%	24%	5%	22%	24%	59%	18%	14%	34%	20%	33%	32%
	Total	78%	4%	10%	10%	8%	8%	13%	71%	15%	15%	15%	13%	12%	15%	69%	12%	11%	11%	12%	12%	13%
delays Manuf	C1	14%	-12%	-12%	-12%	-3%	-5%	12%	28%	-22%	-24%	-25%	-4%	-6%	0%	26%	-22%	-22%	-25%	-21%	0%	-14%
	C2	3%	2%	3%	5%	1%	1%	1%	49%	-29%	7%	5%	-27%	-29%	1%	23%	-21%	-8%	4%	-18%	-22%	-6%
	C3	9%	-3%	-8%	3%	-7%	9%	-7%	41%	-25%	-38%	-17%	-38%	-10%	-40%	9%	5%	-7%	4%	-5%	3%	-7%
	C4	31%	-4%	-24%	-30%	-17%	-30%	-30%	40%	-19%	-29%	-39%	-16%	-38%	-39%	46%	-26%	-17%	-44%	-29%	-41%	-41%
	Total	13%	-5%	-10%	-9%	-7%	-7%	-6%	40%	-24%	-23%	-22%	-22%	-22%	-22%	23%	-14%	-12%	-10%	-17%	-14%	-14%
delays retail	C1	2.1%	-1.1%	-1.2%	-1.3%	0.5%	0.3%	3.9%	11.3%	-10.6%	-10.7%	-10.6%	-2.3%	-2.8%	-4.2%	6.8%	-5.6%	-5.6%	-6.0%	-2.4%	1.8%	-2.1%
	C2	2.0%	-0.9%	1.7%	2.0%	-0.9%	-0.7%	1.6%	11.1%	-9.2%	3.5%	1.9%	-9.5%	-9.1%	0.5%	12.0%	-9.8%	-2.2%	1.8%	-9.9%	-10.2%	-1.7%
	C3	13.9%	-0.8%	-13.1%	-4.0%	-12.7%	-0.4%	-13.3%	10.5%	-4.4%	-9.9%	-6.4%	-9.9%	-2.4%	-9.6%	7.2%	0.7%	-5.3%	1.1%	-5.1%	0.6%	-5.1%
	C4	13.4%	-2.1%	-1.9%	-12.3%	0.6%	-12.6%	-11.9%	8.9%	-2.3%	-5.8%	-8.5%	-0.7%	-8.4%	-8.4%	15.0%	-7.3%	-4.7%	-14.2%	-9.4%	-14.3%	-14.3%
	Total	7.6%	-1.2%	-3.6%	-3.8%	-3.2%	-3.4%	-4.7%	10.3%	-6.7%	-5.9%	-6.0%	-5.7%	-5.8%	-5.5%	10.2%	-5.5%	-4.5%	-4.4%	-6.6%	-5.5%	-5.8%

An overall improvement can also be observed within the fixed delivery date case. Altogether there are plenty of hardship cases among the scores where performance of remaining ROP customers is clearly negatively impacted by half the customer base engaging in collaborative replenishment. It is altogether difficult to put a pattern behind such cases but it seems that larger customers seem to be disadvantaged more often in case any other customer is engaging in collaborative replenishment. This is surely the case within FW2 where the dominant customer 2 experiences shortcomings in any case customers other then itself start being replenished via CPFR. This should be mainly due to a change in ranking system once collaboration is put into place. Altogether the percentage of scores with decreased performance outcome diminishes to 25% in case of FW1, 10% in case of FW2 and 20% in case of FW3.

Three collaborative customers cases

The final step reveals the magnitude of the individual improvements for each customer that the move from pure ROP to predominantly collaborative replenishment results in. For the case that only one customer remains with traditional ROP delivery it will be especially interesting to see how performance metrics will turn out for this particular retailer.

Flexible delivery-date framework

For the case of 3 out of 4 customers engaging in CPFR global as well as individual improvements are extremely solid among frameworks 1 and 2. Here the remaining ROP customer mainly benefits from the overall improved production and delivery planning due to better demand visibility. The number of cases with diminished performance is almost zero. In

Table 7: performance scores of flexible date delivery scenarios incl. three or more CPFR customers

flexible-date delivery - 3 CPFR customers and 1 ROP

		FW 1						FW 2						FW 3					
		RRRR	CCCR	CCRC	CRCC	RCCC	CCCC	RRRR	CCCR	CCRC	CRCC	RCCC	CCCC	RRRR	CCCR	CCRC	CRCC	RCCC	CCCC
SL Gap	C1	2.5%	-2.1%	-2.0%	-2.1%	-0.8%	-2.0%	3.3%	-3.1%	-3.0%	-3.1%	0.2%	-2.8%	0.1%	0.7%	0.1%	0.2%	3.4%	0.6%
	C2	2.2%	-1.1%	-1.4%	2.2%	-1.1%	-1.3%	3.7%	-2.8%	-2.7%	0.8%	-2.8%	-2.4%	6.5%	-3.9%	-4.8%	1.8%	-3.9%	-4.0%
	C3	2.3%	-1.6%	0.3%	-1.8%	-1.6%	-1.7%	3.9%	-3.7%	-2.0%	-3.8%	-3.7%	-3.5%	8.1%	-6.4%	-2.0%	-7.0%	-6.6%	-6.6%
	C4	2.6%	-1.3%	-1.8%	-2.1%	-1.9%	-1.8%	4.1%	0.0%	-3.9%	-4.0%	-3.9%	-3.6%	0.8%	3.5%	-0.2%	0.1%	0.5%	0.4%
	Total	2.4%	-1.5%	-1.2%	-0.7%	-1.3%	-1.7%	3.7%	-2.8%	-2.8%	-1.6%	-2.3%	-2.8%	5.2%	-3.0%	-2.4%	-1.7%	-3.1%	-3.5%
perfect weeks	C1	85%	8%	9%	9%	6%	8%	77%	18%	18%	19%	13%	16%	98%	-4%	0%	0%	-5%	-3%
	C2	83%	4%	6%	1%	4%	4%	71%	15%	14%	7%	15%	13%	62%	15%	16%	12%	16%	17%
	C3	84%	7%	6%	9%	7%	8%	74%	21%	17%	22%	21%	19%	62%	19%	16%	20%	21%	19%
	C4	83%	8%	8%	8%	7%	7%	72%	17%	23%	24%	24%	21%	92%	-5%	-1%	-2%	-4%	-3%
	Total	84%	7%	7%	7%	6%	7%	74%	18%	18%	18%	18%	17%	79%	6%	8%	7%	7%	7%
delays Manuf	C1	31%	-26%	-25%	-26%	-8%	-24%	77%	-64%	-67%	-72%	-48%	-61%	40%	-23%	-34%	-35%	-15%	-26%
	C2	32%	-22%	-23%	-1%	-22%	-20%	78%	-46%	-47%	-10%	-55%	-44%	22%	-15%	-19%	0%	-15%	-15%
	C3	34%	-28%	-12%	-29%	-28%	-26%	76%	-67%	-46%	-73%	-69%	-63%	25%	-18%	-6%	-23%	-19%	-20%
	C4	32%	-16%	-27%	-28%	-26%	-25%	74%	-49%	-68%	-72%	-69%	-65%	44%	-15%	-37%	-37%	-32%	-31%
	Total	32%	-24%	-22%	-22%	-21%	-24%	76%	-57%	-57%	-59%	-61%	-58%	30%	-18%	-21%	-20%	-19%	-21%
delays retail	C1	4.7%	-3.3%	-3.0%	-3.1%	-1.6%	-3.0%	6.6%	-5.4%	-5.4%	-5.9%	-3.0%	-5.4%	1.0%	1.0%	0.0%	0.0%	1.6%	1.0%
	C2	3.7%	-1.1%	-1.7%	1.4%	-0.9%	-1.5%	7.1%	-4.6%	-5.4%	1.6%	-5.2%	-3.7%	7.7%	-5.0%	-5.6%	-1.7%	-5.3%	-5.2%
	C3	4.9%	-2.8%	-1.4%	-3.2%	-3.1%	-3.0%	8.2%	-7.3%	-5.0%	-7.5%	-7.1%	-6.8%	10.3%	-8.3%	-5.4%	-8.4%	-8.1%	-8.1%
	C4	4.6%	-2.5%	-2.6%	-3.1%	-2.9%	-2.6%	7.8%	-4.6%	-6.8%	-7.1%	-6.8%	-6.9%	1.3%	2.0%	-0.4%	0.0%	1.0%	0.7%
	Total	4.5%	-2.4%	-2.2%	-2.0%	-2.2%	-2.5%	7.4%	-5.5%	-5.7%	-4.7%	-5.6%	-5.7%	5.1%	-2.6%	-2.9%	-2.6%	-2.8%	-2.9%

case all four customers are engaged in collaboration there is not one case with non-improved outcome which is very encouraging. Nevertheless there are individual scenarios that still result in slightly degrading performance even though a high degree of collaboration is established. Framework 3 makes such shortcomings even more obvious. Apparently the two small customers C1 and C4 suffer substantially if both large customers C2 and C3 are replenished collaboratively. In particular service level gap of C4 increases from 0.8% to 4.3% in case all other three customers are engaged in CPFR. Similar outcome is recorded in case C1 is the single remaining ROP customer. Furthermore both customers have even slightly diminished performance even if they engage in collaborative replenishment together with the two large customers. This kind of outcome is most likely due to the particular distribution setup of framework 3 with two small customers being replenished every two weeks whilst the two dominant customers that account for the vast majority of demand are replenished weekly. Due to a first come first serve policy within the all ROP framework C1 and C4 accounting for only a fraction of overall demand could achieve very superior replenishment performance which is not the case anymore if the large customers get scheduled priority due to collaborative replenishment. The overall rather disappointing outcome for C1 and C4 that is apparent even in case of a full collaboration framework is thus rather a result of the unusually good performance within the default all ROP framework than a shortcoming of CPFR.

Fixed delivery-date framework

The fixed delivery date case reveals significantly improved performance on a global as well as individual level. Interestingly we can identify one particular customer among each framework that has to be most concerned about an extensive collaboration framework without its participation. Within FW1 this is customer 2 which would incur a noticeable drop in performance among all considered performance measures if all other customers apart from C2 would be involved in collaborative replenishment. A very similar situation occurs for C2 within framework 2 and C3 within framework 3.

Table 8: performance scores of fixed date delivery scenarios incl. three or more CPFR customers

fixed-date delivery - 3 CPFR customers and 1 ROP

		FW 1						FW 2						FW 3					
		FFFF	CCCF	CCFC	CFCC	FCCC	CCCC	FFFF	CCCF	CCFC	CFCC	FCCC	CCCC	FFFF	CCCF	CCFC	CFCC	FCCC	CCCC
SL Gap	C1	1.1%	-0.9%	-0.9%	-0.9%	0.6%	-0.9%	7.2%	-7.0%	-7.0%	-7.0%	-0.8%	-6.9%	5.0%	-4.7%	-4.8%	-4.8%	-1.3%	-4.1%
	C2	1.1%	-0.6%	-0.7%	1.4%	-0.6%	-0.6%	5.6%	-5.0%	-5.1%	2.9%	-4.8%	-4.8%	10.7%	-8.5%	-9.2%	-0.4%	-8.8%	-8.5%
	C3	15.7%	-15.4%	-5.0%	-15.5%	-15.4%	-15.2%	7.5%	-7.3%	-4.3%	-7.4%	-7.3%	-7.3%	5.2%	-4.1%	2.0%	-4.1%	-3.9%	-3.9%
	C4	11.8%	-2.9%	-11.6%	-11.6%	-11.4%	-11.7%	7.9%	-3.1%	-7.7%	-7.7%	-7.7%	-7.7%	11.8%	-8.0%	-11.2%	-11.0%	-11.0%	-10.8%
	Total	6.8%	-4.9%	-4.0%	-6.0%	-6.2%	-6.6%	6.6%	-5.8%	-5.7%	-2.7%	-4.7%	-6.1%	8.2%	-6.3%	-5.0%	-3.9%	-6.4%	-6.7%
perfect weeks	C1	93%	3%	3%	4%	0%	3%	69%	27%	27%	27%	12%	27%	81%	17%	16%	16%	9%	15%
	C2	92%	0%	1%	-8%	1%	-2%	71%	19%	19%	-3%	17%	16%	62%	18%	17%	8%	16%	18%
	C3	59%	36%	13%	37%	35%	35%	73%	23%	14%	24%	24%	23%	74%	11%	0%	8%	9%	9%
	C4	66%	8%	28%	29%	27%	29%	71%	11%	25%	24%	24%	23%	59%	26%	33%	33%	33%	31%
	Total	78%	12%	11%	15%	15%	16%	71%	20%	21%	18%	19%	22%	69%	18%	16%	16%	17%	18%
delays Manuf	C1	14%	-10%	-11%	-11%	-3%	-10%	28%	-20%	-22%	-25%	-2%	-15%	26%	-21%	-22%	-22%	-15%	-17%
	C2	3%	2%	0%	5%	3%	3%	49%	-22%	-27%	4%	-26%	-21%	23%	-18%	-21%	-9%	-18%	-18%
	C3	9%	-6%	4%	-7%	-6%	-5%	41%	-34%	-25%	-40%	-35%	-31%	9%	-4%	3%	-7%	-5%	-4%
	C4	31%	-21%	-29%	-30%	-28%	-29%	40%	-24%	-37%	-39%	-36%	-33%	46%	-38%	-40%	-40%	-38%	-37%
	Total	13%	-9%	-9%	-11%	-8%	-10%	40%	-25%	-28%	-27%	-25%	-25%	23%	-17%	-17%	-16%	-17%	-16%
delays retail	C1	2.1%	-0.9%	-1.3%	-1.2%	0.3%	-1.1%	11.3%	-10.6%	-10.7%	-10.7%	-4.6%	-10.0%	6.8%	-5.7%	-5.9%	-5.6%	-3.6%	-5.2%
	C2	2.0%	-0.7%	-0.9%	2.9%	-0.4%	-0.9%	11.1%	-9.5%	-9.8%	2.1%	-9.1%	-8.5%	12.0%	-9.3%	-9.8%	-4.4%	-10.2%	-9.7%
	C3	13.9%	-13.0%	-3.5%	-13.3%	-12.6%	-13.0%	10.5%	-9.7%	-6.4%	-10.0%	-10.0%	-9.5%	7.2%	-5.1%	-0.2%	-5.2%	-5.4%	-5.4%
	C4	13.4%	-4.3%	-12.6%	-12.3%	-12.4%	-12.7%	8.9%	-4.0%	-8.3%	-8.3%	-8.0%	-8.1%	15.0%	-11.0%	-14.1%	-14.1%	-14.0%	-13.7%
	Total	7.6%	-4.6%	-4.5%	-5.7%	-6.1%	-6.7%	10.3%	-8.5%	-8.8%	-6.9%	-8.0%	-9.0%	10.2%	-7.7%	-7.5%	-7.3%	-8.2%	-8.4%

4.3 Achievements overview

Hereafter we accumulated the outcome of the previous 6 tables (including 3 subtables each) to give a better representation about the impact of increased collaboration from an overall (manufacturers') point of view (first table) and from the position of individual customers (second table).

Table 9: impact on global performance scores resulting from increased collaboration

	FW1						FW2						FW3					
	flexible date			fixed date			flexible date			fixed date			flexible date			fixed date		
Number of CPFR customers	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Total improved performance	81%	100%	100%	75%	94%	100%	94%	100%	100%	100%	100%	100%	75%	81%	100%	94%	100%	100%
Total diminished performance	0%	0%	0%	6%	0%	0%	0%	0%	0%	0%	0%	0%	19%	0%	0%	0%	0%	0%

The first table demonstrates the degree of improvement of global performance metrics scores as a result of increased collaboration. We can clearly see that collaboration leads instantly to remarkable improvements since apparently at least 75% of global performance scores within each scenario significantly improve even from a single customer being engaged in collaborative replenishment. Furthermore, seen from an overall perspective, negative side-effects seem to be minimal since only 1 out of 6 scenarios reveals significantly diminished outcome for some of their performance scores. From the viewpoint of a manufacturer there should thus be no imminent threat from engaging in collaborative replenishment apart from cost and trust issues etc. as outlined before.

Table 10: impact on individual performance scores resulting from increased collaboration

	FW1								FW2								FW3							
	flexible date				fixed date				flexible date				fixed date				flexible date				fixed date			
Number of CPFR customers	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Total improved performance	30%	44%	86%	94%	33%	43%	72%	81%	38%	78%	94%	100%	53%	72%	91%	100%	31%	46%	61%	63%	56%	64%	92%	100%
- among ROP customers	6%	0%	63%	-	17%	15%	50%	-	17%	56%	75%	-	38%	44%	63%	-	15%	27%	50%	-	39%	35%	69%	-
- among CPFR customers	100%	88%	94%	94%	100%	71%	79%	81%	100%	100%	100%	100%	100%	100%	100%	100%	81%	65%	65%	63%	100%	96%	100%	100%
Total diminished performance	17%	13%	6%	0%	41%	25%	14%	12%	20%	10%	5%	0%	22%	10%	6%	0%	34%	23%	23%	25%	23%	20%	3%	0%
- among ROP customers	23%	25%	19%	-	54%	50%	44%	-	27%	21%	19%	-	29%	21%	25%	-	46%	46%	38%	-	31%	40%	13%	-
- among CPFR customers	0%	0%	0%	0%	0%	0%	4%	12%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	15%	25%	0%	0%	0%	0%

The unspoiled positive viewpoint towards initiation of collaboration is put somewhat into perspective when looking at it from the viewpoint of a customer. The second table therefore shows the accumulated scores of individual customers classified into significant improvement and diminished performance for each of the three frameworks grouped into flexible and fixed date delivery. The actual figures in the table state the percentage of the numerous individual customer scores that either improved, did not change or diminished within each of the 18 sub-tables that were presented before. Following that outline, a *total improved performance* of 30% within the 1 collaborative (CPFR) customer setting within the flexible delivery date case of framework 1 stands for 30% of overall scores (19 out of 64 scores) that were highlighted green to indicate significantly improved performance. *Total diminished performance* of 17% stands for 11 out of 64 scores being highlighted red to indicate a decline in performance. Looking at the *total improved performance* we can see that there is a clear uptrend with an increasing percentage of improved outcome for each additional customer joining collaborative replenishment. More interesting than the overall percentage is the fraction of ROP customers that actually improved their performance due to others joining CPFR. Looking at both figures we see that for each framework there is a distinct point within the widening collaboration framework from which on there is a significant stage of improvement. These points can be either after 1 customer joins CPFR, 2 or 3. These improvement points of each framework are highlighted green. We can thus see that each scenario seems to have a distinct point of most significant improvement as in two cases the most substantial step is achieved with just 1 CPFR customer, in 1 case it's the second step and in 3 cases the step from 2 to 3 customers being engaged in collaboration. This should be an interesting insight to reveal the most recommendable stage or minimum necessary scope of collaboration for each framework to reach the point of significant performance impact and the level of collaboration necessary to largely diminish possible negative side-effects for non-collaborating customers. The third stated row of numbers point out the level of significant improvement among CPFR customers. As we can see this figure is always high which does not come as a surprise and shows us that whoever is engaged in CPFR commonly achieves direct benefits as a result. However, it appears that the success ratio among early adopters (first customers to engage in CPFR) is in many cases higher compared to late adopters which should promote a certain pioneer attitude. This supposition is also supported by the fact that in more than half of the investigated cases the first collaborating customer does never again reach the initial degree of improvement once additional customers enter the collaboration framework. The *total diminished performance* row shows a continuous reduction of scores indicating negative outcome as the scope of collaboration widens. This goes along with the increase of overall improved performance and is another indicator of the positive effects of increased demand transparency. In contrast to the improved performance among remaining ROP customers that increases with a widening collaboration framework as was mentioned before, the percentage of diminished performance scores does not seem to reduce significantly as collaboration intensifies. Thus a non-collaborating customer is just as likely to experience a drop in performance independent of how many other customers are already involved in collaboration. Thus we can conclude that the chances of a remaining ROP customer to substantially improve performance increase as the degree of collaboration widens, whilst the threat of performance decline persists on a steady level even if all other customers are engaged in collaboration. The final row of the table indicates the possible threat of a CPFR customer to achieve an inferior outcome as a result of engaging in collaboration. We can see from the results this fear seems rather unjustified.

5 Conclusions

In addition to prior studies (Lee et al., 2000 ; Waller et al., 1999 ; Småros et al., 2003) this paper has put major focus on the developments within heterogeneous replenishment environments to reveal possible advantages and drawbacks within the introduction process of a collaborative replenishment system with a varying number of customers. This, we believe, is particularly necessary to focus attention on since most of the research in this field is driven by major market players studying mainly the possible advantages from their point of view which is certainly different from a small or medium sized company. Moreover, enquiries about heterogeneous environments should certainly be of use to market leaders as well considering the trend to more selective CPFR agreements instead of broad multilateral involvement as suggested by Moberg et al. (2003). The above study further extends previous approaches in focusing attention on performance impacts for each individual market participant, particularly on non-participants of collaboration initiatives which has not been considered before. Moreover, many previous analyses tended to use rather artificial demand situations and very approximate data. The actual scenario is based on real sales, production and distribution data within three distinct supply chain frameworks. Using that data running over a three years timeframe and implementing further market intelligence obtained surely adds additional validity to the simulation model and hence makes drawing reliable conclusions more likely. Going furthermore beyond previous approaches as Småros et al. (2003) suggested, a CPFR joint forecasting system was implemented in the simulation to take advantage of available seasonal factor and promotional activity data as well as actual point of sale demand information on a weekly basis. Hence to generate a global forecast that is used by the manufacturer and the retail echelon for production scheduling and replenishment strategies once a collaboration agreement is established. Contrary to previous approaches the main focus of performance comparison was on delivery fulfilment capabilities and service level gaps at store level. This was due to the particular conditions and preferences of the participating companies and the available data. This however gives a supplementary view on supply chain efficiency achievements due to increased demand visibility apart from reduced inventory levels, fill rates and production smoothing as a result of reduced bullwhip-effects which is the main focus of attention most previous studies.
Altogether the investigation presented the outcome of a wide variety of possible replenishment settings between suppliers and various customers. We could see that a widening scope of collaboration clearly reveals benefits for the customers being involved as well as for remaining non-collaborating ones. However, considering the fact that most collaboration agreements go along with a necessary prioritization of the involved customers, there are many cases where remaining ROP customers experience shortcomings as a result of a developing collaborative framework which they are not participating in. As we saw from the table above, in between 23% to 54% of key performance indicator scores of non-collaborating customers somewhat diminish right after the first client is engaged in collaborative

replenishment. This figure remains on a similar level even if additional customers join the collaboration initiative. A possible solution to this might be changing delivery prioritization policies towards a more balancing approach as has been proposed within a previous paper (Thron et al. 2005). This nevertheless often fails to be acceptable in practice. Altogether the investigation makes it thus obvious that there are winners and losers within an increasing collaboration framework. Comparing the gains from each customer after being the first to engage in collaborative replenishment with the achievements from the all CPFR scenarios it becomes apparent that the initial improvements at least match and often even surpass the results from an all CPFR case. Hence a customer can gain significantly from being the first and maybe sole CPFR customer instead of being one amongst others. Such findings could support a strategy among customers to be the first and only collaboration partner of a manufacturer. From the perspective of a manufacturer this would nevertheless be rather unwanted since a full collaboration framework should reveal the most benefits. However, as we saw from the simulation outcome stated in the tables above, within many cases engaging only the largest 1 or 2 customers often reveals global achievements fairly close to a full CPFR implementation case. Any additional, often minor performance improvement would thus have to be measured against substantial implementation and maintenance efforts due to further collaboration agreements with less significant customers which might not be worthwhile implementing. From another perspective, a large retail company could urge a supplier not to engage further customers in collaboration since its own performance might slightly drop and its competitors would be advantaged. Within other cases such as framework 3 it might be the small customers that due to their special circumstances should discourage any collaborative progress since it would bring them no benefits or could make them being worse off altogether. Overall the results of the investigation give very interesting insights into a developing collaborative framework and should be of high value to any decision maker of any involved supplier or customer. The outcome of an in-depth investigation could surely influence the attitude towards collaboration among all involved supply chain parties and detailed knowledge can prove to reveal a significant strategic and tactical advantage in the process of defining a supply chain collaboration framework in one’s own favour.

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