

Efficient store replenishment through Internet-based information-sharing and collaborative supply-chain practices

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Abstract

The advent of e-business has enabled the emergence of new and advanced forms of information sharing and collaboration, creating several challenges and opportunities in the supply chain environment. In this paper, which is an overview of my Phd Thesis, a collaborative store replenishment practice supported by an Internet-based platform is examined. By enabling information and knowledge sharing between retail store managers and suppliers' salesmen, this practice leads to increased order accuracy and, as a result, to fewer out-of-stock situations. The research presented has been empirical in nature, involving a field experiment with a major retailer and several suppliers in Greece. The empirical results from the field experiment show a reduction in out-of-stock situations by more than 50 percent, which has important implications for practitioners, as low shelf availability and the respective sales loss is one of the major issues retailers and suppliers face today. Qualitative findings regarding the practical aspects of the process and the role of the technology, as well as organizational issues are also acquired.

Collaboration in the supply chain

The advent of e-business has created several challenges and opportunities in the supply chain environment. The Internet has made it easier to share information among supply chain partners and the current trend is to try to leverage the benefits obtained through information sharing (also called visibility) across the supply chain to improve operational performance, customer service, and solution development (Swaminathan and Tayur, 2003).

Since the early 1990s, there has been a growing understanding that supply chain management should be built around the integration of trading partners (Barratt and Oliveira, 2001). Bowersox et al. (2000) state that firms collaborate in the sense of "leveraging benefits to achieve common goals". Anthony (2000) suggests that supply chain collaboration occurs when "two or more companies share the responsibility of exchanging common

planning, management, execution, and performance measurement information". Anderson and Lee (1999) state that industry participants "collaborate on planning and execution" of supply chain strategy to achieve a "synchronised supply chain".

In retailing, supply-chain collaboration has taken the form of practices such as Continuous Replenishment Program (CRP), Vendor Managed Inventory (VMI) and Collaborative Planning, Forecasting and Replenishment (CPFR). VMI is a technique developed in the mid 1980s, whereby the manufacturer (supplier) has the sole responsibility for managing the customer's inventory policy, including the replenishment process, based on the variation of stock level in the customer's main warehouse or distribution centre (Cooke, 1998). VMI is probably the first trust-based business link between suppliers and customers (Barratt and Oliveira, 2001). CRP moves one step ahead of VMI and reveals demand from the retailers' stores. The inventory policy is then based on the sales forecast, built from historical demand data and no longer purely based on the variations of inventory levels at the customers' main stock-holding facility (Andraski, 1994).

Collaborative Planning, Forecasting and Replenishment (CPFR) can be seen as an evolution from VMI and CRP, addressing not only replenishment but also joint demand forecasting and promotions planning, focusing on promotions and special-line items. CPFR is based on extended information sharing between retailer and supplier, including point-of-sales (POS) data, forecasts and promotion plans.

Based on these short descriptions, VMI and CRP are more about efficient replenishment and supply, whereas CPFR puts more emphasis on the demand side. What makes the distinction in the evolution path followed by these collaboration practices is the amount of information exchanged between the trading partners and the process(es) enabled by this information sharing. In this paper we describe a new supply-chain collaboration practice, what we call Process of Collaborative Store Ordering (PCSO), which requires extensive information

sharing and daily interaction between supply chain partners enabled by the web and Internet technology.

In the following section we discuss the technology infrastructure that has enabled collaborative practices up-to-now and what are the current trends in this area. In section three we describe the process of collaborative store ordering, while in section four we present both quantitative and qualitative results and practical implications from a large-scale field experiment. We conclude in section five with remarks and suggestions for further research in this area.

IT enabled collaboration between trading partners

Efficient information and data exchange is the most essential requirement for implementing the collaborative practices referred to above. In the traditional ordering process, retailers provided manufacturers with only data on quantities of goods required once a week (through ordering). VMI/CRP and CPFR dramatically increase the total volume of information transmitted between retailers and suppliers. Table 1 summarises the evolution in increased information exchange from pure ordering to CPFR and the underlying technology supporting the exchange of information and collaboration between the trading partners.

	Traditional ordering process	Supply-Chain Collaboration Practice	
		VMI/CRP	CPFR
Information Exchanged	<ul style="list-style-type: none"> Orders Dispatch advices 	<ul style="list-style-type: none"> Orders Suggestive orders Inventory report (including store demand and warehouse shipments in CRP) 	<ul style="list-style-type: none"> Orders Inventory reports Aggregated POS data Sales forecasts Promotion plans
Technology supporting information exchange	<ul style="list-style-type: none"> Paper EDI EDI over Internet (lately) 	<ul style="list-style-type: none"> EDI (mainly) EDI over Internet (lately) 	<ul style="list-style-type: none"> XML/ASCII files over Internet
Technology supporting collaboration	<ul style="list-style-type: none"> Internal ERP systems 	<ul style="list-style-type: none"> Internal specialized application (mainly) Collaborative platform – retail exchange (lately) 	<ul style="list-style-type: none"> Collaborative platform – retail exchange

Table 1. Information exchange and underlying technology from traditional ordering to CPFR

As we move from VMI/CRP to more advanced forms of collaboration, such as CPFR, the amount of exchanged information increases and so do the requirements towards the underlying technology infrastructure.

Electronic data interchange (EDI) has been a key enabling technology for efficient replenishment and supply chain coordination (Hill and Scudder, 2002). Without EDI, CRP wouldn't have been economically viable, as the amount of daily information processed and transmitted in the channel is too large to handle manually. Information technology is a necessary condition for the CRP innovation, thus serving as an enabler for this new form of interorganisational relationships and joint channel process redesign (Lee et al., 2003).

However, EDI is also expensive and too complicated compared to the alternatives that have emerged lately for secure and reliable communication over the Internet and for information exchange in XML format (Stefansson, 2002). Furthermore, EDI confines the exchanged information to certain types, as defined by the respective standard EDI messages (e.g. Inventory Report (INVRPT) message supporting CRP), whereas new forms of supply-chain collaboration require many more types of information to be exchanged between the trading partners and these types may vary significantly in different occasions.

In order to cope with this increasing need for extended information exchange, the retail sector has started moving away from EDI to new ways of information exchange, mainly enabled by Internet-based communication platforms and retail exchanges (Sparks and Wagner, 2003), also referred to as electronic marketplaces (e-marketplaces). Such exchanges are characterised by the retailers' direct access to distributors and suppliers, enabling businesses to interact via a neutral intermediary (the exchange) to conduct either one-to-one or multiple transactions. Thus, suppliers gain access to more buyers, and buyers can contact many suppliers. Such exchanges also hold out the hope of a more efficient supply system, through better and more rapid communications facilitating improvements in planning, deployment of transport fleets, warehouse management and procurement procedures (WWRE, 2000). Although these could provide members with cost and service benefits in line with their global ambitions, they

might also change the nature of some business relationships (Sparks and Wagner, 2003).

However, the third-party operated e-marketplace is not the only option for operating an Internet-based collaboration platform. Sparks and Wagner (2003) report that suppliers are wary of further involvement in e-marketplaces. Disillusioned by pricing and other concessions, they are still waiting to see the promised volume and liquidity levels. On the other hand, they see the emergence of private exchanges, namely invitation only networks that connect a single company to its customers, suppliers or both. A few retailers e.g. Wal-Mart, have had the will and the finance to create priority supply chain information systems and the power to force suppliers to adopt them. Sainsbury is also working on software solutions to build collaborative applications into its private exchange (Grocer, 2002).

Eng (2003) further identifies two main barriers to implementing strategic collaborative supply chain processes:

- (1) technical uncertainty on reliability of e-marketplaces in that migration from EDI to an e-marketplace system requires technical support and integration of various supply chain activities in a company; and
- (2) sharing of strategic information with other participant organisations is not a common practice. This hinders the extent of the types of collaborative and strategic supply-chain management activities that can be carried out in the e-marketplace.

In the following discussion we touch upon these issues, as we describe a strategic collaborative supply chain process enabled by an Internet-based platform.

Collaborative store ordering: An improved replenishment practice

A typical grocery retail store (supermarket) has more than 10.000 products in its assortment. Deciding what to order every day at the store level is, naturally, a daunting task. Currently, the store ordering and replenishment process is a combination of direct-store-delivery (DSD), where the respective product suppliers are those preparing the order and delivering their products directly to the store, and centralized-delivery, where the responsible store personnel prepare and send the order to a central warehouse, which in turn delivers the products of several suppliers to the store. Various IT systems have been traditionally supporting these processes.

Ogawa (2002) distinguishes between three different types of systems used to support store ordering to the central warehouse. These range from simple replenishment-ordering systems, merely supporting the typing or hand-scanning and electronic transmission of the order, to automated-ordering and hypothesis-testing ordering systems, relying on decision support tools using sales data and other information in order to prepare the order, which is either automatically sent or first proposed to and confirmed by a user.

In the case of direct-store-deliveries, supplier salesmen may use hand-held devices (e.g. PDA's) to type-in the order and send it electronically over mobile networks while still being in the field. This type of system doesn't provide any decision support, but in some cases past order data may be used to facilitate the order decision making.

The employment of such systems by both retailers and suppliers in the store ordering process had an indisputable positive effect on process efficiency, but has not been proved sufficient to address the out-of-shelf problem, as reported in several studies (Gruen et al., 2002; Roland Berger, 2003). A reason for this can probably be sought in the difficulty to correctly estimate consumer demand in such a complex environment and the limited information that is available to either retailers or suppliers when working independently to prepare a store replenishment order. In their attempt to address the problem, retailers and suppliers have clearly turned, during the last decade, towards collaborative replenishment practices, such as CRP/VMI and CPFR.

Combining the characteristics of conventional store ordering systems with information-sharing and collaboration capabilities and applying the notions of CRP/VMI and CPFR at daily store level define new collaborative store ordering processes. The following description illustrates how a web-platform can be used to support collaborative store ordering for both DSD and central warehouse ordering. The central web platform is updated daily with store-level information, including point-of-sales (POS) data, delivery quantities, product assortment, promotion activities, new product codes etc. Most of these data come from the retailer's central information system (e.g. product assortment, product catalogues) and directly or indirectly from the store information system (e.g. POS data), but some information may also come from the central warehouse or the suppliers' information systems. Based on this information, the system running on the central web platform prepares respective order proposals per individual store. For centralized

deliveries, the store personnel review the respective order proposal and, upon confirmation, the order is sent to the retailer's central warehouse. For direct-store-delivery, the supplier salesman first reviews the system's order proposal, which is then sent to the store for final confirmation and then to the supplier for execution. Both the stores and the suppliers' salesmen access the system through the web. This is schematically depicted in Figure 1.

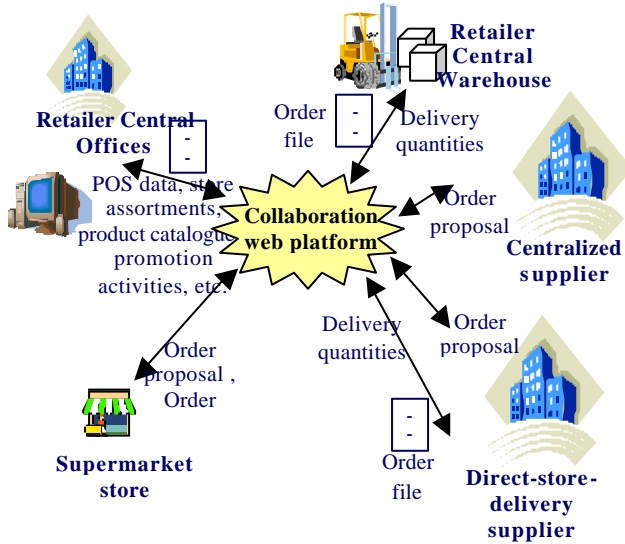


Figure 1. Collaborative store ordering through a web platform

Through the collaboration platform, both parties have access to enriched information concerning the ordering process, which can be jointly evaluated in preparing an order. Table II summarizes the pieces of information available to the store manager and the supplier's salesman. What is apparent from Table II is that with the process of collaborative store ordering, the required pieces of information are jointly evaluated to a great extent by both the supplier salesman and the store manager, whereas without PCSO each piece of information is evaluated separately by either the store manager or the supplier's salesman or may not be accurate or available at all.

Type of information	Centralized		DSD	
	Without PCSO	With PCSO	Without PCSO	With PCSO
Product sales during the last replenishment cycle	R(d)?	R(d) S(d)	S(d)?	R(d) S(d)
Replenishment cycle start date	-	R(d) S(d)	S(d)?	R(d) S(d)
Date of last sale	-	R(d) S(d)	-	R(d) S(d)
Minimum-order-quantity (MOQ)	R(d)	R(d) S(d)	S(d)	R(d) S(d)
Store assortment	R(d)	R(d) S(d)	R(d) S(r)?	R(d) S(d)

Average weekly sales	R(d)	R(d) S(d)	-	R(d) S(d)
Product stock in the store	R(d)?(m)	R(d)?(m) S(d)?	S(m)	R(d)?(m) S(d)?(m)
New product	R(r)?	R(d) S(d)	S(i)	R(d) S(d)
Promotional product	R(r)?	R(d) S(d)	S(i)	R(d) S(d)
In-store promotion	R(r)	R(d) S(d)	R(r) S(r)?	R(d) S(d)
Non-delivered item or back-order	R(r)?	R(d) S(d)	S(d)?	R(d) S(d)
Replacement product	-	S(i)	S(i)	S(i)
Product marketing plan	-	S(i)	S(i)	S(i)
Product competition	-	S(i)	S(i)	S(i)
Store consumer profile	R(i)	R(i)	R(i)	R(i)
Store competition	R(i)	R(i)	R(i)	R(i)
Shelf-space capacity	R(m)	R(m)	R(m) S(m)	R(m) S(m)

R: the respective type of information is available to and evaluated by the retail store manager
S: the respective type of information is available to and evaluated by the supplier salesman
(d): the respective type of information is provided in digital format through an ordering system
(r): the respective type of information is provided as a report, usually in hard-copy
(i): the respective type of information is unstructured, based on intuition and knowledge of the user
(m): the respective type of information is collected through a manual process, e.g. shelf check, counting etc.
?: the respective information may not be accurate or may not be available in all cases

Table II. Availability of information required in store ordering with and without PCSO

Collecting as much of this information as possible on a single computer screen or order-proposal report can further facilitate the order-decision-making process, instead of requiring the user to separately evaluate each single piece of information (e.g. by consulting a new product's report or a promotions report, or by physical store checking etc.). Figure 2 presents how the collaboration platform presents all the information available in digital format on a single screen to both retail store manager and supplier salesman in order to support the order-decision-making process.

The screenshot shows a table of product orders with columns for product name, quantity, price, and date. Callouts highlight specific features: 'Suggestive Order' points to a product entry; 'Point-of-sales (POS) data' points to a date field; 'Stock' points to a quantity field; 'Dates of last order and last sale' points to a date field; and 'Flags indicating exceptions: e.g. new products, store promotion, promo-code, out-of-stock ...' points to a small icon in the left margin.

Κατηγορία	Περιγραφή	Μονάδα	Ποσότητα	Τιμή	Ημερομηνία	Επισημείωση
Κατηγορία: ΖΑΧΑΡΩΔΗ	ΕΡΜΗΕ ΑΝΤΑΚΚΟ ΚΡΕΜΟ ΣΑΠ. CLAS 3IC 180300ML	18	18			
Κατηγορία: ΜΠΑΤΑΡΙΕΣ-ΦΑΚΟΙ	CEET DUR. PLUS 842MIN 1500AA1, 5V20TK(+26CF)	300	300	290	29/11/2002-7/1/2003	12
Κατηγορία: ΚΑΡΑΜΕΛΕΣ-ΤΕΥΧΑΕΣ	FERRERO KAPAME TIC-TAC MENTA 11224 T	85	80	91	21/11/2002-7/1/2003	28
	FERRERO KAPAME TIC-TAC ΠΟΡΤΟΚ. 12024 T	85	96	151	22/11/2002-7/1/2003	32
	V6 TENDRA ARCTIC BREEZE 15D/B02420	24	24	97	29/11/2002-7/1/2003	23
	V6 TENDRA FRESHMINT/ΣΕΒΕΤΙΟ 20D/B02420	48	48	175	29/11/2002-7/1/2003	17
	V6 TENDRA JUN. 4P40 YA/ΣΕΒΕΤΙΟ 20D/B02420	24	24	149	22/11/2002-7/1/2003	25
	V6 TENDRA SPEARMINT/ΣΕΒΕΤΙΟ 20D/B02420	48	48	204	29/11/2002-7/1/2003	10
	V6 TENDRA SWEET CHERRY 20D/B02420	24	24	72		
		48	48	181		
Κατηγορία: ΔΡΑΚΟΝΙΔΙΑ	DOB N08 24X200	48	48	12	29/11/2002-8/12/2002	47
	STIVE 20X400TP	40	40	2	29/11/2002-28/11/2002	21
	STIVE 24X250TP	48	48	1	29/11/2002-28/11/2002	5
	DESTIVE 24X200	0	48	20	29/11/2002-12/12/2002	6

Figure 2. Order proposal screen in PCSO

PCSO can be used both for products delivered to the store directly by the supplier and for products delivered via the central warehouse, providing store personnel with a common user interface. The store personnel can use the system for centralized ordering, even if the supplier is not involved in the ordering process, but in this way the benefit of the expert knowledge and extra attention paid by the supplier salesman is lost. On the other hand, this allows for the gradual adoption of this collaboration process by the suppliers without disturbing the retailer's internal operations.

On the suppliers' side, PCSO enables a supplier to get involved in the ordering process of centralized products and gain access to store-level information that was out-of-reach before. It thus gives the possibility to separate the physical distribution of products from the ordering process, combining the logistics benefits of centralized deliveries with the merchandising and order-accuracy benefits of direct-store-deliveries.

Pilot Results and Practical Implications

The objective of conducting a field experiment for testing PCSO in practice was to measure the impact of this new practice on order accuracy and ultimately shelf availability, in respect to both DSD and centralized deliveries. In addition, a pilot test was necessary for both retailers and suppliers to understand the practical implications of this process and identify any process difficulties or barriers that were not apparent upfront. Implementing PCSO through an Internet-based collaboration platform was also quite a technical challenge back in 2001, when the first field experiment was conducted, as there were not ready-made solutions to support the online store-level collaboration and sharing of big

amounts of data on a daily basis and in a many-to-many environment. The pilot could thus help identify any drawbacks or difficulties associated with the technical and system usage aspects as well.

The case setting for the field experiment was provided by the Greek grocery retail environment, where the third biggest grocery retailer in Greece and initially three of its top suppliers (one direct-store-delivery supplier and two centralized suppliers) together with a service provider started a pilot implementation to experiment with collaborative store ordering. The field experiment went live on October 1st, 2001, and ran initially for six weeks in five (5) stores (pilot stores) that were representative of all the stores in the retail chain. During the experiment, the five stores used the Internet-based platform for their collaboration with the direct-store-delivery supplier and for ordering the products of the two centralized suppliers to the retailer's central warehouse, involving around 600 products in total. For the rest of the products they followed the traditional process.

After the initial field experiment, the retailer extended the system to support the full ordering to the central warehouse, irrespectively of suppliers' participation. Other suppliers gradually joined in and field tests were repeated in 2002 and 2005, while some suppliers stopped after the first experiment.

Measuring the Impact on Shelf Availability and Inventory Levels

The impact of PCSO on shelf availability and inventory levels was assessed by pre- and post measurements. Currently, a physical shelf check is probably the only way to measure shelf availability, as the technology is not in place yet to enable other ways of measurement. Thus, physical shelf checks were used to measure both shelf availability and the reasons behind out-of-shelf. Shelf checks were performed once per day at random times on a representative set of 120 products of the three suppliers taking part in the experiment. These 120 products belonged in about 20 categories of dry grocery goods not influenced by seasonal patterns, including home and cloth detergents, shampoos, breakfast cereals, batteries, etc. and were selected so as to represent the whole spectrum from slower-moving items to faster-moving items. During a physical shelf check, the researcher was inspecting the shelf position of each specific product to see if the product was on shelf or not. In case the product was not found on the shelf, the researcher was investigating the underlying reason, e.g. by checking the product's back-room inventory, the previous order etc. The causes behind out-of-shelf

that interested us in this case were the ones relating to wrong ordering, i.e. either the product was ordered in wrong quantity (“wrong order”) or the product was not ordered at all (“no order”). The respective variables, x_1 and x_2 , used in the out-of-shelf measurements are defined in Table III below.

Variable	Description	Values
$x_1 =$ Total OOS	Describes if there is an out-of-shelf situation for a specific product, in a specific store, on a specific date, the time of observation	$x_1 = 1$: there is an out-of-shelf situation $x_1 = 0$: there isn't an out-of-shelf situation
$x_2 =$ OOS caused by wrong/ no order	Describes if there is an out-of-shelf situation for a specific product, in a specific store, on a specific date, the time of observation, which has been caused by the fact that the product was not ordered in the right quantity or was not ordered at all during the last replenishment cycle	$x_2 = 1$: there is an out-of-shelf situation caused by wrong/no order; if $x_2 = 1$ then $x_1 = 1$ $x_2 = 0$: there isn't an out-of-shelf situation caused by wrong/no order (although there may exist an OOS attributed to some other reason); if $x_1 = 0$ then $x_2 = 0$
$x_3 =$ Level of stock (Control variable)	Describes the amount of product (in consumer units) that exists for a specific product in a specific store, both on shelf and in the back-room, the time of observation	If $x_3 > 0$ then $x_2 = 0$ If $x_3 = 0$ then $x_1 = 1$

Table III. Variables used in the shelf availability measurements

Wong (2006) defines a different measure for shelf availability taking into account not only the situations where shelf stock equals zero, but also the amount of products available on the shelf. However, this measure cannot be tracked with the current information infrastructure available in the stores. Thus, in all similar studies, out-of shelf is measured through spot physical checks, as defined above.

Spot measurements do not capture the duration of OOS and thus the derived measurement is an approximation of the actual level of out-of-shelf in the store. Another inadequacy has to do with the fact that the subjects taking part in the experiment (in our case, the order decision makers in the stores) take notice of the fact there is a measurement and this influences their behavior, referred to as the Hawthorne effect (Heylighen, 2003). In order to cope with the Hawthorne effect, the physical store checks were performed for two consecutive weeks at each stage (before and at the end of the experiment) and the comparison took place between the second week of measurements, so that the impact of the Hawthorne effect was comparable.

In order to check whether any changes in the shelf availability were ought to an increase in store inventory we also measured the store inventory as a control variable before, during and at the end of the experiment, for the same sample of products (see variable x_3 in Table 3). Stock levels were determined through a physical stock count, because stock information was not maintained correctly in the specific stores' information system. Stock counts took place once per week, on Saturday evenings (after the closing of the store). Obviously, these measurements were not enough to systematically monitor the inventory levels. However, they provided some indication on how the total inventory of the measured products varied on average after the busiest day of the week, throughout the pilot testing. In addition, while ‘inventory turns’ is usually the variable used to check if the level of inventory kept in the store is optimum (Chopra and Meindl, 2001), as it associates the level of inventory to the product sales, for the purposes of our research it was sufficient to just consider the stock level, as defined in Table 3, since what we wanted to monitor was whether a reduction in the out-of-shelf situations occurred as a result of increased inventory levels.

Based on the findings of shelf availability measurements before the pilot start, in September 2001, the overall level of OOS was 9,8% for centralized products and 12% for DSD products. More than 70 percent of the OOS for the products of the two centralized suppliers were attributed to two main reasons: wrong order quantity, i.e. the quantity ordered was not enough to fulfill consumer demand till the next replenishment cycle, and no-order at all, i.e. the product had not been ordered at the last replenishment cycle although it did not exist in the store. The distribution of OOS causes for the products of the direct-store-delivery supplier was similar, with again more than 70 percent of the OOS attributed to ‘wrong order quantity’ and ‘no order’. This is mathematically expressed as:

$$\sum_{i=1}^n x_{2i} / \sum_{i=1}^n x_{1i} > 70\%$$
At the end of the pilot, the total level of OOS for the products of the direct-store-delivery (DSD) supplier who was using PCSO in collaboration with the retailer for the ordering in the five pilot stores had been reduced from 12 percent to 4 percent, a 67 percent reduction, whereas the level of OOS caused by wrong/no order had been reduced by 72 percent (see Figure 3).

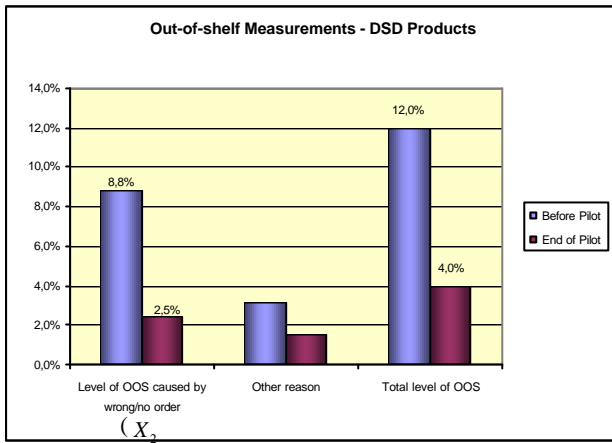


Figure 3. Comparing the OOS rate for DSD products before and at the end of the pilot

For the centralized products of the two suppliers, a reduction of 59 percent, from 9.8 percent to 4 percent, in the ‘Total level of OOS’ and a similar (66 percent) reduction in the ‘Level of OOS caused by wrong/no order’ before the pilot and at the end of the pilot is observed (see Figure 4).

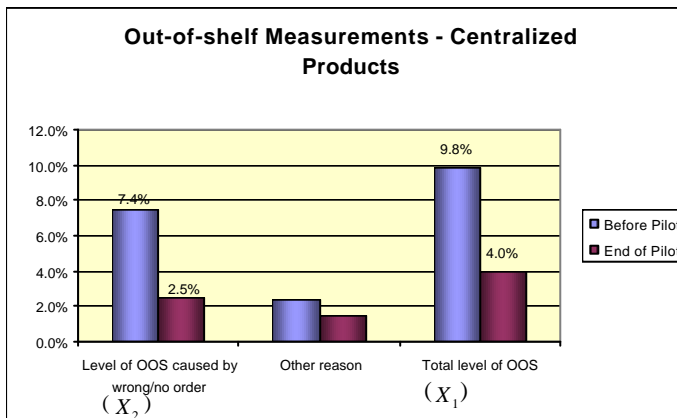


Figure 4. Comparing the OOS rate for centralized products before and at the end of the pilot

Using the nonparametric Mann-Whitney statistical test, which is appropriate for pair-wise comparisons between two groups for ordinal variables that have the same distribution in both groups and where normality cannot be assumed (Webster 1998), it appears that the difference is significant both regarding the ‘Total OOS’ (x_1 variable) and the ‘OOS caused by wrong/no order’ (x_2 variable) when comparing the situation before the start of the field experiment (before the pilot) and at the end of the experiment (end of pilot) for the DSD and the centralized products.

For the same period, Figure 5 presents the total level of store inventory for the selected products of the two centralized suppliers and the DSD supplier based on the physical stock counts for the four consecutive stock measurements.

The results of the nonparametric Kruskal-Wallis statistical test, which is used in this case for simultaneous comparison of the stock variable among all the groups (Webster, 1998), show no significant difference among the four stock-count measurements performed for DSD and centralized products respectively, indicating that the reduction in the out-of-shelf situations was not related to any increase in the total level of store inventory.

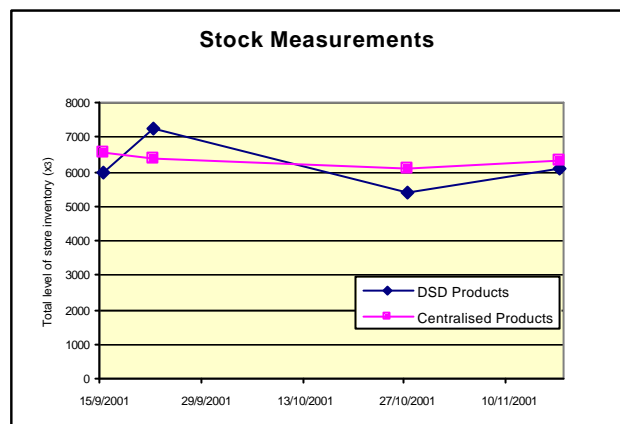


Figure 5. Total level of store inventory before and during the pilot

In September 2002, the same weeks a year later, the shelf availability measurements were repeated, but this time only for the DSD supplier and in three of the initial five pilot stores. At this time, the process of collaborative store ordering between the retailer and the DSD supplier had been used for eleven months continuously. The total level of OOS for the products of the DSD supplier in these three stores had been reduced from 15.4 percent to 7.5 percent, a reduction of 51 percent. At the same time, the level of OOS caused by wrong/no order had been reduced by 94 percent, from 11 percent in 2001 to 0.7 percent in 2002. Based on the Mann-Whitney statistical test, the difference is significant only in regard to the ‘OOS due to wrong/ no order’ variable, which is what interests us in this case.

Attempting an interpretation of the above findings, we could say that while for some products the order quantities and respective inventory might had increased, in order to fulfill previously unsatisfied demand, for slower-moving items this was reduced, thus leaving the store upon closing with the same level of total inventory as before.

A weakness of the experiment relating to the use of PCSO is that we cannot distinguish to what extent this effect was caused by the introduction of the new system in the store ordering process and to what extent it is attributed to the supplier-retailer collaboration in this context. In addition, we cannot say whether the distribution of causes is the same for DSD products and centralized products, given the different processes used for ordering them. Another limitation of the experiment, relating to the use of the system, is that we cannot say whether some specific pieces of information that were not readily available before or other system characteristics have played an important role, more than others, in achieving this result.

In 2005 another PCSO field experiment was conducted, with the same retailer but this time with another supplier, delivering products to the stores both directly (mainly cosmetics categories, which are characterized by high complexity and specialization) and through the central warehouse (the rest of the product categories, such as shampoos and toothpaste). The pilot involved five stores located in the Attica region and all the products of the supplier, both DSD and centralized. While pre- and post pilot measurements regarding shelf availability were not conducted, as described above, the supplier reported a 64% sales increase in the pilot stores, compared to a 6% increase in the rest of the retailer stores in Attica and to a 3% increase in the total retailer stores (ECR Europe, 2005).

The above results from the field experiments are obviously not enough to fully justify the impact of PCSO on shelf availability. However, they give a positive hint towards this direction, suggesting that it's worth further examining and testing this new practice. Another dimension of the concept worth looking at in more detail is the organizational transformations associated with the new process as well as the various technical and coordination challenges, as shortly described below.

Qualitative Research Findings

In this section we present some qualitative findings regarding the challenges of implementation as well as retailers' and suppliers' attitude and incentives in respect to PCSO. These findings are based on the feedback collected from the initial pilot users, through both structured questionnaires and informal interviews, but also through close monitoring of the PCSO practice for a number of years as well as through interviews with a number of other suppliers and retailers not involved in the experiments.

Despite the positive quantitative business results associated with the process of collaborative store ordering, there were several barriers and challenges of implementation. These include both technical challenges as well as organizational and coordination challenges, summarized as following:

Technical challenges:

- Data-integrity and synchronization issues, as this process is heavily dependent on information coming from many different sources. Several data-integrity and validation checks had to be implemented for the operation to work smoothly.
- Quality of the automated inter-organisational system links, as initially these relied on point-to-point FTP links between retailers' and suppliers' systems and the web platform. Issues were resolved by employing the web-services technology to support them in combination with several failure-control mechanisms.
- Web user-interface combined with slow Internet connections. The web interface had to be redesigned several times for making it user friendly and efficient for a store employee to review an order proposal of over 500 products a time using a dial-up Internet connection. Printing-out the order proposal and minimizing the interaction with the web-site are actions that have contributed to overcoming this issue.
- Scalability of the centralised software architecture. When all the 160 stores of the retailer went online, the initial web platform experienced serious delays and scalability issues. The platform had to be totally redesigned in order to cope with such large numbers of stores and information volumes (million of records on a daily basis, including POS data from all the stores, product assortments from all the stores etc.)
- Controlling the various points of system failure, ranging from Internet connectivity issues in the stores to back-end integration and file-transfer issues between the central platform and the various information systems, to hardware printer failures in the stores etc. Several control mechanisms and thorough testing, involving pilot testing before broader phased roll-out, were employed to address this issue.

Organizational challenges:

- User involvement challenges: Make the actual users in the stores like the system and feel positively about the new process change was one of the major challenges. In addition, learning users to use the system correctly and exploit the

available information for making informed decisions was another challenge on its own.

- Technology/ business alignment and business process redesign: An initial attempt to use a pre-defined e-business platform to support the process of collaborative store ordering resulted in a total failure, mainly due to the misalignment between new and existing business processes. Only after both the internal business processes were carefully redesigned and the web platform was better aligned to the internal processes was the system accepted by the organization.

Multi-party co-ordination challenges:

- The challenges of the Application Service Provider (ASP) model: Supporting collaborative store ordering through an ASP intermediary, instead of each retailer building its own collaboration platform, represents significant economies of scale and efficient communications in a many-to-many environment, especially in as fragmented a market as the Greek grocery retail environment. However, this requires that all the major retailers and suppliers use the intermediate collaboration platform, which is not yet the case. Furthermore, utilizing an ASP in this case has similar advantages and disadvantages to more traditional IT outsourcing (Kern et al., 2002).
- Supplier-retailer coordination challenges: While the suppliers initially appeared enthusiastic about collaborative store ordering and the possibility to have direct access to daily POS data and store-level information, several barriers soon had a slow-down effect on their decision to exploit this new opportunity. These related to technology, organisational, and collaboration barriers, as also reported by Hsiao (2003).

Overall, comparing the approach of direct-store-delivery suppliers against the attitude presented by centralized suppliers, we see that direct-store-delivery suppliers have shown stronger incentives for adopting PCSO. This could be explained by the fact that for direct-store-delivery suppliers, PCSO separates the order-taking process from the rest of the tasks performed during a physical store visit (e.g. inform store managers about new products, checking of the shelves, etc.). This fact gives a salesman the possibility to dynamically schedule the physical store visits and focus on the stores that need more attention according to his/her judgment and not strictly follow an order-taking schedule. Furthermore, the adoption of PCSO may lead to improved results while reducing the number of physical store visits, thus providing cost reduction opportunities for direct-store-delivery suppliers.

On the other hand, centralized suppliers seem to be more reluctant to invest in resources to support their ordering process at store level. The changes in their internal organizations are too many to justify the decision for just one retailer. In addition, they seem to prefer to leave this responsibility to the retailer, since in their annual deal covering centralization they usually have to offer the retailer higher discounts for this possibility. A scenario that appears attractive to centralized suppliers is to get involved in the ordering process of selective stores, probably those generating higher volume sales for them or representing lost business opportunities. In any case, borderlines of roles for all users have to be clear in order to avoid overlapping areas and confusion of responsibility, especially regarding the process of store ordering to the Central Warehouse, where currently the responsibility lies with the retailer. Centralized suppliers though express great interest in having access to the daily point-of-sales data of the store in order to monitor their out-of-shelf rates, their promotion activities etc. and they seem more eager to get this information in the form of statistics, which is also in-line with their organizational structure.

From the retailers' perspective, PCSO gives the possibility to outsource the store ordering process for centralized products to their suppliers, which is not the current practice at the moment. This practice is currently used in CRP/ VMI supply-chain collaboration models at the Central Warehouse (Blatherwick, 1998). However, retailers cannot put pressure on the suppliers to move to new forms of collaboration if the suppliers are not convinced to do so themselves, as such practices require significant organizational changes. In addition, whether retailers will be open to sharing all this information with their suppliers over an independent service provider platform, whether they will do this through private retail exchanges or whether they will do this at all, is still to be answered. Such a decision may greatly affect the adoption rate of PCSO and other similar collaborative practices, such as CPFR (Hölmstrom et al., 2002). From informal discussions with all major Greek retailers, it comes out that many of them feel concerned about having a big proportion of their internal data hosted on the platform of an Application Service Provider. On the other hand, suppliers do not feel comfortable with the idea of being connected to a separate platform for each retailer. The existence of a third party provider may further play an important role in facilitating and doing the project management for new collaboration projects as well as in supporting the

data-alignment between retailer and supplier (Roland Berger, 2003).

Conclusions

In this paper we have attempted to analyze and evaluate the impact of a collaborative store replenishment practice, enabling information and knowledge sharing between retail store managers and suppliers' salesmen over an Internet-based platform, in order to achieve increased order accuracy and, as a result, improved shelf availability. The results from the field experiment, though limited, show a reduction of out-of-shelf situations by more than 50 percent combined with no significant statistical variation in total observed inventory levels.

These positive results are reinforced by the fact that the Greek retailer has further extended the use of the PCSO platform to all 200 stores of the chain in order to support internal store ordering to the Central Warehouse, while another major retailer has also followed. However, collaboration with the suppliers moves on slowly, as it involves organizational changes and coordination on both sides. The retailer had decided to stop inviting suppliers to join PCSO before roll-out to all the stores was completed and the system ran smoothly for all internal store ordering. The involvement of a new supplier in 2005 and the positive results that accompanied it marked anew the turn of the retailer into collaboration with suppliers.

Apart from shedding light on the impact of the PCSO practice, the study presented in this paper contributes also in presenting a systematic way of using a quantitative analysis based on shelf-availability and stock measurements in order to evaluate the results from the field experiment. This approach is suitable for assessing changes applied in inventory management policies in a retail context. Furthermore, there are few cases in the literature, if any at all, using such a quantitative analysis in order to assess the business impact of introducing an information system in an interorganizational context.

On the other hand, the lessons acquired from the qualitative analysis pertain to other supply chain collaboration initiatives, such as CPFR, involving supplier-retailer collaboration in a many-to-many environment and accompanied by organizational changes and coordination issues. From an e-business perspective, the study contributes in presenting practical issues associated with new Internet-enabled supply chain management practices and draws attention to issues other than technical aspects.

While the study has been carried out in the Greek grocery retail market, it is relevant to practitioners in other western markets as well, as the big retail chains operating in Greece and their suppliers, which are mainly multinationals, operate in a similar way as in the rest of Europe, as reported in a recent study comparing retail practices in more than seven western European markets (ECR Europe, 2005). Besides, shelf availability, which is the focus of this study, is recognized by practitioners in the sector as one of the top challenges they need to face in order to increase consumer satisfaction (Olofsson, 2006).

However, more implementations and pilot experiments, other than the first cases reported in this paper, are required in order to shed more light on the different aspects of this new paradigm. Other limitations of the study, as already mentioned, relate to the fact that from the field experiment and the pertaining quantitative analysis we cannot distinguish what has been the contribution of the different aspects of the PCSO practice on the results achieved. Additional analysis is required in order to assess the impact of the information system per se, the importance of different pieces of information in improving order accuracy, as well as the effect of the introduced process changes and collaboration. Further investigation concerning questions relating to the adequacy of the information sharing infrastructure and to the business model and operation mode of the collaboration platform is also required. At the same time, the limitations of the study presented in this paper are clear indications for future research in this area.

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