IMPLEMENTATION OF SUSTAINABLE SUPPLY-CHAIN PRACTICES: FIRST INSIGHTS FOR THE ROLE OF INFORMATION SYSTEMS BASED ON A CASE STUDY OF COLLABORATIVE ORDERING IN THE FMCG

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Abstract

In response to increasing demands of incorporating sustainability concerns and environmental practices into a firm’s supply chain management, firms are transforming their policies to exceed their current boundaries. As a consequence, they tend to take actions including the adoption of green practices and the compliance to corporate laws and regulations. Apart from the use of different types of indicators, their attempts emphasize on the adoption of dedicated Information Systems or relevant components that focus on environmental impact measuring. Such systems act as enablers in the environmental supply chain management and, especially in food supply chain, their role is even more critical as the short life cycles, the speed of response and the constraints posed by the lead times make the technological implementation harder. Within this context, this paper is trying to assess the impact of environmental practices implementation through the use of relevant information systems focusing on decision making. The data needed is discussed mainly giving emphasis on the challenges of executing such strategic supply chain initiatives. The case study used refers to the FMCG sector and, more specifically, to a major European-based food producer and its downwards supply chain to the retailers.

Keywords: Supply-chain collaboration, Collaborative ordering, Information Systems, FMCG, IS Implementation, Environmental IS, Simulation, Sustainability.
INTRODUCTION

The dynamic character of today’s competitive environment forces firms to reconsider their priorities and the principles existing across their supply chains. Within this context, it seems to be a general consensus about the benefits of green logistics (Meixell and Gargeya, 2005) as the introduction of environmentally sustainable practices seems to become of upmost importance.

As stakeholders’ pressures (especially these originating from government regulators and global competition) strain, companies tend to adopt a certain level of commitment to environmental and sustainability practices (Hassini et al., 2012). However, these companies are lacking a common standard for evaluating sustainability metrics (Searcy et al., 2009) and some authors even argue that there exist some incompatibilities between the known principles of performance measures and supply chain dynamics (Lehtinen and Ahola, 2010). Thus, there is need for more research on sustainable practices and environmental measures across the supply chain (Bunse et al., 2011).

Emphasizing on the adoption of sustainable practices across the supply chain, the benefits offered to corporate environments are lying not only in the areas of energy savings and fuel efficiency, but also affect other, more traditional Key Performance Indicators (KPIs), such as the costs and the supply chain efficiency (Ala-Harja and Helo, 2015). However, research studies that are focusing on the relationship between the general management and the environmental performance of the supply chain are still infrequent and the attempts made in order to understand this connection are not enough. To this extent, Yang et al. (2013) studied the relationships between internal and external green practices integration focusing on the green performance in the container shipping context, while Azevedo et al. (2011) made an attempt to investigate the connection between green practices of supply chain management and supply chain performance.

Nevertheless, apart from the research interest, the business impact of the environmental practices across the supply chain raises the interest of firms that are trying to implement more and more such initiatives into their existing business parts. In grocery retailing and the Fast-Moving Consumer Goods (FMCG) sector, the emergence is more than conspicuous. Many initiatives, such as the Efficient Consumer Response (ECR), are aiming at deploying such practices and try to set up collaborative contexts among their partners (suppliers, retailers, distributors and technology-enablers).

All that interest finds ground in many corporate practices and the re-engineering of certain processes seems to bring a vast of benefits. More specifically, the sectors that seem to be benefitted the most are the most traditional ones, such as the transportation, the replenishment and the ordering.

As a part of the bullwhip effect (Lee et al., 1997), the ordering sector deals with the backwards abnormalities created to the supply chain. Such irregularities tend to affect not only the manufacturing, but also the transportation. Thus, costs tend to become unstable and extremely high. The existence of information sharing and collaborative practices across the supply chain seem to be an underlying factor in the solution of this problem.

To our point of view and within this context, the Information Technology can act as an enabler in the supply chain environment, as the automation potentials it offers can become the drivers in the implementation of new decision making strategies. The role of Information System, underlined by this paper, is becoming more and more critical as the information asymmetry which exists in the field creates more difficulties and does not allow the normal operation of the system. Especially in food supply chains, the need for quick response rates and the constraints posed from the short life cycles underline the necessity for the use of such systems.

The above challenges emphasize on the requirement for the adoption of Supply Chain Information Systems that will support the environmental and collaborative practices arising. In the next sections, we are attempting to approximate the area of Information Systems for Collaborative Ordering and to present a relevant case study. The scope is to make an initial mapping of the data needed for the implementation of such systems and to conclude with a discussion and suggestions for further research.
THEORETICAL BACKGROUND

2.1 Green supply chain management

During the last two decades, more and more studies are emphasizing on green logistics and supply chain management and are trying to incorporate environmental issues in the supply chain (Geffen and Rothenberg, 2000, Bowen et al., 2001, Zhu and Sarkis, 2004). Although traditional logistics pay attention to the organization of the warehousing, the transport management and the inventory management, green logistics introduce new concepts in the field and attempt to re-engineer the traditional processes (Byrne and Deeb, 1993). Rodrigue et al. (2001) define green logistics as “supply chain management practices and strategies that reduce the environmental and energy footprint of freight distribution”. Moreover, they emphasize in the waste management and material handling green logistics offer.

However, in a corporate level, green logistics are not quite confined and the general concept of the green supply chain is needed. Green operations cover not only the transportation, but also the manufacturing and the network design (Srivastava, 2007, Rao and Holt, 2005). Within this context, the most emphasis has been given on identifying the relationship between the environmental factors and the supply chain performance as a total (Vachon and Klassen, 2008). More specifically, previous studies have been emphasizing on the importance of collaborative practices among the supply chain players in order to improve environmental performance. For instance, Yang et al. (2013) focused on the impact of both internal and external green and collaborative practices and the managerial implications they create in increasing the corporate performance and competitiveness. Moreover, Vachon and Klassen (2008) investigated the impact of collaborative practices in manufacturing processes and they have analyzed both process and product-base performance.

2.2 Food supply chains and the ordering problem

Food logistics remain one of the most costly sectors worldwide and a great share of the environmental impact occurs in their production and transportation (Ala-Harja and Helo, 2015). To this extent, the structures of food logistics are being transformed into more automated forms and integrated systems of the last decade are trying to confront specific supply chain problems (Gimenez, 2006).

One of the most common and significant problems across the supply chain remains the information asymmetry that leads to the ordering problem. Lee et al. (1997, 2004) are attempting to explore the information distortion that is created by the ordering process and misguides the operational decisions, including production and inventory levels. The “bullwhip effect” that comes as an outcome of that process affects the managerial decision making can be only encountered by transforming the traditional ordering process into more collaborative forms (Shapiro and Byrnes, 1992).

The traditional ordering strategies include the order placement by the retailer to the supplier and, then, the replenishment from the supplier to the retailer. However, during the last decades, a lot of collaborative practices that make use of information sharing have made their appearance including Vendor Managed Inventory (VMI), Continuous Replenishment Program (CRP) and Collaborative Planning, Forecasting and Replenishment (CPFR). VMI was developed in the mid-1980s and is a technique whereby the supplier is exclusively accountable for managing the customer’s inventory level. This includes the responsibility of the replenishment process and of keeping the inventories at the right level based in the stock level the customer has in its main warehouse or distribution center (Blatherwick, 1998). CRP moves the whole process one step ahead, where the retailers share their demand information to their suppliers. Thus, the inventory management made by the suppliers is based on real demand data and on sales forecasting systems, while the bullwhip effect is decreased (Andraski, 1994).

Some more steps ahead from the VMI and the CRP, the need for joint demand forecasting and promotions management leads to the adoption of CPFR, which is relied on extended information sharing among the retailer and the supplier including not only demand information, but specific point-of-sales (POS) data, forecasts and promotion plans (Holmström et al., 2002). Last but not least, category man-
management evolves the management of a whole product category by a specified supplier based on POS data and forecasting and is also a very common business practice (O’Keeffe and Fearne, 2002).

2.3 Information systems for supply chain

Among all these challenges in the supply chain sector, the use of Information Systems that integrate environmental parameters becomes of utmost importance. As Information Technology is widely used and enables collaboration practices across the supply chain, the need for specific and sophisticated infrastructure in this sector remains among the listed priorities (Pramatari, 2007). Moreover, IT has a great influence on the effectiveness of Supply Chain Management and it plays a significant role on achieving higher customer service (Gunasekaran and Ngai, 2004), as IT-enabled Supply Chains enhance the traditional procedures and add value to the operation of the firm (Motwani et al., 2000).

During the last decade, a vast number of Information Systems dedicated to supply chain operations has been developed. However, the incorporation of environmental parameters differentiates the development and, frequently, such initiatives fail (Chouinard et al., 2005). On the contrary, the challenges that compliances to “green” laws and ecological awareness bring into ground underline the importance of the incorporation of environmental parameters in the general supply chain information systems. To meet that requirement, companies are trying to adopt sustainable practices into their systems and care about improving their environmental impact in a more technological way (Watson et al., 2010).

Given all the aforementioned, the concept of supply chain management re-design by incorporating environmental drivers is more than ever in the forefront of the corporate priorities. Within this context, the emerging needs of specific tools that could handle a firm’s environmental performance by simultaneously keeping the traditional KPIs stable remain in the top-list of both researchers and firms.

RESEARCH METHODOLOGY

The research methodology of this paper relied to a case study from the FMCG sector. In order to analyse how supply chain decisions impact on traditional supply chain metrics, such as cost efficiency and on-time deliveries, in combination with environmental metrics, such as CO$_2$ emissions, a full dataset from the supply chain under study was collected and scenarios analyses were conducted via data manipulating techniques and simulation. The type of decisions examined was related to replenishment and ordering parameters. Analytical data manipulation and simulation were used, while the scope of the analysis was to finalize the data needed in order to be able to implement and use an Environmental Information System.

More specifically, the research methodology of this paper, depicted in Figure 1, is relied to a three-phase analysis.

- **Research Motivation**

Here, we emphasized on the existing literature and the gaps existing especially on the fields of Sustainable Supply Chains, Ordering and Replenishment problems and Information Systems and IT Assessment and generated the research objective of this work.

- **Exploratory Phase**

In that phase, we examined our data and case study and, after the scenarios generating approach, we decided to move on to the data analysis framework by attempting to give answers to the formed research questions.

However, our input data needed to be transformed and manipulated adequately. Thus, we developed some algorithms, mainly based on SQL and Java techniques, in order to formulate them.

- **Confirmatory Phase**
At this last phase, we made the simulation experimentation and the analysis of the data in order to conclude to the data needed and the challenges arising when trying to implement Collaborative Supply Chain Practices.

Figure 1. The Research Methodology of this Paper

CASE STUDY

The grocery sector remains one of the most crucial and difficult to handle sectors worldwide. The big number of products and the daily costly ordering and replenishment processes do not at all facilitate the changes made by the incorporation of new information systems or parameters related to effectiveness. Across the European market, the sector is also centralized and the deliveries usually follow the path from the production site to big distribution centres and then to local warehouses. Few cases exist where the direct in-store delivery occurs, but this mainly happens when logistics collaborations between the manufacturer and the retailer exist. Of course, these collaborations require much of trust among the cooperating parties and indicate that the retailer has to be sizeable and trustworthy.

Within this context, our case study is trying to assess collaborative ordering techniques under the umbrella of an environmental information system in the FMCG sector. More specifically, the problem that arose in that supply chain was that one major retailer negotiated over the frequency and size of the orders, while, at the same time, was also trying to pose restrictions about the pallet height that the supplier would use in its orders.

4.1 Case Study Description

The case study examined refers to a project which aims to contribute to an energy-efficient supply chain by providing the system, services, collaborative platform and management tools. These will enable energy and carbon footprint data monitoring, management and sharing in order to support both operational and strategic decision making across the supply chain. The project specifically focuses on the consumer goods sector and emphasizes on industry adoption and quantifiable impact assessment. This specific supply chain was selected as the negotiations between the suppliers and some major retailers in the German market were putting a lot of pressure on its operation. Thus, the need for some objective indicators that would prove the most efficient point of operation was more that conspicuous.

More specifically, all the changes and the scenarios examined refer to the impact assessment across the supply chain. In this context, the purpose is to examine the role of specific data categories into the
mapping of the energy outcomes across the supply chain and which the minimum dataset needed in order to implement Environmental Information Systems in the area of collaborative ordering is.

4.2 Case Study Specifications

The key figures of the network under study are as follows:

- 532 locations, divided into: 3 supplier’s sites: 1 production site and 2 distribution centres (DCs) and 529 retailers’ local warehouses
- 282 Stock Keeping Units (SKUs) / trading units
- Real retailers’ order data in a year (from the local retailers’ warehouses): 6,789 orders for DC1 and 6,429 orders for DC2. Please note that the order frequency depends on the size each retailer’s warehouse has, but in most case the frequency is twice or three times per week.

EXPERIMENTAL DESIGN

5.1 Experimental Factors

As mentioned above, the method used in order to test the research scenarios of this paper is the Simulation. Thus, we needed to examine some determinant factors that in some way affect the outcomes and analyse their impact. In that phase, we selected to test two specific decision variables: the order pattern and the pallet height. Regarding the first, we mean the way orders are placed from the retailer to the supplier side, with an emphasis on their frequency. Regarding the level of pallet height, we mean the maximum height allowed for a full pallet. This factor was selected because of a negotiation existed between the supplier under study and his biggest retailer, as the first used 120cm pallets in his production line and the second accepted only 105cm in his warehouses.

5.2 Performance Indicators

Apart from the experimental factors, performance indicators play a significant role. Within this paper, the indicators that we are going to examine were selected based on the real KPIs the firm under study used and they include the transport cost, the CO₂ emissions, the service level and the truck saturation that accrue from the deliveries on this supply chain. Transport costs are defined as the expenses involved in moving the products across the supply chain and they are computed as the product of the pallets transported in each route multiplied with the freight cost of this route. CO₂ emissions include the carbon dioxide emissions that accrue from the products’ transportation. CO₂ emissions’ computation is based on the type of the means of transport used and is taking place for each pallet transported. Finally, service level gives the percentage of customers that do not experience a stock out, and truck saturation gives the truck fullness rate.

5.3 Conceptual Model

The Conceptual Model designed as a part of this paper depicts the business decisions that need to be taken as a function of the experimental factors chosen, which affect SC environmental performance.
5.4 Experimental Design

A designed factorial experiment is carried out to indicate the relative importance of the two experimental factors. In order to handle the data transformation SQL and JAVA algorithms were developed. The first dataset (AS-IS situation) was not transformed. However, the two other datasets have been under transformation. The order lines and their quantities have been changed in a way to ensure the order pattern changes. Moreover, the pallet height constraint posed implies some more changes made.

5.5 Description of the Experimental Scenarios

Scenario 0 (AS-IS): No changes in the order dataset are made.
Scenario 1: In this case, the quantity is split into half and the order frequency is doubled in order to generate a new order between the existing.
Scenario 2: Pallet height changes from 105cm to 120cm including full pallet constraint (only full pallets of products are delivered).

OUTCOMES & FIRST INSIGHTS

The scenarios have given different results regarding the transport cost and the CO₂ emissions, while the service level remains stable and the truck saturation shows small percentage differences (6-8%).

As seen in Figure 4, Scenario 1 related to higher order frequency has, as expected, both increased transport costs and higher CO₂ emissions. However, the increase in CO₂ emissions is much higher than in transport costs as a 3PL cost-matrix is used. Scenario 2 also leads to higher costs and CO₂ emissions. When comparing the two scenarios, we see that the order frequency has a much more significant
impact in terms of cost (16.9%) but especially CO$_2$ emissions (74.6%), as compared to pallet-height changes (with 6.2% and 8% percent increase in transport costs and CO$_2$ emissions respectively).

![Figure 4. Transport Cost and CO$_2$ emissions Outputs](image)

However, where the business value is lying is not in the outputs themselves, but in the business understanding of the case within the context of Information Systems. Given that this data handling and manipulation required only the order data and parameters, such as the CO$_2$ emissions/km and the transport cost/km, the implying fact is that no need for simulation or any other robust modelling systems exists. On the contrary, the incorporation of such metrics into the supply chain information system in combination with a simple calculating logic regarding the transport costs and the CO$_2$ emissions is more than enough.

It is now more than obvious that green supply chain decisions can be connected to the performance analysis of the supply chains, but multi-criteria analyses are not needed. Although food remains a fragile product, the partial adoption of optimization techniques could increase the environmental performance of the supply chain. To this extent, the design of a Sustainable IS should only take into consideration parameters, such as transport cost and CO$_2$ emissions, in the context of incorporating them with the traditional supply chain data. However, more experimental designs will take place.

**CONCLUSIONS & FURTHER RESEARCH**

In this paper, we have presented the first insights regarding the employment of an environmental perspective in a major European supplier’s information systems within the context of collaborative ordering. The amount of data needed in order to implement such scenarios is in a fundamental level, but the rule of information sharing remains. However, if this data is incorporated in the current information systems, the decision making will be facilitated taking into account environmental parameters.

As it may have been obvious, in this work we attempted to manipulate the data in a way in order to diminish limitations. However, the simulation limitations and the simplification level a simulation model may still exist and have a minor effect on the results. Moreover, both the experimental factors and the performance indicators used up to now in this research are limited and two levels of the vertical supply chain are missing, including the final retail store and the customer, and, thus, the service and inventory levels cannot be calculated to that basis.

Although some first insights have been already analyzed and described, the factors addressed by this paper are not sufficient enough in order to ensure the success of the collaboration practices among the stakeholders. However, given that this paper presents only the first experiments and results of that case, the presentation of that work will try to illuminate all these aspects.

These limitations urge us to continue to this research field and try to investigate more insights for the role of IS in environmental supply chains. This future research will not only take into consideration the absence of the data from the experiments tested, but is also trying to design more business scenarios in immature near fields, like urban transportation and last-mile deliveries, where we are currently working.
References


