IQ AS AN ENABLER OF THE GREEN AND COLLABORATIVE SUPPLY CHAIN

(Completed Research Paper)

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Abstract:
This communication investigates the role that information quality (IQ) can play in the development of Green Supply Chain Management (GSCM). GSCM is about integrating environmental concern into the interorganizational partnerships. Thus, companies are today seeking ways to meet both economic and environmental benefits through costs and CO_2 reduction. Information sharing is key for supply chain performance but the literature on the impact of IQ in Supply Chain Management (SCM) is scarce. A field study in the retail distribution industry in France is designed in order to determine the dimensions of IQ that are critical to different supply chain processes. An in-depth qualitative analysis of interviews is conducted including all the supply chain network actors (distributors, manufacturers, logistics service providers, standardization organizations, professional associations, and consultants). Our results indicate that the IQ dimensions that will have significant economic and environmental benefits are depending on the nature of the information flow. Our research findings also permit to correlate and explain the dynamics between economic and environmental benefits and how IQ can be an enabler… or not.

Key Words: Information quality, supply chain management, economic benefits, environmental benefits.

INTRODUCTION

Since Forrester [10] the reason why organizations should share information across the supply chain network is no longer a big question mark. Researchers and practitioners all agree that sharing information about product, demand and supply will significantly improve the overall performance of the collaborative supply chain network [16, 17, 18]. Now, researchers have to focus on which information is shared and how it is shared. As a matter of fact, today's high-velocity[1] society requires an increasing amount of information in order to efficiently manage a large number of different processes across the supply chain network [14, 27]. In particular, current environmental concerns lead firms to integrate environmental considerations in the performance of their supply chain [29, 35]. We will therefore define Green Supply Chain Management (GSCM) as integrating environmental concerns into the inter-organizational practices of Supply Chain Management (SCM). Our definition is based upon the work of [30].

The objective is then two-fold: achieve the highest possible performance from both an economical and environmental perspective. In this context the quality of the data and information exchanged is obviously a key factor of success [5, 15, 37]. However, the actual contribution of information quality (IQ), and especially of the diverse dimensions of IQ, remains unclear. Our primary research question is thus: What can IQ do to improve the Green and Collaborative Supply Chain? To answer this question, we propose to analyze, from different actors' viewpoints, the contribution of IQ on the development of green and collaborative supply chain networks. A field study conducted in the retail industry allows deriving some key findings on several logistical processes monitored and managed by the various supply network actors: retailers, suppliers and logistics service providers.

The rest of the paper is organized as follows. The literature on the evolution of supply chain management (SCM) is first reviewed. Then we present the background of IQ as an enabler of the collaborative and green supply chain. In the methodology section, we describe the field of application we focus on – the supply chain of consumer goods and retailing industries – and the field study methodology conducted. Our results indicate that several IQ dimensions concerning a set of critical information enable the development of green and collaborative supply chain networks. Moreover, it appears that green considerations derive from economic considerations. Then these results are finally discussed in the conclusion.

EVOLUTION OF SUPPLY CHAIN MANAGEMENT

The concept of SCM has emerged as a result of successive organizational changes from "managing its logistics" towards "managing interdependencies among supply chain actors" [3]. With respect to an increasing environmental conscience, the 21st century is definitely about conciliating economic and environmental benefits; SCM evolution to the Green and Collaborative Supply Chain is now a reality [6, 22]. In the following sections we examine the conditions and enablers of information sharing and the specific needs and capabilities of the collaborative and green supply chain.

Supply Chain Management and information sharing

For the purpose of this paper, "a Supply Chain is defined as a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer." [23, p.4]. Depending on the degree of complexity of the supply chain, and the number of actors, the supply chain network may present different levels of analysis. In this paper, we concentrate on supply chains involving suppliers, clients, and logistics providers.

Within the supply chain network, close cooperation enables the overall supply chain profitability [31].

[1] Eisenhardt [9] defines the concept as follows: *"In a high-velocity environment, changes in demand, competition, and technology are so rapid and discontinuous that information is often inaccurate, unavailable, or obsolete."*

Furthermore, information sharing is key since inefficiencies are mainly linked to asymmetric information or distorted information [17, 34]. Information can be viewed as a tool permitting to coordinate interorganizational activities, as well as a mean for reducing cost and improving the overall supply chain efficiency [32]. Questions are therefore on how individual organizations accept to share information and on the type of information shared. A firms' willingness to share information appears to be dependent upon the type of information. Frazier et al. [11] suggest that strategic information sharing should be considered from two different levels: internal strategic information (internally processed data on future long-term plans) and external strategic information (externally processed data on customers and competitors). Internal strategic information is proprietary and sensitive information whilst external strategic information is nonproprietary and thus less sensitive since it originates outside of the firm's organization.

In the next section we explore various models and tools that have been leveraged in order to improve both supply chain efficiency and profitability through better coordination of activities.

From Collaborative Supply Chain Network to Green Supply Chain Management (GSCM)

Understanding how information is shared leads researchers to take into account considerations about coordinating activities and decision making along the supply chain [19]. Ideally, as these authors further explain, the decision making is under the control of one single actor, such a system is referred to as a centralized system. In a decentralized system, entities of a supply chain network pursue their own goal and optimize their own benefits. In such systems, there is a need for some incentive and action plans in order to allocate resources efficiently and distribute benefits among the participating units.

Some researchers have tried to develop suitable solutions permitting to ensure the coordination of activities and flows in decentralized structures. From the concept of Third-party-Value-Added Network [2], Advanced Planning Systems (APS) have emerged. APS are intelligent software that typically operates across a complete supply chain in order to ensure optimization of resources and demand allocation, inventory management, transportation and distribution routes. The need for coordination of activities, resources, physical goods, and information across the supply chain network has gradually transformed the role of the Third-party-Logistics Provider (3PL) into Fourth-Party-Logistics Provider (4PL). Table 1 adapted from van Hoek [33] summarizes the key differences between 3PL and 4PL.

CARACTERISTICS	3PL	4PL
Involvement	Physical goods movement and execution	Coordination and Management of logistics operations
Asset intensity	High (warehouses, trucks…)	Low (information systems…)
Knowledge intensity	Low (execution standard tasks)	High (organization of flows..)
Dependence of manufacturer	Medium (low switching cost, multiple competitors…)	High (manufacturer's fulfillment capabilities depend on IS provided)
Contact points at manufacturer	Execution level (daily contacts)	Strategic Senior level (Supply Chain design, strategy and coordination)
Performance measurement of service provided	Limited to throughput, quarterly evaluations	Customer service levels and strategic supply chain key performance indicators
Strategic Information sharing by manufacturer	Limited to informing 3PL about changes impacting logistical execution	Customer and supplier lists, service policies and strategic priorities

Table 1: Different role and responsibilities of 3PL vs 4PL [adapted from 33]

In order to meet stakeholder pressure [13] as well as growing environmental regulations [8], supply chain networks are evolving to include consideration of environmental externalities (greenhouse gas, pollution and

waste). GSCM is defined as "integrating environmental concerns into the inter-organizational practices of SCM including reverse logistics" [30, p.3]. As a matter of fact, environmental goals and industrial competitiveness have for quite some time been considered as antinomies and therefore the green supply chain was only for companies that could afford it [6]. In particular, several firms claiming to be "environmental compliant", "social responsible" and pursuing "sustainable growth strategies" have still not implemented an Environmental Management System (EMS) nor adopted the international environmental standard of ISO14001. If 83% of the companies declare to take into account environmental concerns in their strategic decisions, only 35% of them confirm that they are currently operating in, or part of, a green supply chain [4].

Combining economical and environmental performance of supply chains seems to be a real challenge for the 21st Century. On the one hand, some authors do claim that environmental improvements do not necessary imply heavy investments. Being green improves productivity and that's where one may argue that GSCM is a true competitive advantage [26]. Pollution control preventions are cost-effective actions, not only for the environment but also from the economic point of view of the firm. On the other hand, some researchers find an exponential growth of total logistics costs across the supply chain when reducing the level of CO2 [35]. For instance, a 17% reduction in greenhouse gasses requires a logistic cost increase of 10,097% [5].

INFORMATION QUALITY AS AN ENABLER OF GSCM

For close cooperation and development of new supply chain forms and objectives, both data consistency and cross-functional SCM application integration are important elements for IT infrastructure integration [27]. In particular, "data consistency is relatively more important, in comparison to cross-functional application integration, suggesting the high degree of importance of data quality and standards as facilitators of process integration". Moreover, in collaborative supply chain networks IQ is a predictor and enabler of firm performance [28]. However, the SCM literature has not paid enough attention to IQ. The question of the contribution of IQ to the development of GSCM has to be investigated. In particular, IQ is a multi dimensional concept [1, 30, 36]. In SCM literature, IQ dimensions that are valuable and/or necessary for supporting current supply chain evolution are not well understood. Pierce [25] built a fictional case on the order process of an online retailer and proposes a Quality Specification table for a customer order based upon Wang and Strong [36]. This proposal is interesting but not sufficient. First of all, it is based upon a fictional case and not real-life empirical data. Second, it does not identify the specific quality dimensions that will have significant economic and environmental consequences. The analysis of which IQ dimensions have to be taken into account and managed for environmental benefits development, is therefore both theoretically and empirically important. Among the different researches that propose several dimensions for IQ, this paper relies on the Wang and Strong [36] classification (Table 2). Indeed, recent researches [20, 29] explained that this classification can be viewed as a basis for IQ research.

DIMENSION	DEFINITION
Accuracy	The extent to which data are correct, reliable, and certified free of error
Believability	The extent to which data are accepted or regarded as true, real, and credible
Objectivity	The extent to which data are unbiased (unprejudiced) and impartial
Reputation	The extent to which data are trusted or highly regarded in terms of their source or content
Value-Added	The extent to which data are beneficial and provide advantages from their use
Relevancy	The extent to which data are applicable and helpful for the task at hand
Timeliness	The extent to which the age of the data is appropriate for the task at hand
Completeness	The extent to which data are in sufficient breadth, depth, and scope for the task at hand
Appropriate	The extent to which the quantity or volume of available data is appropriate

amount of data	
Interpretabilty	The extent to which data are in appropriate language and units and the data definitions are clear
Ease of understanding	The extent to which data are clear without ambiguity and easily comprehended
Representational consistency	The extent to which data are always presented in the same format and are compatible with previous data
Concise representation	The extent to which data are compactly represented without being overwhelming
Accessibility	The extent to which data are available or easily and quickly retrievable
Access security	The extent to which access to data can be restricted and hence kept secure

Table 2: Data Quality dimensions [36]

METHODOLOGY

This paper mainly explores how IQ improvement enables environmental performance in inter-organizational practices. From the literature review performed, the research is designed in order to analyze 1) types of information that are key in several SC processes; 2) the dimensions of IQ that have a positive impact on both economics (reduced cost, increased profits) and environmental externalities (greenhouse gas, pollution, waste) of supply chains.

The empirical approach relies on qualitative methods, because the research is mainly exploratory [12]. Moreover, identifying the type of information and IQ dimensions that are relevant for GSCM development involves a deep understanding of processes and context of a supply chain. We therefore conducted a field study in the retail industry and performed interviews with different actors of integrated supply chains. The objective is indeed to provide concrete empirical evidence from different actors' viewpoints. 25 interviews, that constitute the primary source of data, were conducted in 2010. They have been tape-recorded and transcribed to ensure the validity of the findings. They are detailed in Table 3 that presents the type of firm (retailer, manufacturer, logistic service provider, consulting firm or standard association) and interviewees' position.

The interview guide was adapted from interviewees' company and position, even though it was structured around five main areas. The first part concerns the description of current sharing operations developed to improve economic performance of supply chains the firm is operating in. This allows us to identify supply chain processes the firms consider as key to develop GSCM. The second section examines the characteristics of the IS supporting these experiences in order to extract which information is key. The third part focuses on IQ. This part is not conducted with questions about predefined dimensions, but rather questions about dysfunctions in the current experiences. This allows identifying which failures or problems are derived from poor IQ. The fourth part concerns the economic and environmental considerations of shared experiences. More prospective, the last part aims at understanding economic and environmental effects expected from an improvement of some IQ dimensions.

RETAILERS	
Retailer 1	Supply Chain Director
Retailer 1	Operations Manager
Retailer 1	CEO
Retailer 2	Supply Chain Director
Retailer 2	Supply Chain Manager
MANUFACTURERS	
Manufacturer CPG	Quality Management Director
Manufacturer CPG	Product Data Manager
Manufacturer Food	CEO
Manufacturer Food	CIO
Manufacturer Textile	Supply Chain Manager
LOGISTICS SERVICE PROVIDERS	
4PL_1	Commercial Director
4PL_1	Key Account Manager
3PL_1	CIO
3PL_1	CEO
3PL_2	CEO
4PL_2	Commercial Director
3PL_3	Logistics Manager
3PL_3	CIO
4PL_3	Commercial Director
STANDARD AND PROFESSIONAL ORGANIZATION	
GS1	Key Account Manager
GS1	Electronic Exchange Manager
ECR France	General Secretary
IS Consultant	CIO
GSCM Consultant	Associate
SCM Consultant	Associate

Table 3: List of interviewees

We conducted a thematic qualitative analysis of the interview transcripts [24] Analysis of the interviews was conducted from a dictionary of evolutionary themes, derived from both the literature review and field study considerations that have emerged. The dictionary themes are related to four major categories (process, type of information, IQ dimensions, economic and environmental effects). By using the 15 dimensions of Wang and Strong [36] for coding interviews, we identified in each interview the IQ dimensions that are described as the more relevant for economic and environmental improvements. Then we extracted the three main IQ dimensions for the different information sharing processes identified.

RESULTS

The results are presented for two main processes: the ordering and the synchronization process. For each process we identify the IQ dimensions that will impact GSCM initiatives. First, we present the purchase and supply order process and the detailed order information (product code, quantity, destination, and date of delivery). Second, we describe the data synchronization process and the product information (including logistics dimensions such as weight, lot-size, Global Product Classification code). Finally, we explain the strong correlation between economic and environmental benefits.

IQ in the Purchase and Supply ordering process

Information sharing is a prerequisite for optimizing the overall performance of the supply chain network primarily by reducing the bullwhip effect. Whenever IQ is ensured within the ordering process it also contributes to significant environmental benefits (reduce waste of materials, energy consumption,

transportation distances and CO2). A purchase order requires as a minimum the following information: a product code, the desired quantity, the address of the final destination and the date of delivery. If one of these elements is inaccurate, incomplete or eventually unavailable, there are negative environmental consequences as well as additional cost involved. From the field study, both logistics service providers (LSP) and manufacturers all confirm the necessity to ensure clean purchase orders.

We have noticed that the LSP can play a very active role in the data cleaning and classification process: *"We participate in the data cleaning process with our customers. Especially on the distribution side. It is a huge task. You have a carrier who receives an order from a company X to deliver to retailer A's site ABC. You also have a company Y that place an order for delivery to the same site ABC. But, on the order form the address is not identical. Consequently, in the system you actually have 2 addresses. This example is a very simple one… No later than yesterday I made a case on a retailer for which we had recorded 800 different addresses for the same site*." Errors like "*wrong address*" or incorrect "*delivery date*" result in at least one return of goods and a second delivery. This concludes in environmental harm (additional transportation distance, energy consumption and CO2 emission). One LSP reports the following: *"When a delivery is being refused by the addressee we will have to schedule a second delivery and this implies additional cost."*

Furthermore, an "*error on the product code*" causes numerous problems within the ordering process since it may eventually block the fulfillment of the complete order. As a matter of fact, when the order is being transferred by Electronic Data Interchange (EDI), it cannot be processed automatically and is put on-hold within the manufacturer's or the LSP's system (depending on whether the order is being shipped directly from the manufacturing facility to the retailer or via a LSP managed distribution center). First, a delay in the order process is issued from the manual intervention requirement (phone, fax in order to confirm the correct product code). Second, once the product code have been correctly entered and identified in the system, the complete order is being released. As one consumer goods manufacturer explains: *"Before, whenever we encountered 2 missing references on a purchase order we would prepare them for a partial shipping as soon as possible. We do not do that anymore, because there is too much additional cost involved. We have a partial order preparation, a non-optimized transportation and a postponed reception at customer site… It is really something that creates a lot of turbulence across the complete supply chain."*

Finally, the purchase order must not only be clean but it also needs to be transmitted in a timely manner and accessible to the manufacturer. Any additional conditions like mandatory delivery date or specific time for delivery at the point-of-sale, can only be completely fulfilled by the supplier if the purchase order is transmitted on time. A SME[2] in the food industry made the following statement: *"The retailer will typically indicate a specific date and time of delivery. We will then calculate the shipping date depending on our distribution scheme. This permits us also to check that the order was transmitted in a timely manner, or not. There is actually only one point where we typically negotiate with the retailer and that's on the time of delivery. They systematically argue and apply penalties. It is subject to disagreement."*

In summary, we identified three main dimensions of IQ that may enable firms in collaborative supply chain networks to perform GSCM (Table 4). We also noted that along with one dimension, namely accuracy, the importance of timeliness is of outmost importance since we are in frequent transactional information flows.

[2] SME: Small and Medium size Enterprise. In France a SME employs 20-249 people.

Information Quality dimensions	Information examples	Dysfunctions/ Problems	Environmental impacts
ACCURACY/ TIMELINESS	Product identification Order quantity Date and place of delivery	Unknown product identification => purchase order blocked and delivery delayed or delivery of wrong product Wrong order quantity or place => additional transportation Purchase order transmitted too late => lead time conflict and impossible to respect delivery date and time	Waste of material, energy, fuel, transportation and CO_2
COMPLETENESS	Completeness of purchase order Completeness of inventory information (status, receptions, shipped quantities)	Missing information in purchase order => purchase order blocked Missing inventory information => wrong supply calculation	Additional warehouse and transportation activities Excess inventory (or disruption). Waste in manufacturing, warehouse and transportation.
REPRE-SENTATIONAL CONSISTENCY	Duplicated information Wrong date format	Delivery address misinterpreted => delay or no delivery Inconsistent date format => DD/MM/YY is typical date format in France but MM/DD/YY is more frequently used in Northern Europe/Scandinavia	Additional logistics cost (express delivery and/or penalty for delayed delivery). Additional CO_2 and non-optimized transport (partial delivery).

Table 4: Information Quality dimensions within the Purchase and Supply ordering process

IQ in the data synchronization process

In addition to the ordering process, the synchronization of product information (master data) between manufacturers and retailers also emerge as a process for which IQ is key in terms of environmental benefits. Data synchronization represents the process involving the timely updating of data between business partners: "*Data synchronization represents a concept and tool that allow to be sure to always share information with our partners, and in particular logistics information*." Upstream from the transactional exchanges, product information exchanges through data synchronization can facilitate physical flows. Indeed, data synchronization permits business partners to ensure relevance, interpretability and accessibility of updated information that are used during physical flows of product.

When investigating the impact of IQ within the data synchronization process it is relevant to integrate, in addition to retailers and manufacturers, considerations from standardization organizations (GS1) as well as from professional associations (ECR France). The former develops standards for electronic information exchange, and the latter is focused on collaboration practices and methods between retailers and suppliers.

GS1 France explains that the international product information standard permits to define 500 attributes for a product. For the French market 170 attributes have been selected and these attributes permit to describe a

product from a business perspective, *"These 170 attributes are essentially commercial, logistic and marketing data that permit to manage sales, orders, delivery and invoicing of the product… In average 80 attributes are actually being used."* We have noted that the synchronization process of product related information is mainly on a dyadic basis. Data synchronization is being handled on a machine-to-machine basis and not through the network of data pools developed for synchronization purposes: Global Data Synchronization Network (GDSN). Knowing that GS1 France has about 32000 members, the following quote illustrates the extremely low adoption rate of a formalized data synchronization process, *"We have about 2000 suppliers using data synchronization. But, if we exclude those who do not go through GDSN we have probably only 200 suppliers. Machine-to-machine processes are today more frequently used than GDSN."* One major supplier does explain to us the reasons why they stick to a dyadic approach and do not adopt GDSN, *"How can we be assured that the retailer will be able to link all the information to one single code? In France we have 4 or 5 major retailers, it is thus possible to work on a machine-to-machine basis and we have decided that whenever it is possible we will only exchange on a dyadic basis."* Some major retailers are also pushing their suppliers to adopt a product data synchronization process but the operational results are quite disappointing as the IS Manager of a SME explains, *"We have put in a lot of effort in order to meet the requirements of Retailer X and we are fully operational on the synchronization process since January 2009… But for the moment we have not transmitted one single record […]. Their [Retailers'] organization is huge and complex. This could explain the difference between rhetoric and reality."*

Nonetheless, there is no doubt that IQ suffers because of lack of synchronization. A recent study carried out as a joint-initiative between retailers, suppliers and GS1 looked at the logistics units' measurements in the product information record and compared it to physical measurements by auditing a number of warehouses at both the retailers' and the suppliers' sites. The result of this data quality study was summarized by one participant, *"42% of the product information records were correct. 58% of the product information records on the cardboard box level as well as on the pallet level were also correct. These results show that there is no data synchronization between the manufacturer and the retailer. Furthermore, in some cases the retailer proceeds to correct the errors… This explains why the result on the logistic units is not as bad as on the product information records. But, the retailer does not feedback his corrections to the manufacturer. This in turn means that whenever the manufacturer will publish a new record, the new record will replace the old record and the corrected data will disappear… This audit actually showed us that in average 50% of the product information records contain errors."*

As a consequence, poor quality information is transmitted to the complete supply chain network and harm both economic and environmental performance. One major retailer confirms this statement, *"When the weight is wrong and the dimensions are wrong, the calculated volumes are wrong. And everyone along the supply chain needs to calculate volumes at some point of time in order to anticipate transportation needs. If my volumes are wrong, either I get a surplus capacity, or I have to order an additional urgent transport…that is bad quality. I could give you numerous micro-examples like this one. They are micro-dysfunctions that add up and in the end create terrible damages."* Another retailer summarizes the IQ and data synchronization process problem as follows: *"It really does not matter much whether I send information from point-to-point or whether I send it to multiple addressees, because if data quality is not ensured in my base I will just send "crap" everywhere…"* And he concludes by underlining that for any information system the biggest question mark remains: *"How can we guarantee information quality?"*

In summary, we have identified the dimensions of IQ that should not be neglected within the data synchronization process since they seem to directly impact both economic and environmental profits and loss (Table 5). An interesting note is that as far as data synchronization is concerned, two additional dimensions are linked to the three main dimensions, namely accuracy and timeliness. This is explained by the volume of data exchanged even though we are no longer on a frequent exchange process (as within the order process).

Information Quality dimension	Information example	Dysfunction/ problem	Environmental impact
RELEVANCY/ ACCURACY	Set of information included in product information record	Missing critical information Inaccurate critical information	Impossibility to anticipate planning of transportation or warehousing activities
INTERPRETABILITY	Weight, dimensions of boxes and pallets	Different interpretation between a manufacturer and a retailer	Waste, additional rework
ACCESSIBILITY/ TIMELINESS	Use of GDSN is limited; machine-to-machine is more frequent No updating in a timely manner	No inter-organizational synchronization and no intra-organizational diffusion	Bad data is being used and creates surplus capacities or additional workload, express transport or non-optimized utilization of resources

Table 5: Information Quality dimensions within data synchronization process

Environmental and economics correlation

Among the 25 interviews, only two managers did not directly link economic and environmental benefits in their discourse. This is an interesting result since it indicates a trend towards environmental benefits through economic optimization processes. The environmental benefits (lower level of CO_2 emission and elimination of waste) are not neglected but they seem to result from cost reduction and optimization processes rather than a true green consciousness. The two managers that did distinguish between environmental and economic benefits explain it as follow, *"We are paying a lot of attention to the design of transportation systems that do no harm to the environment. We are not the actor but the prescriber of these optimized transportation systems. As far as our own manufacturing system is concerned we are directly integrating environmental criteria and we are making sure to meet our objectives in terms of greenhouse gas reduction and also water consumption reduction."* Furthermore, the geographic location of their facilities and manufacturing units (40 factories worldwide) is directly correlated to the volume of business on each continent. An interviewee claims that from an environmental perspective, *"This is almost the ideal situation."*

Nonetheless, this situation might indeed be ideal but it appears as an exception since the rest of the managers interviewed (23 out of 25) actually claims that environmental benefits do derive from economic optimization process and actions. The CEO of a retailer puts it this way, *"I do not think anybody waited for "le Grennelle de l'environnement[3]" to take environmental benefits into consideration. But, we did not tackle the problem from an environmental consideration; we did it from an optimization consideration."* This is also confirmed by a food manufacturer, *"I believe economic and environmental benefits are linked together, it is true opportunity, it is really fuel for [sustainable development]."*

[3] A French government initiative to integrate public policy on ecological and sustainable development issues http://en.wikipedia.org/wiki/Grenelle_Environnement

However, when discussing this point with a 4PL we also got a slightly more radical view of how economic and environmental are linked together, *"The drivers of any organization are price, capabilities of doing and quality. And they account for in that order… I have never heard anybody adding carbon foot print to that list."* The manager does underline the fact that there is a difference between evaluating the carbon footprint (for external communication purposes) and actually using it for decision purposes, *"As you know the firm is one of the worldwide leaders in logistics and transportation. Therefore we have to be able to communicate on the carbon footprint. Within a couple of weeks any of our customers are going to be able to access our website and get not only a lead time quote for the delivery from point A to point B, but also the evaluated CO2 emission. But, from an operations perspective there is nothing behind this frontal webpage."*

Finally, we also recorded a new word that perfectly illustrates the strong links between economic and environmental benefits. One retailer actually calls the phenomenon *"econological"*. Therefore, it is all about the combined effects of cost savings, resources optimization, and waste elimination. These combined effects are all obtained through optimization processes that have both economic and ecological benefits.

DISCUSSION AND CONCLUSION

In this part, the field study results are discussed following three subsections followed by the conclusion.

IQ perceptions depending on the type of information

From the field study, we can infer that the dimensions of IQ expected to have a positive environmental impact in logistics processes are not the same when considering the type of information exchanged. When analyzing logistical processes, we have identified two different types of information with environmental impacts (Figure 1).

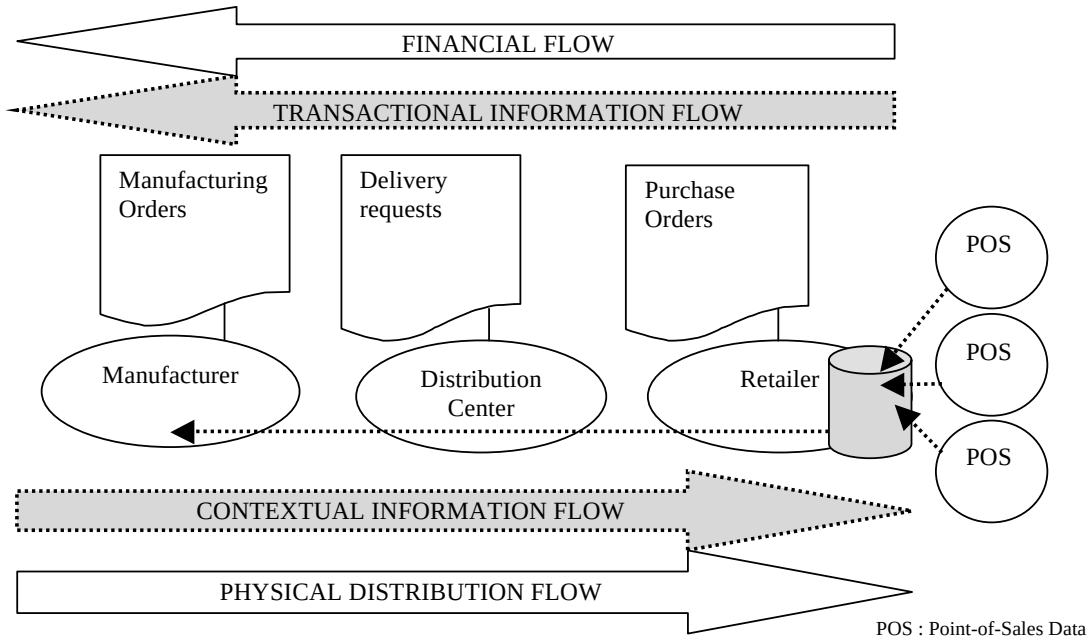

Figure 1: The Purchase and Supply Ordering Process

On the one hand, information included in orders and invoices and on the other hand information included in product information. Therefore it is theoretically relevant to distinguish transactional information and contextual information [18]. Whereas transactional information encompasses considerations on volumes ordered, delivery dates, and geographic positions of warehouses, contextual information is more about characteristics of products and delivery units, and especially dimensions and weights of delivery units for logistics processes. The literature has for a while emphasized the importance of IQ for transactional information in order to ensure supply chain performance [17, 27, 28]. In recent years, the quality of contextual information, about product and price descriptions, is also presented to have positive impact on supply chain coordination [7, 18, 21]. In this paper we show that both transactional and contextual IQ is perceived to be a strong enabler of the collaborative and green supply chain.

IQ as an enabler of the collaborative and green supply chain

Whatever the process of information sharing and the type of information concerned, IQ is presented as a strong enabler of the collaborative and green supply chain. This result is in line with previous researches that have emphasized the importance of IQ in SCM [15, 17, 27]. However, the analysis of the role IQ can play in the development of GSCM has not been taken into account in previous researches [5, 15]. In particular, we have shown that IQ dimensions that are considered to be the more relevant for the development of green SCM are not the same for transactional and contextual information [18].

Based on Wang and Strong [36], the results indicate that for the ordering process, the three main dimensions of IQ are accuracy, completeness, and representational consistency, whereas for the data synchronization process, the three main dimensions are relevancy, interpretability, and accessibility. These diverse perceptions from the actors of the supply chain networks analyzed mainly come from the fact that the ordering process and the data synchronization process present differences in terms of frequency and volume of exchanges.

From economic to environmental benefits

Finally, it appears that most of the firms analyzed consider environmental benefits of IQ and information sharing in logistics operations as a positive and necessary consequence of economic benefits.

Indeed, contrary to some research explaining that reducing CO_2 emissions induces additional logistics costs across the supply chain [5, 35], our results are more in line with Porter and van der Linde [26]: Green considerations are correlated to productivity improvement since for most of the firms, being green can only occur when economic benefits are first assumed. Indeed, information sharing and IQ are prerequisite to supply chain operations optimization and supply chain operations optimization means both economic and environmental benefits within the whole supply chain. In addition, in order to achieve current environmental concerns [30, 35], the question is therefore about the repartition of economic benefits among the different actors of the supply chain network.

CONCLUSION

In this paper, following the literature review on SCM evolution and IQ in the supply chain, we have conducted a field study in supply chains networks involving manufacturers, retailers and logistics service providers. We have shown the role IQ can play for the development of the green supply chain. In particular, by considering the different actors of the analyzed supply chain network, we have presented the necessary distinction between two processes for which IQ improvement allow environmental benefits achievement, especially by greenhouse gas reduction issued from transportation optimization. The first process is the ordering process for which accuracy, completeness and representational consistency are the IQ dimensions

the most relevant to consider. This is mainly derived by the high frequency of exchanges of transactional information. The other process is the data synchronization process for which relevancy, interpretability and accessibility are the most relevant dimensions for business partners that share contextual information.

Consequently, supply chain managers may concentrate on these IQ dimensions in these processes to develop GSCM in order to meet both stakeholder pressure [13] and growing environmental regulations [8]. Some areas of future research can also be identified from this analysis. First, an interesting area to investigate is if the results may be generalized to other types of products or services in different supply chain configurations. Otherwise, complementary analysis with in-depth case studies may be achieved to understand how companies manage IQ internally before and after exchanges in order to identify best practices both for transactional and contextual information [18]. Finally, the correlation between economic and environmental benefits needs to be better understood. From the field study conducted, we can conclude that IQ improvement considerations for the development of the green supply chain are first derived from efficiency improvement. Indeed, most of the firms consider that environmental benefits in their supply chain can only occur if economic benefits are first assumed. Can green actions be developed independently from economic efficiency research in supply chain networks?

REFERENCES

[1] Ballou, D. and H. Pazer, Modeling Data and Process Quality in Multi-input, Multi-output Information Systems. *Management Science*, 31(2) 1985, pp. 150-162.

[2] Ballou, R. H., *Business Logistics Management*, 4th ed. Prentice-Hall, 1999.

[3] Bowersox, D., D. Closs and R. Drayer, The Digital Transformation: Technology and Beyond. *Supply Chain Management Review*, January 2005, pp. 1-9.

[4] Carbone, V. and V. Moatti, Greening the Supply Chain: Preliminary results of a global survey. *Supply Chain Forum: An International Journal*, 9(2), 2008, pp. 66-76.

[5] Chaabane, A., A. Raudhin, M. Paquet and M. Benkaddour, An Integrated logistics model for environmental conscious supply chain network design. *14th Americas Conference on Information Systems*,Toronto, Canada, 2008.

[6] Corbett, C. and R. Klassen, Extending the Horizons: Environmental Excellence as Key to Improving Operations. *Manufacturing & Service Operations Management*, 8(1), 2006, pp. 5-22.

[7] de Corbiere, F., Data Quality and Interorganizational Information Systems: The Role of Electronic Catalogues. *15th Americas Conference on Information Systems (AMCIS)*, San Francisco [CA], USA, 2009.

[8] Delmas, M. and M. Montes-Sancho, An Institutional Perspective on the Diffusion of International Management System Standards: The Case of the Environmental Management Standard ISO 14001. *Business Ethics Quarterly*, 21(1), 2011, pp. 103-132.

[9] Eisenhardt, K.M., Building Theories from Case Study Research. *The Academy of Management Review*, 14(4), 1989, pp. 532-550.

[10] Forrester, J.W., Industrial Dynamics: a major breakthrough for decision makers, *Harvard Business Review*, July-August 1958, pp. 37-66.

[11] Frazier G., E. Maltz, K. Antia and A. Rindfleisch, Distributor sharing of strategic information with suppliers. *Journal of Marketing*, July 2009, pp. 31-43.

[12] Georges A. and A. Bennett, *Case studies and Theory Development in the Social Sciences*, Belfer Center for Science and International affairs, 2005, Harvard University.

[13] Hall, J., Environmental Supply Chain Innovation, *Greener Management International*, 35, 2001, pp. 105-119.

[14] Hamish, R., L. Oliver and N. Gow, Co-operating to Compete in High Velocity Global Markets: The Strategic Role of Flexible Supply Chain Architectures, *Annual Meeting of the Western Coordinating Committee on Agribusiness*, 2002, Las Vegas, USA.

[15] Hartono E., X. Li, K.S. Na and J.T. Simpson, The Role of the Quality of shared information in Interorganizational systems use. *International Journal of Information Management*, 30(5), 2010, pp. 399-407.

[16] Lambert D. and M. Cooper, Issues in Supply Chain Management. *Industrial Marketing Management*, 29(1), 2000, pp. 65-83.
[17] Lee H.L., V. Padmanabhan, and S. Whang, Information Distorsion in a Supply Chain: The Bullwhip Effect. *Management Science*, 43(4), 1997, pp. 546–558.
[18] Legner C. and J. Schemm, Toward the Inter-organizational Product Information Supply Chain – Evidence from the Retail and Consumer Goods Industries, *Journal of the Association for Information Systems*, 9(4), article 10.
[19] Madnick S., R. Wang, Y. Lee and H. Zhu, Overview and Framework for Data and Information Quality Research, *ACM Journal of Data and Information Quality*, 1(1), 2009, article 2.
[20] Madlberger, M., Can Data Quality Help Overcome the Penguin Effect? The Case of Item Master Data Pools. *19th European Conference on Information Systems*, Helsinki, Finland, 2011.
[21] Li, X. and Q. Wang, Coordination mechanisms of supply chain systems, *European Journal of Operational Research*, 179(1), 2007, pp. 1-16.
[22] Melville, N., Information Systems Innovation for Environmental Sustainability, *MIS Quarterly*, 34(1), 2010, pp. 1-21.
[23] Mentzer, J.T., W. DeWitt, J.S. Keebler, S. Min, N.W. Nix, C.D. Smith and Z.G. Zacharia, Defining supply chain management, *Journal of Business Logistics*, 22(2), 2001, pp. 1-25.
[24] Miles, M.B. and A.M. Huberman, *Qualitative Data Analysis*. Sage Publications, Thousand Oaks, 1994
[25] Pierce, E., What's in your information product inventory?, In Wang, R., E. Pierce, S. Madnick and C. Fisher (Eds.), *Information Quality*, M.E. Sharpe, Armonk, NY, pp. 99-114.
[26] Porter, M. and C. van der Linde, Toward a New Conception of the Environment-Competitiveness Relationship, *Journal of Economic Perspectives*, 9(4), 1995, pp. 97-118.
[27] Rai, A., R. Patnayakuni and N. Seth, Firm Performance Impacts *of* Digitally Enabled Supply Chain Integration Capabilities. *MIS Quarterly*, 30(2), 2006, pp. 225-246.
[28] Ramayah, T. and R. Omar, Information exchange and supply chain performance. *International Journal of Information Technology & Decision Making*, 9(1), 2010, pp. 35-52.
[29] Sadiq, S., N. Yeganeh and M. Indulska, 20 years of Data Quality Research: Themes, Trends and Synergies. *The 22nd Australasian Database Conference*, Sidney, Australia, 2011.
[30] Sarkis, J., Q. Zhu and K.h. Lai, An organizational theoretic review of green supply chain management literature. *International Journal of Production Economics*, 130(1), 2011, pp. 1-15.
[31] Simatupang, T. and R. Sridharan, The Collaborative supply chain: a scheme for Information sharing and incentive alignment. *International Journal* of *Logistics Management*, 13(1), 2002, pp. 15-30.
[32] Tan, K.C., A framework of supply chain management literature. *European Journal of Purchasing & Supply Management*, 7(1), 2001, pp. 39-48.
[33] Van Hoek, R., UPS Logistics and the move to 4PL - or not?, *Transportation and Logistics Educators Conference*, Philadelphia, USA, 2004
[34] Wang, E and H. Wei, Interorganizational Governance Value Creation: Coordinating for Information Visibity and Flexibility in Supply Chains. *Decision Science*, 38(4), 2007, pp. 647-674.
[35] Wang, F., X. Lai and N. Shi, A multi-objective optimization for green supply chain network design. *Decision Support System*, 51(2), 2011, pp. 262-269.
[36] Wang, R. and D. Strong, Beyond accuracy: what Data Quality means to data consumers. *Journal of Management Information Systems*, 12(4) 1996, pp. 5-34.
[37] Wiengarten, F. and P. Humphreys, Collaborative Supply Chain Practices and Performance: exploring the key role of information quality, *Supply Chain Management: An International Journal*, 15(6), 2010, pp. 463-473.