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Data Quality and Interorganizational Information Systems: The Role of Electronic Catalogues

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ABSTRACT

Electronic exchanges of information between Businesses have continued to grow. The question of data quality has always been understood to be an important area of research; but after 40 years, there is still a lack of research dealing with the quality of data exchanged between organizations. Even if the literature recognizes that Interorganizational Information Systems (IOSs) use can improve data quality, no research analyzes in depth how data quality can be improved by the implementation of an IOS. In this paper, we aim at understanding the contribution of electronic catalogues to data quality improvement in electronic data exchanges. Emerging from an exploratory case study of data flows between retailers and manufacturers in France, our results show that electronic catalogues can contribute to the improvement of several data quality dimensions.

Keywords (Required)

Data quality, Interorganizational Information Systems, electronic catalogues, retail industry, case study.

INTRODUCTION

Electronic exchanges of information between Businesses have continued to grow over the last decades (Elgarah, Falaleeva, Saunders, Ilie, Shim and Courtney, 2005). Electronic Data Interchange (EDI) and the Internet use are well-known examples of Interorganizational Information Systems (IOSs) in B2B exchanges (Christiaanse, van Diepen and Damsgaard, 2004; Zhu, Kraemer, Gurbaxani and Xu, 2006). Defined as "*automated information systems shared by two or more companies*" (Barret and Konsynski, 1982), IOSs are more and more needed to support interorganizational processes (Venkatraman, 1994). Organizations can benefit from IOS adoption and use in several ways: productivity, flexibility and competitiveness enhancement (Cash and Konsynski, 1985), transaction costs reduction (Malone, Yates and Benjamin, 1987), value creation (Porter and Millar, 1985)… Data quality improvement is presented by researchers as one of the advantages that companies can benefit from IOS adoption (Mukhopadhyay and Kekre, 2002), especially when data integration is achieved (Bergeron et Raymond, 1997; Zhu et al., 2006).

Data quality becomes a subject of greater importance and consequences of poor data quality are often underestimated by companies themselves (Balou and Pazer, 1985; Fisher and Kingma, 2001; Pierce, 2005). But even if data quality is a topic of growing interest since the beginning of the eighties (Nelly and Cook, 2008), there is still a lack of research dealing with the quality of data exchanged between organizations (Nicolaou and McKnight, 2006). Despite the potential impact of IOS use on data quality improvement assumed in the literature (Mukhopadhyay and Kekre, 2002; Zhu et al., 2006), no research analyzes in depth how the quality of data flows can be improved by the implementation of an IOS.

To invest this subject, we focus on the implementation of electronic catalogues in the French large retail industry in order to exchange product information (or product master data). Product information is defined as a set of data that represents the identifying, technical, logistical and marketing characteristics of a product (Becker, Matzner, Mueller and Winkelmann, 2008; GS1, 2006; Legner and Schemm, 2008). Over the last ten years, the retail and consumer goods industries have

developed standards and technologies to integrate product information from manufacturer's internal database to retailer's one through the use of electronic catalogues (Nakatani, Chuang and Zhou, 2006). We define an electronic catalogue as a repository of product information (article master data) that allows to exchange messages containing product information.

Because data quality is recognized to be a multidimensional concept (Zmud, 1978; Ballou and Pazer, 1985; Wand and Wang, 1996; Wang and Strong, 1996), our research question is the following: how the use of electronic catalogues to achieve product information flows from manufacturers' to retailers' internal databases can contribute to improve data quality dimensions? To answer this question, we follow a two steps analysis. Indeed, we think findings about data quality dimensions improvement by the use of electronic catalogues need to first analyze how electronic catalogues are implemented. In the following sections, theoretical basis of our research is first addressed. We then present our research design and the case study before discussing results.

THEORETICAL BACKGROUND

The theoretical basis of the research is a combination of two components. First, a literature review on IOS concepts is performed to specify electronic catalogues in a coordination exchanges perspective. Second, to understand the role electronic catalogues can play on data quality improvement, we present data quality definition and dimensions.

IOS concepts

Interorganizational relationships (IOR) involve resource exchanges between organizations (Ring and Van de Ven, 1994). Because of the necessity of coordinating these exchanges between organizations, coordination becomes a fundamental aspect of IOR success (Van de Ven and Walker, 1984). Coordinating information exchanges between organizations should have a real impact on their performance and leads to the development of IOSs (Porter and Millar, 1985).

IOS implies automation of data flows between companies, so that no human intervention is needed (Cash and Konsynski, 1985; Malone et al., 1987; Suomi, 1992). In the case of data flows from the sender's database to the receiver's one, automation is concerned by the way data are sent from the sender's database to the outbound of its internal system, by the way data are exchanged from the outbound of the sender's system to the inbound of the receiver's system, and by the way data are integrated in the receiver's internal database from the inbound of its internal system (Swatman and Swatman, 1991; Truman, 2000). So we do not consider only data transmission, but also data emission and data reception.

Automation can not be achieved without standardization. IOS standards are defined as "*a set of technical specifications that are agreed upon and used by IOS developers to describe data formats and communication protocols, which enable computer-to-computer communications*" (Zhu et al., 2006). The literature dealing with standards lets appear two major forms of standards (Christiaanse et al., 2004; Markus, Steinfield, Wigand and Minton, 2006). On one hand, when a company imposes its standards to its partners, we face the case of proprietary standards. On the other hand, industry or global standards are standards that are shared by all the companies of a sector.

Interorganizational coordination of data exchanges can be apprehended through different ways. For instance, some researchers have adapted the transaction cost theory (Williamson, 1985) to data exchanges in order to define electronic configurations of exchanges, such as electronic hierarchies and electronic markets (Malone et al., 1987; Bakos, 1991), electronic dyads and multilateral IOS (Choudhury, 1997). An another way to address coordination of data exchanges is the interdependence view of coordination between units initiated by Thompson (1967), who identified three ways in which units may be interdependent. The first is sequential interdependence, where the output from a unit becomes the input to the next one. Second is reciprocal interdependence, in which the outputs of each become the inputs for the others. Third is pooled interdependence, where units share common resources. Considering units to be the organizations involved and the resource to be the data, Kumar and van Dissel (1996) identified three types of IOS: pooled IOS, or hub-and-spoke IOS (Liu and Kumar, 2003), where data are centralized in a hub; value/supply-chain IOS characterized by sequential interdependence; and networked IOS where interdependence is reciprocal between companies (table 1).

EDI is for instance a typical supply-chain IOS, since data are shared through sequential interdependence between a seller and a buyer (Liu and Kumar, 2003). Electronic catalogues belong to a new wave of information technologies that cross boundaries of companies by the use of more open standards and the Internet (Christiaanse et al., 2004). Electronic catalogues emerged as a new opportunity to coordinate electronic data exchanges, through a pooled interdependence between companies (Legner and Schemm, 2008).

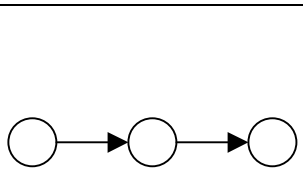
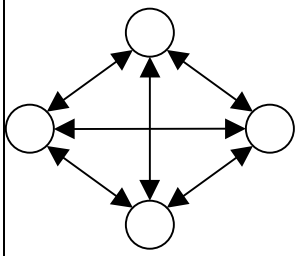
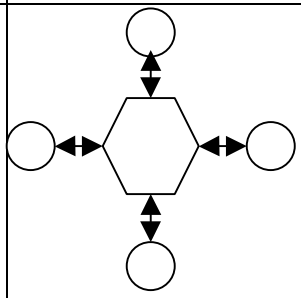
Interdependence	Sequential	Reciprocal	Pooled
Structure			
IOS	value/supply-chain	networked	hub-and-spoke

Table 1. Type of IOS in the interdependence view (Liu and Kumar, 2003)

To answer our research question dealing about the influence of electronic catalogues on data quality improvement, our results will first describe the forms of electronic catalogues that are implemented. However, we concentrate on their contribution to improved data quality without getting into the details on the form of the interorganizational interdependence. Indeed, we focus on electronic linkages between the previous existing IS of the company, the electronic catalogues implemented and its partners' IS.

Data quality

With more and more computerized applications, companies have been seriously concerned with data quality problems and have realized that poor data quality induces costs and risks (Balou and Pazer, 1985; Fisher and Kingma, 2001; Pierce, 2005). Because several definitions have been associated to the notion of quality (Reeves and Bednar, 1994), there is no single definition of data quality accepted by researchers. The most common view is that quality data are data that are fit for use (Lee, Strong, Kahn and Wang, 2002).

Feltham observed that "relevance, timeliness, and accuracy are often listed as desirable attributes of information" (1968, p. 684). Since then, data quality is recognized to be a multidimensional concept (Wand and Wang, 1996; Lee et al., 2002). Many researchers define the dimensions of data quality they consider to be relevant and measure them in order to explain classical phenomena in IS, such as user satisfaction (Bailey and Pearson, 1983; Ives, Olson and Baroudi, 1983) or IS success (DeLone et McLean, 1992). We rather focus on researches that try to empirically identify the dimensions of data quality. In that direction, researchers have explored different ways to conceptualize data quality since Feltham's contribution (Zmud, 1978; Ballou and Pazer, 1985; Lee et al., 2002). For instance, Wand and Wang (1996) proposed an ontological decomposition of data quality in four intrinsic dimensions: complete, unambiguous, meaningful and correct. Data quality defects that can occur are identified by comparing the data in the information system with the part of real world it represents. To introduce the subjective aspects of data quality, Wang and Strong (1996) addressed the following decomposition (figure 1).

Thanks to the research design conducted by Wang and Strong (1996), this decomposition in 15 dimensions of data quality is today recognized to be a major advance in data quality and information quality field. When most of the researchers dealing with data or information quality intuitively or theoretically identify the dimensions they consider to be relevant for their research, Wang and Strong (1996) identified data quality dimensions by studying what data quality means for data consumers. Beginning their research with 179 dimensions or attributes they found in the literature, their final decomposition is issued from their several steps analysis of the meaning data consumers were according to data quality.

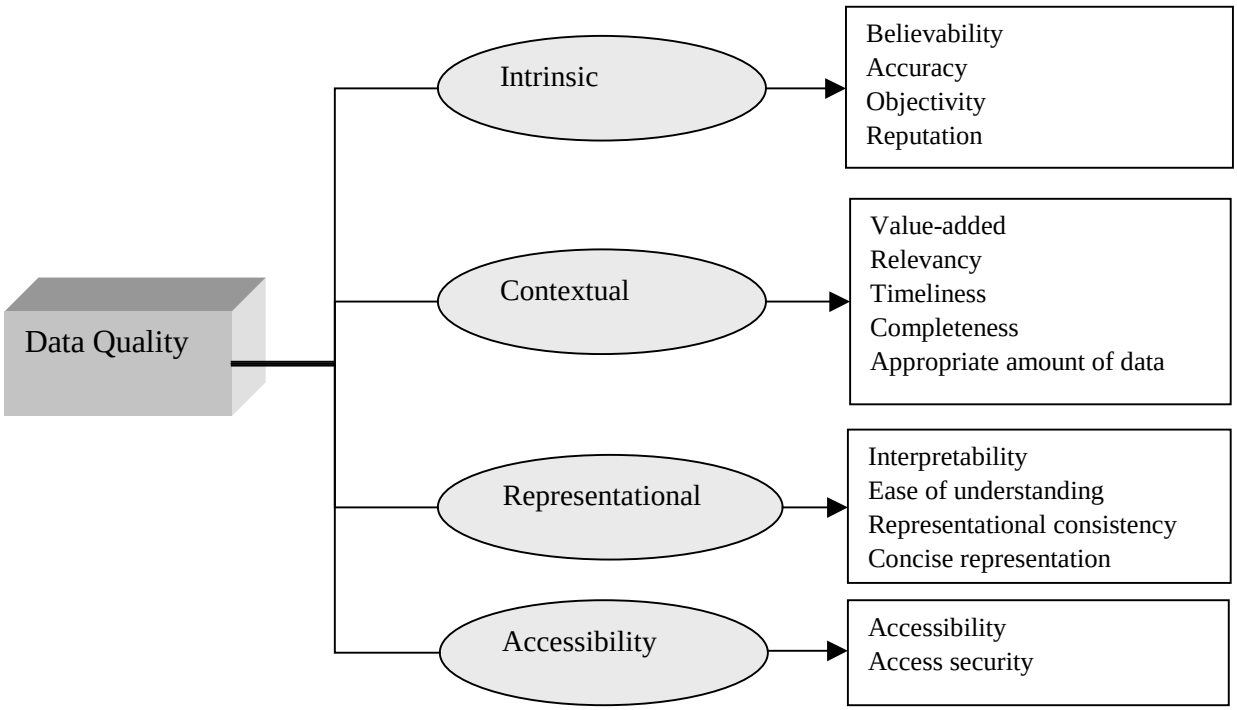


Figure 1. Data quality dimensions, adapted from Wang and Strong (1996)

We selected this decomposition to discuss about the expected impact of electronic catalogues on data quality improvement.

METHODOLOGY

Foundations

In this research, we followed a critical realism epistemology (Mingers, 2004). Indeed, we consider that the expected influence of electronic catalogues use on data quality improvement is independent from our conception, but that it can be only observed through social actors' representations. Qualitative methods seemed to be the most appropriate methods to address our research question, because they are recommended when the research aims at addressing a comprehensive framework of a contemporary phenomenon. Moreover, we followed recommendations addressed by Yin (2003). Because our research question is an how question, because we do not have any control over events and because of the emerging character of electronic catalogues, the research methodology chosen for this paper was an exploratory single case study.

Selecting the case of the French large retail industry, with each company as unit of analysis, was mostly derived from the research question (Miles and Huberman, 1994; George and Bennett, 2005). We aimed at understanding how the use of electronic catalogues to automate product information flows from manufacturers' to retailers' own information systems can participate to the improvement of data quality dimensions. Hence, we needed to take into account a sample of both retailers and manufacturers in the large retail industry. To conduct this case study with a maximum of variety on electronic catalogues implementation, we analyzed several sending companies (manufacturer) and receiving companies (retailer) in order to have a depth analysis of the large retail industry rather than a depth analysis of one retailer and/or one manufacturer.

Data collection and analysis

The retailers concentration in the French large retail industry allowed us to include all the seven major French retailers in our sample (Carrefour, Auchan, Casino, Système U, Leclerc, Intermarché, Provera). 95% of the market is in their possession. On the manufacturers' side of the relationships, we concentrated on companies implementing electronic catalogues in order to automate emission of product information. In that way, we focused on global companies and on French companies that have

national brands consumers find in every point-of-sales. At the end of data collection, 10 global manufacturers and 8 national ones were included in our sample.

As Miles and Huberman (1994), Yin (2003) or George and Bennett (2005) advise researchers to process, data were collected at different levels and through a variety of methods: semi-structured interviews, reviews of company and project documentation, reviews of electronic catalogues documentation. This triangulation of various techniques of data collection provides multiple perspectives on issues studied (Eisenhardt, 1989) and enhances the validity of the findings.

Primary source of data is issued from semi-structured interviews conducted between 2005 and 2007. Because we focused on building technologies, we interviewed managers that were responsible of electronic catalogues implementation. 40 interviews were tape-recorded and transcribed for data analysis. Interviews were approximately two hours in length and were designed as follows:

- In a first part, we aim at understanding the strategy of the company about electronic exchanges of data and in particular product information. One of the objective of this part was to verify that electronic exchanges of product information are motivated by data quality improvements.
- Then, we asked interviewees to describe how their company want to use electronic catalogues. This part of the interview was performed to analyze in depth how the company implement electronic catalogues to exchange product information with its previous internal IS and with the different electronic organizations proposed by its trading partners. Moreover, we asked interviewees to develop the characteristics they are according to electronic catalogues for product information exchanges, such as automation of flows, standardization, technical functionality...
- Finally, the final part of interviews was conducted to identify which dimensions of data quality are expected to be improved. From this point of view, we did not want to influence answers of interviewees. This part of interviews was designed in a very open structure, in order to let interviewees discuss about data quality defects their company faces with traditional exchanges of product information, before the use of electronic catalogues. In addition to identify these defects, our questions were then oriented to understand how interviewees estimate that electronic catalogues can contribute to eliminate, or at least reduce, these defects.

As recommended by Miles and Huberman (1994), a thematic qualitative analysis of the interviews was carried out through two steps of analysis. In descriptive analysis, data were summarized in line with pre-determined themes issued from the literature review performed (for instance the fifteen data quality dimensions) or with emerging themes issued from interviews (for instance the electronic catalogues characteristics we did not have anticipated). In this first step of analysis, we classified sentences or paragraphs issued from interviews in themes related to three main categories: the configuration of electronic exchanges through electronic catalogues, the characteristics of electronic catalogues, and the data quality dimensions that were considered to be improved. Through this method, data were first described in a logical and meaningful way. Then, in thematic analysis, the researcher analyzes cause-and-effect relationships between themes. Coding was performed with QSR N'Vivo software, in which data were linked to the themes. Then, interviews from a same company were associated. By the use of the software, we extract results, such as the number of companies estimating each data quality dimension can be improved or the number of manufacturers (retailers) implementing a specific configuration of electronic catalogues. We also extract the links between electronic catalogues characteristics we identified and data quality dimensions improvement.

THE CASE STUDY

Electronic catalogues implementation

Traditional methods already in use in the retail industry to exchange product information are not automated methods. In the absence of the technology, retailers face a combination of manufacturers sending product information by fax, another by Excel spreadsheet, another by phone, sometimes through several exchanges for a solely product information. Without the automation, the retail industry proposes a very manual, error-prone process.

The results of the data coding process allow us to identify two main forms of electronic catalogues. The first one refers to the implementation of an external electronic catalogue, also named Data Pool (Source Data Pool for manufacturers and Recipient Data Pool for retailers). 5 retailers and 10 manufacturers have chosen to use electronic catalogues as databases outside the boundaries of their information systems. The second form of electronic catalogue means the implementation of an internal electronic catalogue, also named Product Information Management (PIM). The 7 major retailers and 14 of the 18

manufacturers we studied have chosen to implement such a specialized database to manage product information in their own information system. Table 2 presents the different configurations of electronic catalogues implementation we face.

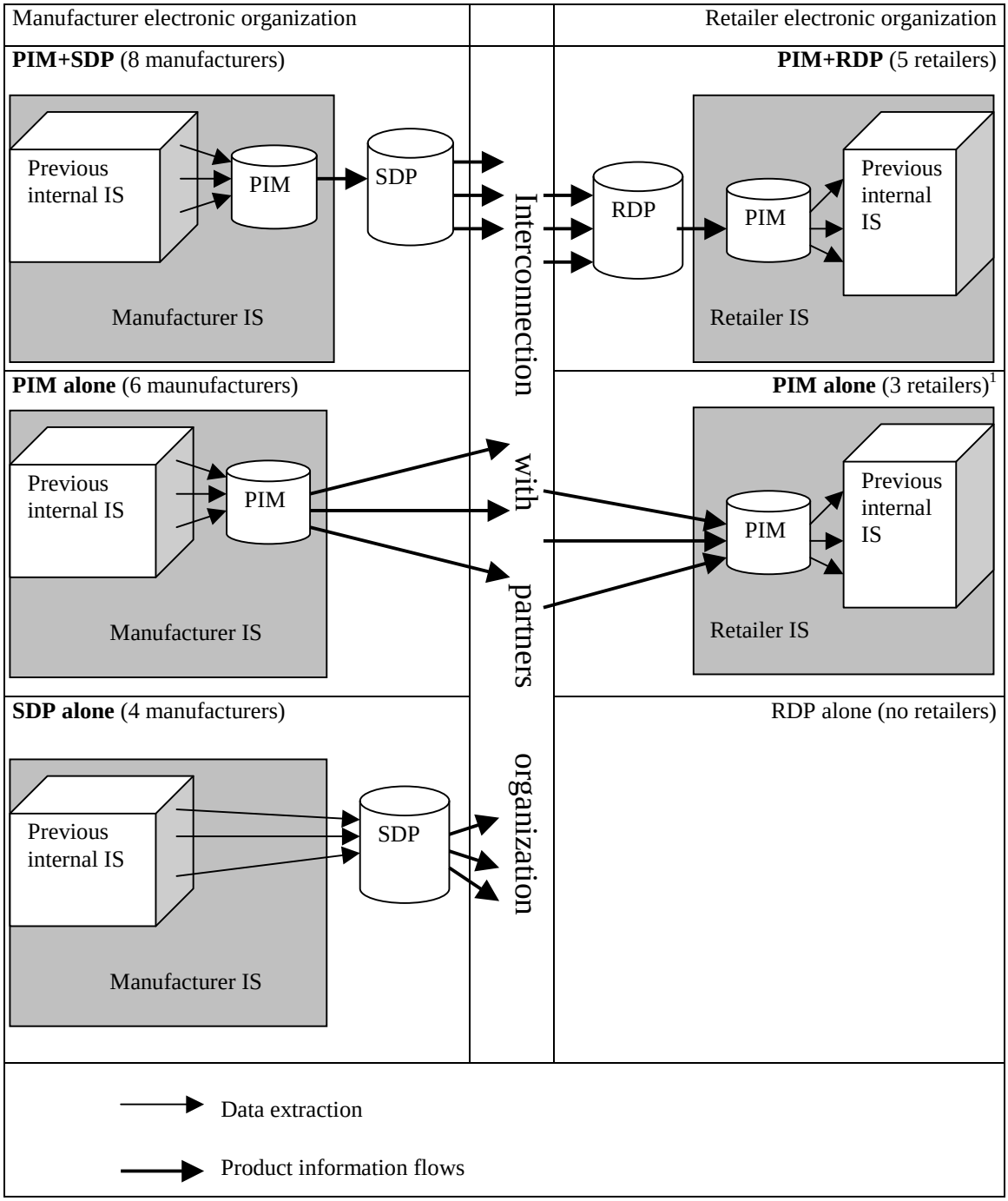


Table 2. Electronic catalogues implementation

Expected impact on data quality improvement

Product information flows by the use of electronic catalogues can contribute to improve several data quality dimensions. Without distinguishing the type of electronic catalogue implementation chosen by each companies, data analysis showed that

[1] One of the seven retailers combines reception through its RDP and direct reception through its PIM

12 of the 15 dimensions of Wang and Strong decomposition can be improved by the use of electronic catalogues from the interviewees' point of view. We specify in the second line of table 3 how many firms of the 25 we analyzed consider each dimension can be improved. Through the thematic analysis linking data quality dimensions and electronic exchanges, five elements of electronic catalogues use are associated to the improvement of these dimensions. Before developing their signification, we present the potential role of these five characteristics for the improvement of each dimension (tinted cells in table 3). In these marked cells, we indicate the number of firms that have linked the characteristic to the dimension improvement.

	Accuracy	Believability	Objectivity	Reputation	Value-added	Relevancy	Timeliness	Completeness	Appropriate amount of data	Interpretability	Ease of understanding	Representational consistency	Concise representation	Accessibility	Access security
Occurrence	25	25	21	13	11	12	25	25	12	0	17	19	0	12	0
Automation	16	16	20				25								
Data centralization			14	10										12	
Controls	15	21						25							
Data standardization					8	10			8		17	18			
Process standardization	12	12					20	18							

Table 3. Expected influence of electronic catalogues use on data quality dimensions improvement

Concerning the automation of data flows, companies estimate it is an opportunity to improve accuracy, believability, objectivity and timeliness. It is not because flows are automated that data are accurate and believable, since it depends on the value attributed to each data when it is created. But, contrary to traditional exchanges, automated exchanges reduce risks of inaccuracy or unbelievability by the fact data are only entered once. Additional human errors introduced during exchanges are avoided. In that sense, objectivity of data is also improved because they are certified not to be modified during exchanges. Moreover, timeliness is expected to be enhanced because data can be integrated faster in the retailers' information systems than when they are re-entered.

Data centralization is a key contribution of electronic catalogues and may have positive impact on objectivity, reputation and accessibility. When data are centralized, only one value is accorded per data exchanged, which is an advance in terms of objectivity. Moreover, data storage is centralized and data retrieval easier, so some companies consider that source reputation and accessibility are improved.

Among the functionalities proposed by electronic catalogues, computerized controls are expected to improve accuracy, believability and completeness. Coherence controls are performed by electronic catalogues to detect inaccurate or unbelievable data as often as possible. Using electronic catalogues also means completeness enhancement because product information with missing value can be rejected.

Implementing electronic catalogues is generally associated with a strategy to use global standards, developed by GS1 (association of retailers and manufacturers in order to build standards). The EAN.UCC data model allows to exchange data that were not previously exchanged. This is for instance the case of allergens or vines for wines. The appropriate amount of data, their value-added and relevancy, are considered to be enhanced by some of the companies of our sample. Moreover, using a standardized message to exchange product information is supposed to be an advance in terms of representational consistency and ease of understanding. Indeed, product information is presented in the same model for the communications with all the partners of the company and all the industry shares theoretically a common definition for each data.

Finally, project managers strongly estimate that electronic catalogues use also induces process standardization. Implementing electronic catalogues, companies share in a more common view the conditions of exchanges between different actors in the supply chain, and so they better know why and when product information has to be exchanged. Delays to exchange messages are constrained and expected to improve timeliness of data. Completeness of data may be enhanced since companies exactly know the data that have to been exchanged. Moreover, each retailer may benefit from controls performed by others to improve accuracy and believability since neutral data (such as the name of the product or its barcode number) are shared by all the retailers in the catalogue of the manufacturer involved.

DISCUSSION AND CONCLUSION

In this paper, considering the data quality dimensions identified by Wang and Strong (1996), we have shown how the use of electronic catalogues can contribute to data quality improvement. Indeed, from project managers' point of view, electronic catalogues use induces data centralization, automation of flows, data standardization, additional controls, and processes standardization. These elements are expected to have positive impact on several data quality dimensions.

A comparison between companies implementing external catalogues and those implementing only internal catalogues firstly appeared as a strong opportunity to discuss about the differences between sequential coordination of data flows and pooled coordination of data flows. Indeed, from a theoretical perspective, the implementation of external catalogues corresponds to the description of hub-and-spoke IOSs (Kumar and van Dissel, 1996) where data are shared by companies in a central hub, whereas their absence introduced supply-chain IOSs with sequential interdependence (Kumar and van Dissel, 1996). The implementation of internal catalogues without external ones induces that manufacturers send a message per retailer and retailers receive a message per manufacturer, so data are not shared with other companies than the two involved in the focused dyadic relationship. These considerations should be in line with results showing that external catalogues are expected to provide more data quality improvements, especially because data and process standardization should be greater. However, when we distinguished the results in terms of data quality improvement by comparing companies using external catalogues and those implementing only internal catalogues, no significant differences emerged. This result needs further explanations.

In fact, it appears that coordination of data exchanges by using electronic catalogues is not so simple and implies to discuss about the resource shared. Indeed, the use of external catalogues means that the technology is shared, but not necessarily the data. Some companies have decided to use an external data pool to centralize the flows of data, but these data are not stored in the external data pool. In this configuration, data are exchanged in a multilateral IOS (Choudhury, 1997) but through a sequential interdependence. When companies decided to exchange data without external data pool, they do not share the technology with other companies than the two involved in the dyadic relationship. So data are exchanged in an electronic dyad (Choudhury, 1997), but it does not mean that they are exchanged through a sequential interdependence. Indeed, some manufacturers have decided to send one message per retailer from their internal catalogue, but to send the same data, at the same time, to all the retailers. In this configuration, data are exchanged through a pooled interdependence. Considering data coordination in addition to electronic catalogues forms, a further research should be performed with a deeper analysis on the expected contribution in terms of data quality improvement of the four following types of electronic exchanges: sequential interdependence in multilateral IOSs, sequential interdependence in dyadic IOSs, pooled interdependence in multilateral IOSs, pooled interdependence in dyadic IOSs.

Finally, several limits of the research introduce further researches. Our results are issued from project managers' expectations. A complementary research should be performed to evaluate the expected impact of electronic catalogues use from data users' point of view, in order to compare the results with project managers' expectations. Moreover, we do not have distinguished the level of implementation in which each company is. According to Avison and Fitzgerald (2006), the System Development Life Cycle has the following basic structure: Feasibility study; System investigation; Systems analysis; Systems design; Implementation; Review and Maintenance. Some of the companies we have studied had projects that should be categorized in the systems design phase since the structure of the IOS they wanted to use was decided, but not the electronic intermediary supplying their electronic catalogue. Others were implementing their electronic catalogues, so that their project was in the implementation phase. The last ones had already implemented their electronic solution and were beginning to use it with some partners, so that their project should have been characterized in the review phase. A further research may compare results on data quality improvement expectations by distinguishing the phases in which projects can be categorized.

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