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From Ideal Data Synchronization to Hybrid Forms of Interconnections: Architectures, Processes, and Data

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Abstract

With the emergence of new technologies, companies can organize their electronic data exchanges by implementing hybrid interorganizational information systems (IOS). This paper presents a new analytical framework by considering IOS as the product of interconnections between the parts of IS developed by connected firms to support a given interorganizational process. We focus on updating internal databases through data synchronization between a set of suppliers and a set of clients. From the literature, we built types of sending and receiving systems based on three variables; namely, shared data, structural linkages, and message interdependency. Analytically, we derived possibilities of interconnections between these sending and receiving systems with asymmetric characteristics. In a field study, we empirically investigated IOS built to support product information flows from suppliers' to retailers' internal, databases by considering how suppliers built their sending systems, how retailers built their receiving systems, and how their interconnections led to different forms of IOS. Interconnections occurring between systems with asymmetric characteristics show the existence of several hybrid forms of IOS, both in design and use. We finally explain that, even if companies can benefit from their use, hybrid forms are less efficient than are extreme forms, those that are the result of interconnections between systems with symmetric characteristics.

***Keywords**: Interorganizational Information Systems, Analytical Framework, Sending Systems, Receiving Systems, Interconnections, Structural Linkages, Shared Data, Message Interdependencies, Product Information Management.*

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1. Introduction

IS research has long investigated how and why companies integrate their systems (Tanriverdi, Rai, & Venkatraman, 2010). Electronic data exchanges promise to eliminate manual data entry steps and remove proprietary data standards, which yields system integration and cost reduction. With Internet-based interorganizational information systems (IOS) such as extranets, electronic catalogues and electronic marketplaces (Sila, 2010; Williamson, Harrison, & Jordan, 2004), one of the next steps of data exchange development is synchronizing the data that are common between companies and their multiple business partners. In interorganizational relationships, data synchronization keeps partner firms from having to re-enter data because a single update ripples accross the firm and its multiple partners through all the relevant systems. This benefits companies by not only saving time but also avoiding errors and improving data integrity. With data synchronization, linked companies automatically update the data they share (Legner & Schemm, 2008) and thus improve multilateral data integration.

However, companies can choose to implement technologies that provide bilateral rather than multilateral data synchronization (de Corbière & Rowe, 2011; Nakatani, Chuang, & Zhou, 2006). In addition, companies are often faced with questions about how to interconnect the IOS part that they have built with those parts developed by their partners, many of whom may have different types of data and relationships. As such, system designs may vary in their architectures, data standards, and processes (Markus, 2000; Rai, Sambamurthy, & Agarwal, 2008; Steinfield, Markus, & Wigand, 2011). We need to better understand how systems controlled by different parties with different characteristics can be synchronized and how such interconnections lead to hybrid IOS that are defined as interconnected systems with different design characteristics.

Studying how hybrid forms of IOS interconnect and synchronize is important for two main reasons. First, practically, a better knowledge of hybrid forms allows managers to design their own systems because they will know ahead the interconnection possibilities with their partners. Thus, firms can synchronize data without forcing partners to adopt a single standardized model (or being forced to themselves). Second, theoretically, while the extant literature focuses on an IOS as a single system (Lyytinen & Damsgaard, 2011; Robey, Im, & Wareham, 2008), it misses a portion of the actual IOS; that is, those that "emerge" from systems developed independently by each business partner and that subsequently have to interface (Gosain, Malhotra, El Sawy, & Chehade, 2003). This suggests that researchers need to analyze such IOS as comprising three or more subsystems—two or more of which are developed separately by each firm, while a distinct subsystem is the interface permitting interconnectivity between these original firm subsystems. Understanding IOS synchronizing data between trading partners in multilateral networks is dependent on the description of: the systems the senders build, the systems the receivers build, and interconnections between these systems. Hence, we need to examine when and why sending and receiving systems are compatible. In addition, because they are understudied in the literature, we need to identify which hybrid forms of IOS built with different (asymmetric) characteristics exist, and to examine their efficiency relative to symmetric systems.

Accordingly, the research question is "How can sending and receiving systems that are designed with asymmetric characteristics be interconnected for data synchronization and form hybrid IOS?". To provide answers to this question, this study: 1) analyzes the possibilities for interconnections between sending and receiving systems that are designed with asymmetric characteristics, 2) examines through a field study whether and how instantiations of such resulting combinations occur, and 3) discusses the relative efficiencies of hybrid forms.

To deal with the issue of the possible forms of IOS managing data synchronization, we investigate product information exchanges between consumer goods and retail industries. Product information pushes the technical frontier of electronic data exchanges because: a) it contains unstructured and loosely structured information such as textual descriptions of products, b) it contains dimensional information (products come in many sizes, colors, and logistical units, each of which must be unambiguously differentiated from the others), and c) it contains relatively invariable information (e.g., product descriptions) and variable information that may be unique to each partner who purchases the product (e.g., price and delivery terms). The object investigated overcomes the limitations of EDI theory-building research (Robey et al., 2008), which only concerns transactional data and not a broader set of IOS, particularly those that exchange process-level or contextual data (van der Aalst & Kumar, 2003; D'Aubeterre, Singh, & Iyer, 2008; Legner & Schemm, 2008; Rai & Tang, 2010).

We thus contribute to the IOS literature in three ways. First, we provide an analytical framework that integrates three important variables of IOS for data synchronization, and discuss systematically how they can be combined to build hybrid forms with asymmetric characteristics. Second, we empirically explore the existence of the diverse hybrid forms by focusing on contextual information between manufacturers and retailers, and thereby go beyond beyond the traditional perspective of transactions. In particular, this exploration allows a better understanding of how systems that are designed differently can interconnect. Third, we explain the inferior performance of hybrid forms of IOS relative to systems built with symmetric characteristics.

This paper is organized as follows. In Section 2, we review the literature on data synchronization and the three variables—structural linkages, message interdependencies, and shared data—that we use to characterize IOS. This leads us to infer an analytical framework (Section 3) in which we derive a typology of systems built by each firm, and the possibilities for interconnections by discussing logically the combinations of variables and their corresponding characteristics. In the methodology Section 4, we describe the field of application we focus on—product information management in the French retail and consumer goods industries—and the field study methodology conducted to investigate whether and how some of the combinations we have identified theoretically occur. In Section 5, the results indicate that our proposed framework can be used to categorize the various instantiations of hybrid forms for data synchronization. In the discussion Section 6, we note that hybrid forms of IOS exist from diverse variable considerations, and explain why they remain less efficient than do forms reflecting interconnections between systems involving symmetric characteristics. In Section 7, we conclude by indicating areas for future research.

2. Data Synchronization and Related Variables in an Integration Perspective

Section 2.1 first presents data synchronization and how it can be analyzed with three main dimensions of IOS: architectures, data, and processes (Rai et al., 2008; Steinfield et al., 2011). Accordingly, we describe ideal data synchronization as it is presented in the literature. In Section 2.2, we introduce other possible forms of IOS for data synchronization and review how the IOS literature treats the three selected variables.

2.1. Data Synchronization in a Multilateral Perspective

2.1.1. Data Synchronization Definition and Analysis

Data synchronization in IOS represents the process involving the timely updating of data between business partners (Legner & Schemm, 2008; Nakatani et al., 2006). With automated updating, data consistency is improved across supply chain partners (Rai, Patnayakuni, & Seth, 2006). The principle of automated updating between business partners' databases is not new (Barrett & Konsynski, 1982). In 1987, Malone, Yates, and Benjamin explained that the evolution of a supplier/buyer relationship should lead to continuous sharing of information following three stages. With a standalone database, a company lets its trading partner access it for queries and updates with human intervention. With linked databases, supplier and buyer databases are separated but interfaced for automatic exchanges. A shared database contains information for both parties. Data synchronization as defined earlier concerns the second case.

The objective for partners is to have in their respective databases the same values for the data they have in common. Data synchronization between databases of trading partners focuses mainly on exchanges related to contextual information, rather than transactional information per se (Legner &

Schemm, 2008). Whereas transactional information is exchanged to coordinate the physical demand and supply chain, contextual information exchanges aim at guaranteeing that partners share current data characterizing products, prices, or companies. Upstream of commercial transactions, IOS that support data synchronization are thus systems for collaborative purposes (Chatterjee & Ravichandran, 2004; Lee, Aggarwal, Shin, Cha, & Kim, 2006; Holland & Lockett, 1997; Romano, Pick, & Roztocki, 2010).

Data synchronization, as a form of electronic data exchange, is a collective action problem (i.e., a problem that should be considered not only at an interorganizational level with one partner, but also at the level of a network of partners) (Lyytinen & Damsgaard, 2011; Markus, Steinfield, Wigand, & Minton, 2006). In the network theory perspective, multilateral networks description requires consideration of the structure of relationships, the governance of the network structure, and the content of each relationship (Provan, Fish, & Sydow, 2007). In IS, key constructs that differentiate multilateral networks are: the structure of linkages, the governance of the network, and the content of what is shared through the links (Bakos, 1991; Gosain et al., 2003; Rai et al., 2008; Tang, Rai, & Wareham, 2011). In particular, for analyzing the design and implementation of IOS, Steinfield et al. (2011) consider the architecture of linkages, the exchange process, and the data standard used as the three fundamental dimensions (Steinfield et al., 2011).

In line with this stream of research, we thus consider for data synchronization: 1) the structural linkages between the databases involved (Bakos, 1991; Choudhury, 1997), 2) the coordination of data flows between these databases (Gosain et al., 2003; Legner & Schemm, 2008), and 3) the shared data (i.e., the set of data that is exchanged and included, or not, in data standards) (Gosain et al., 2003; Steinfield et al., 2011). In the following sections, we review how the literature presents the ideal form of data synchronization, and how it can more precisely conceptualize these three dimensions: 1) structural linkages can be very different (one to one, one to many or many to many) across multilateral networks, 2) when we consider several senders and several receivers, data flows can be coordinated according to various schemes, and 3) shared data that are exchanged can include private data or not, in addition to the standard data.

2.1.2. Ideal Data Synchronization

In the literature, data synchronization systems are presented in their ideal form (see Legner & Schemm, 2008; Nakatani et al., 2006). Ideal data synchronization occurs with GDSN (global data synchronization network). GDSN encompasses an architecture (a network of electronic catalogues) and standards for the firms to interconnect their IS. Table 1 describes how GDSN[1].

Consequently, several buyers can subscribe to a given product, and, when the supplier updates data for this product, data are synchronized with these buyers. Thus, for data synchronization analysis, the bilateral perspective of the diverse databases for the automated updating proposed by Malone et al. (1987) has to be extended to a multilateral perspective because, in its ideal form, data synchronization is achieved in a multilateral structure. Moreover, the data standard includes only common data that are exchanged between one supplier/manufacturer and its clients/retailers. We thus face point-to-multipoint flows of data in a sharing interdependency of common data. Consequently, if firms faithfully implement data synchronization as conceived by industry consortia under the GS1 umbrella, sending and receiving systems built by manufacturers and retailers have the following main characteristics:

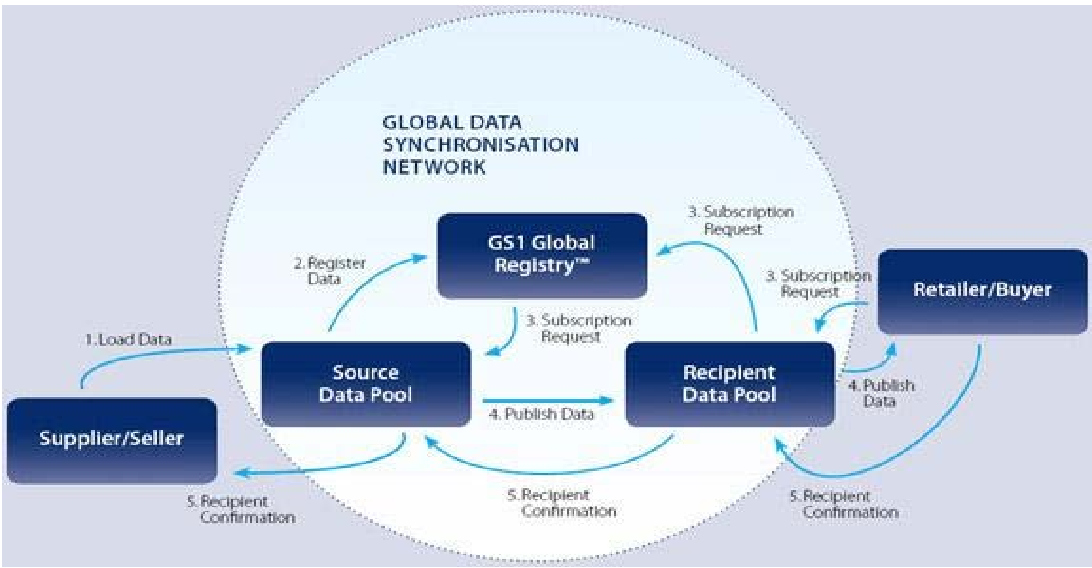
- In terms of architecture, multilateral linkages are implemented so that each firm builds one logical link to communicate with all its partners. Practically, companies implement external electronic catalogues, or data pools, that are GDSN certified.

- In terms of data standards, each firm implements the GS1 data standard that includes only common data; that is, data that are independent from the bilateral relationship between one supplier and one client.

[1] http://www.gs1.org/gdsn/ds/how

- In terms of coordination processes, each firm respects the GDSN point-to-multipoints flow of data, so that messages from one supplier are shared between several retailers.

Table 1. GDSN Principles (How GDSN Works, n.d.)
There are five steps that allow trading partners to synchronize item, location and price information with each other (Figure 1): 1. Load data: The seller registers product and company information in its data pool. 2. Register data: A small subset of the data is sent to the GS1 Global Registry. 3. Subscription request: The buyer, through its own data pool, subscribes to receive a seller's information. 4. Publish data: The seller's data pool publishes the requested information to the buyer's data pool. 5. Recipient confirmation: The buyer sends a confirmation to the seller via each company's data pool, which informs the supplier of the action taken by the retailer using the information. The GS1 global registry is the GDSN's "information directory" that details who has subscribed to trade item or party data, guarantees the uniqueness of the registered items and parties, and ensures that all data pools in the network comply with a standards-based set of validation rules.



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- In terms of coordination processes, each firm respects the GDSN point-to-multipoints flow of data, so that messages from one supplier are shared between several retailers.

2.2. From Ideal to Other Forms of Data Synchronization: An Investigation of Three Variables

As with all electronic data exchange systems, companies make independent choices in the design and the implementation of the part of the IOS for which they are responsible. Consequently, companies may choose characteristics that depart from the ideal case for each variable highlighted as being essential in the above data synchronization analysis. Following the theoretical analysis of data synchronization, sending and receiving systems that are interconnected for data synchronization may differ on three variables that are essential for characterizing them: structural linkages representing the implemented architecture, shared data included in data standards, and message interdependencies reflecting data processes.

2.2.1. Structural Linkages: An Essential Variable for Describing Architectures

From a cost-effectiveness viewpoint, in its ideal form, data synchronization is realized in a multilateral IOS. A multilateral system provides many-to-many interconnections between multiple buyers and sellers (Choudhury, 1997; Robey et al., 2008). From a structural point of view, a multilateral IOS consists of building a single logical interorganizational link for each firm to communicate with a large number of trading partners (Choudhury, 1997). For each firm, an electronic intermediary provides an external database that centralizes data to be sent to, or received from, the partners of the firm. When different, electronic intermediaries who manage the external databases have to interface with each other for sending and receiving systems to interconnect.

The part of the literature that focuses on electronic markets has highlighted instantiations of such IOS, especially electronic marketplaces (EMPs) (O'Reilly & Finnegan, 2010; Soh, Markus, & Huat, 2006). Among the four types of IOS described by Rodón and Sesé (2010), markets are typically multilateral IOS. Hubs and nets are outside the boundaries of IOS for data synchronization because they reflect configurations of IOS with non-standardized rules. However, hierarchies authorize data integration for the timely updating of data in dyadic relationships.

Electronic hierarchies have mainly been described through EDI, which is implemented by companies that have existing commercial relationships in order to automate existing manual processes (Riggins & Mukhopadhyay, 1994; Subramani, 2004). For some time, the migration from proprietary networks and standards to more open networks (i.e., Internet) and standards (such as Extensible Markup Language (XML) Schemes) has been engaged in order to limit costs (Christiaanse, van Diepen, & Damsgaard, 2004; Zhu, Kraemer, Gurbaxani, & Xu, 2006). However, Web-EDI systems do not change the EDI principle of point-to-point data exchanges between two companies. This form of IOS provides one-to-one interconnection in each dyad without the intervention of an electronic intermediary (Damsgaard & Truex, 2000). Schematically, interconnection occurs between the internal IS of the partners, with each internal IS performing the functionality of sending or receiving the data. In an industry analysis encompassing a set of suppliers and buyers, interconnections between these sending systems and receiving systems lead to electronic dyads (Choudhury, 1997). In electronic dyads, each firm builds one logical link with each of its partners.

In addition to the one-to-one and many-to-many interconnections presented above, we need to consider the one-to-many interconnections that IOS provide. These are presented by some researchers as a third type called private trading exchanges (Soh et al., 2006), sell-side/buy-side B2B systems (Turban & Volonino, 2008), or electronic shopping/broadcast sales systems (Choudhury, 1997). However, from a structural point of view, Choudhury (1997) views these systems as specific types of multilateral IOS. Indeed, in a focal firm analysis, the focal firm builds one logical electronic linkage with the intermediary to communicate with several partners. In a multilateral networks analysis, we finally face hybrid forms of IOS between some firms implementing dyadic linkages, whereas others implement multilateral linkages.

2.2.2. Shared Data: An Essential Variable for Distinguishing Data Standards

The data that are shared constitute an essential variable for understanding how data are exchanged and integrated in interorganizational relationships. For data synchronization, we propose to differentiate the shared data that are integrated in data standards in terms of private versus common data. In 1991, Bakos insisted on the need to distinguish types of exchange according to the data exchanged. He explained that bilateral integration is relevant for transactional data that are dependent on the specific relationship between one seller and one buyer. Typically, EDI for transactional data exchanges is an instantiation of information links, as defined by Bakos (1991). Conversely, electronic markets mean investments in multilateral information sharing that is more convenient with common data; that is, those that are not dependent upon specific negotiations between sellers and buyers, such as market prices and product offerings a seller wants to provide to several buyers (Bakos, 1991).

In particular, we know the importance of data privacy in B2B relationships (Bensaou, 1997; D'Aubeterre et al., 2008; Klein & Rai, 2009), in B2C relationships (Culnan & Armstrong, 1999), and e-commerce (Dinev & Hart, 2006). Consistent with this portion of the literature, this research asks how the data that are shared influence the choice of a particular form of electronic exchange. For data synchronization, we define private data as data that are issued from specific negotiations between suppliers and clients. Typical private data are negotiated prices between a supplier and a client. In contrast, common data are independent of dyadic negotiations, and can be shared among a set of trading partners. Typical common data are brand names. It is particularly important to take into account the data exchanged in the multilateral perspective that is proposed in the ideal form of data synchronization. Indeed, whereas common data may be synchronized between more than two companies, private data have to be synchronized between the supplier and the client of the concerned dyad. This means that when a company introduces private data in its data standard, data cannot be synchronized in the ideal form of data synchronization.

2.2.3. Flow of Messages: An Essential Variable for Describing Data Processes

In the ideal form of data synchronization, data exchanges are coordinated in a hub-and-spoke IOS (Kumar & van Dissel, 1996; Liu & Kumar, 2003). Hub-and-spoke IOS are characterized by pooled interdependence because data are common resources shared by several companies in a hub. Thus, data are processed in a point-to-multipoint flow of messages (Rai et al., 2008). However, companies can also conceive their systems to synchronize data in a point-to-point flow of messages with each of their business partners, which reflects sequential interdependencies in value/supply chain IOS (Kumar & van Dissel, 1996).

To address data processes, we propose analyzing data flows from the interdependency perspective by the use of coordination theory, in which Malone and Crowston (1990; 1994) define coordination as the management of dependencies between activities. Malone et al. (1999) propose three universal types of dependencies: 1) flow dependency, where the resource created by an activity serves as an input for another activity in a sequential step; 2) sharing dependency, where a resource is pooled for several activities; and 3) fit dependency, where two activities co-create a resource together. Considering the coordination of data flows between databases imply a focus on interdependencies of messages between data emission and data reception (Figure 2). In the flow interdependency of messages, data are not shared with companies other than with the focused sender and receiver, and therefore we face a combination of independent flows of data, each from one sender to one receiver. Sharing interdependency of messages means that data from senders are shared with several receivers through a database that acts as a hub. Fit interdependency of messages means that data from several senders are combined to be sent to receivers through a hub.

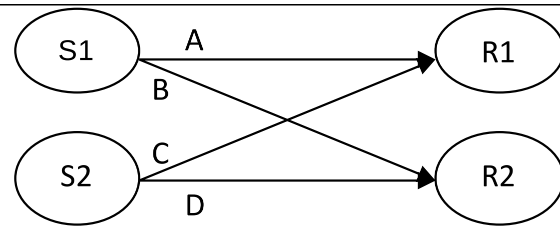
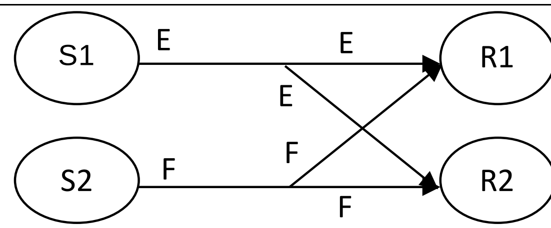
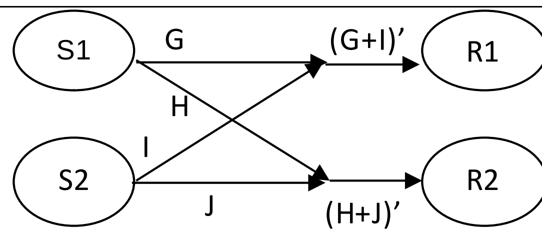
Interdependency	Configuration
Flow Messages A and B (and C and D) are independent. Data in messages can be identical or not	
Sharing Messages E and F from senders are shared between several receivers	
Fit Messages G and I (and H and J) are joined in new messages: resulting messages are combinations of data from different sources	

Figure 2. Interdependency of Messages Configurations for Data Synchronization

In ideal data synchronization, data are processed in sharing interdependencies of messages. However, companies can also synchronize data in dyadic relationships, in which data are processed in a flow interdependency of messages.

3. Analytical Framework: From Ideal to Hybrid Forms of IOS

Considering the literature review conducted on the three variables that are essential for describing data synchronization alternatives, the flow interdependencies of messages seem to be in line with the structure of data flows proposed in electronic dyads, and sharing interdependencies with that of data flows proposed in multilateral IOS. Previous research has presented IOS archetypes based either on structural linkages (Choudhury, 1997) or on interdependency of data (Kumar & van Dissel, 1996). In relationship with the common versus private data (D’Aubeterre et al., 2008), one could conclude from this literature that:

- Multilateral IOS are more convenient to coordinate sharing interdependency of messages (especially when companies exchange common data that are independent of dyadic relationships) by exemplifying the ideal form of data synchronization.

- Electronic dyads are more convenient to coordinate flow interdependency of messages (especially when companies exchange private data that are dependent upon each dyadic relationship).

In addition to these two classic forms of IOS, this research investigates whether other forms, especially hybrid forms, exist for data synchronization. In Section 3.1, we first characterize sending and receiving systems that firms may implement, and then articulate possibilities of interconnection. These sequential steps would allow us to better describe the resulting IOS and to highlight hybrid forms of IOS from an analytical point of view.

3.1. Analysis of Sending and Receiving Systems

From the literature analysis, in order to characterize an IOS for data synchronization, we consider structural linkages, interdependencies of messages, and shared data as the three variables that characterize the sending (or receiving) system firms build to synchronize data with their partners. To identify sending and receiving systems that firms may build, we combine the three variables by considering their compatibilities and incompatibilities. At the message level, data privacy influences data processes. Between a sender and a receiver, private data are defined as data that are dependent on the dyadic relationship, and thus as data that cannot be integrated into a message that is shared among several receivers. Messages containing private data cannot be coordinated through sharing interdependency, whereas both sharing and flow interdependencies can be managed by message flows when only common data are exchanged.

In addition, structural linkages influence the coordination mechanisms that drive message flows. We can link the typology of Choudhury (1997) for logical electronic linkage and considerations with message interdependencies (Malone et al., 1999). When electronic dyads are used, firms build individual logical links with each of their partners, and thus message flows between partners can only manage flow interdependencies. Indeed, even if a firm sends a common message to two partners when it uses dyadic linkages, the message is exchanged twice with each of its partners. We thus face two parallel flows of the same message, and, even if the two partners receive the same message, the receptions are independent, and thus sharing interdependency cannot be managed during exchanges. Consequently, sharing interdependencies cannot be managed with dyadic linkages. In contrast, if a multilateral IOS is used, the firm builds a single logical link to communicate with all its trading partners. Thus, both flow and sharing interdependencies can be managed by the coordination of messages when multilateral linkages are used.

Table 2 presents the diverse types of systems each firm can build to synchronize data with its partners. As underlined in the previous paragraph, there are incompatibilities between dyadic linkages and sharing interdependencies, and between private data and sharing interdependencies. Thus, from a logical perspective, firms may build five different sending (or receiving) systems by combining their choices of structural linkages (dyadic and multilateral linkage), shared data included in messages (presence or absence of private data), and message interdependencies (flow and sharing). For instance, firms implementing system V exchange each message that contains some private data with only one partner, without the use of an external database. In contrast, firms implementing system I implement a GDSN-compliant system.

Table 2. Types of Sending Systems and Receiving Systems

Structural linkages	**Multilateral linkages**				**Dyadic linkages**			
Shared data	Only common		Including private		Only common		Including private	
Messages interdependency	Sharing	Flow	Sharing	Flow	Sharing	Flow	Sharing	Flow
System type	I	II	Imp.	III	Imp.	IV	Imp.	V

3.2. Analysis of IOS Resulting from Interconnections

From a logical viewpoint, following the analytical distinction of the five types of sending and receiving systems, 25 interconnections can occur (Table 3). Interconnections between systems with symmetric characteristics have long been described in the literature. For instance, EDI is typically an instantiation of IOS resulting from interconnections between sending system V and receiving system V. In cell SVRV, the resulting IOS provides bilateral exchanges of point-to-point flows of messages, including private data, such as the exchange of orders from one customer to one supplier. At the opposite end of the spectrum, interconnections between sending system I and receiving system I represent the ideal form of data synchronization (Legner & Schemm, 2008).

Table 3. Interconnections Between Sending and Receiving Systems

		Receiving system				
		I	II	III	IV	V
Sending system	I	SIRI: Ideal data synchronization system	**SIRII: Hybrid**	**SIRIII: Hybrid**	**SIRIV: Hybrid**	**SIRV: Hybrid**
	II	**SIIRI: Hybrid**	SIIRII: Symmetric system	**SIIRIII: Hybrid**	**SIRIV: Hybrid**	**SIRV: Hybrid**
	III	**SIIIRI: Hybrid**	**SIIIRII: Hybrid**	SIIIRIII: Symmetric system	**SIIIRIV: Hybrid**	**SIIIRV: Hybrid**
	IV	**SIVRI: Hybrid**	**SIVRII: Hybrid**	**SIVRIII: Hybrid**	SIVRIV: Symmetric system	**SIVRV: Hybrid**
	V	**SVRI: Hybrid**	**SVRII: Hybrid**	**SVRIII: Hybrid**	**SVRIV: Hybrid**	SVRV: Typical EDI system

Beyond the case of interconnections between systems with symmetric characteristics, the interesting issue is examining the diversity of interconnected systems when sending and receiving systems have been designed differently. In particular, resulting hybrid IOS are issued from interconnections between sending and receiving systems that present asymmetric characteristics for at least one of the three variables presented above as being essential. A priori, there are no incompatibilities between the characteristics of the considered variables for the systems to be interconnected. We thus choose to investigate whether the following hybrid (H) IOS occur:

- Data hybrid, resulting from the interconnection between a system built to exchange both common and private data and a system built to exchange only common data,
- Process hybrid, resulting from the interconnection between a system built to coordinate messages in flow interdependency and a system built to coordinate messages in sharing interdependency,
- Structure hybrid, resulting from the interconnection between a system built to exchange data by the use of dyadic linkage and a system built to exchange data by the use of multilateral linkage.

In order to refine the analytical framework, we need to identify "what is" (Gregor, 2006, p. 620). Thus, the empirical part of the paper describes the different forms of IOS performing data synchronization that actually exist in the field. Analyzing the existence of hybrid forms for data synchronization seems to be particularly valuable at the time of XML schemes development. XML schemes proposed by industry consortia facilitate the development of interoperability frameworks (Gosain, Malhotra, & El Sawy, 2004). Thus XML standards allow the conception, implementation, and use of data synchronization in its ideal form, but also facilitate IS interconnections that have been designed differently. Issued from the implementation of these new standards, the diverse IOS performing data synchronization may support different degrees of synchronization. Following the definition of data synchronization (Legner & Schemm, 2008; Nakatani et al., 2006), a high degree of synchronization is close to realtime updating between multiple partners. In this view, the degree of data synchronization depends on the number of databases involved during exchanges, on their functionalities, and on mechanisms that coordinate exchanges.

Via refining the analytical framework, we are ultimately able to investigate performance. Performance is recognized to be an important outcome of IOS (Robey et al., 2008), especially for those developed for better integration of data in interorganizational relationships (see Bensaou, 1997; Johnston & Vitale, 1998; Patnayakuni, Rai, & Seth, 2006; Truman, 2000). Performance outcomes of data synchronization systems in terms of value/cost considerations will be addressed in the discussion section. In Section 6.3, we argue that hybrid forms of IOS are less efficient that IOS forms issued from interconnections between systems with symmetric characteristics.

4. Methodology

The methodology employed was prescribed in order to find empirical evidence of interconnections between sending and receiving systems that are designed differently and that have not yet been presented and discussed in the previous literature on IOS. Moreover, data synchronization between manufacturers' and retailers' databases is relevant when investigating the previous questions. Product information exchanges include considerations about data privacy and structural linkages that question the coordination mechanisms that manage interdependencies. We thus investigate the conditions of the existence of 25 possibilities of interconnections proposed in Table 3 between sending and receiving systems I to V (see Table 2).

4.1. Research Design and Field

To find whether hybrid forms of IOS can exist and how they were used to support a given process in an industry, we conducted a field study. We selected qualitative methods because our research objectives require a deep understanding of the sending/receiving systems and of their interconnection possibilities from the firms' perspectives. The research design is comparable to a "multiple cases, multiple embedded units" design (Yin, 2003), where the units of analysis in this field study are the individual manufacturers and retailers embedded in dyadic supplier-buyer relationships and operating in France. Indeed, in order to present and discuss several types of interconnections between sending and receiving systems, we needed to analyze a certain number of firms (cf. 4.2).

We offer here a specific explanation of the IOS we analyzed. We focused only on systems that allowed integration of data from manufacturers' internal databases into those of retailers, and thus we did not include IOS such as Extranets, proposed by some retailers for their suppliers to re-enter the data. Extranet allows data integration from the retailer's point of view, but not from the manufacturer's point of view, and thus data cannot be synchronized with automated updating.

Systems interconnection is important in the retail industry in order to synchronize data between internal databases of manufacturers and retailers (Legner & Schemm, 2008). This is particularly the case in France where discount operations are very frequent and where a large product assortment is offered in every point-of-sale. Over the last ten years, the retail industry has developed standards and technologies to exchange product information from manufacturers' to retailers' internal databases through the use of electronic catalogues (Legner & Schemm, 2008; Madlberger, 2011; Nakatani et al., 2006). We define these as electronic data pools that contain data describing articles and also coordinate their exchanges. Product information is defined as a set of data that represents the identifying, technical, logistical, and marketing characteristics of a product (Iwicka, 2007; Nakatani et al., 2006).

The existing literature on product information exchanges mainly presents GDSN as a mechanism to automatically update product information between manufacturers and retailers (Legner & Schemm, 2008; Nakatani et al., 2006). Empirical evidence found in previous works (de Corbière & Rowe, 2011; Legner & Schemm, 2008; Nakatani et al., 2006) shows that GDSN use is not widely adopted by companies in the retail and consumer goods industries. Even if the number of firms that have subscribed to GDSN is constantly growing[2], norms appropriation leads to the development of French extensions and sometimes proprietary extensions that substantially reduce the application of GDSN's main principle: "publish once, send to all; subscribe once, receive from all". Some firms estimate that the standard does not cover their data needs (especially for private data described above); others believe that the use of an external catalogue incurs costs that can be avoided by the use of internal electronic catalogues.

These considerations have led some companies to use an external catalogue in order to build a multilateral linkage (Choudhury, 1997), albeit to synchronize product information outside GDSN to avoid subscription to the global registry and exchange complementary data. Other firms have decided to implement only product information management (PIM)—an internal, private, electronic catalogue—to manage product information within their own systems, and to synchronize data without external catalogues. Interconnections between PIMs constitute typical electronic dyads (Choudhury, 1997) because a company builds one logical link from its PIM to the PIM of each of its partners. Given the different possibilities of interconnections in terms of shared data, structural linkages, and message interdependencies, we analyze how different IOS forms enable data synchronization over time, regardless of the level of synchronization itself.

4.2. Firm Selection

The concentration in the French mass retail industry allowed us to include all seven major French retailers in the analysis (Carrefour, Auchan, Casino, Système U, Leclerc, Intermarché, and Provera). In 2008, they shared 95% of the market, giving them bargaining power over manufacturers thanks to their concentration and their position in the distribution chain. On the manufacturers' side of the relationships, we were limited to a sample of the population due to their number and diversity. We analyzed companies implementing electronic catalogues in order to automate their sending of product information. We focused on global companies operating in France, and on French companies that had national brands that consumers could find in every point-of-sale. These firms have some autonomy in designing their sending systems without being forced into specific standards by retailers. Indeed, even if the balance of power has shifted from manufacturers to retailers in recent decades (Draganska, Klapper, & Villas-Boas, 2010), national brands are considered to be a source of bargaining power for manufacturers because they allow product differentiation in consumers' minds, and remain necessary to the performance of retailers (Ailawadi, Borin, & Farris, 1995; Draganska et al., 2010). This is particularly true in France where, even if they represent only 3% of the suppliers of the retail industry, large manufacturers contribute to 60% of its turnover.

Firm selection was also based on the snowballing principle. We asked firms if they could assist us in meeting some of their partners or competitors who had designed their systems differently. We stopped manufacturer selection when we had a consequent diversity of sending systems and when we reached theoretical saturation. At the end of the data collection, 18 manufacturers were included: Nestlé, Kraft foods, l'Oréal, Colgate Palmolive, Danone, Coca-Cola, Georgia Pacific, Cadbury Schweppes, Reckitt Benckiser, Lactalis, Fleury Michon, Tipiak, Cecab d'Aucy, Lavazza France, Pernod, Lesieur, Gastronome, and Paste.

4.3. Data Collection and Analysis

The primary source of data was semi-structured interviews conducted between 2005 and 2007 in seven retailers and 18 manufacturers. In addition, we collected company and project documentation for data triangulation (Eisenhardt, 1989; Yin 2003)[3]. Because we focused on building technologies, we interviewed managers who were responsible for electronic catalogue implementation. Forty interviews were tape-recorded and transcribed for data analysis (Table 4).

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[2] http://www.gs1.org/gdsn/statistics.

[3] To enhance validity of the findings, additional data were collected from intermediaries proposing electronic solutions for product information exchange. This allowed us to better understand the interconnection schemes.

Interviews were approximately two hours in length and aimed at:

- Understanding the company strategy on electronic data exchange and, in particular, product information,
- Describing the receiving system (or the sending system) the company had implemented or was implementing, and
- Understanding how the company perceived the interconnection with the systems of its trading partners.

Table 4. Interviewees Per Firm

Retail1	1	Manu1	1	Manu10	2
Retail2	3	Manu2	2	Manu11	1
Retail3	1	Manu3	1	Manu12	1
Retail4	2	Manu4	1	Manu13	3
Retail5	2	Manu5	1	Manu14	1
Retail6	4	Manu6	2	Manu15	1
Retail7	1	Manu7	1	Manu16	2
		Manu8	2	Manu17	1
		Manu9	1	Manu18	2

We conducted a two-step thematic qualitative analysis of the interview transcripts (Miles & Huberman 1994). In the first step, a descriptive analysis, we summarized the data according to pre-determined themes issued from our research framework. Through this method, we first described data in a logical and meaningful way to define the types of sending and receiving systems the companies implemented or were implementing. In the second step, a thematic analysis, we analyzed relationships between themes. We performed this second step in order to understand and analyze empirically the interconnections between sending and receiving systems that we had found. Coding was performed with QSR N'Vivo software, in which sentences or paragraphs were linked to the themes.

We used main themes in two categories. The first category that emerged from the second part of the interview guide (cf. Appendix A) consisted of a system description of the company. We first asked the manager a general question regarding the description of the sending or receiving system of their company. If necessary, we then asked additional questions to obtain associated details about the data standard, the organization of flows, and the architecture. We coded data issued from these empirical categories into items of the selected theoretical variables: shared data, message interdependencies and structural linkages. The combination of the data corresponding to these themes allowed us to classify the position of the firm among the systems built theoretically.

The second category of themes was about the interconnection with the firm's partners systems. This emerged from the last part of the interview guide. We used a binary approach to code interconnections (or not) with each of the partners' systems. For instance, if the interviewee explained why they considered their firm's system to be potentially connected with the partner's system I, we attached these sentences to the theme "systemI_interconnection". In a contrasting case, we attached the sentences to the theme "systemI_non_interconnection".

QSR N'Vivo has a function that allows the extraction of relationships between themes through tables, which was useful in understanding the interconnections between receiving systems and sending systems implemented by companies. We built different tables. For each sending or receiving system, we extracted a table with the firms implementing a type of system in columns and the five partner systems in lines. A code automatically appears in the cells of QSR N'Vivo when the firm considers that its system is to be connected with one of its partners' systems. When we found dyads considering having both their systems connected based on the description of these systems, we selected a type of interconnection among the diverse possibilities that we had derived theoretically. In order to prescribe the existence of emerging forms of IOS, we then identified the reality of each interconnection among the three possibilities: fully operational (i.e., data are synchronized through the interconnection), being tested (i.e., data have been exchanged through the interconnection but data synchronization is not yet operational), or being built (i.e., companies envision data synchronization but have not realized exchanges at the time of data collection).

Finally, instead of focusing on a specific IOS and explaining its characteristics and its adoption by companies, we concentrated on the characteristics of the part of the IOS developed by each of the companies to define sending systems and receiving systems, after which we proposed an analysis of their interconnection leading to the IOS.

5. Field Study Results

The results are presented as follows. Sections 5.1 and 5.2 focus on sending and receiving systems of the investigated firms. They both begin with a table of results that synthesize each firm's system design in terms of structural linkage and architecture, shared data, and message flows. For each firm, these tables summarize informants' perceptions that are extracted from coding by selecting relevant reports verbatim (Appendix B). Then, in Section 5.3, we present and analyze interconnections between the different sending and receiving systems.

5.1. The Sending Systems

Manufacturer sending systems are synthesized in Table 5 by extracting detailed informants' perceptions presented in Table B-1 (Appendix B). Eight manufacturers designed their sending system with multiple dyadic linkages (since they did not use an external catalogue), and 11 with one multilateral linkage (since they used an external catalogue: a source data pool of the GDSN or an external catalogue to realize synchronization with French retailers outside GDSN). With respect to message flows, 15 designed their systems to manage flow interdependency of messages (since each message was sent to only one retailer), and five decided to coordinate data flows through sharing interdependency (as each message was sent to several retailers). Concerning shared data included in messages, six manufacturers designed their systems to send only common data, whereas 14 decided to exchange additional private data. These first results constitute empirical evidence of the relevance of the three variables we considered to describe the sending systems for product information exchanges in the consumer goods industry.

We found 20 sending systems for 18 firms because some firms decided to use two sending systems in parallel. For instance, manufacturer #17 decided to use GDSN, with multilateral linkage to send only common data into messages that were shared with several retailers, and to use its PIM with dyadic linkages in order to coordinate flows of additional messages containing some private data through flow interdependency. Among the five firms that implemented sending system I, only four used a source data pool of GDSN. Manufacturer #9 sent its common data in a unique message to all retailers with the use of an external catalogue that was not GDSN certified. Moreover, among the seven manufacturers that implemented sending system III, three used an external catalogue that was not GDSN certified, and four used a catalogue belonging to GDSN. However, the former manufacturers did not use GDSN standards since their catalogue exchanged messages that included data outside the GS1 global standard. Finally, sending system II was not empirically supported: the use of multilateral linkages to exchange common data did not lead to two types of sending systems because the flows were always managed through sharing interdependency. In fact, the four sending systems are dependent on two variables (logical linkages and shared data) because the message interdependency is given by the combination of these variables (Table 6).

Table 5. Description of the Sending Systems of the Manufacturers

Firm	Structural linkage	Shared data	Message flows	Type of sending system
Manu1	Dyadic linkage	Only common data	Flow	Sending system IV
Manu2	Multilateral linkage	Common and private data	Flow	Sending system III
Manu3	Multilateral linkage	Common and private data	Flow	Sending system III
Manu4	Multilateral linkage	Common and private data	Flow	Sending system III
Manu5	Dyadic linkage	Common and private data	Flow	Sending system V
Manu6	Dyadic linkage	Common and private data	Flow	Sending system V
Manu7	Multilateral linkage	Only common data	Sharing	Sending system I
	Multilateral linkage	Common and private data	Flow	Sending system III
Manu8	Multilateral linkage	Only common data	Sharing	Sending system I
Manu9	Multilateral linkage	Only common data	Sharing	Sending system I
Manu10	Dyadic linkage	Common and private data	Flow	Sending system V
Manu11	Dyadic linkage	Common and private data	Flow	Sending system V
Manu12	Dyadic linkage	Common and private data	Flow	Sending system V
Manu13	Dyadic linkage	Common and private data	Flow	Sending system V
Manu14	Multilateral linkage	Common and private data	Flow	Sending system III
Manu15	Multilateral linkage	Common and private data	Flow	Sending system III
Manu16	Multilateral linkage	Common and private data	Flow	Sending system III
Manu17	Multilateral linkage	Only common data	Sharing	Sending system I
	Dyadic linkage	Common and private data	Flow	Sending system V
Manu18	Multilateral linkage	Only common data	Sharing	Sending system I

Table 6. Types of Sending Systems

	Multilateral Linkages	Dyadic linkages
Containing only common data	Sharing (Sending system I)	Flow (Sending system IV)
Containing some private data	Flow (Sending system III)	Flow (Sending system V)

5.2. The Receiving Systems

Retailer sending systems are synthesized in Table 7 by extracting detailed informants' perceptions presented in Table B-2 (Appendix B). Three retailers designed their receiving systems with multiple dyadic linkages (since they did not use an external electronic catalogue), and five retailers designed theirs with one multilateral linkage (since they used a recipient data pool that was GDSN certified). Three wanted to exchange only common data, and five included additional private data. A further six designed their system to coordinate messages reception through flow interdependency (since they did not consider sharing messages with their competitors), whereas two built their systems to manage sharing interdependency (since they considered sharing messages with their competitors).

Similar to sending systems, this first result provides empirical evidence of the relevance of considering structural linkages, shared data, and message interdependency to describe the receiving systems for product information exchanges in the retail industry. While most retailers chose a single type of receiving systems, retailer #2 deliberately chose three in order to offer more possibilities to its suppliers (system I, III, and V)—this explains why Table 7 presents nine receiving systems instead of seven.

Table 7. Description of the Receiving Systems of the Retailers

Firm	Structural linkage	Shared data	Message flows	Type of receiving system
Retail1	Multilateral linkage	Only common data	Sharing	Receiving system I
Retail2	Multilateral linkage	Only common data	Sharing	Receiving system I
	Multilateral linkage	Common and private data	Flow	Receiving system III
	Dyadic linkage	Common and private data	Flow	Receiving system V
Retail3	Multilateral linkage	Common and private data	Flow	Receiving system III
Retail4	Multilateral linkage	Common and private data	Flow	Receiving system III
Retail5	Dyadic linkage	Only common data	Flow	Receiving system IV
Retail6	Multilateral linkage	Common and private data	Flow	Receiving system III
Retail7	Dyadic linkage	Common and private data	Flow	Receiving system V

We did not find the five anticipated forms of receiving systems. The use of multilateral linkages to exchange only common data (two retailers) did not lead to two types of receiving systems. Whether or not the messages were designed from the manufacturers' IS to manage flow or sharing interdependency, the retailer received the messages without distinction. Receiving systems I and II were thus merged because the design of the message flows was not the concern of the retailer but that of only the manufacturers. We will now use receiving system I when referring to this receiving system in order to have symmetry with sending systems (especially because the receiving systems were using recipient data pools of GDSN), and observe GDSN standards, both from communication protocols and data standard perspectives. Moreover, the retailers that had implemented receiving system III were using external catalogues that were all GDSN certified. However, they asked for additional data on top of the global standard, and thus did not follow GDSN standards. Finally, the four receiving systems are dependent on two variables (logical linkages and shared data) because the message interdependencies are derived from a combination of these variables (Table 8).

Table 8. Types of Receiving Systems

	Multilateral Linkages	**Dyadic linkages**
Containing only common data	Flow or sharing (Receiving system I)	Flow (Receiving system IV)
Containing some private data	Flow (Receiving system III)	Flow (Receiving system V)

5.3. Interconnections Leading to IOS

This section deals with the question of interconnections between the four sending systems of manufacturers and the four receiving systems of retailers. We use Table 3 to present in Table 9 the interconnections between the systems, which lead to different forms of IOS. In each case, we present the number of dyads that reflected the existence of interconnections when the manufacturer and the retailer both agreed on the interoperability of their own systems. In particular, the three numbers in parenthesis indicate the number of dyads for which interconnection was, respectively, fully operational, being tested, or being built.

Table 9. The Different Interconnections

	Receiving system I sharing interdep., multilat. linkage, common data	Receiving system III flow interdep., multilat. linkage, private data	Receiving system IV flow interdep., dyadic linkages, common data	Receiving system V flow interdep., dyadic linkages, private data
Sending system I sharing interdep., multilat. linkage, common data	SIRI (7,1,1)	SIRIII (2,6,3)	SIRIV (4,0,1)	SIRV (3,0,1)
Sending system III flow interdep., multilat. linkage, private data	SIIIRI (3,3,1)	SIIIRIII (6,4,6)	SIIIRIV (5,0,1)	SIIIRV (4,2,1)
Sending system IV flow interdep., dyadic linkages, common data	SIVRI (0,0,0)	SIVRIV (0,0,0)	SIVRIV (1,0,0)	SIVRV (0,0,0)
Sending system V flow interdep., dyadic linkages, private data	SVRI (1,2,1)	SVRIII (4,5,4)	SVRIV (5,0,0)	SVRV (6,1,3)

We now present the main conclusions that can be extracted from Table 9 by considering each cell.

Before dealing with interconnections between systems I, III, or V, we begin with interconnections, including sending and/or receiving systems IV. At the time of data collection, system IV had been chosen by only manufacturer #1 and retailer #5. Moreover, manufacturer #1 hesitated integrating private data in its data standard, and was slow at evolving from system IV to system V: "If GS1 standard evolves, we will evolve with it, and we will add private data in the data standard. As long as it is not the case Retail2 can wait". In addition, retailer #5 had chosen its system before the emergence of electronic data pools and the XML standard, at a time when EDI was the referred IOS for product information exchanges. Retailer #5 was now considering migrating to the current standard by using a recipient data pool, the one proposed by GS1 France:

> *There are retailers on Agentrics, others on 1Sync[4], thus it will have an impact on the choice of suppliers. And we haven't got a problem with this* […]. *Because it manages well French extensions, Parangon[5] can be a good choice for us*. Therefore, this retailer should move from receiving system IV to receiving system I.

Consequently, except for cell SIVRIV, which characterizes the interconnection between symmetric systems IV for this retailer and this manufacturer, it was difficult to find possibilities for the interconnection with system IV and other systems. Manufacturer #1 did not find interconnection agreement with retailers using receiving systems I, III, and V (cells SIVRI, SIVRIII, SIVRV): "The only one with whom it works is Retail5. With Retail2, Retail7 and Retail4, it does not work because they are not standard. The others, I'm not quite sure where they stand". For cells SIRIV, SIIIRIV, SVRIV, we found dyads that already used an IOS resulting from the interconnection between the receiving system IV of retailer #5 and sending systems I, III, and V. This result underlines the possibilities of interconnection between systems that are designed differently: "With Retail5 we do a kind of synchronization, but it is not the same thing, as they have no data pool" (Manufacturer #8). However, since the retailer was not certain of maintaining receiving system IV, these interconnections will not be taken into account in the discussion.

[4] Agentrics (now SA2 Worldsync) and 1Sync are GDSN certified catalogues
[5] Parangon is the GDSN catalogue built by GS1 France

Similarly, the most interesting results are not the interconnections represented by the diagonal cells SIRI, SIIIRIII, and SVRV. Indeed, these cells characterize IOS issued from interconnections between systems with symmetric characteristics, and we obviously found dyads that had built these types of interconnection.

From the cells SIIIRV and SVRIII, we found interconnections between systems III and V. These systems proposed exchanging messages containing some private data through flow interdependency. But system V is based on dyadic linkages, whereas system III is based on multilateral linkages. Therefore, cells SIIIRV and SVRIII show that interconnections between systems that are designed differently in terms of structural linkages are possible. For instance, concerning cell SIIIRV, manufacturer #4 commented, “Today, Retail7, it works”, and the retailer of this dyad offered, “We are in operations through this channel, with three firms”. Concerning cell SVRIII, we also found dyads that confirmed that interconnection is possible when sending and receiving systems are designed with different structural linkages: “We exchange with Retail3. It works, so it’s good, because it allows us to make progress on standard synchronization” (Manufacturer #6).

Represented in cells SIRIII and SIIIRI, some IOS emerged from interconnection between systems I and III. These systems are symmetric in terms of structural linkages because firms built multilateral linkages, but they present asymmetries in their design for both message interdependency and shared data. Between manufacturers that implemented sending system III and retailers that implemented receiving system I (cell SIIIRI), the sender had the larger data standard. Thus, there were no interconnection problems since, in use, the retailer received all the data it asked for: “With Retail2, we do GDS plus since we synchronize more data than with the standard. Thus with retailers who stick to the standard, it’s obvious” (Manufacturer #14). Between sending system I and receiving system III (cell SIRIII), the retailer designed its data standard with the larger set of data, asking for private data. Consequently, interconnection was blocked when the retailer refused messages that did not include the private data: “With Retail4 we don’t exchange. It’s like Retail7. When the client refuses briefs without the special offer number or the price rebate, it refuses GDSN standard, thus we cannot exchange for we are pure and only GDSN” (Manufacturer #8).

For interconnection to occur, the retailer had to accept receiving only the common data sent by the manufacturer. In addition to the message with common data, the retailer then asked for a second message that complemented the first one with private data.

> [The manufacturer] *will choose to be GDSN, will select a Source Data Pool which will synchronize itself with our Recipient Data Pool which will send us, via GDS, standard data. Thus, on top of this, it must send us through another channel the additional data, which currently are not included in the standard* (Retailer #2).

The interconnection represented in cell SIRIII actually led, in use, to the interconnection represented in cell SIRI because additional data asked by the retailer were not exchanged in this configuration. These additional data could be synchronized through a second interconnection represented in cells SVRV, SIIIRIII, SIIIRV or SVRIII, or by other methods that did not synchronize (data entering in Extranets, Excel spreadsheets sent by e-mails, etc).

We can thus conclude that interconnection of systems is possible when a firm wants to exchange only common data, and the other additional private data. In such cases, the firm that designs its system to exchange private data has to accept the exchange of messages containing only common data for the systems to be connected.

Finally, we also found dyads that agreed on the interconnection between systems I and V (cells SIRV and SVRI). For these systems, we face asymmetries in terms of shared data, messages interdependency and structural linkages; thus, we face a combination of each asymmetry already presented. Therefore, cells SIRV and SVRI represent the most complex cases of interconnection. Similar to cell SIRIII, interconnections represented in cell SIRV actually led, in use, to interconnections represented in cell SIRIV, since the retailer that accepted this interconnection only received common data.

6. Discussion

In Section 6.1, we discuss the centrality of three variables identified in the initial literature review and confirmed in the research—structural linkages, shared data and message interdependency. Then (Section 6.2), for each variable, we analyze the relationship between the existence of hybrid IOS in design and their existence in use. In Section 6.3, we finally discuss their use and relative performance with respect to GDSN.

6.1. The Design and Implementation of IS Interconnections for Data Synchronization IOS

Previous research has identified several essential elements needed to manage inter-firm relationships: data consistency, processes, architectures, and standards. Although the literature has focused on both dyadic and multilateral connections, more diverse forms, such as our hybrid forms, have not been previously identified. Our key contribution is the conceptual elaboration of the interconnections between systems having asymmetric characteristics. As such, this research contributes to a much more nuanced view of how one may conceptualize IOS. This paper develops a framework for analyzing different forms of IOS that perform data synchronization. This analysis is accomplished by recombining three variables—structural linkages, shared data, and message interdependency—that are essential for describing the coordination of data exchanges. The variables are consistent with constructs reported in the literature on IOS that improve data integration, and are generally referred to as architecture, data, and process (Elgarah et al., 2005; Markus, 2000; Rai et al., 2008; Robey et al., 2008; Steinfield et al., 2011).

In building the framework, we began with a categorization of a firm's IS architecture as reflecting either dyadic or multilateral database linkages (Choudhury, 1997). Next, we classified a firm's data processes according to the relative interdependencies of its data messages. We made this classification of data messages through the lenses of coordination theory and Malone et al.'s (1999) typology of interdependencies. Accordingly, companies we considered could choose between either flow or sharing message interdependencies to synchronize data with business partners. Finally, we operationalized data standards as the nature of shared data—common versus private—included in the messages being exchanged (D'Aubeterre et al., 2008; Legner & Schemm, 2008).

As an operationalization of the variables described above, we tested the framework on the IS in the 25 firms sampled. Interviews also confirmed that, from a managerial perspective, the three variables we identified were, in fact, vital for the design and implementation of sending or receiving systems. This research suggests that the framework is both stable and sufficient for describing the diverse IOS performing data synchronization. However, one can find suggestions that other variables may be relevant as well (see Appendix B). For instance, a firm's capabilities, external pressures from partners or competitors or perceived benefits also play a role in the choice of a particular sending or receiving system. These former variables are adoption factors of IOS (Iacovou, Benbasat, & Dexter, 1995). They explain the choice of a given system among a set of possibilities; however, they do not at all describe the system that was implemented (i.e., its opus operatum).

This leads to the conclusion that companies consider structural linkages, shared data and message interdependency as the three main variables characterizing the part of IOS they design and implement to synchronize data with their partners.

6.2. Emergence and Use of Hybrid Forms

This section returns to the existence of interconnections between systems that present asymmetries in terms of message interdependencies, structural linkages, and the shared data, after which we describe how they are used.

Considering the message interdependency perspective (Malone et al., 1999), we found empirical evidence that manufacturers who want to send messages through sharing interdependency interconnect with retailers who have a system designed for managing flow interdependency of messages. Thus, message interdependencies do not need to be the same in order for receivers and senders to interconnect their systems. Therefore, process hybrids exist. Concerning the message interdependency in use, the receiving system acts in response of the sending system. In fact, when a process hybrid exists the sending system imposes its message interdependency characteristics onto the receiving system.

As a result, we face two types of message flows empirically found in the IOS: 1) point-to-point flows when each message is exchanged per dyad from one sender to one receiver, and 2) point-to-multipoint flows when a message is exchanged from one sender to several receivers. Thus, interconnections of systems designed to manage different types of flow of messages exist. In use, they lead to IOS that coordinate flows of messages through a type of interdependency. It should be interesting to extend these considerations to fit interdependency and to test multipoint-to-point and multipoint-to-multipoint flows of messages. In particular, do hybrid forms of IOS also exist when sending and receiving systems have been designed with fit versus flow or sharing interdependencies?

Taking the structural linkage perspective, Choudhury (1997) describes two forms of IOS: dyadic IOS (or electronic dyads) in which all firms build dyadic linkages, and multilateral IOS in which all firms build multilateral linkages. Our research revealed the existence of not only these two forms but also an hybrid form of IOS. Indeed, we have found empirical evidence that there are interconnections between firms that build dyadic linkages and those that build multilateral linkages. Therefore, structure hybrids exist. These hybrid forms of IOS can be placed on a continuum between two extremes: dyadic IOS and multilateral IOS. Figure 3 presents this continuum in the interconnection of eight firms: four senders (S1, S2, S3, and S4) and four receivers (R1, R2, R3, and R4). S1, S2, R1, and R2 use dyadic linkages, and S3, S4, R3, and R4 use multilateral linkages. Thus, the interconnection between S1, S3 and R1, R3 is an example of a hybrid form of IOS in terms of architecture.

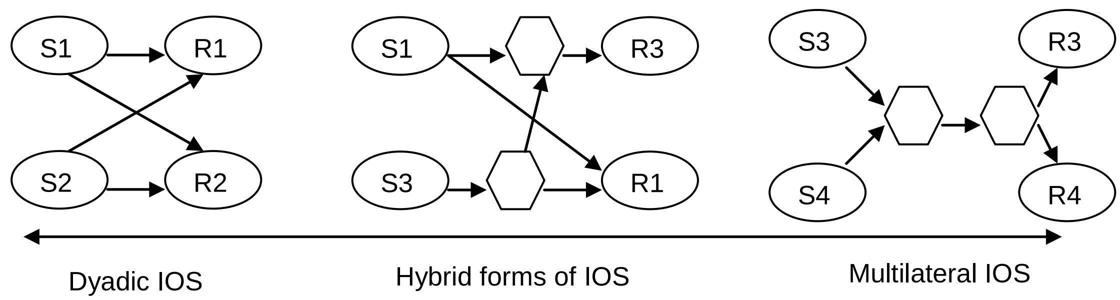

Figure 3. The Continuum of IOS Forms

During interconnection, sending and receiving systems do not evolve from the structural linkage perspective. Contrary to message interdependency, from a structural perspective, hybrid forms of IOS exist both in design and use for data synchronization.

Taking the shared data perspective, our results show that interconnections exist not only between companies that design their system for messages containing only common data, but also for those that design their system for messages containing private data. Therefore, data hybrids exist. However, from this perspective, there is a condition for IOS emergence: the firm that designs its system to exchange common and private data has to accept the exchange of only common data for the systems to be connected.

This argument leads to a discussion of the standards. Even when presented as a key element for IOS adoption and diffusion (Markus et al., 2006; Zhu et al., 2006), this is not a problem of technical standards. Indeed, interconnection between different technical standards does not appear as a problem. Electronic catalogues, both internal and external ones, can perform the translation between different technical standards in order to achieve external integration with the standard of the partner and internal integration with the internal standard (Gosain et al., 2003). Because of the importance of internal integration in order to achieve benefits promised by electronic data exchanges (Mukhopadhyay & Kekre, 2002), the technology of electronic catalogues, both internal and external, is a real opportunity for companies. Concerns about standards are more about the data standard than about technical standards.

Thus, empirical evidence presented in this paper shows that interconnection between systems designed with different data standards leads to the implementation of the smaller data standard composed only of common data. To conclude, interconnection between systems with different data standards does exist, but this means that during interconnection, only common data are exchanged.

6.3. Performance Issues

In this section, we discuss the different existing forms of interconnections in order to understand their performance in terms of synchronization.

6.3.1. Performance of Hybrid Forms: Insights from the Field

Concerning interconnections between systems that present asymmetric interdependency of messages in their design, we have already explained that, in use, process hybrids lead to IOS that coordinate flows of messages through a type of interdependency. Therefore, there are no additional works for interconnecting systems with asymmetric interdependency of messages. However, for the sender, when the point-to-point flow of message is effectively used, the risk emerges that the data are not simultaneously synchronized with all business partners. When the processes are not shared between multiple partners, some delays in data synchronization can occur.

We have shown that interconnections between systems that present asymmetric structural linkages are possible and lead to structure hybrids, but some of them need additional economic negotiations for interconnection realization. In particular, to interconnect with internal electronic catalogues of suppliers, there can be a request for a financial contribution from the suppliers by the external electronic catalogue of retailers. Some manufacturers accept paying in order to develop their competencies in data synchronization. Even if data synchronization mainly benefits retailers from an efficiency viewpoint, accepting such interconnection also benefits manufacturers in terms of learning (Subramani, 2004). Other powerful manufacturers, such as Manufacturer #9, refuse this financial contribution and effective exchanges of product information even though interconnection was technically possible, since tests had been validated:

> *We had looked at some connections and we had tried to work on a design like that of Retail1. And here, there's a financial issue, a payment problem: Agentrics positioned itself as a toll booth and here we said no, we refused. It is out of the question that we pay a subscription to Agentrics if we have certified data.*

In that configuration, data are not synchronized because of divergent points of views in the economic model of the data synchronization system. Consistent with previous research in the IOS literature (Hart & Saunders, 1997) and the retail industry literature (Draganska et al., 2010), we found that interfirm power influences effective information exchanges.

Finally, data hybrid exists with the interconnections between systems that present asymmetries in terms of shared data but induce additional work. In line with previous literature (Christiaanse et al. 2004; Markus et al., 2006; Zhu et al., 2006), the development of proprietary data standards threatens IOS efficiency in multilateral networks. Asymmetries in terms of shared data require distinguishing whether the firm that introduces private data in the design of its system is data sender or data receiver. When the retailer builds a receiving system to exchange only common data, synchronization does not involve all the data the manufacturer can exchange. Through this hybrid IOS design, data synchronization may be less efficient than through interconnections between symmetric systems. In this case, the retailers generally ask for complementary data outside the synchronization system, and some of the manufacturers refuse a second exchange since they are able to send all the data through their sending systems. From their perspective, a second exchange (automated or manual) is synonymous to additional coordination costs and work, whereas they have developed a sending system that allows exchanging all data at once. Consequently, data synchronization is more expensive or threatened in such mode of use.

Conversely, when the manufacturer builds a sending system to exchange only common data, synchronization does not involve all the data the retailer wants to receive. Data synchronization from these interconnections involves additional costs, since the retailer has to reenter data that are not synchronized, and/or the manufacturer has to send these data through in another way—either with a second synchronization system that performs automatic updating of complementary data, or without a synchronization system (for instance, when the manufacturer re-enters data in the retailer extranet).

6.3.2. From Data Synchronization to Databases Synchronization, or the Limitations of Hybrid Forms

In terms of consequences of IOS (Robey et al., 2008), for data synchronization, hybrid forms are less efficient than are the extreme forms presented in previous literature. In particular, structure hybrids generally need additional economic negotiations for interconnections realization. Moreover, process hybrids can induce additional delays for data synchronization with diverse business partners. Concerning data hybrids, data synchronization is typically less efficient when the companies do not share the data standard (i.e., the set of data that have to be synchronized).

Concerning data standard issues, the macro-level perspective on data privacy that we considered in this paper can be extended to a micro-level perspective on all the data included in messages. Indeed, a company can refuse to exchange common data, such that its partner cannot exchange these data in a dyadic relationship. The emergence of a global data standard may appear when all the firms of a specific industry find consensus on the data that have to be exchanged, as well as on their signification (Markus et al., 2006). Outside the industry standard, we face proprietary standardized messages because the data included in the message are dependent upon the negotiation of the data standard between two companies. Thus, buyer/seller negotiations are the core condition of exchange emergence for optional data (i.e., data that are included in the industry standard but not compulsory yet), or sometimes meant for additional data (e.g., data that the industry standard does not include).

We can derive from the previous considerations regarding each variable that, in an ideal world when investment is not an issue, GDSN is the most efficient IOS in use for data synchronization realization. GDSN efficiency is issued from companies' sharing of the structure of exchanges, the coordination mechanisms for messages flows, and, more importantly, the data standard (Legner & Schemm, 2008; Nakatani et al., 2006). However, GDSN adoption remains costly (Legner & Schemm, 2008), and its efficiency remains dependent on the number of business partners involved (Madlberger, 2011). Moreover, GDSN standards do not always fit with companies' strategies, especially for those that operate in a national market or for those that consider data synchronization relevant if, and only if, it allows the synchronization of data that are not included in the industry standard.

The relative efficiency of the IOS forms used for effective data synchronization is summarized in Table 10. Data synchronization is theoretically optimum with the real-time updating of data between business partners. Consequently, IOS forms of data synchronization will be all the more efficient when facilitating structure, process and data sharing for automatic updating of data between business partners.

In fact, data synchronization will be all the more efficient when it allows database synchronization between business partners. Database synchronization is realized if, and only if, the set of common data between the databases is timely aligned. To realize database synchronization, data synchronization assumes the timeliness of values alignment of the corresponding data. However, it is not sufficient because database synchronization also needs data alignment between the databases from a quantitative viewpoint in order that the set of data exchanged between the databases, the data standard, can be shared in the industry. These considerations are in line with recent literature on IOS (see Klein & Rai, 2009; Markus et al., 2006). In a configuration analysis (Lyytinen & Damsgaard, 2011) between a set of companies, data synchronization in its ideal form is more efficient than hybrid forms. However, in an industry analysis, hybrid forms provide great value for companies. Indeed, when companies have partners that have made different choices in terms of data synchronization systems, they can communicate with all of them by the design and the implementation of a single system. In particular, given the interorganizational relationship portfolio characteristics, different IOS capabilities are required and the value impacts of specific capabilities are contingent on these characteristics (Rai & Tang, 2010).

Table 10. Relative Efficiency of Data Synchronization Systems	
Ideal form of data synchronization	Structure, process, and data are shared in the industry. Data synchronization efficiency is only limited by the delays between data emission by the senders and data integration by the receivers.
EDI form of data synchronization	Structure, process, and data are shared in each dyad but may be different between dyads: dyadic coordination costs are thus necessary upstream IOS use.
Structure hybrids	Structure is not shared between the concerned partners. Some additional costs may occur for interconnection realization.
Process hybrids	Process is not shared between the concerned partners. Some additional delays may occur according to the diverse flows of messages.
Data hybrids	Data are not all shared between the concerned partners. Additional costs do occur for the second synchronization or the manual exchange of data that are not shared in the synchronization system.

This paper goes a step further by explaining what these hybrid forms are and how they allow interconnections between systems that have been designed differently. In an industry, firms can manage their relationship portfolio with symmetric forms of IOS with some of the partners, and with hybrid forms of IOS with other partners. Thus, hybrid forms foster data integration at the industry level.

7. Conclusion

By considering IOS as resulting from the interconnection between sending and receiving systems, we provide a distinct perspective from past literature on IOS that can be complementary to more recent approaches (Lyytinen & Damsgaard, 2011). Following this conception of IOS, we have analyzed the possibilities for interconnections between systems that are designed with asymmetric characteristics. Corresponding to architecture, processes, and data standards at a more general level, the variables refer to structural linkages, message interdependencies, and shared data. Focusing on data synchronization in the consumer goods and retail industries, we have investigated the diversity of IOS issued from the interconnection between sending and receiving IS for interorganizational product information management.

In the literature on data synchronization, the three variables have not been systematically analyzed together, and combinations of their characteristics have never been empirically investigated in multilateral networks. These diverse combinations are important, not only practically because they allow a greater development of IOS and foster new possibilities for automated updating between different sending and receiving systems, but also because, by doing so, they allow for a greater integration effect at the macro level. More importantly, for each company, this integration effect can be achieved in a flexible way. We expect these results to be extended to other messages or industries in order to confirm that: 1) combining data standards, data processes and architectures allows for better characterization of IOS, and 2) interconnections between systems with asymmetric characteristics lead to forms of IOS other than the polar types (EDI and GDSN).

Moreover, considering interconnections between sending and receiving systems that present asymmetries for each variable, we have discussed the patterns of hybridization. Although hybrid forms are less efficient than extreme forms, they allow companies, by the implementation of one and only one system, to interconnect with all their partners, even with those who have made different choices in the design of their system. In the long term, each partner can change its system as long as it remains compatible with the other. In that sense, since there are more hybrid arrangements than there are possibilities for establishing dyads or multilateral relationships, systems become more resilient to changes made by partners.

To go a step further, since hybridization between dyadic and multilateral linkages exists in both design and use considerations, future research should analyze the stability of the resulting hybrid forms of IOS by investigating the effects class of problems (Robey et al., 2008), and, in particular, investigating the consequences in terms of data quality. More generally, the question of consequences of hybrid forms will have to be explored by considering complementary economical and relational perspectives.

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8. References

Ailawadi, K. L., Borin, N., & Farris, P. (1995). Market power and performance: A cross-industry analysis of manufacturers and retailers. *Journal of Retailing, 71*(3), 211–248.

Bakos, Y. (1991). Information links and electronic marketplaces: The role of interorganizational information systems in vertical markets. *Journal of Management Information Systems*, *8*(2), 31-52.

Barrett, S., & Konsynski, B. (1982). Inter-organization information sharing systems. *MIS Quarterly*, *6*(4), 93-105.

Bensaou, M. (1997). Interorganizational cooperation: The role of information technology – an empirical comparison of U.S. and Japanese supplier relations. *Information Systems Research*, *8*(2), 107-124.

Chatterjee, D. & Ravichandran, T. (2004). Beyond exchange models: Understanding the structure of B2B information models. *Information Systems and e-business Management, 2*(2-3), 169-186.

Choudhury, V. (1997). Strategic choices in the development of interorganizational information systems. *Information Systems Research*, *8*(1), 1-24.

Christiaanse, E., van Diepen, T., & Damsgaard J. (2004). Proprietary versus internet technologies and the adoption and impact of electronic marketplaces. *The Journal of Strategic Information Systems*, *13*(2), 151-165.

Culnan, M. J., & Armstrong, P. K. (1999). Information privacy concerns, procedural fairness, and impersonal trust: An empirical investigation. *Organization Science, 10*(1), 104-115.

D'Aubeterre, F., Singh, R., & Iyer, L. S. (2008). A semantic approach to secure collaborative inter-organizational ebusiness processes (SSCIOBP). *Journal of the Association for Information Systems*, *9*(3), 231-266.

Damsgaard, J., & Truex, D. (2000). Binary trading relations and the limits of EDI standards: The Procrustean bed of standards. *European Journal of Information Systems*, *9*(3), 173-188.

de Corbière, F. & Rowe, F. (2011). Adoption factors of electronic data exchange and technology: Can we distinguish two phases? Paper presented at the 19th European Conference on Information Systems, Helsinki, Finland.

Dinev, T., & Hart, P. (2006). An extended privacy calculus model for e-commerce transactions. *Information Systems Research*, *17*(1), 61-80.

Draganska, M., Klapper, D., & Villas-Boas, S. B. (2010). A larger slice or a larger pie? An empirical investigation of bargaining power in the distribution channel. *Marketing Science*, 29(1), 57-74.

Eisenhardt, K. (1989). Building theories from case study research. *Academy of Management Review*, *14*(4), 532-550.

Elgarah, W., Falaleeva, N., Saunders, C., Ilie, V., Shim, J. T., & Courtney, J. (2005). Data exchange in interorganizational relationships: Review through multiple conceptual Lenses. *Database*, *36*(1), 8-29.

Gosain, S., Malhotra, A., & El Sawy, O.A. (2004). Coordinating for flexibility in e-business supply chains. *Journal of Management Information Systems*, *21*(3), 7-45.

Gosain, S., Malhotra, A., El Sawy, O.A., & Chehade, F. (2003). The impact of common e-business interfaces. *Communications of the ACM*, *46*(12), 186-195.

Gregor, S. (2006). The nature of theory in information systems. *MIS Quarterly*, 30(3), 611-642.

Hart, P., & Saunders, C. (1997). Power and trust: Critical factors in the adoption and use of electronic data interchange, *Organization Science*, *8*(1), 23-42.

Holland, C. P., & Lockett, G. A. (1997). Mixed mode network structures: The strategic use of electronic communication by organizations. *Organization Science*, *8*(5), 475-488.

How GDSN works. (n.d.). Retrieved from http://www.gs1.org/gdsn/ds/how

Iacovou, C. L., Benbasat, I., & Dexter, A. S. (1995). Electronic data interchange and small organizations: Adoption and impact of technology. *MIS Quarterly*, *19*(4), 465-485.

Iwicka, E. (2007). eCom standards in the GS1 community 2006. Retrieved from http://www.gs1.org/docs/ecom/eCom_Standards_in_the_GS1_Community_2006.pdf

Johnston, H., & Vitale, M. (1988). Creating competitive advantage with interorganizational information systems. *MIS Quarterly*, *12*(2), 153-165.

Kim, Y., Choi, T. Y., Yan, T., & Dooley, K. (2011). Structural investigation of supply networks: A social network analysis approach. *Journal of Operations Management*, *29*(3), 194-211.

Klein, R., & Rai, A. (2009). Interfirm strategic information flows in logistics supply chain relationships. *MIS Quarterly*, *33*(4), 735-762.

Kumar, K., & van Dissel, H. (1996). Sustainable collaboration: managing conflict and cooperation in interorganizational systems. *MIS Quarterly*, *20*(3), 279-300.

Lee, W., Aggarwal, P., Shin, H., Cha, T., & Kim, S. (2006). A typology of interorganizational relationships: A marriage, a fling, or something in between. *International Journal of e-Business Research*, *2*(2), 1-21.

Legner, C., & Schemm, J. (2008). 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), 119-150.

Liu, R., & Kumar, A. (2003). Leveraging information sharing to increase supply chain configurability. Paper presented at the 24th International Conference on Information Systems (ICIS), Seattle, WA.

Lyytinen, K., & Damsgaard, J. (2011). Inter-organizational information systems adoption - a configuration analysis approach. *European Journal of Information Systems*, *20*(5), 496-509.

Madlberger, M. (2011). Can data quality help overcome the penguin effect? The case of item master data pools. Paper presented at the 19th European Conference on Information Systems, Helsinki, Finland.

Malone, T. W., & Crowston, K. (1994). The interdisciplinary theory of coordination. *ACM Computing Surveys*, *26*(1), 87-119.

Malone, T. W., & Crowston, K. (1990). What is coordination theory and how can it help design cooperative work systems? Paper presented at the 3rd Conference on Computer-supported Cooperative Work. Los Angeles, CA.

Malone, T. W., Crowston, K., Lee, J., Pentland, B., Dellarocas, C., Wyner, G., Quimby, Y. J., Osborne, C., Bernstein, A., Herman, G., Klein, M., & O'Donnell, E. (1999). Tools for inventing organizations: Toward a handbook of organizational processes. *Management Science*, *45*(3), 425-443.

Malone, T. W., Yates, J., Benjamin, R. (1987). Electronic markets and electronic hierarchies. *Communications of the ACM*, *30*(6), 484-497.

Markus, M. L. (2000). Paradigm shifts - e-business and business/systems integration. *Communications of the AIS*, *4*(1) retrieved from http://aisel.aisnet.org/cais/vol4/iss1/10/.

Markus, M. L., Steinfield, C. W., Wigand, R. T., Minton, G. (2006). Industry-wide information systems standardization as collective action: The case of the U.S. residential mortgage industry. *MIS Quarterly*, *30(SI)*, 439-465.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. (2nd ed.). Thousand Oaks, CA: Sage.

Mukhopadhyay, T., & Kekre, S. (2002). Strategic and operational benefits of electronic integration in B2B procurement processes. *Management Science*, *48*(10), 1301-1313.

Nakatani, K., Chuang, T. T., & Zhou, D. (2006). Data synchronization technology: Standards, business values and implications. *Communications of the AIS*, *17*(1) retrieved from http://aisel.aisnet.org/cais/vol17/iss1/44/.

O'Reilly, P., & Finnegan, P. (2010). Intermediaries in inter-organisational networks: Building a theory of electronic marketplace performance. *European Journal of Information Systems*, *19*(4), 462–480.

Patnayakuni, R., Rai, A., & Seth, N. (2006). Relational antecedents of information flow integration for supply chain coordination. *Journal of Management Information Systems*, *23*(1), 13-49.

Provan, K., Fish, A., & Sydow, J. (2007). Interorganizational networks at the network level: A review of the empirical literature on whole networks. *Journal of Management*, *33*(3), 479-516.

Rai, A., Patnayakuni, R., & Seth, N. (2006). Firm performance impacts of digitally enabled supply chain integration capabilities. *MIS Quarterly*, *30*(2), 225-246.

Rai, A., Sambamurthy, V., & Agarwal, R. (2008). How CIOs can enable governance of value nets. *MIS Quarterly Executive*, *7*(4), 193-204.

Rai, A., & Tang, X. (2010). Leveraging it capabilities and competitive process capabilities for the management of interorganizational relationship portfolios. *Information Systems Research*, *21*(3), 516-542.

Riggins, F. J., & Mukhopadhyay, T. (1994). Interdependent benefits from interorganizational systems:

Opportunities for business partner reengineering. *Journal of Management Information Systems*, *11*(2), 37-57.
Robey, D., Im, G., & Wareham, J. D. (2008). Theoretical foundations of empirical research on interorganizational systems: Assessing past contributions and guiding future directions. *Journal of the Association for Information Systems*, *9*(9), 497-518.
Rodón, J., & Sesé, F. (2010). Analysing IOIS adoption through structural contradictions. *European Journal of Information System*s, *19*(6), 637-648.
Romano, N. C., Pick, J. B., & Roztocki, N. (2010). A motivational model for technology-supported cross-organizational and cross-border collaboration. *European Journal of Information Systems*, *19*(2), 117-133.
Sila, I. (2010). Do organisational and environmental factors moderate the effects of Internet-based interorganisational systems on firm performance? *European Journal of Information Systems*, *19*(5), 581-600.
Soh, C., Markus, M. L., & Huat, G. K. (2006). Electronic marketplace and price transparency: Strategy, information technology and success. *MIS Quarterly*, *30*(3), 705-723.
Steinfield, C., Markus, M., & Wigand, R. T. (2011). Through a glass clearly: Standards, architecture, and process transparency in global supply chains. *Journal of Management Information Systems*, *28*(2), 75-108.
Subramani, M. (2004). How do suppliers benefit from information technology use in supply chain relationships? *MIS Quarterly*, *8*(1), 45-73.
Tang, X., Rai, A., & Wareham, J. (2011). Bridging and bonding in exchange networks: A structural embeddedness perspective of B2B digital intermediation. *IEEE Transactions on Engineering Management*, *58*(1), 4-20.
Tanriverdi, H., Rai, A., & Venkatraman, N. N. (2010). Reframing the dominant quests of information systems strategy research for complex adaptive business systems. *Information Systems Research*, *21*(4), 822-834.
Truman, G. E. (2000). Integration in electronic exchange environments. *Journal of Management Information Systems*, *17*(1), 209-244.
Turban, E., & Volonino, L. (2008). *Information technology for management: Improving performance in the digital economy* (7th ed.). Hoboken, NJ: Wiley.
van der Aalst, W. M. P., & Kumar, A. (2003). XML based schema definition for support of inter-organizational workflow. *Information Systems Research*, *14*(1), 23-46.
Wareham, J., Mathiassen, L., Rai, A., Straub, D., & Klein, R. (2005). The business value of digital supply networks: A program of research on the impacts of globalization. *Journal of International Management*, *11*(2), 201-227.
Williamson, E. A., Harrison, D. K., & Jordan, M. (2004). Information systems development with supply chain management. *International Journal of Information Management*, *24*(5), 375–385.
Yin, R. (2003). *Case study research: design and methods* (3rd ed.). Thousand Oaks, CA: Sage.
Zhu, K., Kraemer, K. L., Gurbaxani, V., & Xu, S. X. (2006). Migration to open-standard interorganizational systems: Network effects, switching costs and path dependency. *MIS Quarterly*, *30(SI)*, 515-539.

Appendices

Appendix A. Interview Guide

Presentation of the interviewee, her/his firm and general questions:

- How did you exchange product information before the availability of tools like electronic catalogues and PIMs?
- For you, is exchange designed for permanent products or promotions and special offers?

On the sending or receiving system:

A) Opening questions:

- Could you describe the system you are implementing to synchronize product information?
- What are the technologies and standards you have chosen?
- Where do you stand now?

B) To pick up the threads of the description on ARCHITECTURE:

- Why have you chosen this solution?
    - In the case of an external catalogue: why not just an internal catalogue? Why a GDSN catalogue or non GDSN (local)? Why this one, rather than an equivalent one?
    - In the case of an internal catalogue/PIM: why not an external catalogue? Why this one, rather than an equivalent one?

C) To pick up the threads of the description on DATA STANDARD:

- What do you think of the GS1 standard?
- Does it suit your needs?
- What is currently lacking in it?

D) To pick up the threads of the description on MESSAGE FLOWS:

- What are the data flows between your internal databases and your catalogue?
- Is it a pushed or pulled flow?
- It is automated or is there human intervention?
- Which are the events triggering the sending or the receiving of the message?

On partners and interconnections:

E) Opening questions:

- With which type of partners do you exchange product information?
- Is it dependent on firm size/type of product/ product lifecycle (permanent or promotion)/type of system?

F) To pick up the threads of the description of symmetric systems:

- Do you have partners who are on the same wavelength?
- How do you operate with them?
- Where do you stand now?

G) To pick up the threads of the description on different architectures:

- How do you operate with your partners who have made such a different choice of architecture (GDSN catalogue/ external catalogue out of GDSN, internal catalogue only)?
- Where do you stand now?

H) To pick up the threads of the description on different data standards:

- How do you operate with your partners who want (don't want) to exchange data out of standard?
- Where do you stand now?

I) To pick up the threads of the description on different message flows:

- How do you operate with your partners who insist on having a message for all retailers (one message per retailer)?
- Where do you stand now?

J) On experience feedback:

- What is the experience feedback on tools and technologies?
- What are the positive points? What are the difficulties encountered? At which level? How can you solve them? Will you change/evolve?

APPENDIX B: Detailed tables of results

Table B-1. Description of the Sending Systems of the 18 Manufacturers

Firm	Structural linkage and architecture	Shared data and standard	Description of message flows
Manu1	"We have decided to implement an internal catalogue to control our flows."	"The data standard is simple. It is based on GS1, following international standards."	"When we do an update we send the updated brief to the retailers who, beforehand, have been defined as receivers of the data."
Manu2	"The Group naturally went for 1Sync. The idea is GDS, with automatic synchronization with retailers."	"Starting from the Global standard we add specific data in 1Sync so that the set of data corresponds to 100% of what Retail2 asks for."	"Once everyone has added the data they own in 1Sync, then the category manager publishes the data for the client. We send a message directly to Retail2 with 100 % of the data they ask for."
Manu3	"From our PIM we could send product information directly to the client which means we do 1to1 connections. And, anyway, the goal is to have a Platform which redistributes to all. Hence the choice of an external data pool."	"We wish and we want specific stuff. There is a common base which covers the majority of the standard. This is where the motto is applied and that's good. But the product brief as we use it with retailers, as we design it, contains specific data."	"For us, indeed, 1Sync is a kind of router. We have a message that leaves the company and arrives at a retailer, the one which was targeted."
Manu4	"The parent company imposes some Tools like SAP, but also 1Sync for data synchronization on all its subsidiaries."	"We are currently adapting our tool to comply with international standards, with the French extension standard, but also to Retail2 business model."	"The company policy is not to key in anything on 1Sync. We send a package to 1Sync which corresponds to what the client wants to receive and 1Sync redirects this package toward the client."
Manu5	"From SAP, a business collector transforms our data in XML towards our PIM. […] And it is the PIM that synchronizes the data with the clients systems."	"We have everything, including the data that are relationship dependent."	"We do point-to-point with Retail5, Retail2 and Retail7, and we send 100% of our information."
Manu6	"The strategy I told you about is no external data pool because it is expensive."	"I think that if we want to go towards complete virtualization of the product brief, we must do the prices. That's what we do with Retail2."	"We are not developing ourselves on a classical external data pool vision with Global Data Synchronization, but rather on a LDS, Local Data Synchronization… which could be summed up as a point-to-point link."

Table B-1. Description of the Sending Systems of the 18 Manufacturers (cont.)

Firm	Structural linkage and architecture	Shared data and standard	Description of message flows
Manu7	"At the corporate level the project is to use 1Sync for all product briefs."	"Data standardization, it's done. It's the briefs standardization that causes problems because some retailers will want given data that others will not. We; we are 1Sync, therefore GDSN, therefore global standard."	"We are a driving force behind GDS through GDSN and global registry. Thus we feed 1Sync and the networked catalogues interoperability allows us to diffuse the briefs to all our clients."
	"We are doing tests to synchronize directly with some clients, outside GDSN."	"As Retail2 insisted, we are working on a parallel solution to send the prices. But I don't think we'll make it. We're gonna wait for the price message stability, to put it on 1Sync."	"With Retail2, we modified the standard message, to include the prices, the rebates as a function of the quantities, etc. And we are doing tests to synchronize directly."
Manu8	"All subsidiaries use 1Sync."	"All we put in 1Sync becomes common to all retailers of a Target Market."	"Once the data are loaded in 1Sync, we can publish toward all retailers."
Manu9	"We go for an external catalogue to avoid all connectivity problems."	"The current standard is good; it is even too wide. Thus and above all, one should not add particular variables or specific ones. Those who do that are shooting themselves in the foot, for it is an open door to everything and nonsense!"	"The idea is the basic idea of GDS: Publish once, send to all."
Manu10	"We were under the impression we had to have our own internal catalogue. And then to flow into the other retailers' catalogues."	"In our sending messages we add prices for the retailers which want that; As a matter of fact, it would be good if they all agree."	"It must be sent to the right person; one should not confuse the receiver. One should put the right price, the right rebates."
Manu11	"We needed a tool to centralize data internally…Once this was in place, we told ourselves an external provider was useless."	"The advantage of the internal solution is that we use it as we want; thus we create different datasets according to the retailer. For Retail5, it's100% common; For Retail7 or Retail2, we have additional data."	"It's our sales administration which decides to send a product brief according to the modifications we do or as a result of the request of a retailer."
Manu12	"We have decided to implement a PIM, that of Agena, which will feed the retailers' systems."	"We respond to Retail2's request, thus to all particular data they want…and we'll do the same with others."	"We do Retail2 mappings, Retail5 mappings."
Manu13	"It is not worth using a market catalogue. Our PIM offers all the functionalities to do synchronization."	"Messages are built on GS1 standard, with supplementary data for certain retailers such as Retail2."	"We are following on from PRODAT PRICAT messages[6]. We changed standards, but there is still a data flow that starts from our company to go to the retailer."
Manu14	"We chose the best architecture: using GS1 catalogue which is the reference for synchronization."	"We transfer the price; we transfer the particular conditions…the dates. Finally, it is 1to1."	"I send the brief and explain "*this brief, I want to send it to Retail5. Thus, they take this brief, they translate it in Retail5 language to send it to Retail5*". Same for Retail2, same for the others. This is the value added of the service provider."

[6] PRODAT and PRICAT are the EDI version (EANCOM Language) of standardized messages of product information and price specifications.

Table B-1. Description of the Sending Systems of the 18 Manufacturers (cont.)

Firm	Structural linkage and architecture	Shared data and standard	Description of message flows
Manu15	"Keeping internal some activity is not the goal. The external catalogue is the default choice."	"We don't have much choice. We send what the client asks. Private or common data, if we have it we send it."	"A message always has a defined recipient. It is the category manager who says "*This brief publish it for this retailer*"."
Manu16	"Given our French market roots, GDSN data pools are useless. We've begun with an external catalogue solution, specialized on the French market."	"We adjust ourselves on what our clients' request."	"Data are first loaded on the catalogue, with all the specifications and constraints of each client; then the catalogue send the product brief to the retailer."
Manu17	"Constraints for all project leaders in markets are threefold; it's 1Sync."	"Constraints for all project leaders in markets are threefold; […] the standards and a unique product brief for all, all, all the external and internal actors."	"a unique product brief for all, all, all the external and internal actors." "1Sync is GDSN compliant. Thus data are published in 1Sync, and 1Sync diffuses the message to its homologue counterparts."
	"For the moment, the price message is not available, it is not approved. We asked 1Sync to work on it, but for the moment we send that directly from our place."	"Retail2 requests prices, rebates data, etc. And with Retail7, it's the same for all that is related to request for proposal."	"The price cannot be included in the product brief, which is shared by definition. Thus the price must be transferred in another message with a clearly defined recipient!"
Manu18	"The approach was structured through an electronic catalogue. We chose the famous 1Sync which allows having a central datapool - a warehouse and the hub of the information."	"We absolutely don't want that notions linked to commercial conditions be able to wander, even electronically. No way: it's the set of common data of GS1 and that's all."	"1Sync pushes automatically new briefs." "Bridges are created, links between the retailer catalogue and that of 1Sync in order to forward the information."

Table B-2. Receiving Systems of the 7 Retailers			
Firm	**Structural linkage and architecture**	**Shared data and standard**	**Description of message flows**
Retail1	"We go through Agentrics; we have a unique entry point."	"At the beginning when I requested a product brief and explained "*we are going to synchronize data, and you're going to send me product briefs*", they didn't want to or could not send me a price. I didn't speak about complex pricing, only a basic purchasing price which is common, since it is the price in the sales conditions."	"We started off on international standards because we leant back on Agentrics. And today, I do not see many suppliers ready to do EDI. There are some maybe, but at the limit, they go through providers like Influe or others who could tomorrow do both EDI and GDSN."
Retail2	"What was important for our design was the data present in 1Sync"	"We remain standard as much as we can on all possible data. However, there are data we need which are not provided by the standard, such as prices." "Retail2 must receive this data for the buyer who is concerned."	"[The manufacturer] will choose to be GDSN, will select a Source Data Pool which will synchronize itself with our Recipient Data Pool which will send us, via GDS, standard data. Thus, on top of this, it must send us through another channel the additional data, which currently are not included in the standard."
	"Some suppliers also send us 100% of the data through 1Sync"	"Some suppliers also send us 100% of the data through 1Sync."	"Some suppliers also send us 100% of the data through 1Sync, hence out of the network."
	"We also synchronize with the PIM." "From the local providers we receive messages via AS2[7] and directly from our largest suppliers."	"We call [the message] 100% because it contains all the data Retail2 expects."	"Then, [the manufacturer] will send us an XML; We call it 100% because it contains all the data Retail2 expects. In fact we are in charge of receiving this file, of transforming it and of producing a mapping to integrate it in our systems."
Retail3	"We want to be fed by GS1."	"All our particular agreements with suppliers, even at the level of logistical characteristics, must be taken into account."	"We are doing proprietary. By definition a product brief is made for one and only one retailer."
Retail4	"Our goal is to use Agentrics as unique entry point on which all other catalogues – 1Sync, LCPs – would be connected."	"At Retail4 today, we ask suppliers to include their prices. And believe me, we are at least as much concerned by the fact that we do not want that Retail1 or Retail2 knows the fact that we are going to sell a product, on such and such a date, at such price."	"They send different product briefs to each retailer. They only need to have a catalogue able to handle all the data of each retailer. Me, Retail4, I request this. Retail1 requests that. The catalogue provider must be able to handle these different models."

[7] AS2 (Applicability Statement 2) specifies rules for secure data transportation over the Internet.

Table B-2. Receiving Systems of the 7 Retailers (cont.)

Firm	Structural linkage and architecture	Shared data and standard	Description of message flows
Retail5	"To be complementary to point-to-point exchanges, for suppliers who did not want or could not do EDI, we attested that the electronic catalogue of the supplier is able to send us the information we want in the proper format." "We are not network structured, but rather in point-to-point with multiple sources."	"We are still not compliant with GDSN standard. We keep using PRODAT common data."	"I speak of data synchronization, of data alignment. Not of GDSN. That is to say, as soon as information change about a product, the updated brief is automatically sent to all the clients who have subscribed to this product." "The flow is direct with national catalogues like Equadis and Catalogic8 whom we then certified."
Retail6	"With Parangon, we can receive from all our suppliers, those that are GDSN and those that are not. Indeed, since suppliers using LCPs9 are connected to Parangon, I get data the same way as if they were directly connected with me."	"We define our own data standard, while keeping an eye on GS1 standards."	"Transferring prices through GDS, I can't believe it. In a shared system, there is always fear that neighbors can see your data. And that, I think it must not be neglected. Prices transfer is inevitably in point-to-point."
Retail7	"It is where suppliers are that we set a connection to exchange with them."	"We mixed product information and request for special offers. We started from GS1 standard and we supplemented it."	"They fill in all the fields which are GS1 compatible; they add the pricing part and they deliver the information so that we know that their reply corresponds to such a request for proposal."

[8] Equadis and Catalogic are external catalogues that are not GDSN certified.

[9] Local Catalog Provider (LCP) provides an external catalogue for product information exchanges on a given market. These Catalogues are not GDSN certified.

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