Abstract number: 007-0150

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Authors:

Dr. Pamela Danese
Department of Management and Engineering
University of Padova,
Stradella S. Nicola, 3
36100 Vicenza, Italy.
Tel +39 0444 998789 – Fax +39 0444 998888
E-mail: pamela.danese@unipd.it

Dal Pont Giorgia
Department of Management and Engineering
University of Padova,
Stradella S. Nicola, 3
36100 Vicenza, Italy.
Tel +39 0444 998789 – Fax +39 0444 998888
E-mail: pamela.danese@unipd.it

Prof. Dr. Pietro Romano
Department of Electrical, Managerial and Mechanical Engineering
University of Udine
Via Delle Scienze, 208
33100 Udine, Italy
Tel +39 0432 558246 – Fax +39 0432 558298
E-mail: pietro.romano@uniud.it

Prof. Andrea Vinelli
Department of Management and Engineering
University of Padova
Stradella S. Nicola 3
36100 Vicenza, Italy
Tel +39 0444 998740 - Fax +39 0444 998888
e mail: vino@gest.unipd.it

POMS 18th Annual Conference
Dallas, Texas, U.S.A.
May 4 to May 7, 2007

SUPPLY CHAIN COLLABORATION: A ONE-BEST-WAY PRACTICE?

Abstract

Supply chain (SC) collaboration in supply chain management literature is commonly considered a one-best-way recipe to improve performance. The basic assumption is "the more collaboration – the better the management of the supply network". This article challenges this assumption, by introducing explanations that different forms of supply chain collaboration exist and different aspects of collaboration might be important under different conditions. Using Galbraith's contingency theory as its starting point, and case-study method, this article proposes a contingency theory of SC collaboration in logistics processes. It is suggested that specific conditions – i.e. goals of the collaboration, products sold by companies involved in the collaboration, elasticity of demand, number of potential partners, and stage of development of the collaboration - can affect the information processing required to implement SC collaboration. In turn, the characteristics of the information processing determine the information and communication technologies and liaison devices used to support collaboration.

Keywords: Case studies; information technology; logistics/distribution; supply chain management

SUPPLY CHAIN COLLABORATION: A ONE-BEST-WAY PRACTICE?

Introduction

Today, inter-network competition is one of the main characteristics of business. According to a supply chain management (SCM) perspective, organizations do not seek to achieve cost reductions or improvements in profit at the expense of their supply network partners but, rather, seek to make the supply network more competitive as a whole (Romano, 2003). Managing collaboration among supply network partners is a strategic task that can contribute to the competitiveness and profitability of both individual firms and entire networks. This explains why in recent years we have witnessed a growing excitement and top management's attention on the subject of supply chain (SC) collaboration: through information sharing, joint decisions, or integrative practices based on information and communication technologies (ICTs). The pivotal importance of SC collaboration in SCM literature has also been reinforced by the impressive results achieved by successful programmes in supply networks coordinated by large, high performing focal firms, such as Wal-Mart, Procter & Gamble, and Henkel (Seifert, 2003).

Although these cases demonstrate that SC collaboration contributes to improved supply network performance, some doubts can be expressed concerning the universal applicability of supply chain management concept in general and collaboration in particular. According to Ho, Au and Newton (2002), the absence of context in most research on SCM is a major shortcoming of the current status of its theoretical development. With respect to SC collaboration, Mouritsen et al. (2003) argue that more needs to be known about under which circumstances different forms of collaboration are beneficial for the participants. There are some few studies based on the contingency perspective in the SCM field (Fisher, 1997; Van Donk and van der Vart, 2004). However, there is still little empirical research directly addressing the question: How can contextual factors affect SC collaboration?

To fill this gap, this article concentrates on SC collaboration practices aimed at integrating logistics processes along supply networks. Logistics has been chosen because it is one of the most thoroughly investigated areas in SCM, and that if properly managed can lead to cost reduction and service enhancement (Christopher, 2005). Furthermore, logistics represents an interesting research setting for the purpose of this study because companies implement different forms of SC collaboration to integrate logistics, but the reasons why companies choose different types of collaboration are still not clear.

This research contributes to filling this specific gap in the literature by proposing a contingency explanation of: how relevant contextual factors can influence SC collaboration. Galbraith's contingency theory (Galbraith, 1973; Galbraith and Kazanjian, 1986) helped illuminate and interpret the underpinning logic behind the implementation of different forms of SC collaboration. Galbraith's theory suggests to investigate (1) the link between the *context* and the *information processing* required to implement the collaboration, (2) the links between these *information processing* and the *ICTs* and *coordination mechanisms* adopted to support the collaboration.

Understanding the mechanisms by which context affects SC collaboration provides a fascinating area of research. From a theoretical point of view, a contingency theory of SC collaboration significantly contributes to the advancement of theory, as shows that different forms of SC collaboration exist and different aspects of collaboration may be important under different conditions. The ambition is to open an interesting debate on the universality of SC collaboration, by introducing explanations of how specific contextual conditions can influence the applicability of SC collaboration practices. In particular, this article proposes that some contextual variables influence the information processing to implement the collaboration, and that this requires adopting precise types of ICTs and coordination mechanisms. Thus rather than focusing on the study of SC collaboration as a decisive factor *tout court*, I direct my attention to the variety of ways in which SC collaboration can be made and the contextual variables that lead to different forms of SC collaboration.

Moreover, from a practitioner's perspective, if companies are to truly engage in SC collaboration and understand how to implement it, a contingency theory of SC collaboration can be valuable to develop mechanisms for proactive managerial action. In fact it can suggest to managers how to select the most appropriate action to be taken when implementing the collaboration; through the analysis of the context where it should be implemented.

The paper is organized as follows. First, it analyzes the existing literature on SC collaboration in logistics processes. Then the article introduces Galbraith's contingency theory and shows how it applies to this study of SC collaboration. The study's research methodology follows. Then, the paper describes the analyses conducted to answer the research questions and develop the results; and includes specifically the data analysis conducted for analyzing the relationships between (1) contextual factors and information processing, and (2) information processing and ICTs/liaison devices used to support collaboration. Theoretical and managerial implications are then discussed. The article ends with conclusions and suggestions for future research.

Literature review on SC collaboration in logistics

Logistics concerns coordination of information and physical flows related to the production and distribution of goods through the supply network (Christopher, 2005). Companies can collaborate in various ways to accomplish the aim of integrating logistics processes. One of the most advanced SC collaboration practices is collaborative planning, forecasting and replenishment (CPFR) (VICS, 2002; Seifert, 2003). CPFR programs concern collaboration where two or more companies jointly plan a number of promotional activities and work out synchronized forecasts, on the basis of which the replenishment processes are determined. CPFR can be considered the natural evolution for companies already implementing other SC collaboration practices, such as Vendor Managed Inventory (VMI) or Continuous Replenishment (CR) (Barratt and Oliveira, 2001). VMI is a technique developed in the mid 1980s whereby the manufacturer (supplier) has the responsibility for managing the customer's inventory policy, including the replenishment process. CR practice is similar to VMI, but in this case the manufacturer (supplier) can use POS data to predict customer's future sales and manage the replenishment process. At the heart of the CPFR process lies the aspiration to cover the gaps left by these SC collaboration practices. As suggested by the CPFR model developed by the Voluntary Interindustry Commerce Standards committee (VICS), the CPFR has a more comprehensive focus that includes promotional, and sales and order forecast plans. Moreover, collaboration deals with synchronizing the dialogue between the parties, through joint decisions and exception management. In fact, participating companies jointly set promotional, sales and order forecast plans, and cooperate in identifying and resolving exceptions, that require the readjustment of the plans (e.g. stock-out situations).

The belief that SC collaboration in logistics can take a number of different forms across supply networks, and that companies follow well-defined integration paths towards advanced forms of collaboration is widely diffused in SC collaboration literature. Larsen *et al*. (2003) state that SC collaboration in logistics can be implemented in various ways; as it can be differentiated both in terms of scope of the collaboration - indicating the number of business areas involved (e.g. definition of promotional or sales forecast plans) - and depth of the collaboration - measuring the integration of business processes (e.g. degree of discussion, co-ordination/synchronization). In particular the authors suggest that it can be classified into three levels – basic CPFR, developed CPFR and advanced CPFR - depending on these two variables; and argue that the basic CPFR is frequently the starting point for other collaborative initiatives.

A similar perspective emerges from the Efficient Consumer Response (ECR) Guide on CPFR published in 2001 (ECR, 2001). It suggests that the VICS model has indeed a modular structure as, in some circumstances, it is not needed to collaborate on promotional, sales and order forecast plans. For example, Levi Strauss & Co. incorporates only certain aspects of the CPFR business process in to its retail replenishment service, by creating joint order forecast plans and identifying exceptions (for instance, over/under stock situations, execution problems) (Aviv, 2001). Similarly, Danese (2006) reports GlaxoSmithKline case where manufacturing units and distribution centers of the pharmaceutical group jointly manage order forecast plans and solve the exceptions. The ECR Guide suggests the slogan: "think big, start small, and scale intelligently". To implement SC collaboration, it is necessary to start small, focusing on only a few processes in the early stage of the project's development. The scale intelligently step relies on the lessons learned during the pilot project. Companies need to evaluate their experiences in order to develop their individual plan towards roll-out. They may, for instance, decide to involve more processes in the collaboration.

Several other studies reveal that SC collaboration tends to evolve from basic towards advanced forms of collaboration. Some authors (Spekman *et al*., 1998; Seifert, 2003) also highlight that Information and Communication Technologies (ICTs) used to support SC collaboration change across the different stages of the evolutionary path. Indeed it is plausible that, as SC collaboration evolves towards advanced forms, the ICTs adopted also change. However, it should be noted that sophisticated ICTs are not necessarily a condition for successful implementation of advanced SC collaboration practices, such as CPFR (Helms *et al*., 2000). Companies can sometimes engage in SC collaboration through low-tech approaches, such as face-to-face planning meetings, sending daily sales information via fax, spreadsheets of sales, ordering and promotional data via email. This is possible when there is a low number of companies involved in the collaboration. In fact, although several SC collaboration projects involve manufacturer-retailer dyads, it is worth noting that in some cases a company can collaborate with numerous supply network members, both upstream and downstream in the supply network. SC collaboration between Sara Lee's Hanes and Wal-Mart involves fifty stock-keeping units of underwear, supplied to almost 2,500 Wal-Mart stores. Heineken USA is currently providing collaborative planning and replenishment software to its top 100 distributors.

Finally, it is worth noting that the ICTs are not the only inter-firm coordination mechanism that can be used to support SC collaboration in logistics. Other mechanisms, such as meetings, temporary task forces, or personnel dedicated to manage customer-supplier relationships, seem to be particularly important when it comes to implement a SC collaboration. Literature on CPFR especially highlights the importance of these coordination mechanisms. For instance, the ECR Guide on CPFR (published in 2002) (ECR, 2002) state that meetings are particularly useful when companies collaborate in resolving order/forecast exceptions (discrepancies in sales and order forecast plans). In the Unilever–Sainsbury's–GNX case, reported in this Guide, collaboration takes place among the logistics representatives every Friday, with discussion of key findings and agreement on changes, where appropriate, to bring forecasts into line. Similarly, most companies implementing CPFR continue to hold periodic meetings in which representatives from all areas of the collaborative firms participate (Frankel *et al*., 2002).

Gaps in the literature and discussion

Literature review on SC collaboration in logistics suggest thinking about some important issues.

Firstly, several authors recognize that SC collaboration in logistics can take a number of different forms. Also cases described in supply chain management literature confirm this. The level of integration (e.g. the degree of discussion, data exchanged, plan synchronisation, etc.); business processes and number of partners involved in the SC collaboration can differ. In addition, different types of ICTs and inter-firm coordination mechanisms can be used to support SC collaboration. Simply as an example, the adoption of ICTs ranges from the use of simple tools, such as a fax, to more advanced Internet-based solutions. Despite this, research is still at an early stage of investigating the reasons why a company decides to implement a well-defined SC collaboration practice. Cases often seem to suggest the universal applicability of SC collaboration initiatives, whereas the role of context is overlooked.

Secondly, much of the discussion on the differences among SC collaboration forms has centered on the existence of integration paths: that evolve from basic to more advanced forms of collaboration. According to this perspective, advanced SC collaboration practices can be considered the natural evolution for companies that already implement more basic forms of SC collaboration. However, this perspective does not fully explain the reasons why companies implement well-defined SC collaboration practices, as it seems to suggest that SC collaboration forms are context-free. Instead, it is plausible to suppose that they can be seriously influenced by several contextual factors, such as the supply network structure or strategies pursued by the companies. Several firms deliberately limit SC collaboration to basic practices, even if the collaboration has reached an advanced stage of maturity. Thus, the question is still unanswered as to why SC collaboration in logistics processes varies across supply networks.

Contingency theory for interpreting SC collaboration

Contingency theory is an approach to organizational analysis which emphasizes that the nature and structure of organizations can take on a number of forms and, accordingly, may be related to several contingencies. Figure 1 reflects in a simplified way the logic behind Galbraith's contingency approach that inspired this current study.

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Insert Figure 1 about here

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The depicted set of relationships shows that environmental factors and the strategy pursued by the organization influence the characteristics of tasks to be performed, that in turn lead to a well-defined organizational design. Significantly, contingency factors determine to a large extent the uncertainty of task which the organization must cope (due to the difference between the amount of information required to perform the task and the amount of information already possessed by the organization). The degree of task uncertainty is identified as the key variable on which the alternative organization designs are contingent. It was hypothesized that this is because alternative forms of organization represent alternative capacities for processing information, and *information processing* to execute the task depends on task uncertainty.

Several organization theorists (Daft and Lengel, 1986; Daft *et al*., 1987) developed on Galbraith's information processing view of organization design. However, also in operations management and supply chain management literature, there are various studies based on Galbraith's contingency theory (e.g. Van Dierdonck and Miller, 1980). They demonstrate that to adapt the richness of organizational theory to the particular managerial interest of the operations management discipline can lead to interesting and useful results. In the same vein, this current research aims to propose a contingency explanation of the differences in SC collaboration across supply networks. In particular, the analysis of the contingency theory concept and literature on SC collaboration helped to identify the dimensions that could be of interest in developing a contingency theory of SC collaboration, and suggested some of the ways in which they can be related.

According to contingency theory, the understanding of the *information processing* to execute the task is fundamental for deciding on organization design. This suggests that the information processing required to implement the collaboration should be considered a central dimension towards a contingency theory of SC collaboration. Information processing refers to the intensity of the effort necessary for gathering and processing information for decision making in logistics processes.

With regard to the variables explaining the variety of information processing, the review of the literature on SC collaboration in logistics (as discussed in the previous section) suggests consideration of the following factors, that are important as they determine the amount of information that has to be processed and how it has to be analyzed for decision making.

1. The depth of the collaboration depending on the number and type of business areas involved in the collaboration and the level of integration. Three main levels of depth of collaboration have surfaced by comparing several studies and cases described in the literature on SC collaboration. This study employs the following terminology for the three depth of collaboration levels: *communication*, *limited collaboration* and *full collaboration*. Table 1 summarizes the main characteristics of each level.

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Insert Table 1 about here

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2. The number of interacting units that indicates the number of supply network members with whom the central company collaborates in performing the collaboration. Cases described in literature demonstrate that this number can vary significantly, from few to thousands of actors.

As suggested by Galbraith's theory, companies have to implement mechanisms to satisfy the different types of information processing. How companies exchange and use information are decisions that must be made when deciding on SC collaboration design. In particular, companies have to decide on the *ICTs* that can be adopted to collect, collate, process and disseminate information. Table 2 reports the different types of ICTs, generally used to support collaboration in logistics (Attaran and Attaran, 2002; ECR, 2002, Sparks and Wagner, 2003).

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Insert Table 2 about here

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Additionally, as pointed out in the previous section, decisions are needed on a particular group of coordination mechanisms that are regarded to assume crucial importance when designing SC collaboration. By using Mintzberg's terminology (Mintzberg, 1979), this research refers to these coordination mechanisms with the term *liaison devices* (Table 3). Those of particular importance include: liaison positions, meetings and integrating managers.

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Insert Table 3 about here

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Finally, the last dimension to be taken into consideration to develop a contingency theory of SC collaboration is the *context*. Defining this dimension is an arduous task, as a consequence of the infinite number of contexts where collaboration can take place. Moreover, as argued in the introduction, research is at an early stage of investigating what contextual variables can influence SC collaboration. However, as the research process developed, the analysis of data gathered allowed focus on a narrow set of relevant variables (Table 4).

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Research methodology and case profiles

Since the aim of this research is theory development, a multiple-case study method has been adopted to investigate the research questions (McCutcheon and Meredith, 1993; Meredith, 1998). In particular, the implementation of different forms of SC collaboration in ten supply networks was examined.

Case selection and information processing

The literal and theoretical replication issues guided the selection of the cases. First, companies representative of different types of information processing were selected. As such, the research sample comprised two cases representing the full collaboration level, four cases representing the limited collaboration level, and four cases representing the communication level (see Table 5). Moreover, polar types of cases, in terms of number of interacting units, were selected for each depth of collaboration level. In particular, from the selected cases, a clear distinction between a group of companies collaborating with only a few partners (less than four) – that is, low- class - and a group of companies collaborating with several partners (more than twenty) - assigned to the high-class - emerges. For instance, in case L, the central company collaborated with four customers, while, in case B, the central company collaborated with approximately fifty distribution centers (DCs) located worldwide (Table 6).

It is worthy of note that in two cases (I and H), in 2002, when data began to be collected, the central companies collaborated on a full collaboration level with few partners. The collaboration programme had begun in 2001, and since its adoption had allowed to achieve several benefits. For this reason, in 2004, these two central companies decided to extend collaboration to several other customers and suppliers respectively, and to implement an Internet-based CPFR solution to collaborate to several partners. Initial results were promising and cases H and I are cited in several studies as exemplar cases of CPFR implementation. The selection of these cases helped develop the rationale on the contextual factors that can influence the number of interacting units; that is one of the variable characterizing the information processing.

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Insert Table 5 about here

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Having two instances of each type of information processing in Table 5 allows for literal replication, i.e. to verify whether similar results occur for cases representative of the same type of information processing. Whereas having two instances representing all the types of information processing allows for theoretical replication, i.e. to verify whether contrasting results occur across different types of information processing.

The selection process required, first, to identify a list of cases that appeared to match the required target sample criteria; then, to collect data and information on each case to test this initial judgment. This process was repeated until the target sample was achieved. Overall, twelve central companies were contacted, seven of which were selected to participate in the study. Three of these companies collaborated differently in the upstream and downstream networks, and thus gave the opportunity to examine different SC collaboration projects. For instance, central company 3 (Table 6) collaborated with the DCs on a limited collaboration level, while its collaboration with the other production/packaging plants consisted in just the exchange of data/information on stock levels and available capacity (i.e. communication level). As a result, ten cases of SC collaboration were chosen.

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Insert Table 6 about here

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Analysis and results

This section discusses the link between (1) context and information processing, and (2) information processing and ICTs/liaison devices adopted to support the collaboration.

The main discussion is based on the comparison of the ten cases, through two-variable matrices. Results are then summarized in the form of 'propositions'. Data reduction facilitates the comparison of data. It consists of the characterization of each case across the research variables (context, information processing, ICTs and liaison devices). It is used a set of items to characterize each variable, and each item is classified according to a well-defined rule specified in Table 7. Central in defining these rules was the comparison of data across the cases.

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Insert Table 7 about here

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Contextual factors influencing the depth of the collaboration

The initial analysis tested whether the goals of the collaborations (i.e. strategy of efficiency or responsiveness – see Table 7) could be linked to the depth of collaboration level, i.e. one of the variables determining the information processing. The visual pattern in Table 8 suggests that an interesting relation could exist.

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Insert Table 8 about here

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In particular, it seems that when an efficiency strategy prevails, a collaboration based on the mere communication of data suffices to guarantee the achievement of the goals. In contrast, when a company decides to collaborate to make its supply network more responsive, a deeper collaboration is then necessary. This relationship was considered robust after the analysis of how the other contextual variables varied within the two groups of companies emerging from Table 8.

Evidence from cases helped to better understand the link found. Central company 1 (case A) collaborated with the DCs it replenished with the aim of reducing inventory costs, while simultaneously maintaining a high service level (i.e. strategy of efficiency). The scope of the collaboration was to increase company 1's visibility, by making DCs' data (sales and stock levels) available (i.e. communication level). Before implementing the SC collaboration project, central company 1 estimated the demand of starter batteries on the basis of past deliveries. Moreover, it did not know DC stock level data. Overall supply network inventories were high, and huge investments in stocks were justified by the principle of protection, i.e. the desire to protect company 1 against downstream fluctuation in demand and DCs against stock-out risk. The SC collaboration project, launched in the 1998, contributed to reduce significantly inventory levels in the downstream network, whereas company 1's service level even improved (from 65% to 87%).

Instead, in other cases, the main objective of the collaboration was to increase responsiveness to demand changes. In these situations, the joint definition of plans and exception management proved to be essential. For example, the scope of the collaboration between company 2 and its DCs was to contain investment in stocks, while simultaneously making the supply network more responsive. During the l990s, company 2 decided to re-configure its supply network, with the aim of exploiting production scale economies. The supply network re-configuration led to the closing of several production plants and centralisation of injectable cephalosporin production in the Italian plant. This limited flexibility to switch the production of the drug from one plant to another in an emergency. To solve this problem, company 2 decided to manage DCs' deliveries following the 'VMI min-max' approach, as it allowed company 2 to solve order forecast exceptions (e.g. additional DCs' requests in the frozen period), thus making the supply network more responsive to demand changes. As explained in Table 6, this type of collaboration can be classified as limited collaboration.

However, given the goals of the collaboration, it seems that other factors play a crucial role in choosing the business processes that are to be involved in the collaboration. In fact, information from Table 8 does not help to justify why companies, whose goal is responsiveness, choose to collaborate on a full-level rather than limited-level of collaboration. Differences in product diversity, elasticity of demand and supply network spatial complexity help us better understand this (Table 9).

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Insert Table 9 about here

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The cross-case comparison shows that in cases H and I, the companies involved in the collaboration had in-depth knowledge of the final market, inasmuch as they sold and marketed the same products and operated in well-specified geographic areas. Central company 5, located in Brussels, for instance, sold and marketed consumer and soft goods to retailers located in Belgium who then distributed the products in the Belgian region. Thus the spatial complexity is indeed low (see Table 7). The same considerations can be drawn for the collaboration between company 6 and its suppliers. Managers within company 6 - located in Belgium - collaborated with local suppliers to define promotions and the sales forecast plans of company 6's supermarkets located in Belgium, on the basis of which order forecast plans were established.

It seems that the contribution of members positioned upstream in the network when defining promotional and sales forecast plans, is significant only when they have a thorough knowledge of market dynamics, as in the cases discussed above. Conversely, central company 4 did not collaborate with its DCs/distributors in jointly defining promotional plans and sales forecasts. In fact, in the managers' opinion, this would not offer particular benefits. The distributors, located worldwide, did in fact have the possibility to collect information and data on the market they served and to elaborate accurate sales forecasts without collaborating with the central company, located far from the DCs it replenished.

Moreover, unlike cases H and I, case L companies involved in the collaboration, sold and marketed different products. This seems to limit the opportunity for joint promotional and sales forecast plans to be established. Central company 7 produced and sold corrugated cardboards while its customers produced and sold food. In such situation, it is unfeasible for members positioned upstream in the network to participate in the definition of the promotional and sales forecast plans of its customers.

A further distinguishing feature of the collaborations H and I concerns the elasticity of final market demand in case of price variations. Product shelf prices can significantly influence customer behaviour, hence demand elasticity is very high. In company 6's stores, sales volume could increase by up to 300 per cent during a promotion; in the stores of company 5's customers it varied between 200 and 300 per cent. In these cases, therefore, the impact of promotional plans must be accurately estimated to ensure the manufacturer is able to satisfy the increased demand for a product. As stated by the supply chain manager of central company 6:

> 'demand uncertainty in the food industry is low. Nevertheless, as a result of events such as promotions, there is a high level of demand fluctuations and this can lead to significant waste and losses within the supply network. Through collaboration on sales and promotional plans supply chain efficiency and responsiveness can significantly improve'.

In cases H and I, after the implementation of the collaboration project, forecast accuracy improved; thus making it possible an improvement in stores' service level during promotions.

In summary, the following two propositions describe the relationships between goals, product diversity, demand elasticity, supply network spatial complexity and the depth of the collaboration.

Proposition 1: The depth of the collaboration depends on the goals of the collaboration. In particular:

- *Proposition 1a: When the goal of the collaboration is efficiency, companies tend to limit the collaboration to data exchange (i.e. communication level);*
- *Proposition 1b: When the goal of the collaboration is responsiveness, companies tend to collaborate on a full or limited collaboration level.*

Proposition 2: The adoption of the limited or full collaboration level in performing SC collaboration depends on the product diversity, demand elasticity, and the supply network spatial complexity. In particular:

- *Proposition 2a: Companies tend to collaborate on a limited collaboration level when they market and sell different products or when demand elasticity in case of price variations is low or spatial complexity is high;*
- *Proposition 2b: When companies market and sell the same product, demand elasticity in case of price variations is high and spatial complexity is low, they can collaborate on a full collaboration level.*

Contingent factors influencing the number of interacting units

During the analysis, it emerged that the number of companies that collaborate with the central company (that is, the number of interacting units) was best explained by the influence of two main contextual factors: the number of potential partners and the development stage of the collaboration. Table 10 helps to clarify the relationships between these variables. In particular it suggests that a high number of potential partners and an advanced stage of development are essential conditions for collaboration with a high number of units.

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Insert Table 10 about here

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Evidence from cases shows that the number of units with which the central company collaborates is closely related to its supply network's relational structure. In fact, central companies chose the partners to involve in the collaboration programme depending on the nature of the relationship with customers and suppliers. Existing integration practices - such as the existence of collaborative/long-term buyer–supplier relationships, or SCM initiatives (e.g. adoption of systems to monitor supplier performances, involvement of suppliers/customers in process/product improvements or in quality management) - seem to have profoundly influenced central company selection choices. In some cases, the partners selected for the collaboration are vertically integrated: central company 2, for instance, own the DCs it supplied; central companies 1 and 3 own some local DCs. Thus, on the basis of the nature of relationships existing within the supply network, the central company can identify a certain number of potential partners to involve in the collaboration programme. It might be expected that this drives the number of interacting units with whom the central company will collaborate.

Table 10 suggests that when the number of potential partners is low (i.e. less than four), the number of interacting units is also low. In addition, it emerges that a high number of potential partners is a necessary, but insufficient condition for collaboration with several units. Indeed, in the cases H and I, despite the number of potential partners being high (i.e. more than twenty), central companies 5 and 6 initially decided to limit their collaboration to only a few supply network members. In fact, managers agreed that even if there were several partners that could be involved, a preliminary period, fundamental to acquire experience on how to manage the collaboration, was necessary. In 2003 the collaboration was extended to include several other partners within the supply network. Thus, it seems that, besides the number of potential partners, another variable can influence the number of interacting units: namely the development stage of the collaboration (see Table 10).

The evidence therefore suggests that, the number of potential partners (low or high) - that depends on the supply network's relational structure - and the development stage of the collaboration influence the number of interacting units. In particular, it can be argued that when the number of potential partners is low or the collaboration is in its early stages of development, the number of interacting units is low. In other cases, it can be high.

Proposition 3: The number of interacting units depends on the number of potential partners and on the development stage of the collaboration. In particular:

- *Proposition 3a: A high number of potential partners and an advanced stage of development are essential conditions for collaboration with a high number of units;*
- *Proposition 3b: When the number of potential partners is low or the collaboration is in its early stages of development, the number of interacting units is low.*

Link between information processing and ICTs

By classifying the ICTs according to the rule specified in Table 7 and simultaneously considering the different types of information processing, an interesting relationship emerges (Table 11).

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Table 10 shows that when a company interacts with only a few partners, it is not necessary to implement sophisticated ICTs to support the collaboration. Companies 4 and 7, for example, communicated with their customers via fax and email; similarly, company 2 did so with its suppliers.

Conversely, when the number of interacting units is high, more sophisticated technologies have to be adopted to manage the SC collaboration effectively. Interestingly enough, the level of sophistication seems to depend on the depth of the collaboration.

When companies collaborate with several partners and the collaboration is limited to data communication (i.e. communication level), ICTs that allow electronic data/information exchange and its integration into companies' local systems are adopted. Adoption of these types of ICTs becomes essential to guaranteeing the speed of information transfer and accuracy of information. Indeed, when a company interacts with several units, data exchange via fax and/or email does not guarantee the accurate and timely updating of data. In fact, personnel would have to devote considerable time to interpreting files or faxes received and to inserting data into the company's local system. For these reasons, company 3 communicated with subcontractors via Extranet and with MUs owned by the pharmaceutical group via Intranet. Data and information can be extracted from and imported into local systems. Similarly, company 1 could read and extract DC stock and sales data.

When companies collaborate on a limited collaboration level and the number of interacting units is high, the sophistication of the adopted ICTs increases. As well as using tools to electronically exchange data/information and integrate it in companies' information systems, companies also tend to adopt APS tools to support the collaboration (e.g. to manage order forecast exceptions). For instance, in case B, the central planning system used DCs' stock level data and sales forecast plans to elaborate the Distribution Requirements Planning (DRP). The software adopted was Manugistics. Company 2 could access DRP results via the Intranet. Moreover, to solve order forecast exceptions, it could use Cyberplan, an APS tool produced by Cybertec, allowing planners to choose alternative replenishment plans when an additional product quantity was required by one or more DCs during the frozen period. Similarly, company 3 accessed DC data and DRP plans elaborated by the central system via the Intranet and used an APS tool to solve exceptions.

When companies collaborate on a full collaboration level and the number of interacting units is high, Internet-based CPFR solutions can be adopted to exchange data/information and support collaboration in defining promotional plans, and sales and order forecasts. In case H, when the collaboration was still at an early stage of development, company 5 did not use sophisticated ICTs to collaborate with its customers. However, given that it intended to extend the collaboration to several partners, it was testing the Internet-based CPFR solution powered by Syncra Systems. In 2004, this type of ICT was adopted to manage collaboration with several companies. Similarly, in 2002, company 6 exchanged data/information with suppliers involved in the collaboration via email; but, as in 2004 company 6 decided to extend the collaboration to several other suppliers, the technology offered by the WWRE e-exchange started to be used. Among services offered by WWRE, the Internet-based Collaborative Planner solution was adopted by company 6 and its suppliers to manage the entire CPFR process. Company 6's supply chain manager stated:

> '[...] WWRE gives companies the opportunity to develop and use standards to enhance communication and thus collaboration. Standards allow the suppliers to see customers' data/information and plans in a standard format (and vice versa). Moreover, the Collaborative Planner solution gives the possibility to dramatically reduce the time spent in solving sales/order forecast exceptions.'

Thus, the following proposition is advanced:

Proposition 4: Adoption of the ICTs supporting SC collaboration varies across the types of information processing.

- *Proposition 4a: When the number of interacting units is low, low sophisticated ICTs, such as fax or email, are adopted to support SC collaboration, independently of the depth of collaboration;*
- *Proposition 4b: When the number of interacting units is high, more sophisticated ICTs are adopted to support SC collaboration. Their degree of sophistication depends on the depth of collaboration: as the depth of collaboration moves away from communication towards limited and full collaboration, ICT sophistication increases. In particular, when companies collaborate on a communication level, ICTs supporting the electronic data exchange and data integration into companies' local systems are adopted; when they collaborate on a limited collaboration level, APS tools are adopted; when they collaborate on a full collaboration level, Internet-based CPFR solutions are adopted.*

Relationships between information processing and liaison devices

Cross-case analysis demonstrates that the mix of liaison devices a company can put into practice to manage inter-company relationships can significantly vary. Table 12 summarizes the degree of complexity of the liaison devices adopted to support the collaboration in each of the analyzed cases and, by simultaneously considering the adopted liaison devices and types of information processing, supports the existence of a relationship between these two variables. In fact, if no relationship existed, one would expect an equal dispersion of the different mixes of liaison devices within the matrix.

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Insert Table 12 about here

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When two or more companies communicate (information processing types 5 and 6), liaison positions are adopted as coordination mechanisms. Indeed, it is necessary to entrust a person or a group of people with the issue of managing data exchanges among units participating in the collaboration project. As this person has in fact no formal authority, she/he represents a liaison position, usually with the task of collecting/organizing information and managing inter-firm relationships. For example, in case G when central company 4 communicated its order forecast plans to the suppliers, a person was responsible for collecting documents and files, and sending them to the suppliers. Similarly, in case E, planners from central company 3 were responsible for guaranteeing the accurate exchange of data on time with the subcontractors and other MUs.

In the case of companies collaborating on a limited or full-depth collaboration level, as well as liaison positions, widely adopted coordination mechanisms are meetings that involve members from the interacting units. Meetings are defined by Mintzberg (Mintzberg, 1979, p.63) as 'the prime vehicle used to facilitate mutual adjustment'. In the information processing types 1, 2, 3 and 4, meetings are adopted to exchange data and information or to discuss plans when exceptions occur (e.g. when a DC asked company 2 for an additional product quantity during a frozen period or when a customer required company 7 to rush a delivery). The use of meetings to achieve coordination in the case of limited or full collaboration derives from the necessity to manage a two-way interaction that implies the exchange of data, information and knowledge, rather than a simple one-way communication, on the basis of which final order/sales forecast plans are defined.

In information processing types 2 and 4, as the number of involved units increases, as well as liaison positions and meetings, integrating managers are useful to coordinate units. In fact, these types of collaborations represent complex situations in which the organisation of meetings allows managers to discuss order/sales forecast plans, and contributes to solving exceptions by maintaining an open and encouraging atmosphere so that conflicts are neither intentionally avoided nor resolved through the use of force by one side. Smoothing over conflicts is in fact ineffective because it may leave discord in people's minds and thus undermine the quality of the relationship. However, integrating managers are also needed because when the amount of contact increases it may be useful to entrust a person with the responsibility of managing the collaboration. For example, when company 3's managers exchanged data/information and discussed order forecast plans with the DCs, the product manager, as the integrating manager, had the authority and influence to be able to establish the final forecast should there be any conflict. Moreover, in 2004, when companies 5 and 6 started to collaborate with several customers and suppliers respectively, the Customer Supply Chain manager in company 5 and the category managers in company 6 were responsible for directing meetings and determining final sales/order forecast plans.

Results of the relationship between information processing and liaison devices can be summarized in the following proposition.

Proposition 5: The adoption of liaison devices supporting the collaboration varies across the types of information processing.

- *Proposition 5a: When the depth of collaboration is at a communication level, low complexity liaison devices, such as liaison positions, are adopted to support the collaboration, independently of the number of interacting units;*
- *Proposition 5b: When the depth of collaboration is at a limited/full collaboration level, more complex liaison devices are adopted to support the collaboration. Their degree of complexity depends on the number of interacting units: when it is low, medium complexity liaison devices, such as meetings, are adopted; when it is high, high complexity liaison devices, such as integrating managers, are adopted.*

Discussion: theoretical and managerial implications

The contingency perspective

To understand why SC collaboration is implemented in a certain way, one must appreciate the context where SC collaboration takes place. Choices made by companies are better understood by adopting a contingency perspective, rather than a traditional perspective according to which companies follow an integration path that evolves towards advanced SC collaboration forms. According to several authors, companies initially implement basic SC collaboration initiatives (e.g. exchange data and information). Then, as trust increases, they achieve greater benefits by adopting more advanced collaboration practices, and/or investing in tools, equipment and production systems tailored to meet the requirements of their supply network. There is no reason to disagree with this theory. In fact, companies can arrive at the use of certain practices via a process of cumulative competence building and experimentation consisting in the adoption of new practices or the improvements of existing ones. The data collected in the field supports this assumption. However, this perspective is not always enough to explain different strategies in implementing SC collaboration, as overlooks how context can influence decisions leading to a certain practice.

The contingency model of SC collaboration proposed in this article can offer increased insights as to why companies choose a precise forms of SC collaboration (figure 2).

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Insert Figure 2 about here

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It is proposed that specific contextual conditions can affect the information processing to implement the collaboration, differentiated by depth of collaboration and number of interacting units. In particular, the following factors - goals of the collaboration, diversity of products sold by companies involved in the collaboration, elasticity of demand, number of potential partners and stage of development of the collaboration – can be used to explain the differences among the types of information processing. In turn, information processing determines the ICTs and liaison devices. Thus information processing, ICTs and liaison devices form a coherent configuration matching the context.

Link between context and information processing: a system approach

The key concept in a contingency theory is *fit* and the definition of fit that is adopted is central to the development of theory (Drazin and van de Ven, 1985; van de Ven and Drazin, 1985). The link found between context and information processing reveals the importance of adopting a "system approach" to contingency theory. This means that the context-information processing link must be explained by addressing simultaneously many contingencies.

Conversely, studies in SCM literature that investigate how contextual variables influence supply chain strategies are often based on a "selection approach", namely simple associations are hypothesized among variables in the model (Fisher, 1997).This reductionism makes difficult to interpret real cases of SC collaborations, and models presented operate at a very high level of abstraction. Readily conceding the importance of this macro-view of SC collaboration, a microview – analysing in detail how the different elements of a SC collaboration are determined - is also useful, and could be facilitated by the adoption of a “system approach”.

Figure 3 summarises the link between the contextual variables analysed and information processing, and highlights how each type of information processing depends on a certain mix of contextual variables (see also propositions 1, 2, and 3 in the previous section).

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Insert Figure 3 about here

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Some of the results found comply with other SCM studies. For instance, several authors (Dyer, 1997; Monczka et al., 1998) agree that good relationships increase the level of willingness to collaborate. For this reason, developing the SC collaboration with partners that maintain good relationship with the central company is essential. As a consequence, as illustrated in figure 3, a limited number of potential partners to be involved (i.e. partners that maintain long-term collaborative relationships with the central company,or that had previously implemented other SCM initiatives or that are vertically integrated) determines an information-processing characterized by a low number of interacting units.

In addition, results found on the relationship between the goals of SC collaboration and the depth of the collaboration partially complies with the results of Larsen et al. (2003). They state that different collaboration goals lead to different types of SC collaboration, with distinctions made for the number of business processes involved (e.g. promotional plan, sales, order forecast definition) and the level of integration (e.g. shared information, degree of discussion, coordination/synchronisation, etc.).

Compared to these studies, the originality of the model proposed lies in the demonstration of how different variables *together* affect the information processing. This implies that the goals of the collaboration are not enough to explain the depth of collaboration; and similarly the number of potential partners are not enough to explain the number of interacting units.

Link between information processing, ICTs and liaison devices

Results on the link between information processing and ICTs, and information processing and liaison devices (see propositions 4 and 5 in the previous section) confirm the main Galbraith's argument that if more information needs to be processed, then coordination mechanisms should assure a greater information-processing capability. However, besides this general statement, this research is very precise in explaining how the variables: "number of interacting units" and "depth of collaboration" – that characterise the information-processing – influence the ICTs and liaison devices used.

Proposition 4 states what type of ICTs is appropriate in what situation, and clearly explains the influence of the depth of collaboration and the number of interacting units on ICT adoption and sophistication (Figure 4). Moreover, Figure 5 provides a graphic illustration of the relationship (summarized in proposition 5) between information processing and liaison devices.

Consistently with the present study, a relevant stream of research on networks sought to explore the relations between inter-firm coordination mechanisms (e.g. ICTs or liaison devices) and types of interdependence among the actors involved in managing business processes across supply networks (Grandori and Soda, 1995). However, very little rigorous research has been done to uncover precise relationships among inter-firm coordination mechanisms and types of information processing when companies collaborate for integrating logistics processes. In fact, although studies dealing with inter-firm coordination mechanisms and interactions among companies offer the theoretical basis for analysis of inter-organisational business processes, they do not focus on a well-defined business process. Thus, this article brings new insights in the context of how to select the most appropriate inter-firm coordination mechanism, by focusing on integration of logistics activities within a supply network.

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Insert Figure 4 about here

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Insert Figure 5 about here

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Managerial implications

The contingency model of SC collaboration developed in this study suggests some remarks that could be of interest to different managers.

As previously discussed, one widespread theory used to explain differences in SC collaboration states that companies follow an integration path that evolves towards advanced SC collaboration forms. The risk is to produce some *misunderstandings* and *oversimplifications*. Firstly, this theory leads to consider advanced SC collaboration practices, such as the CPFR, as the natural evolution for companies already implementing other collaborative initiatives. Instead, this research demonstrates that a company could decide to limit SC collaboration to basic practices. Moreover, the implementation of SC collaboration practices seems to be “context-free”, and universality of SC collaboration is not questioned. The message for managers seems to be: “the more collaboration – the better the management of the supply network”. This study contributes to tempering this statement, forging links between SC collaboration practices and context within a contingency framework. This provides managers with important levers for action.

For example, from this research, it can be seen that it is not always necessary to collaborate by managing exceptions and synchronizing plans. When companies implement SC collaboration with the aim of reducing costs (that is, strategy of efficiency), the collaboration can be limited to data communication – e.g. companies exchange data on order forecast plans, stock levels, sales plans, etc. Instead, if companies collaborate with the aim of making the supply network more responsive to demand changes (that is, strategy of responsiveness), then as well as exchanging data, they have to synchronize their plans and manage exceptions.

Moreover, this research strongly suggests managers that full collaboration (i.e. companies jointly develop the promotional plan and manage sales and order forecasts) is convenient only when companies sell and market the same products, demand elasticity in case of price variation is high, and spatial complexity among partners is low. These are all necessary conditions for collaborating on a full collaboration level. If one of these conditions is not satisfied, the collaboration will be limited to simply managing order forecasts.

Additionally, with regard to the number of interacting units, this research states that a company can collaborate with several units, only when the number of potential partners is high and the SC collaboration is at an advanced stage of development.

Finally, this study suggests that it is not always necessary to adopt sophisticated ICTs or complex liaison devices to successfully implement SC collaboration practices. ICT sophistication and liaison-device complexity depends on the information processing and, thus, on the depth of the collaboration and the number of interacting units (see Figures 4 and 5).

A further managerial contribution of this research is that it considers SC collaboration characterized by two dimensions– one technical (the ICTs), the other organisational (the liaison devices). Given the dominant technical inclination of most professionals in the SC collaboration field, this study suggests that one concern might be that technical solutions are prescribed for companies when organisational solutions are needed. It is important to note that this research does not look at the link between ICTs and liaison devices. This reflects the conviction that sophisticated ICTs can not take the place of complex liaison devices and vice versa. The analyzed cases indeed demonstrate that there are some instances where both sophisticated ICTs and complex liaison devices are necessary to successfully put into practice the SC collaboration.

Finally, an additional important implication of this research is that it provides practitioners with a framework for understanding changes necessary in information processing, ICT and liaison device adoption, as they anticipate changes in the environment and company strategy. Foreseeing the implications of these changes, the company can be in a position to make a series of planned changes in information processing, ICTs and liaison devices rather than being forced into reactionary, rushed changes when it finds that the old information processing, ICTs and liaison devices do not fit with the new contingency factors. The value of this type of forward-looking view is well demonstrated in the context of production planning and control systems, by the case of the Xerox Corporation.

Conclusions

How can firms decide how to collaborate? When integrating logistics processes within the supply network, is it better just to communicate data or is it also necessary to synchronise plan and jointly solve exceptions? What type of ICTs and coordination mechanisms should be adopted?

This article offers interesting answers to these conundrums, by proposing a contingency theory of SC collaboration in logistics.

SCM literature considers SC collaboration in logistics a one-best-way practice to improve performance, and assumes that companies gradually increase interorganisational integration within the supply network, evolving from basic to more advanced forms of collaboration. This study articulates reservations as to these assumptions and the universal applicability of the different forms of SC collaboration.

Using data from ten case studies, and Galbraith's contingency theory as its starting point, this article proposes a contingency explanation of the differences in SC collaboration in logistics across networks. It is proposed that specific conditions can affect the information processing required to implement the collaboration, differentiated by depth of collaboration and number of interacting units. In particular, the following factors - goals of the collaboration, diversity of products sold by companies involved in the collaboration, elasticity of demand, number of potential partners and stage of development of the collaboration – can help to explain the differences among the types of information processing. Additionally, it is suggested that information processing, and ICTs/liaison devices have to form a coherent configuration matching the context.

These research findings provide insights, that could be of interest to managers working in different sectors and operating firms positioned in different supply network stages (e.g. suppliers, manufacturers, distributors). An understanding of the contingency model proposed in this article can be especially beneficial for companies where supply network performance measurement systems are adopted, and that follow a make-to-stock (MTS), or assemble-to-order (ATO) production approach. In fact, when collaborating companies adopt no supply network performance measurement systems, they are unable to accurately estimate the real problems of their supply network, establish right objectives of the collaboration and understand the impact of the undertaken collaboration on supply network performances. Thus, they would lack an essential piece of information when deciding how to collaborate, and the usefulness of the contingency model developed vanishes. In addition, it is a truism that sales and order forecast plans are essential only if a company produces following a MTS or ATO approach. In other cases (e.g. make-to-order or engineer-to-order contexts), SC collaboration on promotional, and sales and order forecasts plans loses its importance.

As well as these considerations, the opportunity to use the contingency model found in this research as a managerial tool calls for the testing of results within larger samples of supply networks, whose central companies are representative of a broader range of industries. In fact, although replication logic adopted in this research permits analytical generalization, it is worth noting that the analyzed case studies are limited to a relatively small sample and only a few industries. Future research should evaluate a wider sample of networks involving companies in several industries. This could contribute to confirm or refine the domain of applicability of the research findings, by ascertaining whether they replicate in other industries.

Moreover, this study should be complemented with future large scale cross-sectional studies that ascertain whether supply networks adopting certain SC collaboration practices proposed to match their context exhibit superior performance. In fact, because of many factors affecting supply network performance, only a large sample would be likely to reveal any statistically significant effects.

APPENDIX

Research controls

In order to isolate the relationships among the variables under investigation (i.e. context, information processing, ICTs and liaison devices) from other potentially confounding factors, the study examined supply networks complying with the following research controls. This helped control for variation within cases.

(1) Central companies of the supply networks, that had proposed and coordinated the SC collaboration intervention, had a high awareness of the existing range of SC collaboration practices. All companies collaborated with associations promoting the development and implementation of SCM practices (such as VICS and ECR), and participated to the debate on SCM by presenting and discussing their experience in Master Courses on SCM, and, often, were promoting partners of these courses. Companies which are aware of the whole range of SC collaboration practices are more likely to have made an informed decision regarding the practices adopted.

(2) Supply networks had successfully implemented a formal programme of SC collaboration. Within each supply network, indicators were monitored that indicated benefits achieved after the implementation of SC collaboration for all plants involved. Moreover, some collaboration projects had been the object of academic case studies illustrating best practice in SCM. This assures that companies were using certain practices because those practices had produced positive results for them; practice is likely to be maintained in use and not to be discarded.

It is worth noting that the sample design makes it unnecessary to employ measures of the effectiveness of the SC collaboration practices observed in the cases. In fact, this research develops a contingency theory of SC collaboration, by simply investigating the relationships between context and information processing, and information processing and ICTs/liaison devices, without examining whether these relationships affect performances.

Data collection

All data was gathered through company visits made from 2002 through 2005. Triangulation was used to ensure research reliability by obtaining the same piece of information from different sources: semi-structured interviews, documentation, archival records and direct observations. Data collection focused on variables underlying this research (i.e. context, information processing, ICTs and liaison devices), complemented with other issues enabling the understanding of the observed pattern of use of the SC collaboration practices; such as the history of use of the practices, and the difficulties experienced by the companies in using them.

The semi-structured interviews allowed the researcher to collect information on products/markets, the characteristics of the industry and the central company's strategies, the supply network structure, the SC collaboration project (e.g. ways of collaborating, reasons leading to collaboration, advantages gained, adopted ICTs, etc.). During the interviews a data collection protocol based on a common schema was used for each case. A pilot case-study (case A) was conducted to refine the data collection protocol content. The same questions were asked to different interviewees from the same or different companies within the supply network (see Table 6). Each interview lasted on average two and a half hours. In the case of very long interviews with key informants, more than one visit was necessary to complete the data gathering.

The documents collected concerned: publications on the case studies, descriptive documents on process and product structures, supply network configuration, internal documents on SCM programme implementation and reports on performance measurement. In addition, documents on the SC collaboration project, such as software manuals, leaflets, procedures, front-end agreement reports and the minutes of the meetings were used. Analysis of these documents allowed the researcher to corroborate information collected from other sources: where data discrepancies were found, the aspects generating contradictions were thoroughly investigated.

The archival records made it possible to collect data on the supplier and customer portfolio. This information was central to mapping the supply network configuration and contacting the supply network members involved in the SC collaboration. Other archival records concerned data on product demand trends.

Finally, plant visits were conducted in person to collect further information and verify the correctness of the data/information gathered during the interviews and from documents.

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Table 1. Summary characteristics of the three major depth of collaboration levels

Depth of collaboration level	*Characteristics*
Communication	Companies collaborate simply by exchanging data and information with trading partners. The types of data exchanged can differ. For example, a company can receive order forecast plans from its customers. Alternatively, a company can receive stock level and consumption data (or sales forecasts) from its customers and decide customers' order plans (e.g. VMI or CR). In all cases the collaboration is simply a sort of data communication. Indeed parties do not jointly develop promotional, sales or order forecast plans.
Limited collaboration	Limited collaboration differs from communication by taking the collaboration a little further than mere data exchange. Parties jointly develop order forecast plans and manage exceptions (e.g. discrepancies in the plans). The collaboration is limited to order forecast definition process.
Full collaboration	Compared to limited collaboration, full collaboration is characterized by an increased number of areas in which companies collaborate. The collaboration includes the joint development of promotional, sales and order forecast plans, and sales/order forecast exception management, as suggested by VICS's CPFR model

Table 2. Types of ICTs

Types of ICTs	
- Fax and e-mail	Companies exchange data and information through fax and e-mail. Thus data and information are not automatically insert into companies' local system
- Electronic data exchange and its integration	Support the electronic data exchange and data integration into companies' local systems (e.g. EDI)
- Advanced Planning and Scheduling (APS)	Used to support decision making during the collaboration, through what-if analyses. APS tools allow the decision maker to analyze the consequences of his/her decisions depending on different possible scenarios. Data are exchanged and integrated into local companies' system through Data Import and Export module
- Internet-based CPFR solutions	Considered among the most sophisticated technologies that can be used to support a SC collaboration. They allow (i) web-based collaboration, designed to allow process and information sharing among multiple trading partners; (ii) event management and analysis, to monitor and alert participants to exceptions, status changes and discrepancies. When unexpected variations or problems are found, the application issues a notification, or alert, to the appropriate participants so they can get online, review the exception and take action as required. Internet-based CPFR solutions can sometimes be available in a hub or private trading network, allowing multiple tiers of suppliers and customers to collaborate. They can interact via a neutral intermediary – the (e-)exchange.

Table 3. Types of liaison devices

Types of liaison devices	
- Liaison positions	Jobs created to directly coordinate the work of two units. These positions has no formal authority per se; rather, those who hold them must use their power of persuasion, negotiation and so on to bring the two sides together
- Meetings	Institutionalised forms of meetings which bring members of a number of different units together to deal with a temporary or more permanent and regular issue
- Integrating managers	Essentially liaison managers with formal authority over the collaboration project or a part of it

Table 4. Characterization of the variable context

Context	*Characterization of the context variable*
Goals	Reasons driving companies towards SC collaboration
Product diversity	Refers to the products marketed and sold by companies involved in the collaboration
Elasticity of demand	Average increase of customers' sales volume during promotions
Supply network spatial complexity	Average physical distance between firm/s in the upstream network and the markets served by the firm/s in the downstream network.
Number of potential partners	Number of partners that can be involved in the collaboration as the existence of collaborative/long-term buyer–supplier relationships, SCM initiatives or vertical integration.
Development stage	Number of years since the implementation of the SC collaboration project

Table 5. Types of information processing

		Number of interacting units	
		Low	**High**
Depth of collaboration	**Full collaboration**	*TYPE 1* ▪ CASE I ----> ▪ CASE H ---->	*TYPE 2* ▪ CASE I ▪ CASE H
	Limited collaboration	*TYPE 3* ▪ CASE L ▪ CASE F	*TYPE 4* ▪ CASE B ▪ CASE D
	Communication	*TYPE 5* ▪ CASE C ▪ CASE G	*TYPE 6* ▪ CASE A ▪ CASE E

Table 6. Overview of the cases

Case	Supply network members involved in the collaboration	Interviewees	Information processing
A	▪ Central company 1: manufacturing unit (MU) producing starter batteries ▪ Several distribution centers (DCs) (independent and owned)	Logistics Operations manager and planners (company 1); external consultant involved in the implementation of the SC collaboration project; area managers (company 1), factory manager (DC)	The collaboration is mainly based on the exchange of data and information (i.e. *communication level*). Company 1 can read and extract DCs' stock and sales data. By using this data, the MU forecasts what retailers will require to the DCs, and elaborates the order forecast plans of the DCs, by taking into account DCs' stock levels. However, sales and order forecast plans elaborated by central company 1 are not communicated nor shared with DCs. Company 1 collaborates with *hundreds* of DCs.
B	▪ Central company 2: MU producing injectable cephalosporins ▪ Owned DCs located worldwide and directly replenished by company 2	Logistics Director and production planners (company 2); product managers (DC)	Central company 2 receives stock level data and sales forecast plans from *fifty* DCs. On the basis of this data the central system proposes the replenishment plans, suggesting dates to the central company for the deliveries of final products to each distribution center. The deliveries are decided in order for the stock level at the DCs' facilities to fall within a jointly established range (called VMI min-max range). Replenishment plans have then to be confirmed by the planners within both the central company and the DCs. If a DC does not confirm the plans, or asks for additional orders that fall within the frozen planning horizon, the central company proposes – on the basis of a what-if analysis – alternative delivery plans by estimating the impact of any order time/volume change on the plans of the downstream supply network members. This type of information processing can be classified as *limited collaboration*, as parties jointly develop the plans, but the collaboration is limited to order forecast definiton process.
C	▪ Central company 2 ▪ Owned and independent suppliers	Logistics Director and buyers (company 2); factory managers and planners (suppliers of labels and active agents)	Every Monday morning, company 2's planners send to *two* packaging material suppliers and to the active agent supplier the order forecast plan that includes a 5-month planning period. The suppliers consider the order forecasts that fall within the frozen period as firmed orders. Thus the depth of collaboration is at a *communication level*.
D	▪ Central company 3: MU producing an anaesthetic and responsible for the final packaging of an antibiotic ▪ Owned and independent DCs	Logistics Director and planners (company 3); product team's members (DC)	Central company 3 receives sales forecasts and stock level data from about *thirty* DCs. The delivery plans, elaborated by the MU, are proposed to the DCs that can confirm the plans or ask for modifying, anticipating or postponing the orders. Similarly to case B, DCs' stock levels have to fall within a range jointly established by the MU and the DCs. When order forecast exceptions occur (e.g. a DC asks for anticipating an order), the MU, on the basis of what-if analyses, can propose alternative delivery plans, thanks to the flexibility due to the jointly agreed stock level range. As the MU and DCs jointly define the order forecast plans and solve order forecast exceptions, this type of information processing can be classified as *limited collaboration*.
E	▪ Central company 3 ▪ Production and packaging plants (owned and independent)	Logistics Director (company 3); factory managers (production and packaging plants)	MU decides the production and delivery plans for all the production and packaging plants (more than *twenty*) included within the supply network of the antibiotic packaged and distributed by company 3. The collaboration between the MU and production and packaging plants is mainly based on the exchange of data and information (i.e. *communication level*), as the MU reads stock levels and available capacity of production and packaging plants, and communicate production and delivery plans to them. Exceptions are not discussed nor shared, while plans are centrally decided by the MU.

(continue)

Case	Supply network members involved in the collaboration	Interviewees	Information processing
F	▪ Central company 4: MU producing and distributing air conditioners ▪ Distributors	Sales manager, Comfort & Refrigeration Business Unit managers and product manager (company 4); factory managers (distributors)	Central company 4 receives stock level and sales forecast data from *four* distributors, each of which sells and distributes air conditioners in a specific market. Both company 4 and the distributors elaborate order forecast plans (i.e. deliveries of air conditioners to the distributors) that are then compared to identify exceptions. The exceptions are then solved to achieve a final common order forecast plan. This case is an example of *limited collaboration*.
G	▪ Central company 4 ▪ Suppliers of engines and copper	Factory managers and planners (company 4); factory managers and planners (suppliers of engines and copper)	Company 4 elaborates and sends its raw material order forecast plans to *four* suppliers, producing aluminium (two suppliers), and copper (two suppliers). Each supplier uses this data to organize product deliveries, and plan its production. Thus SC collaboration is limited to a mere data communication (i.e. *communication level*).
H	▪ Central company 5: sales company (located in Belgium) selling and marketing consumer and soft goods ▪ Large customers (retailers)	Customer Supply Chain Manager and sales managers (company 5); external consultant involved in CPFR implementation; supply chain manager (retailer)	Every year, central company 5 and customers involved in the collaboration jointly establish a promotional plan (e.g. promotions to be made in the shops, in what periods, how many stock-keeping units (SKUs) will be included), that is reviewed every 3 months. Then, by using customers' sales data and promotional plan, both the central company and each customer estimate the sales forecast plans (i.e. demand of final customers). Discrepancies in the plans are discussed to obtain a common sales forecast plan. By considering stock level data and the common sales forecast plan, both the central company and each customer elaborate a order forecast plan. Again, by comparing the plans, exceptions (e.g. significant differences) are identified and solved. Hence, the depth of collaboration is at a *full collaboration* level, as companies jointly define promotional, and sales and order forecast plans. Initially, company 5 collaborated on a full collaboration level with *few* partners, but, in 2004, decided to extend the collaboration to *several* other customers.
I	▪ Central company 6: subsidiary of a food retailer located in Belgium, responsible for establishing promotional plans for the local supermarkets and for managing the replenishment of the Belgian DC ▪ Three suppliers producing fats and margarines; candy bars and feminine hygiene products	Supply chain manager (company 6); external consultant involved in CPFR implementation; factory manager and planners within supplier plant producing fats and margarines	Similalrly to case H, the depth of collaboration is at a *full collaboration* level. The joint promotional plan is established every year. It mainly concerns decisions on promotional events (i.e. promotional period and SKUs to be involved). This plan is then reviewed and detailed during the year. Every week, on Friday, suppliers and company 6 elaborate independent sales forecast plans, by using supermarkets's POS data of the last two years, and promotional plans. Afterwards, suppliers' and company 6's sales forecasts are compared. They can't differ more than a certain percentage. Otherwise, an exception occurs. Every Monday, company 6 and its suppliers try to solve the exceptions found by analyzing POS data. Similarly, companies collaborate in defining order forecast plans. Every Tuesday, each company elaborates its order forecast plan, and every Wednesday companies collaborate to solve order forecast exceptions. The collaboration initially involved *three* suppliers; then was extended to include *several* other partners.
L	▪ Central company 7: MU producing corrugated cardboards for product transport ▪ Some customers (food producers)	Chief Supply Chain Officer and planners (company 7); factory manager and planners within a customer's plant	Customers weekly send to company 7 their corrugated cardboards gross requirement plans. By considering customers' stock level of corrugated cardboards, both the central company and customers elaborate deliveries of corrugated cardboards to be made. Exceptions are identified through the comparison of plans. The depth of collaboration is at *limited collaboration* level, as the collaboration concerns just the order forecast definition process. The collaboration involves *four* customers.

Table 7. Data reduction

Variable	Characterization	Rating
Context	Goals	*Strategy of efficiency* (companies aim to reduce costs (e.g. investments in stocks) without penalizing service levels) or *strategy of responsiveness* (the main purpose is to make the supply network more reactive to demand changes)
	Product diversity	*Same products* (SP) (companies involved in the collaboration sell the same products) or *different products* (DP) (companies sell different products)
	Elasticity of demand	*Low* (LDE) (less than 40%) or *high* (HDE) (more than 200%)
	Supply network spatial complexity	*Low* (LSC) (few dozens or hundreds of kilometers); *high* (HSC) (thousands of kilometers)
	Number of potential partners	*Low* (LNP) (less than four) or *high* (HNP) (more than twenty)
	Development stage	*Early* (E) (central companies began to collaborate with the first partners less than 2 years ago); *advanced* (A) (central companies began to collaborate with the first partners more than 3 years ago)
Information processing	Depth of collaboration	Depth of collaboration level (*communication, limited collaboration, full collaboration* – see Table 1)
	Number of interacting units	*Low – High* (LIU – HIU): Distinction between a group of companies collaborating with only a few partners (less than 4) - assigned to the low-class - and a group of companies collaborating with several partners (more than 20) - assigned to the high-class
ICT	Types of ICTs	ICTs are classified into 4 groups forming an ordinal scale of sophistication. The sophistication of each group of ICTs is related to its capability of ensuring effective coordination, and can be evaluated by considering its capability of supporting fast and accurate data/information exchange and the collaboration (e.g. event management). First group (*ICT1*): includes non sophisticated tools, used for data/information exchange (e.g. fax and/or email). Second group *(ICT2)*: encompasses ICTs supporting electronic data exchange and its integration into companies' local systems. Third group *(ICT3)*: includes APS tools. Fourth group *(ICT4)*: involves Internet-based CPFR solutions. This first group represents the least sophisticated ICTs, while Internet-based CPFR solutions are the most sophisticated.
Liaison devices	Types of liaison devices	*High, medium and low degree of complexity (HC, MC, LC)*: The complexity depends on the information-processing capability. As suggested in organizational literature (Galbraith, 1973; Nadler and Tushman, 1987; Gupta and Govindarajan, 1991), the level of complexity high is attributed to the integration managers, medium to the meetings, low to the liaison positions. In this study, the following three mixes of liaison devices emerge: HC: liaison positions, meetings and integrating managers MC: liaison positions, meetings LC: liaison positions

Table 8. Relationship between the depth of the collaboration and the goals

		Depth of collaboration		
		Communication	**Limited Collaboration**	**Full Collaboration**
Goal	**Responsiveness**		▪ CASE B ▪ CASE D ▪ CASE L ▪ CASE F	▪ CASE I ▪ CASE H
	Efficiency	▪ CASE A ▪ CASE C ▪ CASE G ▪ CASE E		

Table 9. Relationship between product diversity, elasticity of demand, spatial complexity, and the types of information processing

		Product diversity, demand elasticity, spatial complexity	
		(SP, HDE, LSC)	**DP or LDE or HSC**
Depth of collaboration	**Full collaboration**	▪ CASE H (SP, HDE, LSC) ▪ CASE I (SP, HDE, LSC)	
	Limited collaboration		▪ CASE L (DP, HDE, LSC) ▪ CASE B (SP, LDE, HSC) ▪ CASE D (SP, LDE, LSC) ▪ CASE F (SP, HDE, HSC)

Note: the ratings were obtained by applying the data reduction rules specified in table 7

Table 10. Relationships between the number of interacting units, the number of potential partners and the development stage of the collaboration

		Number of potential partners	
		Low	**High**
Development stage	**Early**	▪ CASE G (LIU)	▪ CASE H (LIU) ▪ CASE I (LIU)
	Advanced	▪ CASE L (LIU) ▪ CASE C (LIU) ▪ CASE F (LIU)	▪ CASE I (HIU) ▪ CASE H (HIU) ▪ CASE B (HIU) ▪ CASE D (HIU) ▪ CASE A (HIU) ▪ CASE E (HIU)

Note: the ratings were obtained by applying the data reduction rules specified in table 7

Table 11. Relationships between types of information processing and ICTs

		Number of interacting units	
		Low	**High**
Depth of collaboration	**Full collaboration**	*TYPE 1* ▪ CASE I (ICT1) → ▪ CASE H (ICT1) →	*TYPE 2* ▪ CASE I (ICT4) ▪ CASE H (ICT4)
	Limited collaboration	*TYPE 3* ▪ CASE L (ICT1) ▪ CASE F (ICT1)	*TYPE 4* ▪ CASE B (ICT3) ▪ CASE D (ICT3)
	Communication	*TYPE 5* ▪ CASE C (ICT1) ▪ CASE G (ICT1)	*TYPE 6* ▪ CASE A (ICT2) ▪ CASE E (ICT2)

Note: the ratings were obtained by applying the data reduction rules specified in table 7

Table 12. Relationships between types of information processing and liaison devices

		Number of interacting units	
		Low	**High**
Depth of collaboration	**Full collaboration**	*TYPE 1* ▪ CASE I (MC) → ▪ CASE H (MC) →	*TYPE 2* ▪ CASE I (HC) ▪ CASE H (HC)
	Limited collaboration	*TYPE 3* ▪ CASE L (MC) ▪ CASE F (MC)	*TYPE 4* ▪ CASE B (HC) ▪ CASE D (HC)
	Communication	*TYPE 5* ▪ CASE C (LC) ▪ CASE G (LC)	*TYPE 6* ▪ CASE A (LC) ▪ CASE E (LC)

Note: the ratings were obtained by applying the data reduction rules specified in table 7

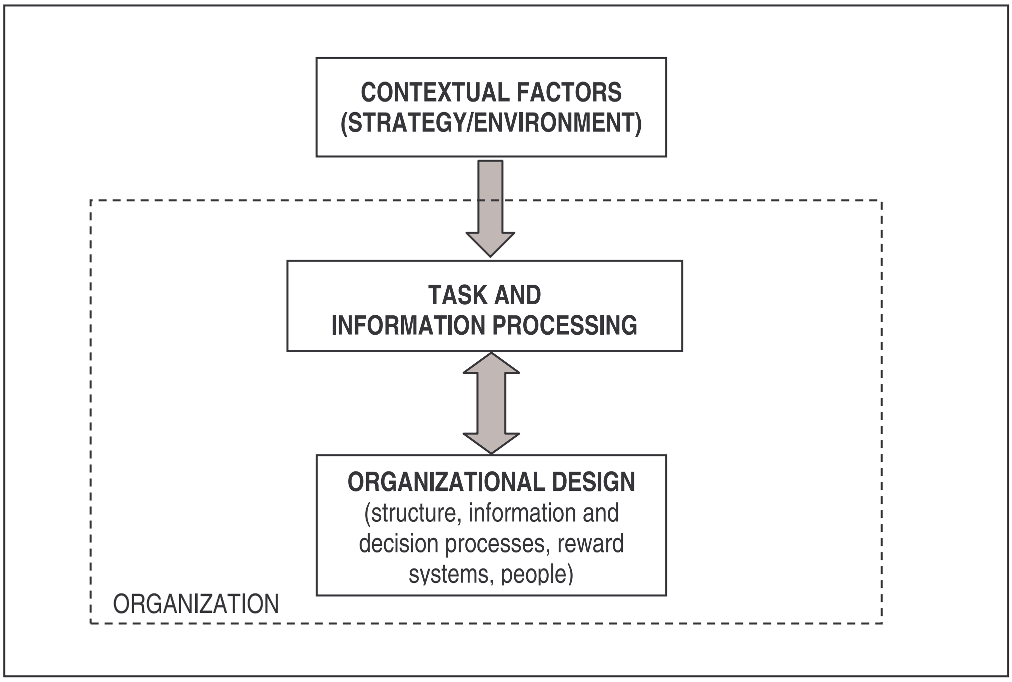

Figure1. The contingency theory

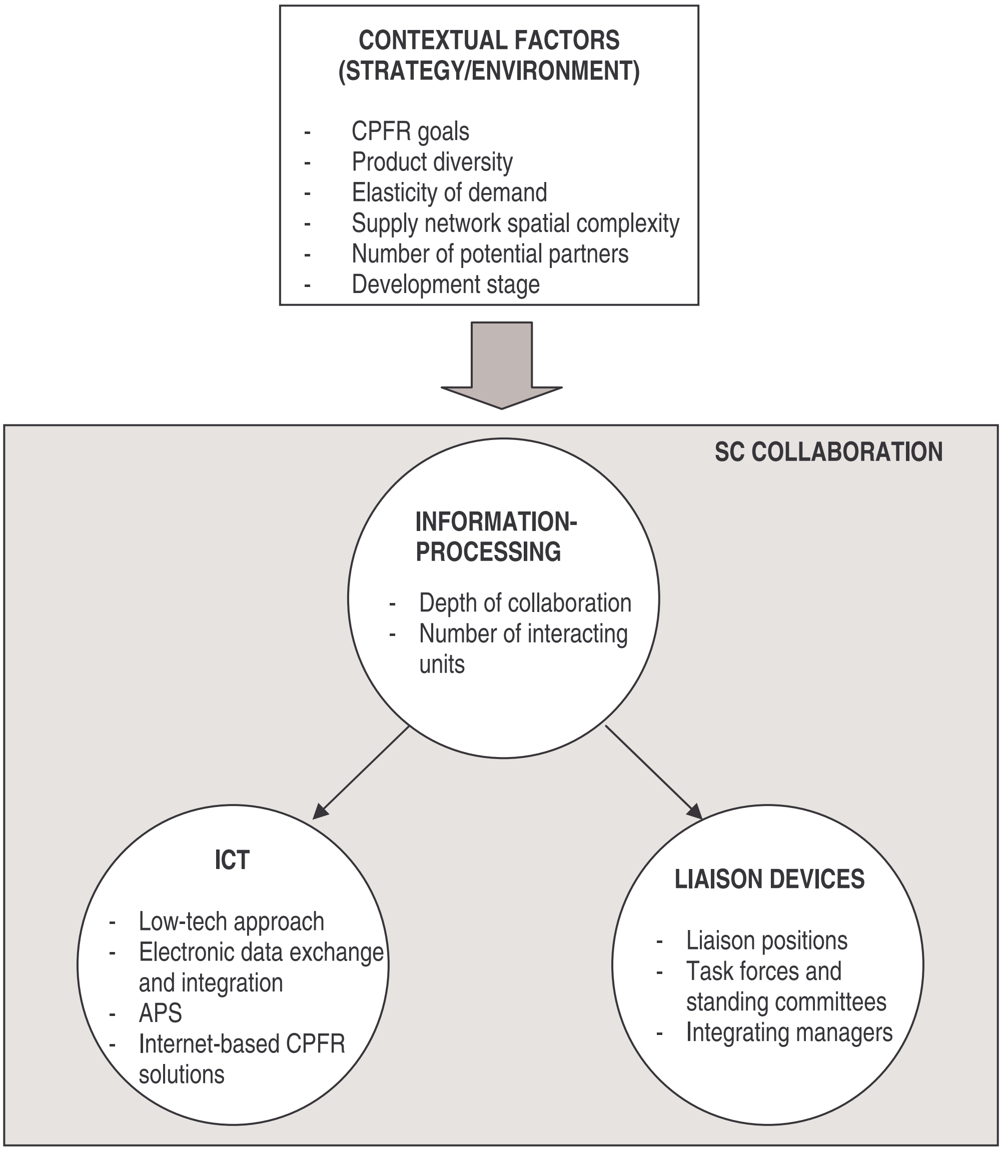

Figure 2. The contingency model

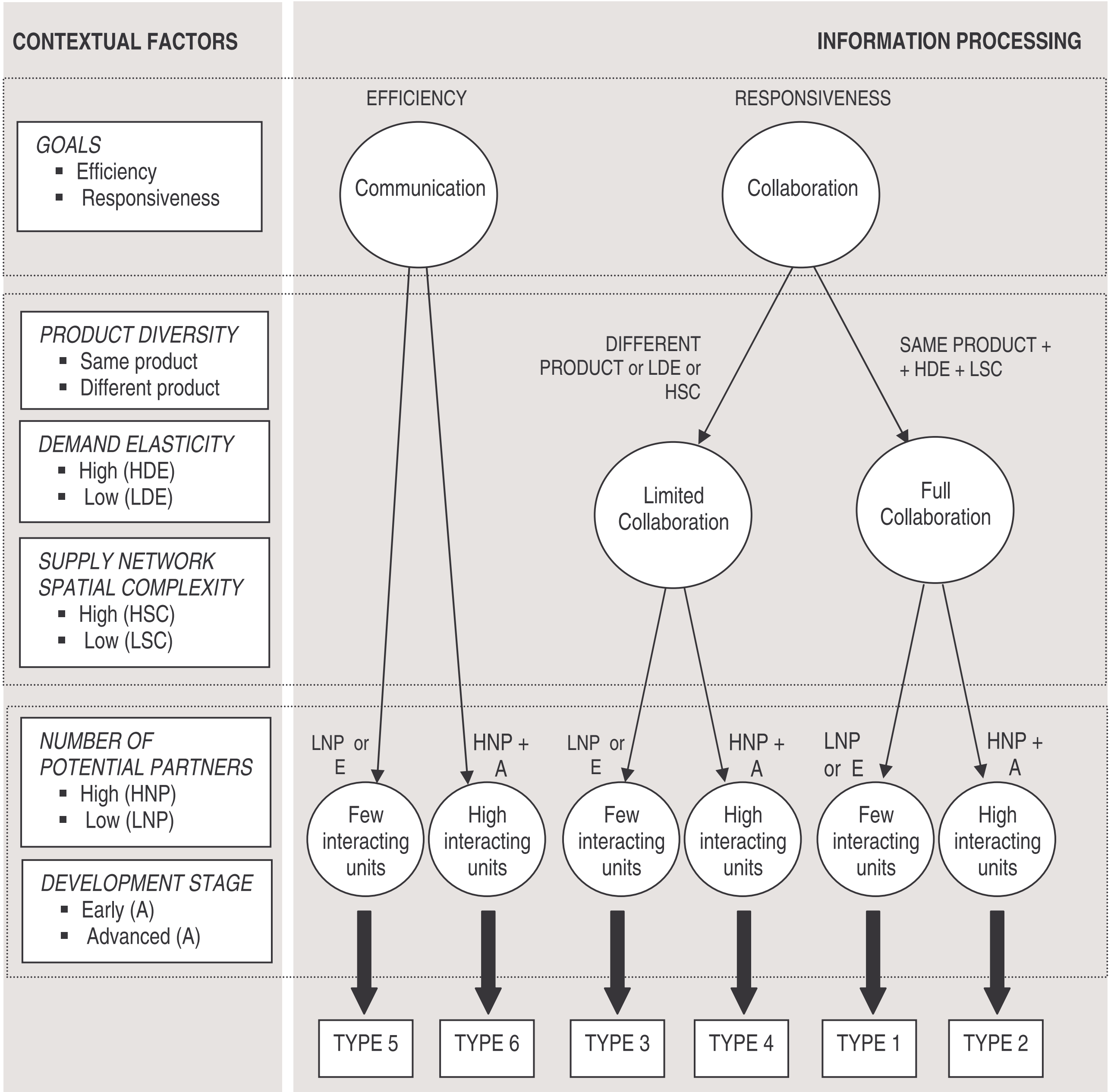

Figure 3. Relationships between contingent factors and different types of information processing

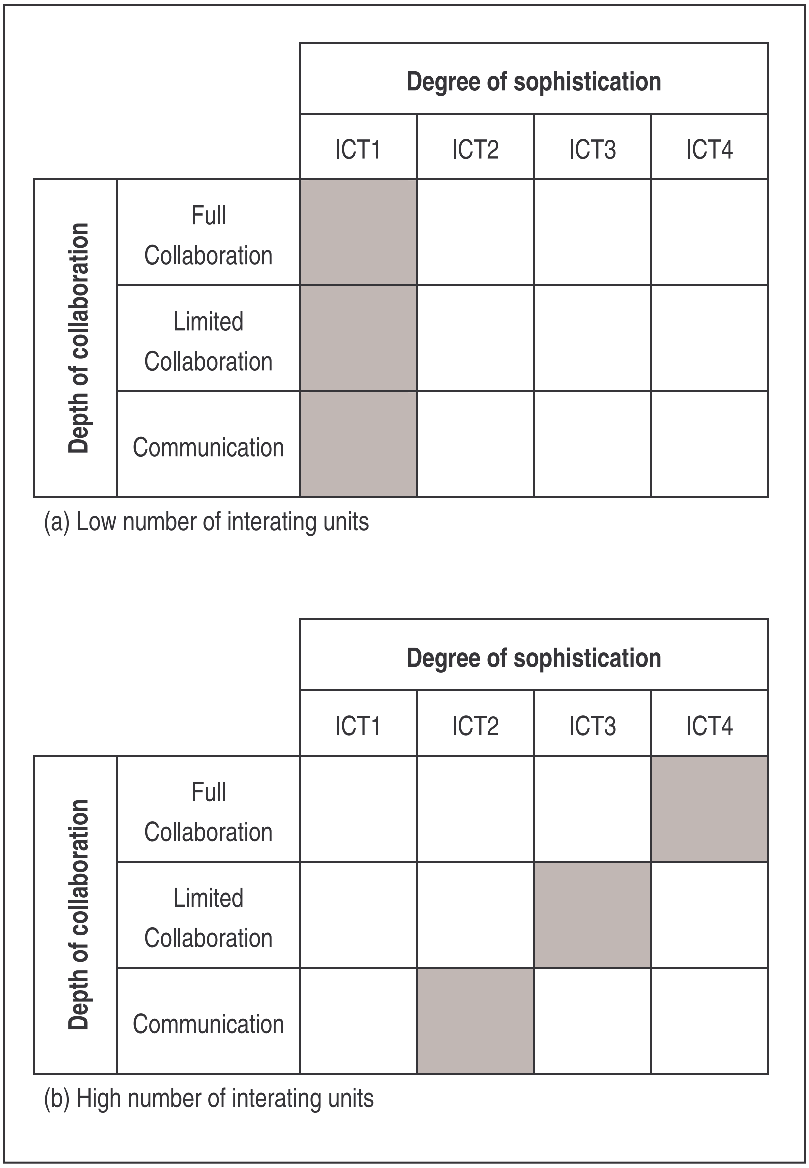

Figure 4. Relationship between ICT degree of sophistication, depth of collaboration and number of interacting units

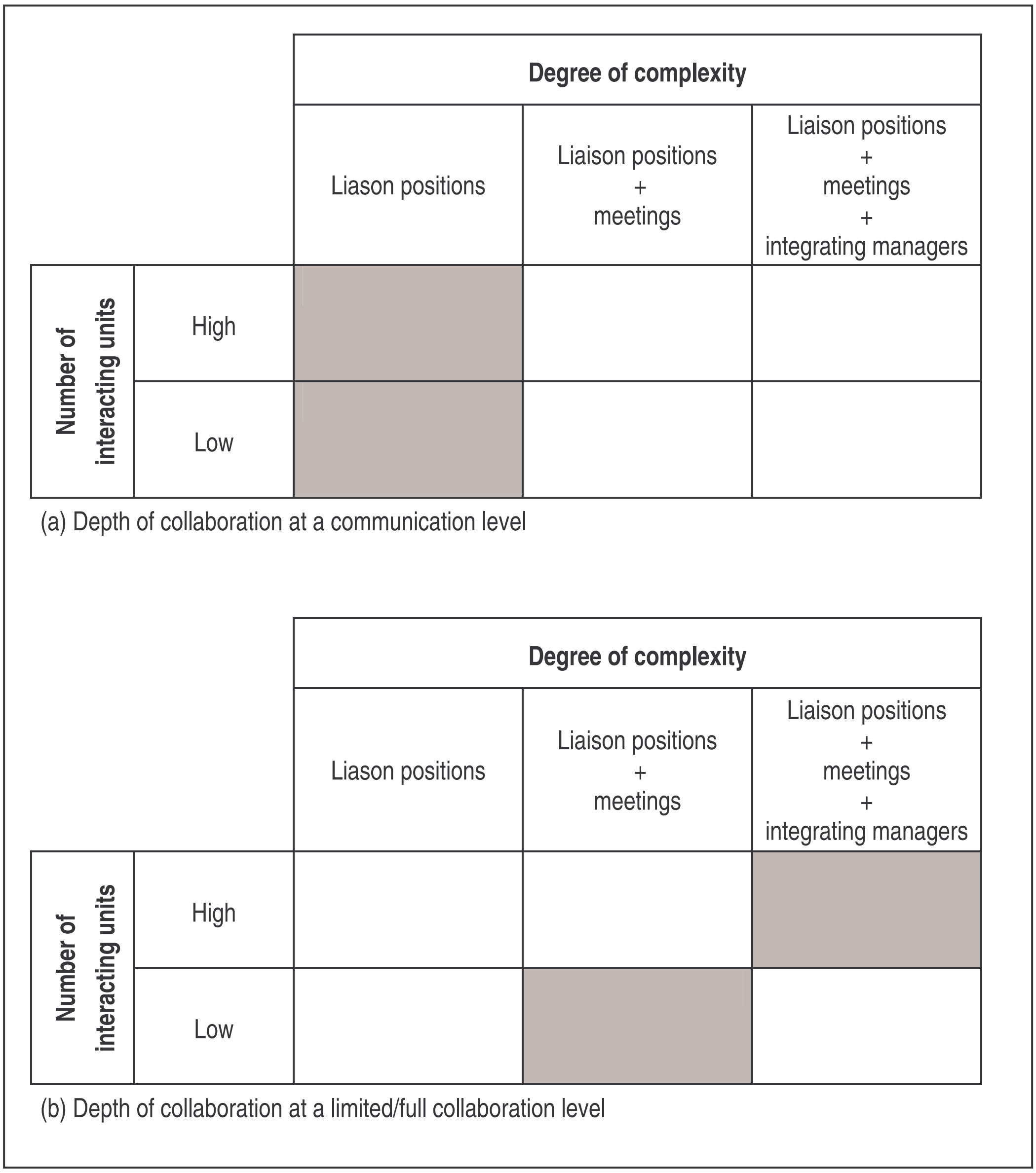

Figure 5. Relationship between liaison device degree of complexity, depth of collaboration and number of interacting units