Introduction

This book is the result of studies conducted during two research projects supported by the Research Cluster GOSPI of the Rhône-Alpes region (France): COPILOTES (2003-2006) and COPILOTES2 (2006-2009). More than 50 researchers from seven research laboratories and six practitioners from four companies participated in these two projects.

Our work is based on the initial hypothesis that the industrial performance of a company depends strongly on its ability to strengthen its relationships with its partners (contractors, suppliers or providers and customers), to integrate its information systems and decision processes, and to synchronize product flows and activities.

In the first project, COPILOTES, we proposed approaches and developed tools to help companies assess their contribution to the performance of each supply chain (SC) to which they belong. This has encouraged them to rethink their organization and initiate new relationships with their partners, focusing on collaboration, coordination, synchronization, and information exchange. The characterization of the overall performance of a SC, the formalization of industrial practices and the evaluation of their impacts on performance have been at the heart of this project, as has the analysis of information exchanged and the value added by these exchanges. The major contributions of this research project are available at www.copilotes.eu/.

The second project, COPILOTE 2, has pursued this research by focusing on the design of decision and information systems that ensure efficient management based on collaborative practices and sharing of information between companies. We have also analyzed the behavior of participants in a SC, as well as the impact of that behavior in terms of collaborative and information-sharing (IS) practices. As most

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SCs are composed of autonomous agents with their own objectives, this may cause biases in both collaborative practices and shared information, affecting local and global performance. Mechanisms of coordination, inter-organizational strategic alignment and strategic behavior have been the key focus of this second project.

The management of dependencies between members of a supply-chain is an aim common to both research projects. According to Malone and Crowston [MAL 99], using a resource produced by another entity, using the same resource in multiple entities, or collectively producing a single resource from multiple entities, constitutes three basic dependencies. These dependencies – flow dependency, sharing dependency and fit dependency – require coordination. For these authors, coordination is "the act of managing dependencies between entities and the joint effort of entities working together towards mutually defined goals" [MAL 94]. This book aims to deal with supply-chain coordination mechanisms: IS, information systems alignment, cooperation, collaboration, integration, etc. However, as Arshinder *et al*. [ARS 08] argue, despite the consensus on Malone and Crowston's definition in the supply-chain literature, there are various perspectives on how to link the concepts of collaboration, cooperation, information systems alignment, integration, and supply-chain (SC) coordination. In this book we therefore adopt Arshinder *et al*.'s broad perspective on SC coordination, which has the advantage of including more elaborate coordination frameworks (for example, Simatupang *et al*.'s taxonomy of coordination modes in a supply-chain [SIM 02]). Based on their approach [ARS 08], we consider the following premises:

– "SC coordination" is a term encompassing cooperation (joint operation), collaboration (working jointly), and integration (combining into an integral whole). It also involves information systems alignment (jointly expanding the information structure beyond the boundaries of each supply-chain member).

– These elements (cooperation, collaboration, information systems alignment, integration) are complementary to each other. They constitute coordination mechanisms to manage interdependencies among supply-chain members.

– The use of these coordination mechanisms depends on complexity and uncertainty: the complexity of supply-chain activities for which efforts are required in order to achieve common goals; the uncertainty and complexity of decision-making regarding logistics operations; uncertainty on the behavior of supply-chain members due to entities that are separated in a supply-chain; etc.

– The value of SC coordination can be captured through control variables that measure the improvement of SC performances and need to be shared between SC members.

The question of the value of SC coordination is at the very core of this book. A need for coordination mechanisms arises from interdependencies between the

activities of SC members, and this need differs depending on sources of complexity and uncertainty. This book therefore addresses, from different points of view, the question of the extent to which or the conditions under which these mechanisms positively affect performance. Figure A.1 uses Arshinder *et al.*'s framework to portray the three parts of this book and to highlight the variety of methodologies used.

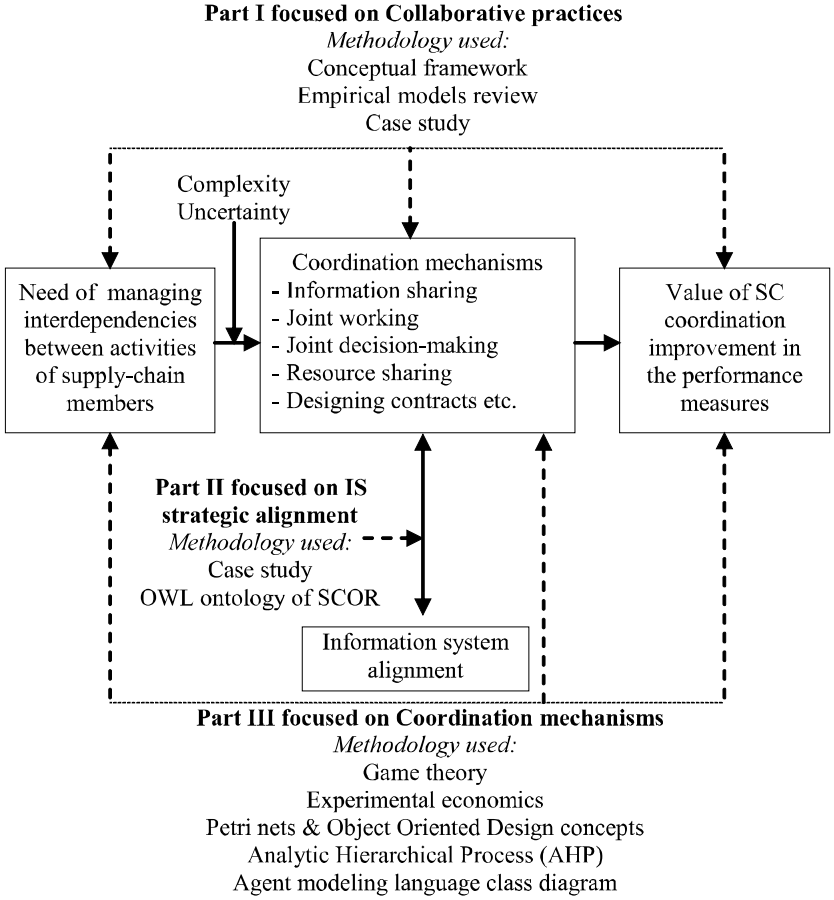

Figure A.1 *Synthesis of Parts 1, 2 and 3 of the book*

Part I

The three chapters in Part I of this book focus on the collaborative practices in SCs. By this we mean the practices that enable independent members of the same SC to work jointly to plan and execute operations when they consider that this collaborative effort has an impact on actual performance [SIM 05]. As Whipple and Russell point out, "collaboration is a very broad and encompassing term" [WHI 07]. Therefore, Part 1 does not address the concept of collaboration but only the range of collaborative practices and their relationships to performance. What are these practices? Moreover, since IS is a core practice, what is the nature of the information that can be shared between a focal firm and customers or suppliers? What are the impacts of these practices on SC performance?

Chapter 1 questions the models, called SC collaboration–performance models, which empirically test the effects of collaborative practices on SC performance. Two main questions frame the debate: How can we recognize a model linking SC collaboration and performance? And how can we compare SC collaboration–performance models? These questions start from the problem examined by Ho *et al*. [HO 02] of weaknesses in empirical research on the relationship between SC management practices and performance.

Discussing SC collaboration–performance models in light of Ho *et al*.'s recommendations, the authors propose two research directions. First, according to [HO 02], they clarify the meaning of the "SC collaboration" construct, i.e. the range of collaborative practices likely to be used for the definition of its measurement scale. From existing categorizations of collaborative practices, they propose a framework that highlights types of collaborative practices prioritized according to the organizational and decision-making levels committed in the relationship. Second, taking the SC collaboration–performance model as a unit of analysis, the authors widen Ho *et al*.'s analysis of the modeling approaches by using the concept of "fit" (fit as moderation, fit as mediation, fit as matching, fit as co-variation, fit as gestalts, and fit as profile deviation) as developed by Venkatraman [VEN 89]. They show the relevance of these functional forms of "fit" for describing and categorizing the modeling approaches of SC collaboration–performance models. They then use this categorization in a systematic review of empirical papers referring explicitly to the relationship between collaborative practices and performance. This review also proves that it is possible to extend Venkatraman's complexity scale of "fit" models to the SC collaboration–performance models. A so-called contingency chart emerges, that allows us to compare SC collaboration–performance models in two dimensions: the complexity of laws of relations between the model variables, and the level of organizational commitment in collaboration that the SC collaboration construct reflects.

Chapter 2 focuses on information-sharing practices. The authors adopt the point of view of a focal firm that has several suppliers and several customers, and that seeks to qualify its organizational configuration (context, strategic objectives and organizational capabilities) and its downstream and upstream information-sharing practices (nature of shared information and exchange mechanism). The framework enables managers of the focal firm to study the conditions and impact of IS and collaborative processes on the functioning and dynamics of each entity in a supply chain. This questioning framework is structured on four levels (theoretical constructs, empirical constructs, attributes, and questions). This in turn is based on two main theoretical constructs, organization configuration and information-sharing practice. The theoretical construct "organization configuration" is composed of three empirical constructs that qualify the internal and external environment and objectives, the product offering, and the SC configuration. The theoretical construct "information-sharing practice" considers six categories of information to be shared, both downstream and upstream and, for each category, the direction of the sharing, either from the focal firm to the partner (supplier or customer), or from the partner to the focal firm. Each type of shared information is qualified by content (level of aggregation, business departments concerned by its use, application component that records it and perceived impact on the performance). It is also qualified by the process that characterizes the exchange (temporal characteristics, origin of the exchange, application component from which the information is extracted, communication technology used for the exchange, and contracting parameters). In conclusion, the authors present two analyses based on this questioning framework and drawn from enquiries conducted within the COPILOTES and COPILOTES2 projects.

Nowadays, companies increasingly face the need to evaluate the impact of their SC management practices, not only for their regular stakeholders (shareholders, employees, suppliers and customers), but also for the external stakeholders representing "civil society", like local residents, non-governmental organizations, customer associations, etc. Consequently, the evaluation system must integrate performance assessment on the economy, environment and society in order to highlight the interactions between these three dimensions. Chapter 3 addresses this issue by considering collaborative practices and sustainable practices together. For this purpose, the authors work in three stages:

– First, they propose a generalized model of industrial performance, encompassing three dimensions: economic, environmental and social. The economic performance is analyzed in terms of five criteria (responsiveness, reliability, flexibility, quality and financial) and the indicators are classified according to their application area (upstream, downstream or transverse) and their orientation (customer *versus* business). Based on the literature, the environmental criteria cover five areas (environmental management, resource management, pollution, danger and

natural environment) and the social criteria another five areas (working conditions, human rights, societal commitments, customers and good business practices).

– In the second stage, the authors build two tools: the first one characterizes the collaborative practices and the second one the sustainable practices of a company. In both models, a practice refers to a well-identified process and is characterized by a degree on a maturity scale and a decisional level where the practice is engaged. In addition, the collaborative practice model integrates a third dimension to take into account a behavior (proactive *versus* reactive) of the company in the use of collaborative practice.

– In the third stage, the authors propose a two-step approach to identify existing correlations between collaborative effort and economic performance, and then to analyze existing relationships between performance and sustainable practices. An application of this approach to the analysis of environmental impacts concludes the chapter.

Part II

Part II emphasizes the inter-organizational alignment between business and information systems at strategic and operational level. According to Henderson *et al.*'s strategic alignment model (SAM) [HEN 93], companies continuously make co-alignments between four domains (business strategy, IT strategy, organization, and IT infrastructure) in order to optimize their performance. However, SC coordination implies the extension of this alignment to the inter-organizational level. How can this alignment be achieved? Part II considers this question from two different perspectives.

Chapter 4 looks at how companies embedded in the same SCs adapt their information systems to reach their strategic goals in respect of their suppliers and customers. The main idea of the chapter is to extend the SAM to the inter-organizational level. The authors use this extended framework as a heuristic device to question the inter-organizational alignment and to better understand the factors and connection modes that companies can set up to operationalize their alignment. The methodology used is a single case study that describes the dynamics of alignments occurring in a jewelry SC during a radio frequency identification (RFID) implementation project between a middle-sized retailer and its supplier, a logistics service provider. The case study describes the project from 2006 to 2009 highlighting the main participants, their expectations, the physical processes and their transformations during the project, the information flows, and the IT infrastructure that supports it. For the analysis of RFID implementation, the authors adapted and completed an existing framework and plotted a map that emphasizes the different routes of intra- and inter-organizational strategic alignments. This analysis

highlighted three characteristics of the complexity of inter-organizational alignment. First, several alignments, and not only one strategic alignment, progressively take place during the implementation project. Second, these alignments have to cross the classical horizontal SC associated with the product and the vertical SC related to the RFID tags. Finally, this study shows the interactions between different types of alignment in the SC, with each intra-organizational alignment affecting the other intra-organizational alignments of partners in the same SC.

Chapter 5 also addresses the question of inter-organizational alignment, but at a finely detailed level. The authors refer to the SAM by considering that alignment of knowledge is a central focus for strategic alignment because knowledge on information systems is represented in a variety of ways (databases or collections of documents, emails and XML schemas, etc.). Therefore, at an abstract level, the interoperability and cooperation of information systems require mechanisms that ensure a *semantic integration*, i.e. mechanisms that allow for comparison and recognition of the resemblances and differences between the various concepts treated. The concept of ontology is a way to meet this challenge of knowledge interoperability. Ontology may be defined as "a formal explicit specification of a shared conceptualization" and the purpose of this chapter is to study how the transmission of information in ontologies facilitates collaboration in a SC. The solution developed by the authors consists in using the well-known SCOR model. This model provides a terminology and standardized processes enabling a general description of SCs and their translation into process maps, as well as a transformation of the textual model of the SCOR model into ontology.

Part III

Part III of this book pays particular attention to the question of coordination between members of the same SC. SC are distributed decision systems with local and autonomous decision makers, so SC coordination is a "pattern of decision-making and communication among a set of actors who perform tasks to achieve a goal" [MAL 97]. The usual goal of coordination is to reduce overall SC costs and to share the savings or the individual participants' benefits [SIM 00]. In other words, SC performances are directly linked to the coordination mechanisms used. In Part III, five chapters analyze the impacts of different coordination mechanisms – such as information-sharing processes – on performance and/or the determinants of these mechanisms that allow for increasing performance, such as trust or risk-aversion attitudes.

In Chapter 6, the coordination mechanism analyzed concerns the sharing of information about demand forecasts in a two-echelon supply chain (a retailer and a supplier). Using a strategic modeling approach, i.e. game theory, the first objective

of this chapter is to analyze SC managers' decision-making in order to assess their potential impacts on the local performance of each participant, as well as on the overall performance of the SC. Game theory offers insights enabling us to anticipate the behavior of rational participants when confronted with conflicting situations, or with cooperative or power relationships, in a context of IS. The participants' different strategies are defined according to this analytical approach, and Nash equilibriums are determined according to the actors' rational optimizing behavior. An example of a strategy is whether or not to send a truthful forecast (for the retailer) and whether or not to trust the retailer's forecast (for the supplier).

A second added value of this chapter consists of highlighting the strong complementarity between the analytical approach and behavioral game theory, i.e. a theory of strategic interactions that is rooted in real human behaviors. Using experimental economics methodology, this chapter aims to go beyond theoretical conclusions by experimentally studying the real behaviors of strategic interactions among participants. Here, the scientific challenge consists:

(i) of testing and assessing a model in a controlled environment; but also

(ii) of identifying typical patterns of human behavior in a given context, which could introduce some innovations into the theoretical models in use.

Our results show that subjects do not follow the theoretical predictions: retailers try to induce suppliers to produce more than the optimal level corresponding to a low demand on the final market, and suppliers do not trust the forecasts transmitted by their retailer. These results open new perspectives on dynamic strategies that evolve over time, and emphasize the need to change the hypotheses used in the analytical models. They also highlight the need to represent in more detail the trust/confidence mechanisms among participants, so that potential behaviors can be differentiated by considering relationship factors.

Firms in modern SCs seek to increase their competitive edge by employing new strategies such as re-centering some of their activities by outsourcing, so their vulnerabilities tend to increase, especially in the current, uncertain environment. Chapter 7 takes into account the operational risks induced by these strategies and introduces a particular coordination mechanism among SC partners as a risk-mitigation action in supply chains, i.e. a supplier selection mechanism to enhance the purchasing policy of the manufacturer.

Based on a global model of a SC with several suppliers and one manufacturer, the authors show how coordination among SC partners can be used as a global mitigation action to reduce a set of SC risks. Examples of such risks include demand fluctuations and uncertainties in the supplier's production capacities impacting inventory levels, backorder costs, and demand fill rate as quality of service. The

coordination mechanism studied here is based on an iterative procedure for supplier selection, while the Analytic Hierarchy Process (AHP) method is used to take several criteria (costs, quality and lead time) into account inside the supplier selection mechanism. For modeling and simulation purposes, the petri net and object oriented design framework are used. In fact, this framework is generic enough to easily integrate intra- or inter-partner mitigation actions as well as the individual behavior of each SC partner. The simulations performed with this coordination model show that it is able to keep the total cost of the system and the back-order cost of the manufacturer low even when the uncertainties increase. Moreover, the coordination mechanism is able to reach high demand fill rates (calculated as the fraction of demand immediately filled by the inventory on hand), even for high uncertainties. The use of the coordination mechanism can improve the fill rate by more than 5% when compared to a model without a coordination mechanism. Now that the framework is set, other criteria and coordination mechanisms can be implemented and tested to measure how these mechanisms contribute to reducing the level of risks in SCs.

Chapter 8 is a joint effort by researchers in management and computer scientists towards an understanding of the role and the impacts of trust in SC. It explores the loop between the strengthening or weakening of trust and the effect of this trust on the performance of SCs. Trust is considered a necessary antecedent of information sharing in SCs, where information sharing has always been seen as beneficial, i.e. reducing costs, improving service levels and reducing lead times and stock-outs.

After an exhaustive literature review on trust in organizational and inter-organizational relationships, this chapter presents a trust model based on 15 criteria, with measurement scales, in order to elaborate an aggregated criterion of trust in a SC relationship and to analyze the links between this trust's criteria, IS and the potentially increased performance of the SC.

Based on this model of trust, a simulation model based on a multi-agent architecture is proposed in order to evaluate the performance of a supply chain, taking into account the level of trust between participants in the chain. This simulation will make the connection between level of trust and level of performance by analyzing IS between the companies (the type of information shared depends on the level of trust and trustworthiness of behavior between the partners). The trust simulation model is validated with a case study, the MIT beer game, which is an example of SC management that has attracted much attention from academic researchers. Multiple rounds of experiments are conducted with different scenarios, focusing on the "behaviors of trust" of agents in the SC. The main finding is that, in a SC, the level of trust directly affects the level and quality of IS, which improves performance by reducing lead time and enabling companies to anticipate variations in market demand.

In the current competitive market context, companies should increase their reactivity through collaboration with the other members of their SC. This collaboration usually involves IS among the members of the SC. Several kinds of information may be shared. Basically, upstream information (lead time, supplier capacities, etc.) is distinguished from downstream information (demand, demand forecasts, etc.) and IS may concern both of information types.

Chapter 9 studies the impact of lead time IS (i.e. upstream) and demand IS (i.e. downstream) in three different SC contexts. The impact of both lead time IS and centralized decision-making is investigated for the first two SCs (one SC with stock in the distribution centre, another without). For the third SC, replenishment policies with three different levels of demand IS (no IS, slow IS and instantaneous IS) are compared. In the first two studies, a warehouse storing products in order to deliver them to several retailers is considered. The various scenarios considered allow us to conclude that lead time IS has considerable impacts in all the cases studied. This kind of IS positively or negatively affects the performance, depending mainly on the type of behavior of the end customer (backorder, i.e. patient customer, or stock-out, i.e. the customer does not come back). It is also affected by the cost of stock-outs, the number of retailers and the type of lead time. Moreover, final demand IS does not always incur savings since it may also require lead time IS. In other words, final demand IS only has a positive impact when the lead time information is also shared. In the third SC context, three replenishment policies, where two of them use downstream IS, are compared: optimization without IS, point-to-point IS and instantaneous IS.

Coordination in SCs also concerns the individual strategic decision on what ordering strategy to use. Indeed, every order placed by a firm not only depends on the firm's state (e.g. inventory level, products currently shipped from suppliers, etc.) and replenishment policy, but also on the state and ordering policy of its clients and suppliers. Strategic decisions on what ordering strategy to use must therefore take account not only of the internal constraints of the company, but also of the constraints imposed by the rest of the SC.

In Chapter 10, the coordination of replenishment policies in a SC is analyzed using game theory, which allows for the study of decisions made by companies when they take other companies' decisions into account. More particularly, the strategic decisions are the three replenishment policies analyzed in Chapter 9. In this setting, the interactions between the replenishment policies of two firms can be analyzed as a non-cooperative static game in which the strategic decisions of companies affect each company's payoff. The nine combinations (i.e. 3^2 combinations of the three policies) are numerically simulated and evaluated in terms of average inventory and backorder costs.

In addition to using game theory to study the multiple effects of the choices made by the different companies, this chapter investigates the impact of two parameters of these companies that may also impact on their choice of a replenishment policy. These parameters are the corporate decision makers' attitude towards risk and the importance given by these decision-makers to the service delivered to their clients. These two parameters are integrated into an original decision criterion, which takes the risk of loss into account.

The main results of this chapter show that information sharing (slowly or instantaneously) is not always the best strategy for firms. The specification of a firm's decision criteria – which account for the performances of joint strategies in terms of inventory holding, backorder costs, and their strategic behaviors supported by game theory tools – shows that firms benefit from information sharing in real time only when market demand is weakly volatile.

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