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Cross-Chain Collaboration in the Fast Moving Consumer Goods Supply Chain

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Preface

This book is the result of almost five years of research and industry-university collaboration. This book is also about collaboration among various companies in a particular industry: collaboration between shippers, logistics service providers, and retailers in the Fast Moving Consumer Goods (FMCG) supply chain. We have explored what Cross-Chain Collaboration Centers (4C) should look like and how they can bring benefits to all companies participating in the collaboration. The content of the book shows that the collaboration between industry and universities has been successful. The content of this book also reveals that collaboration in the FMCG supply chain can be successful provided that opportunities are properly identified and translated into sustainable processes. Some opportunities are obvious, some pitfalls are not.

Cross-chain collaboration can take many forms. But irrespective of the form, 4C must be profitable for all participant. Ton de Kok provides the foundations for the business case of 4C in the FMCG supply chain. Next Robbert Janssen and his co-authors discuss the business models that come with collaboration between the different actors in the FMCG supply chain. Profitability of small-margin businesses like FMCG is strongly depending on the cost of capital. This is particularly the case for logistics service providers. Kasper van der Vliet and his co-author discuss financial concepts that leverage the low risk profiles of shippers and retailers to reduce the risk profile of logistics service providers or other SME's, thereby lower the cost of capital for these companies. As demand is the prime input for a successful business model, Clint Pennings and his co-author discuss the benefits of collaborative forecasting, emphasizing the need to include behavioral aspects of collaboration. Forecasting is one of the application areas for predictive analytics, which is discussed by Sjoerd van der Spoel. He shows how currently available transactional data on quantity, quality and location enables more effective collaboration in supply chains. José Larco and his co-authors discuss the nature of planning and scheduling jobs in control towers, which is quite relevant for effective implementation of 4C concepts. All chapters so far discuss the potential of 4C and the resulting requirements on processes and ICT. Simon Dalmolen and his co-authors provide a broader perspective of the business requirements of 4C and translate them into inter-company ICT requirements.

This book would not have been possible without the support of many. First and foremost, we are indebted to the companies that sponsored our project.

Better stated, we are indebted to the supply-chain management thought leaders from these companies, who pushed us and supported us throughout the project: Jannie van Andel (Unilever), Tim Beckmann (K+N), Gert Jan Jansen op de Haar (iTude, EyeFreight), Tjebbe Nabuurs (Nabuurs), Tom Tillemans (Heinz), Riny Strik (SCA), Patrick Massuger (SCA), Michiel Steeman (ING), Tjarco Timmermans (ING), Ronald Mees (Cordys). As is often the case with thought leaders, some of these people have moved on to other jobs and left the project.

We are also indebted to about 30 BSc and MSc students that graduated on internship projects at the companies mentioned and other companies that showed an interest in the 4C challenges and opportunities. These students have been the main drivers of and means to knowledge dissemination between all participating organizations and towards organizations outside the 4C4More network.

The 4C4More project has been sponsored by Dinalog. From the idea phase in 2009 until the completion of the 4C4More project in September 2015, we strived for knowledge development and dissemination that would strengthen the position of the Dutch logistics and supply-chain management sector in terms of profitability and employment. We believe that we provided a good return on tax payers' money.

Ton de Kok, TUE
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Jos van Hillegersberg, UT

Eindhoven, Rotterdam, Enschede, March 2015

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Chapter 1

Introduction to Cross-Chain Control Centers (4C)

A.G. de Kok – Eindhoven University of Technology

This book is about the Fast Moving Consumer Goods (FMCG) supply chain and its management. The FMCG sector is core to the wealth and well-being of the developed countries. It is a mature industry that often took the lead in new business development, comparable to the role of the automotive sector. This book is about a concept that emerged only recently in the FMCG supply chain: the Cross-Chain Collaboration Center (4C) concept. We discuss the trends that explain its emergence. We provide insights into the hurdles to be taken and the available means to successfully implement 4C in FMCG. We make clear that there is a strong business case for cross-chain collaboration. But a business case is a mirage, if we do not overcome the complexity of joined IT platforms, and the fear of loosing autonomy. This book is about success and failures of business process innovations.

1.1 Logistics and supply chain management in the Netherlands

Logistics and Supply Chain Management are part of the Dutch society's gnome. Its location at the North Sea in the delta of the rivers Rhine and Maas that penetrate deep into the Western-European continent and beyond through the Danube river into the Black Sea, explains its leading role in intercontinental trade and management and execution of transportation on the European continent for over five centuries. Considering the last five decades of developments

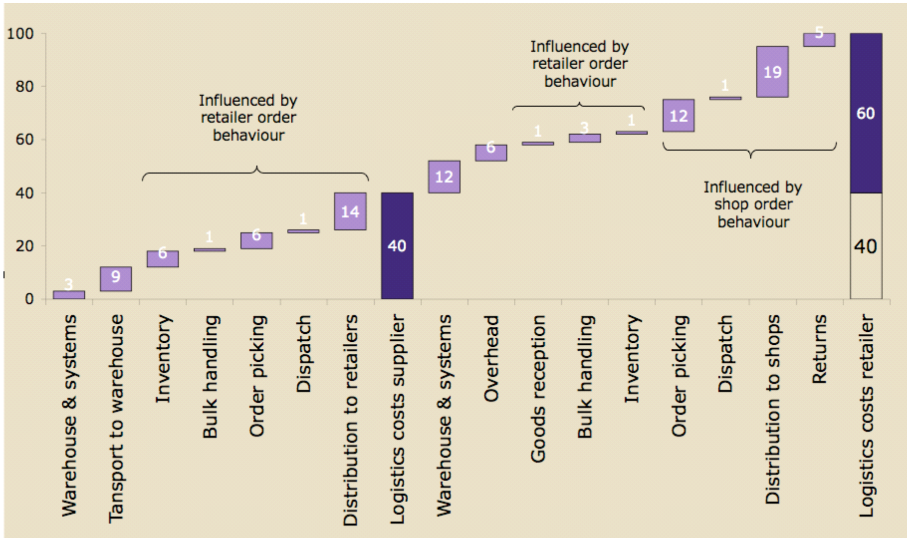

Figure 1.1: Costs of FMCG (dry grocery) supply chain up to retail stores (source: Van der Vlist, 2007)

in Logistics and Supply Chain Management, it can be argued that the Netherlands has made important contributions to the development of both scientific and professional knowledge. An example is the concept of Integrated Logistics developed at Philips, which should be considered as Supply Chain Management 'avant la lettre'. Another example is the frontrunner's role of the Netherlands in electronic customs clearance, where ICT and efficient document handling procedures meet.

Such contributions are the fruits of something that seems specific to the 'Rhineland' modus of operandi of Dutch universities in the areas of Industrial Engineering and Management Science: close collaboration with industry and government in the form of MSc internship graduation projects and creation of industry-university platforms that enable knowledge transfer in an informal way. Obstacles, such as concerns about intellectual property (IP) and liability, hardly play a role. Reputed university faculty spend a substantial amount of time on supervising these MSc students, thereby transferring state-of-the-art knowledge and absorbing relevant technological and organizational developments in industry. This also explains that Dutch scientific research in Logistics and Supply Chain Management has a strong 'operational' and empirical basis, whereas US scientific research is more focused on theory development and has an experimental basis. Thus, Dutch research in the area typically yields knowledge and tools for decision support. These decisions may concern strategic, tactical, and operational levels.

1.2 Scope of applied research

This edited book is the result of the collaboration between industry and universities. The industrial domain concerns Fast Moving Consumer Goods (FMCG), also known as Consumer Packaged Goods (CPG), manufacturing, transportation and retailing. These goods are found in every household, ranging from food to consumer care. They contribute close to 20% of total tonkilometres transported in the EU. Many manufacturers have well-known brands or produce retailer-branded products. Value density is low to moderate, implying that costs are primarily incurred for handling and transportation; see figure 1.1. The market is characterized by regular promotions on a limited set of fast-movers and by a stable demand for slow movers. Assortment in stores ranges from 2000 stock keeping units (SKUs) for low-cost retailers to 30.000 for premium retailers. The power balance in current FMCG supply chains implies that retailers demand high-frequency shipments towards their distribution centers (DCs). In principle, large volumes allow for efficient transport, i.e. full truck loads, but the potential efficiency cannot be realized as manufacturers require a high responsiveness towards the retail DCs. In (Doherty and Hoyle, 2009) it is stated that 24% of goods vehicles kilometers in the EU are driving empty and when carrying load, only 57% of the load capacity is being used. There are no accurate data available for FMCG transport in the EU, but given the required responsiveness in the FMCG supply chain, there is no reason to believe that the efficiency of truck usage is much higher than the overall figures indicate. Given the environmental impact of FMCG transport, including Green House Gasses (GHG) emissions and traffic congestion, there is a need to substantially reduce empty mileage and increase truck utilization. As the name of the game in transportation is *network density* (cf. Daganzo, 2005), further improvement activities should focus on increasing network density. Realizing that the FMCG supply chain has been a front-runner in the improvement of supply chain performance, it is likely that the low hanging fruit has already been harvested. There is a need for out-of-the-box thinking and out-of-the-box management and execution. In order to identify possible routes for further improvement, we put the FMCG supply chain in a wider perspective.

1.3 A flat, complex, and uncertain world

In today's flat world (Friedman, 2005) of global flows of goods, money and information, managing these flows is about managing the information about the real-time whereabouts of goods and money and the destination of these goods and this money. Despite the three decades of Information and Communication Technology (ICT) developments in terms of the transactional aspects of goods and money flows, i.e. their whereabouts and destination, the management of these flows still needs sophisticated human skills to exploit the capability of real-time access to the location and condition of goods on a global scale and of real-time access to credit in various forms to enable trade. The main reason is that current information about goods and money is only part of the management problem. The flows of goods and money are supposed to fulfill future needs. Unfortunately, future needs are not known with certainty, which greatly complicates matters of management. Seemingly obvious courses of action turn out to be ineffective, even if they are based on detailed real-time information about the global state of the supply chain. Shortest routes between origin and destination may be vulnerable to congestion for the very reason that everyone knows they are the shortest. Increasing rates of communication between actors in the supply chain imply more frequent exchange of imprecise information, thereby amplifying the noise in communication, while increasing the workloads of operational decision makers. Providing more detailed information to such decision makers implies more and even more imprecise information to be handled. Most people are unaware of the fact that over 90% of the information in ERP and APS systems are *guesses* and *estimates* about future events and future needs. Specifically, MRP systems with weekly buckets and a planning horizon of two years contain less than 0.1% factual data.

1.4 Uncertainty, slack and business models

The presence of future uncertainty implies that preventive measures must be taken to cope with it. Preventive measures take the form of implementation of slack resources and materials, such as alternative suppliers, flexible workforce, safety stocks and safety lead times, and slack time. However, such slack resources are costly and are often seen as waste to be eliminated. One way to eliminate slack resources and materials is to improve the decision making infrastructure, consisting of ICT systems and their users. ICT systems enable fast communication and sophisticated decision support. Higher skilled users are more capable to understand the problems to be solved, can work with more sophisticated decision support, and can deliver the same customer service at lower slack levels.

We note that decisions about preventive measures that create slack are taken at strategic and tactical level. At the operational level, the slack is exploited when necessary. Slack never used is waste, which is different than stating that slack is waste. Both smart creation of slack and smart exploitation of slack contribute to more efficient and effective supply chains. At the strategic level, slack creation is part of the *business model* of a company. The shipper's decision to deliver off-the-shelf products to the market or to deliver customer-tailored products within a week impact the form in which slack can and must be created. In the context of our research on the FMCG supply chain we deal with off-the-shelf products. The logistics service provider (LSP), who executes the transportation and warehousing activities in the FMCG supply chain, needs to decide about the amount of owned-trucks versus chartered trucks. Another LSPs strategic decision is to use supply-chain-specific resources or generic resources. As mentioned, LSPs should strive for transport network density, and thus LSP business models should start from there.

1.5 Supply chain management activities

In order to provide a direction for further improvement of supply chain performance, taking into account profitability and sustainability, we define supply chain management through all activities it encompasses. Supply Chain Management (SCM) concerns all management activities of a network of legal entities related to the transformation in place, time and shape of input materials into final products, given the product portfolio to be sold to given markets and using given transformation processes and their technologies. We distinguish between

- Strategic management activities, which concern the location and maximum volume of transformation processes, and which legal entities execute which transformation processes
- Tactical management activities, which concern the allocation of transformation processes in volume and time to each legal entity, and the determination of tactical control parameters, such as excess capacity, minimum lot sizes, planned lead time and safety buffers for each stock keeping unit (SKU) within scope
- Operational management activities, which concern all monthly, weekly, daily and real-time planning and control activities that prepare actual execution of the transformation processes

All supply chain management activities aim to satisfy the market needs in location, time and quantity, such that financial targets are met. Thus, supply chain management is an enabler of the short- and long-term viability of the partners in the supply chain.

Eventually, all management activities result into execution activities: order processing, transportation, warehousing, production. These supply chain execution (SCE) activities may be performed by the same legal entities as the ones that perform SCM activities, but they could also be performed by legal entities that only execute. Typical activities that are performed by execute-only legal entities are transportation and warehousing. Even production is nowadays considered primarily an execution activity, with specialized co-packers typically producing many branded consumer packaged products in the FMCG supply chain. However, any execution activity outsourced by the supply chain management partners involves SCM activities of the service provider performing the activity, as resources of the service provider should be used efficiently and effectively. Here, we see the major distinction between a typical material flow perspective of the SCM partners and the typical resource use perspective of SCE service providers.

1.6 Cross-chain collaboration

As pointed out by Fine (1998), competition between companies has evolved into competition between supply chains, or rather supply networks. This has led to concepts such as Vendor Managed Inventory (VMI) and Collaborative Planning, Forecasting, and Replenishment (CPFR) in the Fast Moving and Consumer Goods (FMCG) industry. It has become clear that each of the elements of CPFR has posed new challenges. Collaboration between partners in the supply chain is by no means trivial, as it involves processing information from multiple companies. Companies have to decide what information they are willing to share, but they also need to decide how information can be exploited to improve the supply chain's competitiveness. This relates in particular to planning and forecasting: clearly having transparency upstream and downstream enables more effective and efficient processes. Yet, the software tools are not available to harvest even the low hanging fruit. Designing and using such software requires rare skills and thus education and training. Concerning replenishment: just expressing one's requirements upstream is not sufficient. Requirements cannot always be fulfilled. One needs to provide information about future sales plans and current inventories in order to set the right priorities when upstream availability is not sufficient to satisfy downstream requirements. One should be aware that when flow is created in the supply chain, each stock point is in a permanent zero-inventory condition, so that allocation is the norm.

With this in mind, it has become clear that collaboration between partners in the supply chain needs further study, even more so as CPFR only focuses on vertical collaboration in the supply chain. Van Laarhoven (2008) coined the term 4C, where 4C stands for Cross-Chain Control Center. Later, De Kok (2010) proposed to define 4C as Cross-Chain Collaboration Center, as it became clear that cross-chain collaboration extends beyond control activities. Van Laarhoven (2008) emphasized the need for control towers that manage multiple supply chains. The control tower metaphor has been used frequently, while at the same time this metaphor was perceived as threatening, as it suggests the transfer of authority from partners in the supply chain to some, at the time non-existing, independent legal entity. It seems that in the meantime positioning 4C as a service to partners in the supply chain is more appropriate. Several examples of 4C entities emerged in the meantime. Here, we classify them in relation to the mentioned Supply Chain Management and Supply Chain Execution activities. Let us first provide a definition of a 4C legal entity:

> *A 4C legal entity performs supply chain management (SCM) or supply chain execution (SCE) activities, granted this responsibility by more than one legally independent partner in one or more supply chains.*

The definition emphasizes that a 4C legal entity provides a service to partners in one or more supply chains. The definition assumes that the activities performed are formally the responsibility of the partners that outsource these activities; other partners in the associated supply chains have no legal rights concerning this decision. An issue that has already risen since the emergence of 4C legal entities, is whether the responsibilities granted to the 4C are *compliant with legislation*. It seems that legally the most challenging 4C entity is the one where providers of a specific service, e.g. transportation or warehousing, create a legal entity that acts as a front office of these service providers, exploiting efficiencies and additional service opportunities that arise from pooling resources. In this case, competition authorities may consider the 4C legal entity as a cartel as it may hinder a level playing field for competitors. One of the solutions to this problem has been to make the service created accessible to any party interested and capable of executing the service.

The definition excludes outsourcing of activities by a single company. This is common practice and no legal obstacles exist. The definition allows for a 4C entity performing activities for partners in a single supply chain. A typical example concerns all transportation and warehousing activities. In this case, opportunities may arise by combining transport to and from partners in the supply chain and merging warehousing activities. In the 4C4More project this opportunity was identified related to warehousing activities: category warehouses of FMCG producers could be combined with category warehouses of retailers, thereby removing a link in the supply chain with little added value. The latter was shown by quantitatively modeling the FMCG supply chain (see Van der Vlist et al., 2010; De Kok, 2012). We refer to chapter 2 for more details.

Another typical example of a 4C activity in the context of a single supply chain is collaborative planning. The idea of collaborative planning is that one can create a de facto vertically integrated supply chain that can operate more effectively and efficiently. In De Kok et al. (2005) a case study is presented that demonstrates the benefits of collaborative planning. It also lists the prerequisites for success. Here, mutual dependency and trust are the key prerequisites.

If we categorize the reasons for creating a 4C entity, we consider economies of scale and economies of scope. If the competitive position of a company is determined by its ability to exploit economies of scale in (part of) its supply chain management and execution (M&E) activities, it seems appropriate to have company-dedicated activities in the case of low economies of scale and merger of these activities with that of others in the case of high economies of scale. When the ability to exploit economies of scope determines competitive position, one needs to ensure to have access to sophisticated skills to perform these activities. A 4C entity enables the exploitation of economies of both scale and scope: the legal entity can manage and execute supply chain activities of multiple companies, whereby its learning curve is steeper (economies of scope) and whereby it can ensure more efficient use of scarce resources while maintaining the right quality of service (economies of scale). In table 1.1 we provide a typology of the ways to organize supply chain management and execution activities from a shipper's perspective.

The reasoning expressed in table 1.1 is as follows. Management and execution (M&E) activities that have low economies of scale and scope should be kept in house to ensure that alignment between these activities and the other M&E activities. Outsourcing these activities would not make sense from a cost

Economies of scale	High	Outsource	4C
	Low	In-house capability	Source as a unique service
		Low	High
		Economies of scope	

Table 1.1: Positioning supply chain management and execution activities from a shipper's perspective

and quality perspective, as a service provider would not be able to create a competitive advantage. An example is short-term scheduling activities. M&E activities with low economies of scope and high economies of scale should be outsourced as a service provider is able to create sufficient scale by insourcing M&E activities from multiple shippers. Examples of these are transportation and warehousing activities. M&E activities with high economies of scope and low economies of scale should be sourced as a unique, i.e. tailor-made service (solution). Such activities can create a competitive edge, but M&E activities typically are not core to most shippers. An example is software for forecasting, planning and scheduling (APS systems). M&E activities with both high economies of scale and scope combine the strengths of outsourcing, and sourcing of unique services. These are M&E activities that only can create a competitive edge when sufficient expertise is applied to execution activities at a sufficient scale. An example concerns transportation and warehousing activities of multiple shippers where alignment in timing of execution activities can bring additional benefits, but which can only be realized by sufficient capabilities of decision support tools and the people working with these tools. Another example is the forecasting of demand, where underlying patterns of demand can only be identified after aggregation over multiple items form multiple brands within a category.

As stated, the 4C4More project focused on management and execution activities in the FMCG supply chain, where collaboration between shippers, logistics service providers and retailers can create financial and societal benefits, beyond those created by standard bilateral relationships. Given the collaboration between multiple legal entities we face a large structural complexity: a larger amount of information and data to be handled and a larger amount of resources and materials to be taken into account. Inevitably this implies the need for more sophisticated software and hardware tools and the need for higher skilled SCM professionals. The latter is needed in particular, because the high structural complexity implies that decision support tools will not be able to produce an 'optimal' solution by pressing the 'red button'. In fact, beyond very basic single-location-single-item problems it is mathematically impossible to produce an optimal solution for strategic, tactical and operational problems under the uncertainties in supply and demand processes to be faced. Under appropriate modeling assumptions, decision support tools should produce feasible and 'reasonable' solutions that can be further improved by planners and schedulers that relax binding constraints. This implies that such support tools are able to present those binding constraints, such as fully exhausted capacity, and completely consumed material inventories, in relation to their impact on operational, financial and environmental targets. Skilled supply chain management professionals create solutions that are feasible in practice, while being judged as infeasible by the planning tools that support them. Being able to work with such a seeming inconsistency requires a deep understanding of both models and practice.

1.7 Structure of this book

This book is structured around the work packages as defined in the 4C4More project proposal. Before discussing the various aspects of cross chain collaboration, in chapter 2 we elaborate on the business case for a 4C. We show that both vertical collaboration between shippers, retailers and logistics service providers and horizontal collaboration between logistics service providers bring substantial benefits. One main finding is that horizontal collaboration must be facilitated by vertical collaboration to be effective. The value proposition of 4C is discussed in Chapter 3. Using a well-established framework for developing a business model, a template 4C business model is proposed. The main elements of this business model template, i.e. customer value proposition, key profit formula and the key processes and resources are discussed in further detail. In chapter 4 we show how collaboration can reduce the risk of 4C participants, whereby the cost of capital can be reduced as well. Thus the value of each 4C participant increases. The recently established field of Supply Chain Finance studies and develops mechanisms for financial risk reduction, which exploit structural and temporal properties of supply networks. Reverse factoring is an example of such mechanisms, and is discussed in detail in chapter 4. Chapter 5 focuses on collaborative forecasting. Scientific literature has shown that collaborative forecasting between retailers and shippers can bring substantial benefits. However, these results are based on stylized, i.e. strongly simplified, models of reality. In particular behavioral aspects are ignored. We discuss the results from experiments that show that trust is an important determinant of success. Furthermore the inherent uncertainty of forecasting future demand requires information processing and analysis expertise that may not be available to each individual company. Thus, economy of scope created by a 4C for forecasting can improve forecasting accuracy, thereby building trust between 4C participants. This naturally leads to chapter 6, which discusses business analytics. We discuss the difference between explanatory modelling and predictive modelling (analytics). A well-known methodology for predictive analytics is applied to various aspects of cross chain collaboration, e.g. partner selection and forecasting. In chapter 7 we discuss behavioral aspects of the planning and scheduling task within the control tower of a 4C. We used a case study of a control tower within a company to identify what planners and schedulers really do. We discuss new findings related to the amount of time actually spent on planning itself and the phenomenon of self-interruption. These findings have implications for the job design of planners and schedulers in 4C control towers. Finally, in chapter 8 we discuss the IT aspect of cross chain collaboration, and in particular the IT necessary for a cross chain control center to emerge. We argue that current *intracompany* ERP systems are not capable of supporting operational *intercompany* collaboration. We describe the requirements for ICT architectures in a collaborative setting and zoom in on ICT capabilities for swift business to business integration.

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Chapter 2

Business Case of Cross-Chain Collaboration in FMCG

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Clearly, the 4C4More project, and the other 4C projects initiated by Dinalog since 2010, is not the first to explore the opportunities of cross chain collaboration. In fact, quite a few projects in the 1990s and 2000s have shown that indeed economies of scale in transport can be realized by combining the networks of multiple shippers or by combining the networks of multiple LSPs or both. Despite these findings, hardly any of these projects led to implementation, let alone sustained collaboration. In hindsight the main driver for this lack of success has been a lack of trust: sharing information on one's day-to-day business with competitors, suppliers and customers is a risk (cf. Ruijgrok (2010)). Apparently, the perception of this risk outweighed the perception of the financial benefits. The main supposition behind the 4C business model concepts proposed by several authors, e.g. Verstrepen et al. (2009) and Brandi (2012), is that a separate 4C legal entity, a trustee or orchestrator, removes the risk associated with information sharing, as the trustee will ensure that information from company X is not accessible to company Y, unless this is allowed. In chapter 3 we discuss 4C business models in detail.

Assuming that distrust between 4C partners is removed as the main barrier for success, it is still of importance to identify to what extent collaboration within the FMCG supply chain enables further improvements in customer service, profitability and sustainability. In section 1.2 we mentioned that FMCG supply chain management has developed to a high level of professionalism, so it is unlikely that fruits are hanging low. We pointed out that the challenge is to master higher complexity under uncertainty. Fortunately, over the last two decades, scientific research has made great progress in modeling the complexity of and the uncertainty in real-life supply chains; see De Kok and Graves (2003) for a survey of supply chain management research over the period 1993-2003. This leads to the following observations:

- Empirically valid models exist that enable the 'optimization' of real-life supply chains under demand uncertainty. This enables the analysis of FMCG supply chains from suppliers of shippers to the retailer shelves with a focus on the trade-off between inventory capital investments and shelve availability.
- Large scale transportation-distribution networks with a focus on handling and transportation costs can be solved using software tools from companies like IBM, ORTEC, Barloworld, and OM Partners.
- Transactional ERP systems provide the data required for optimization at strategic, tactical and operational level.

In short, it is possible to determine whether there is a business case for 4C or not, even if it involves large-scale network optimization under uncertainty. We emphasize that the business case, i.e. a positive financial and environmental impact of cross-chain collaboration, is *prerequisite* for the success of a 4C business model. The business case is *not a guarantee* for success. Implementation of a 4C business model requires *mutual trust of partners* and a *'fair' allocation of costs and benefits* among the partners, including the newly established trustee. On top of this, the 4C business model should be legally allowed. The issues of mutual trust and fair allocations will be discussed in subsequent chapters. Here, we focus on our preliminary findings concerning the business case itself.

2.1 4C FMCG supply chain structure

Early 2011, a group of FMCG professionals participating in the 4C4More project formulated a vision concerning the FMCG supply chain structure in 2020. The current supply chain structure as depicted in figure 2.1 is characterized by four *echelons*: the manufacturer's production sites, the manufacturer's distribution centers (DCs), the retailer's distribution centers and the retailer's stores and other outlet stores for channels like home delivery and B2B. The typical service level from manufacturers' DCs to retail DCs is 98%, while typical on-shelve availability in retail stores is 85%. Transportation on each link is outsourced to LSPs. Some shippers share an LSP warehouse as manufacturer DC for a part of their assortment, which has shown to give transportation costs savings on the link between manufacturer DC and retail DC.

The first step towards the 2020 vision would be the implementation of a *4C for transport* on the link between manufacturer DC and retail DC. This is a proven concept, which should be applied consistently. By ensuring that the

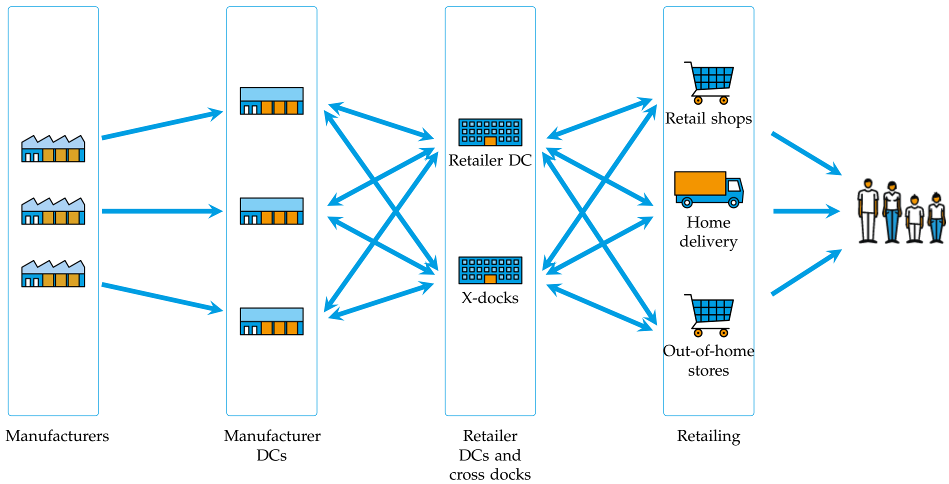


Figure 2.1: FMCG supply chain structure in 2011

logistics performance towards the retailer DC is not affected, this would be a feasible first step, as it primarily involves collaboration between LSPs. By reducing transportation costs and passing some of these costs on to manufacturers and retailers, this would pave the ground for further steps. The resulting supply chain structure is depicted in figure 2.2

The second step would be the integration of the DCs of multiple manufacturers into so-called category warehouses. Thereby the retail store's planogram, i.e. the lay-out of an aisle in a supermarket store, would be mirrored in the manufacturers' DCs. By doing so, shipments prepared at category warehouses could be moved to the retail stores without further handling due to the need for breaking bulk and consolidation. In this step, we would be implementing a *4C for warehousing*. Furthermore, the 4C for transportation activities should be extended to the link between manufacturers' sites and the category warehouses. Further reflection of the FMCG professionals led to the conclusion that the category warehouses should be category cross-dock (X-dock) centers. We underpin this conclusion below when discussing a quantitative modeling exercise involving the FMCG supply chain based on data from Van der Vlist (2007). The resulting supply chain structure is depicted in figure 2.3

In the third step, the retail DCs and category cross dock centers are merged. This eliminates non-value added handling activities, which should bring substantial benefits, given the share of handling in end-to-end costs in the FMCG supply chain. The cross dock operations can only be operated effectively by sharing inventory and pipeline data across the supply chain and by tuning the shipment time tables on each link. By sharing these data with the LSPs, these can optimize routes and truck utilization. This line of reasoning is supported by several in-depth studies (cf. Coppens, 2012; Hernandez Wesche, 2012; Schuijbroek et al., 2013): *vertical collaboration enables effective and efficient horizontal*

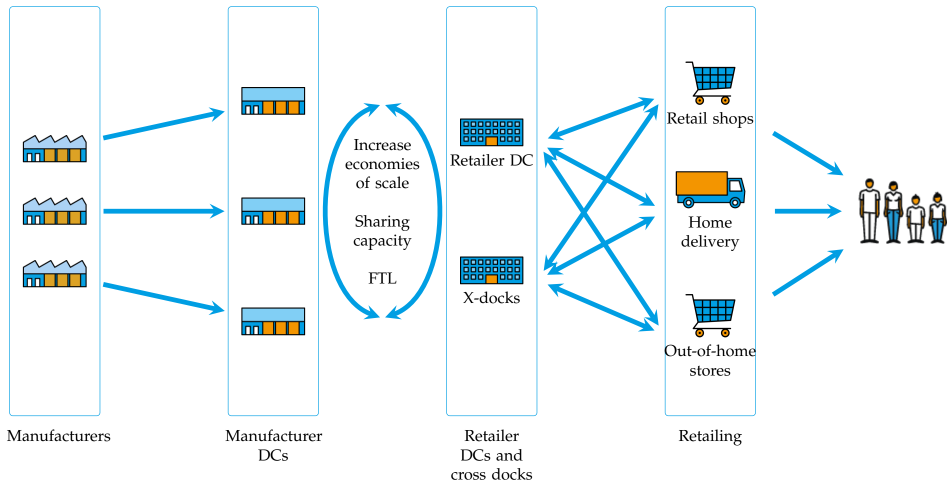


Figure 2.2: Phase 1: LSP collaboration on shipments between manufacturing DCs and retailer DCs

collaboration. Where vertical collaboration is primarily focused on effectiveness, meeting consumer and customer requirements, horizontal collaboration of LSPs must focus on efficient use of resources within the performance constraints set by the shippers. The resulting FMCG 2020 supply chain structure is depicted in figure 2.4

As stated, Van der Vlist et al. (2010) quantitatively analyze the FMCG supply chain, starting from empirical data presented in Van der Vlist (2007). These empirical data are summarized in figure 1.1. Van der Vlist et al. (2010) apply a so-called micro-modeling approach: the total FMCG supply chain is represented by a limited number of five products, carefully selected to represent the total assortment at the retailer stores and parameterizing cost and process parameters, e.g. service levels, lot sizes and lead times, in accordance with actual practice. In this way, the actual operational performance and cost division from figure 1.1 is mimicked. Due to the small scale of the model, it is easy to generate alternative scenarios. We consider the following scenarios:

- Current supply chain scenario with 98% service level from manufacturer to manufacturer DC and 98% service level from manufacturer DC to retailer DC and 98% service level from retailer DC to retailer stores.
- Current supply chain structure, supply-chain-wide optimization subject to 85% retail store shelve availability, retailer determines the ordering frequency in the supply chain, i.e. retailer is the drum.
- Current supply chain structure, supply-chain-wide optimization subject to 85% retail store shelve availability, manufacturer's production lot size determines the ordering frequency in the supply chain, i.e. manufacturer is the drum.

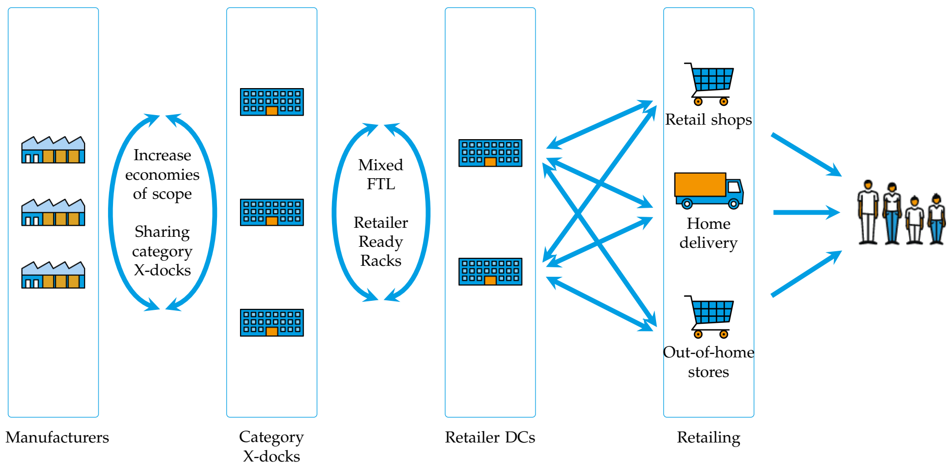


Figure 2.3: Phase 2: LSP and manufacturer collaboration

- Current supply chain structure, supply-chain-wide optimization subject to 95% retail store shelve availability, retailer determines the ordering frequency in the supply chain, i.e. retailer is the drum.
- Current supply chain structure, supply-chain-wide optimization subject to 95% retail store shelve availability, manufacturer's production lot size determines the ordering frequency in the supply chain, i.e. manufacturer is the drum.
- FMCG 2020 supply chain structure, i.e. with a single category cross dock center, supply-chain-wide optimization subject to 85% retail store shelve availability, manufacturer's production lot size determines the ordering frequency in the supply chain, i.e. manufacturer is the drum.

The results of this study are presented in figures 2.5 and 2.6. Referring for details to Van der Vlist et al. (2010), we conclude from figure 2.5 that substantial savings in overall supply chain costs can only be achieved when integrating the manufacturing DCs and retail DCs into cross-docking centers. From figure 2.6 we conclude that the cost reduction is primarily due to the elimination of handling and transportation costs on the link between manufacturer DC and retailer DC. We assume that all costs at the cross dock centers are charged to the manufacturer. We also found that under the current 85% shelve availability it is beneficial to have the manufacturer as drum of the supply chain. But if the target shelve availability is increased to 95%, then the retailer should be the drum. The explanation is that a lower shipment frequency has the most impact on inventory levels at high service levels.

The results demonstrate the business case from an end-to-end supply chain perspective and for the shippers and retailers. The business case for the LSPs is discussed in the next section.

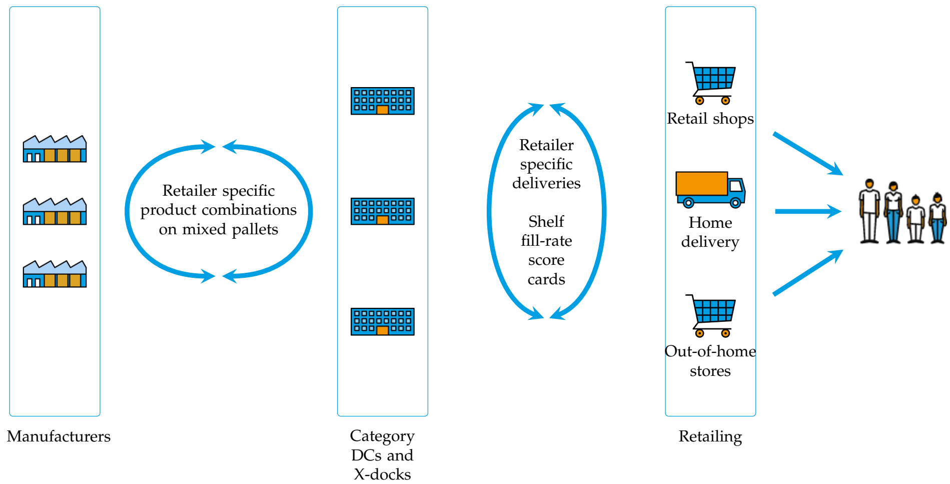


Figure 2.4: Phase 3: Collaboration between manufacturers, LSPs and retailers

2.2 A business case for 4C in FMCG transport

The 4C4More project has been initiated by Unilever (Jannie van Andel) and Kühne + Nagel (Tim Beckmann). At the time, the vision was that LSP collaboration could substantially lower transportation costs: a shipper or retailer should not bother whose truck delivers the goods, just like no one bothers about the bank that owns the ATM from which the money is collected. K+N teamed up with LSPs Nabuurs and Bakker in a feasibility study supported by ORTEC, TNO and TUE. It was agreed that each LSP would make its own trips from the customer orders received, after which the trip would be uploaded to the ORTEC scheduling engine. This software tool would combine trips and vehicles, such that empty mileage would be minimized, truck utilization improved and customer service requirements, e.g. time windows, would be satisfied. Data about a few representative days were used for validation. A major issue emerged: a subset of the trips violated constraints that had been formulated based on interviews with planners and schedulers. Though this seems to be paradoxical, it is in fact quite typical when one formally formulates planning and scheduling constraints. Even the trips that formulate those constraints and are supposed to conform to them, will violate them in practice occasionally because of specific, contingent, knowledge. After carefully cleaning the data, a valid experiment was conducted yielding the results presented in table 2.1.

Given the thin margins in transportation the results of the pilot show that collaboration between LSPs with a substantial market share in regional FMCG transport brings important savings in costs, empty mileage and overall mileage. On an annual basis, savings amount to almost €1,300,000, which easily offsets the investment associated with implementation of the LSP collaboration, esti-

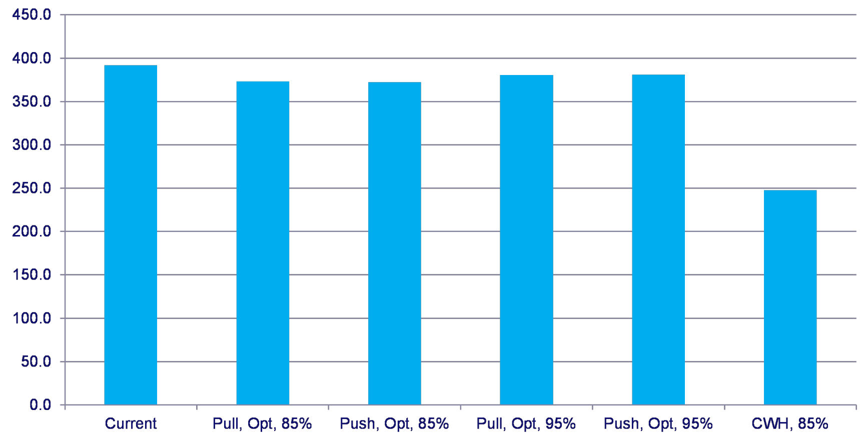


Figure 2.5: FMCG supply chain costs for different collaboration scenarios

Table 2.1: Results on horizontal collaboration of three LSPs in FMCG

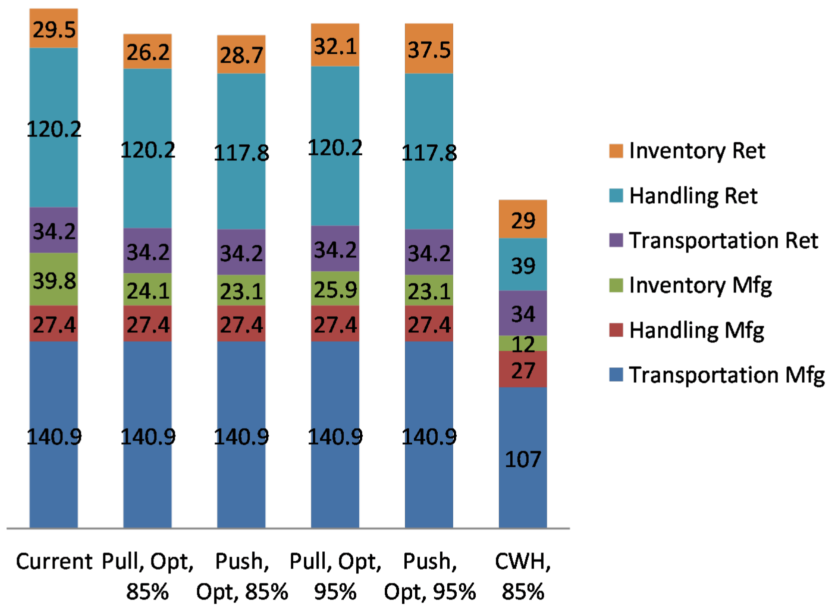
	Relative difference	Absolute difference
Δ Cost-factor	-4,80%	-24,993 per week
Δ Kms driven	-4,70%	-32,463 per week
Δ Empty kilometers	-15,20%	-38,547 per week
Δ Driving hours	-4,90%	-497 per week
Δ Vehicles	-12,90%	-55 per week

mated at €800,000 in total. Furthermore, the 13% reduction in vehicles needed to transport the goods shows a marked contribution to truck utilization.

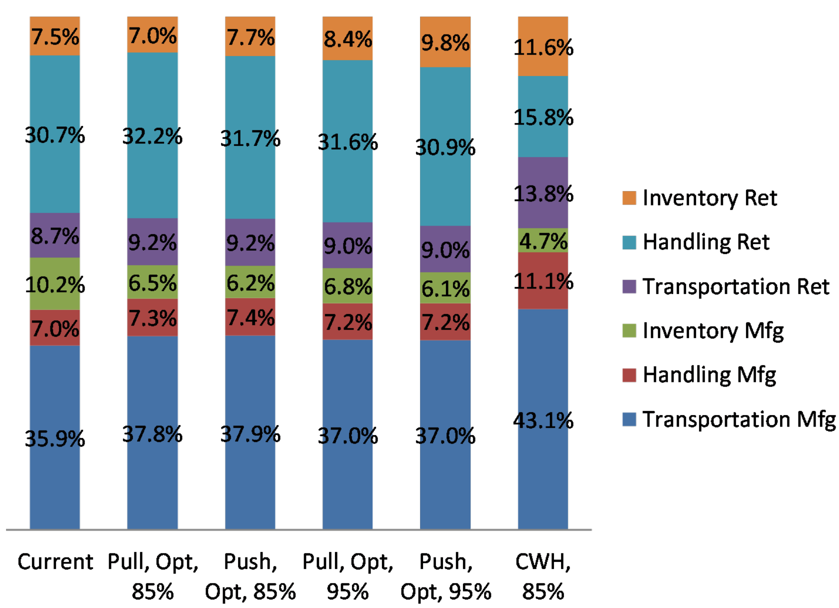
Based on the pilot, the three LSPs decided to take further steps. Unfortunately, it turned out that the competition law, both Dutch and EU, makes it difficult to setup a 4C between competitors in the same market. At the moment of writing, steps have been taken to make the 4C happen, including the establishment of the foundation Ecologistiek that should act as the trustee in the 4C.

2.3 4C impact on retail shipments transportation costs

In the context of a Dinalog breakfast seminar, De Kok (2012) presented the results of a quantitative study of a 4C for transport in FMCG transport between retail DCs and retail stores. The analysis was based on the work by Daganzo (2005) who developed a set of easy-to-use formulas to compute minimal trans-



(a) Absolute costs



(b) Relative costs

Figure 2.6: Absolute and relative cost build-up

portation and handling costs in transportation networks. For ease of reference equation (4.7) from Daganzo (2005) is presented in (2.1):

$$\begin{pmatrix} \text{Total combined} \\ \text{transport cost} \end{pmatrix} \approx c_s N \left[\frac{D(t_{max})}{v_{max}} + L \right] + c_d k L N E(\delta^{-1/2}) + \\ c_d 2E(r) D(t_{max}) N / v_{max} + c_s' D(t_{max}) N \quad (2.1)$$

The formula shows that the total transportation costs depend on a set of parameters, which in fact are easy to obtain from data in ERP systems, transportation planning and scheduling systems and public data.

Table 2.2: Variables used in Daganzo (2005) to compute minimum transportation costs in one-to-many distribution networks

Symbol	Definition
t_{max}	Time interval over which costs are accumulated
$D(t_{max})$	Average demand in units during t_{max}
N	Number of customers
L	Number of shipments from depot to each customer during t_{max}
δ	Customer density function (# customer/km)
k	Distance metric specific constant to translate
v_{max}	Maximum number of units per truck
r	Distance from depot to region
c_d	Cost per vehicle distance
c_s	Cost per stop at customer
c_d'	Cost per unit transported

Based on publicly available data about the number of retail stores in the Netherlands (about 4000), the number of pallets per truck, the cost data taken from Van der Vlist (2007) and Van der Vlist et al. (2010) and geographical data, De Kok (2012) evaluated a number of scenarios, which are presented in table 2.3.

The first scenario represents the current situation. The costs computed with the Daganzo formula appear to be quite close to the costs computed by the micro model in Van der Vlist et al. (2010), which have been aligned with the actual costs presented in Van der Vlist (2007). Having validated the data and the costs derived according to Daganzo (2005), we analyze two 4C scenarios assuming that in each of the five regions in the Netherlands a single 4C manages transportation. We found that the cost improvement is negligible, unless the collaboration between LSPs in a 4C results in a reduction of empty km's between retail store and depot, i.e. a point where a new full truck load can be collected, from 30km to 10km.

Table 2.3: Scenario analysis of FMCG transport from retail DC to retail stores in the Netherlands

Region	Customer density	Number of LSPs	L	N	#RORO per week	$E[r]$	$E[d-1/2]$	cs	cs'	cd	Daganzo	Micro-model
						Scenario 1						
1	0,07	6	6	1288	132	30	9,161847438	90	0,01	0,8	1795737	1808360
2	0,26	6	6	1814	132	30	4,762758549	90	0,01	0,8	2508257	2547882
3	0,05	6	6	94	132	30	10,66612865	90	0,01	0,8	131733	132269
4	0,12	6	6	602	132	30	6,999928679	90	0,01	0,8	835761	845222
5	0,13	6	6	278	132	30	6,817852398	90	0,01	0,8	385241	389741
											5656729	5723474
						Scenario 2						
1	0,07	1	6	1288	132	30	3,740308554	90	0,01	0,8	1776634	
2	0,26	1	6	1814	132	30	1,944388035	90	0,01	0,8	2494266	
3	0,05	1	6	94	132	30	4,354428785	90	0,01	0,8	130106	
4	0,12	1	6	602	132	30	2,857708917	90	0,01	0,8	828939	
5	0,13	1	6	278	132	30	2,783376586	90	0,01	0,8	382177	% reduction
											5612122	0,8%
						Scenario 3						
1	0,07	1	6	1288	132	10	3,740308554	90	0,01	0,8	1529370	
2	0,26	1	6	1814	132	10	1,944388035	90	0,01	0,8	2145884	
3	0,05	1	6	94	132	10	4,354428785	90	0,01	0,8	112021	
4	0,12	1	6	602	132	10	2,857708917	90	0,01	0,8	713369	
5	0,13	1	6	278	132	10	2,783376586	90	0,01	0,8	328886	% reduction
											4829530	14,6%

This is an important finding that is in line with the concept proposed by the three LSPs in the pilot study: only trips where uploaded, implying that the ORTEC software had to focus on minimizing the km's travelled after a trip of a vehicle was finished until the next trip of the vehicle. As in FMCG most trucks deliver full truckloads at each store, it returns empty, or lowly utilized with packing materials for reuse. Thus the focus should be indeed on finding nearby a place to drop-off those materials and collecting a new full truck load.

Given the simplicity of Daganzo's equation (4.7), it is of great interest to further analyze the impact of the FMCG supply chain structure on the business case of 4C in transportation.

2.4 Shipment synchronization

In section 2.1, we showed the business case for 4C in FMCG using a micro-model validated on the data in figure 1.1 from Van der Vlist (2007). This motivated in-depth case studies to get further understanding of the opportunities and challenges when implementing 4C. We already mentioned that some of these studies revealed that vertical collaboration between manufacturers and retailers is a prerequisite for effective horizontal collaboration between LSPs. In Schuijbroek et al. (2013) various forms of vertical collaboration have been investigated, taking into account the impact of the operations of the LSP. The companies involved were SCA, Heinz, and Hero, who share a warehouse operated by LSP Nabuurs, and retailer Sligro. Although a single LSP was involved, this setup enabled to assess alternative scenarios for collaboration, which are presented in figure 2.7.

The collaboration scenarios are based on two aspects: the partner in the supply chain that is responsible for inventory management, and the degree of integration with respect to information systems and information sharing. Schuijbroek et al. (2013) used discrete event simulation to generate the results in terms of costs and operational performance for each scenario.

The most important finding from Schuijbroek et al. (2013) is that synchronization of shipment moments of the manufacturers from the Nabuurs warehouse location to retailer Sligro brings substantial benefits. Implementing such synchronization requires hardly any investment as the current ways of working do not change, only timetables are aligned. Additional benefits of information sharing are outweighed by the necessary investments in IT. This may change when Software as a Service (SaaS) is available in the area of supply chain management. For further details we refer to Schuijbroek et al. (2013).

Another important finding is presented by Coppens (2012) who studied horizontal collaboration between Heinz and Refresco. As Refresco acts as a co-packer for Heinz ready-to-drink products, it seemed obvious to combine shipments from the Refresco site to retail DCs, instead of shipping Heinz ready-to-drink products to the Heinz DC and then to the retail DC. A careful analysis revealed that the benefits of combining shipments at the Refresco site were out-

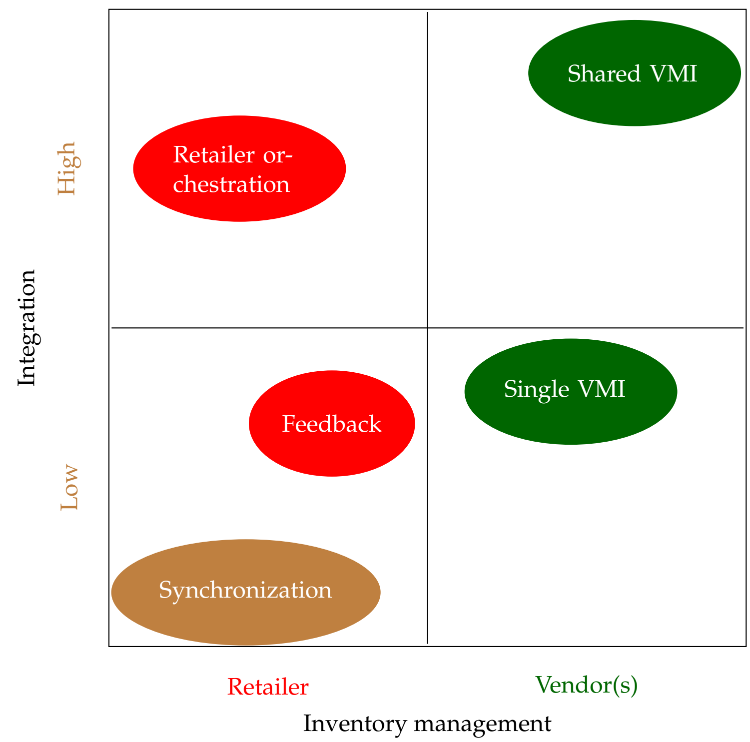


Figure 2.7: Scenarios for collaboration between shippers and retailers

weighed by the increase in costs of the Heinz shipments from the Heinz DC to the retail DC. By removing the ready-to-drink volume from the Heinz shipments, these shipments increased in costs per volume and weight. Thus it is key to carefully define the scope of the 4C implementation and to take into account the impact of 4C operations on non-4C operations. Coppens (2012) also developed a quantitative model that showed that collaboration can be more costly than no-collaboration under normal tariff structures, if the collaboration leads to frequently recurring small shipments due to the mismatch between lot sizes of retail orders shipped jointly and the capacity of a truck in volume or weight.

These in-depth studies show that the business case developed for 4C in FMCG can be realized, provided a detailed assessment is made of the supply chain structure and operations to be implemented. In most cases this requires careful quantitative modeling and discrete event simulation. Investment in such an approach is not only worthwhile to ensure that benefits are reaped, but also as a means to develop and test planning and scheduling rules, inventory management policies and 'swimming lanes' that clearly describe who does what and when.

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Chapter 3

Strategic Business Models for Cross-Chain Control Centers (4C)

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The objective of this chapter is to present different kinds of business models that are available for Cross-Chain Control Centers (4C) and give concrete advice about relevant elements to consider when starting or joining cross-chain collaboration. To this end, we provide a brief overview of the business model literature and show how we can build on this literature to provide a generic 4C business model template. Also, we elaborate the business model perspective by specifying related policy and governance decisions, and discuss the services that could be provided by basic 4Cs and more extensive 4C service providers. We start with a broad view of 4Cs underlining the breadth of the concept, which is the reason why a business model perspective is ultimately needed to provide a thorough understanding of the 4C concept.

3.1 A broad view of 4Cs

Cross-Chain Control Centers (4Cs) are a relatively new phenomenon. Practitioners, consultants and industry experts each hold their own opinions and definitions, which is common with such a new development. Even more, we have witnessed the use of the term Cross-Chain Collaboration Centers (De Kok,

2015) and, more recently, the appearance of the Control Tower metaphor in the Dutch logistics and supply chain industry. We use the term 4C to represent all these notions. However, the fuzziness in definition leads to some confusion about the essence of a 4C. Consider, for instance, the following three illustrative short-hand descriptions of a 4C:

1. A 4C is a control tower, similar to air traffic controllers on airports, that take care of the coordination of logistics activities for various shippers and logistics service providers;
2. A 4C is a company that coordinates warehousing and transport execution for an alliance of logistics service providers;
3. A 4C is akin to an expediter in that it pools freight from multiple shippers and chooses the best fitting logistics service provider to execute the transport.

With all the knowledge and experience gathered during the past four years of research in the 4C4More project, we can safely say that all three examples have been used in clarifying the phenomenon, and we could easily think of another set of illustrative descriptions. The descriptions are quite dissimilar in their own right. The second and third descriptions, for instance, would easily fit with what is commonly known as Fourth-Party Logistics (4PL) in the logistics industry. This does not help to delineate and discriminate the 4C concept. Additionally, the Van Laarhoven Committee who coined the term Cross-Chain Control Center, originally defined the 4C as 'a center from which several supply/demand chains are controlled by means of modern technology, advanced software, top professionals; physical, financial and information flows are controlled here' (Laarhoven, 2008, p.15). Although this is rather broad, it does provide a good starting point for discovering what a 4C is about.

Unpacking the Cross-Chain Control Center concept

Figure 3.1 shows the key concepts extracted from the short-hand descriptions and definitions. For ease of reference, we have aggregated the concepts into four categories: context, actors, resources and activities. These key concepts line up straightforwardly with the definition given in chapter 1 of this book: a 4C legal entity performs supply chain management (SCM) activities and supply chain execution (SCE) activities, granted this responsibility by more than one legally independent partner in one or more supply chains, in the sense that the emphasis of a 4C is on performing the management (control) and execution activities, assigned by supply chain actors, in one or more supply chains.

Certainly, the objective of this chapter is not to dive deep into a methodological discussion of the 4C concept. Instead, we aim to show the breadth of the 4C concept by presenting illustrative descriptions and by discussing related concepts. In practice, we already observe many different businesses that call themselves 4Cs or control towers (Supply Chain Movement, 2013), yet these businesses are as diverse as there are many. Still, in order to compare these

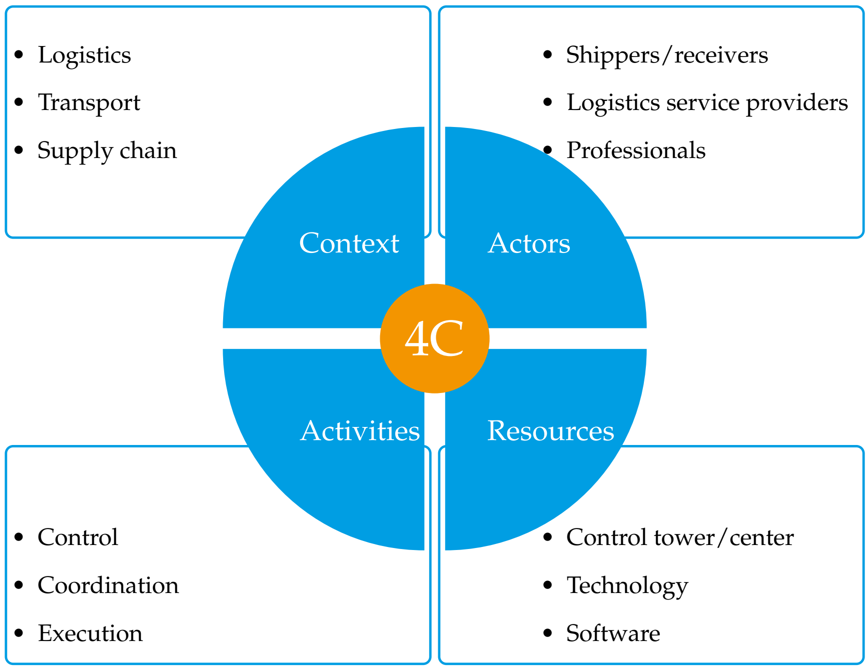

Figure 3.1: Key concepts of a 4C: context, actors, resources and activities

initiatives, it is customary to analyze the underlying business models. Using short-hand descriptions to describe a 4C, or any new innovation for that matter, is something that is common in business model research (Baden-Fuller and Morgan, 2010), which is clarified in the following section. By having an understanding of a 'template' 4C business model, an actual 4C could be designed and operated, which results in new business value creation.

3.2 Business models: what are business models?

Economist Joseph Schumpeter defined five types of industrial innovations: (*i*) launch a new product; (*ii*) use new methods of production; (*iii*) acquire new sources of supply; (*iv*) exploit new markets; and (*v*) develop new ways to organize business (Casadesus-Masanell and Zhu, 2013). Our contribution is mainly about the latter, business model innovation, i.e. changing the logic of how firms do business. From a supply chain perspective, examples of new business models are the design of a joint distribution service, the use of a freight exchange and auction platform, the usage of a common category warehouse, or, indeed, the establishment of a cross-chain control center.

Today, many people are familiar with the business model concept through Alexander Osterwalder's business model canvas (Osterwalder et al., 2010), which is intensively used worldwide. The concept, however, is actually more encompassing than the presented nine-element framework. Not surprisingly, recent years saw substantial attention to the concept of business models from both academics and practitioners (Zott et al., 2011). An early definition of business models links technological innovation to economic value through business models (Chesbrough and Rosenbloom, 2002). That is, without a proper business model it would be difficult to make money from the technology. In a sense, this has been mentioned in chapter 1 of this book noting that there have been many advances in information and communication technology, but that these advances have not always been put to good use in logistics and supply chain execution, perhaps due to lacking business models.

A more general definition of business models, which seems to stick in literature is: 'a business model describes the rationale of how an organization creates, delivers, and captures value' (Osterwalder et al., 2010, p.14). Zott et al. (2011) note that business models have been referred to as descriptions, representations, or even generic architectures of businesses. Sometimes business models are operationalized as conceptual tools or structural templates, amongst others.

Short-hand descriptions of business models

With regard to descriptions, business models are often put forward as condense summaries, such as a 'bricks-and-clicks' model (companies combining physical and online channels) or a 'razor-and-razorblade' model (buy a cheap razor and keep paying recurrent premium rates for purchases of the blades) – very brief descriptions of how products and services are offered to the customer (Baden-Fuller and Morgan, 2010). The previous short-hand descriptions of 4Cs are similar to these dense summaries, in that (significant) detail is avoided for a quick glance at the underlying business model. Table 3.1 shows a variety of short-hand descriptions often used for business models.

Moving beyond short-hand description: business model elements

But a short-hand description only goes so far – often one needs the intricate details of the business model. Since business models are generally conceptualized as a broad, holistic description of how firm conduct business, specifying the boundaries is often a difficult task: what exactly constitutes a business model? As dozens of definitions and component-breakdowns (Zott et al., 2011) of the business model have been proposed over the last decade (DaSilva and Trkman, 2014), we follow the approach employed by other authors (Magretta, 2002; Sinfield and Calder, 2012) who give lists of questions that jointly elicit the elements of a business model, see table 3.2. While it is not intended to be exhaustive, the list provides a starting point for understanding which elements together constitute the underlying business model.

Table 3.1: Examples of short-hand business model descriptions from various industries

Short-hand description	**Explanation**	**Business example**
Brick-and-clicks	Company integrate offline and online presence for offering products	Albert Heijn stores (bricks) and its Albert service (clicks)
Razor and razorblades (also called bait-and-hook)	One item is sold at a low price (or given away for free) in order to increase sales of a complementary good, premium-priced, such as supplies.	Gilette razors and razorblades, HP printers and cartridges
Collectives	A large number of businesses, organizations, people, or professionals pool their resources, share information, and provide benefits to their members	Consumentenbond and cooperatives such as FloraHolland and The Greenery
Low-cost carrier	Airline offering cheap tickets, but charges extra for even basic comforts, such as in-flight drinks, baggage, priority boarding and seat-allocation	Ryanair, EasyJet, Transavia
Freemium	Offering basic services for free, but charging a premium for additional services	Spotify, which offers a free account with ads or a premium account without the commercial breaks
Direct sales model	Direct selling is marketing and selling products to consumers directly, away from a fixed retail location, usually through personal representation	Tupperware products, sold at so-called Tupperware parties at consumers' homes
Franchise model	The practice of using another firm's successful business model, and letting franchisees use that model	McDonalds, which consists of many private enterprises of local franchisees, jointly leveraging the multinational brand

Table 3.2: Business model elements

Element	Example questions	Papers citing these elements
Customer	Who is the target customer?	Osterwalder (2004); Sinfield and Calder (2012); Teece (2010); Magretta (2002); Morris et al. (2005)
Customer need	What does the customer need?	Sinfield and Calder (2012); Teece (2010); Magretta (2002)
Value proposition	What offering will we provide to address that need?	Chesbrough and Rosenbloom (2002); Osterwalder (2004); Teece (2010); Sinfield and Calder (2012); Johnson et al. (2008); Morris et al. (2005)
Channels	How does the customer gain access to that offering?	Osterwalder (2004); Sinfield and Calder (2012); Magretta (2002)
Key resources	What are the key resources needed?	Johnson et al. (2008); Osterwalder (2004); Morris et al. (2005)
Key activities	What are key activities/processes?	Johnson et al. (2008); Osterwalder (2004)
Revenue model	How will our business earn a profit?	Osterwalder (2004); Sinfield and Calder (2012); Teece (2010); Chesbrough and Rosenbloom (2002); Magretta (2002); Johnson et al. (2008); Morris et al. (2005)
Cost structure	What are the most important costs inherent in our business model?	Osterwalder (2004); Teece (2010); Chesbrough and Rosenbloom (2002); Magretta (2002); Johnson et al. (2008); Morris et al. (2005)
Competitive positioning	What are the competitive offerings available?	Teece (2010); Chesbrough and Rosenbloom (2002); Morris et al. (2005)
Key partners	Who are key complementors, suppliers, and partners that we need for our business model?	Osterwalder (2004); Chesbrough and Rosenbloom (2002)
Value network	What role will our business play in providing the offering?	Sinfield and Calder (2012); Chesbrough and Rosenbloom (2002)

From elements to integrated business models approaches

Table 3.2 indicates that there are plenty of elements that can be considered part of the business model. As it is virtually impossible to analyze a business model consisting of so many elements, there are quite some frameworks that take a subset of these elements in trying to organize the business model concept. The most popular approach is Osterwalder et al.'s (2010) Business Model Canvas, consisting of nine elements, which is used in many businesses around the world, and is arguably an excellent resource for application in practice to develop and analyze individual business models. However, in order to explicate common business model themes for 4Cs, we need an even more concise business model framework. Johnson et al.'s (2008)'s Business Model Framework takes four key elements, also present in Osterwalder et al.'s (2010) operationalization of the business model concept: (*i*) customer value proposition; (*ii*) profit formula; (*iii*) key resources; and (*iv*) key processes; see figure 3.2, in which key resources and key processes have been taken together in a single block.

Central to the framework is the customer value proposition, which describes the value a firm delivers to its customers. The key is to deliver unique value to customers, by offering innovative products or services that get the jobs of customers done in such a way that alternative offerings cannot compete, and value is created. The firm then needs to formulate how it is going to appropriate that value using the profit formula. It defines a revenue model, e.g. pay-per-use, subscription, management fee, and estimates how much money can be made using price$\times$volume. Volume can be thought of as the number of products or the number of transactions. The profit formula also details how costs are allocated in the business model, such as direct costs, indirect costs and the existence of economies of scale. Also, firms should strive to express their target unit margin, net margin per transaction, and estimate how quickly resources are used. Finally, in order to support value creation from the business model, key resources and key processes are required. The resources can be tangible and intangible in nature, such as people, equipment, IT infrastructure respectively brand, partnerships and goodwill. Key processes, as well as rules, metrics, and norms, make the delivery of the customer value proposition repeatable (Johnson et al., 2008). The way in which resources and processes are combined in part determines the value that is delivered to the customer (De Man et al., 2014).

Casadesus-Masanell and Ricart (2010) mention that policy choices, asset choices, and governance choices are important in the context of business models. Indeed, it is virtually impossible to discuss some business model design considerations without discussing these explicit choices. For instance, the revenue model concept, as part of business model design, is not very straightforward, unless the revenue model is specified in terms of discrete policy choices such as subscription-based revenues or management fees. Thus, we take these choices into account whilst explaining the 4C business model.

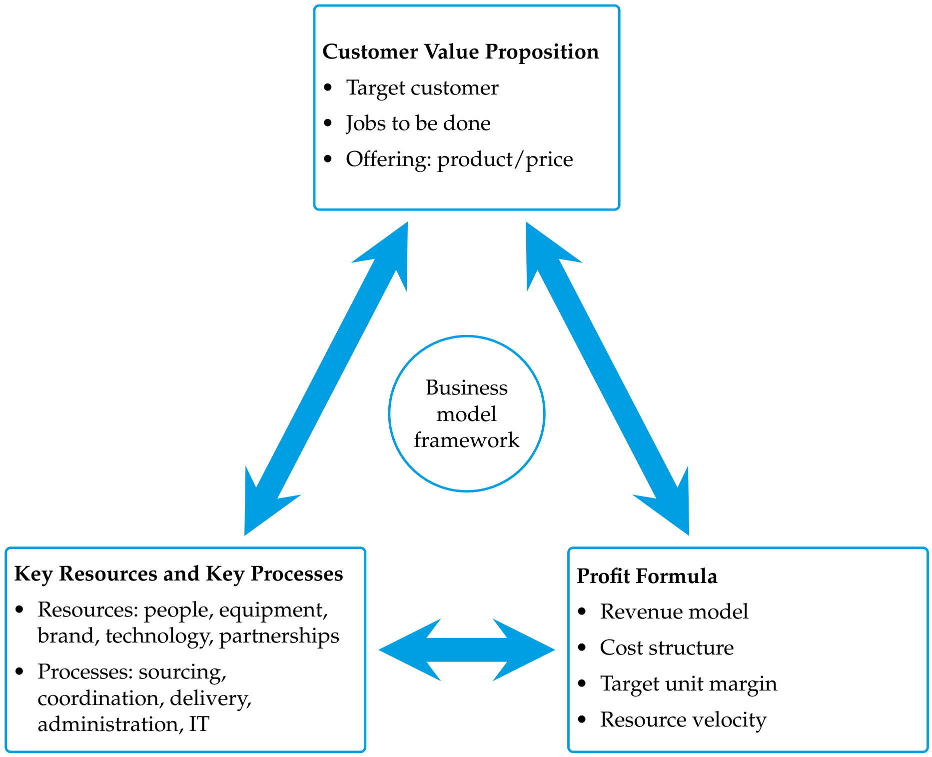

Figure 3.2: Johnson business model framework (source: Johnson et al., 2008)

3.3 A template business model

In this section, we present a template or 'archetype' business model of a 4C, trying to do justice to the breadth of the concept. We consider the customer value proposition, profit formula, and key resources and processes of a 4C. Note that while this book is about the FMCG supply chain, our template business model of the 4C extends beyond FMCG supply chains and can easily be applied in other industries and sectors. Table 3.3 shows the template business model framework for a 4C. Additionally, in table 3.4, we illustrate the kind of service provisioning we believe is part of a basic 4C, and which services could be expected from an extensive 4C service provider. We use these examples in explicating the template 4C business model in the remainder of this chapter.

Table 3.3: Template of a business model framework for a cross-chain control center

Business model element	Description
	Customer value proposition
Target customers	4C clients: supply chain actors, e.g. shippers, LSPs, and others
Job: Improve supply chain performance of 4C clients	Lower costs of supply chain execution, lower emissions, and, higher flexibility and responsiveness through economies of scale
Offer: Exploit latent strategic and operational synergies among clients	Uncover the latent strategic and operational synergies present in the supply chain networks of shippers and LSPs to increase network density
Offer: ICT data sharing and safeguarding	Enable data sharing and guard against unintended information spill-overs among (competing) clients, in a legally compliant fashion
Offer: Neutral collaboration-facilitation and transaction efficiency	Effectively facilitate and mediate alliances among collaborating supply chain actors, e.g. shippers, LSPs, and others
	Key processes
Operational network coordination	Provide network coordination, consolidation and synchronization for clients to improve network density
Alliance management	Offer alliance management activities for the client firms
Project management and consultancy	Execute non-operational consultancy by having highly-qualified personnel capacity available
Administrative handling	Perform administrative controlling for the service provisioning
	Key resources
Operational capacity	Access to operations and logistics capacity, e.g. vehicles, warehouses, equipment, and other
ICT infrastructure and telematics	Deliver the ICT infrastructure to support the service provisioning
Client supply chain network	Access to (potential) partners in the extended supply chains of client firms
Client alliances	Develop and maintain alliances among client firms
Partner network	Access to related advisory/consulting/law firms

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Table 3.3 – *continued from the previous page*

Business model element	**Description**
Personnel	Access to highly-qualified personnel
	Profit formula
Revenue model	Type of compensation mechanism and method to convert service provisioning into cash, such as management fees and transaction revenues
Cost structure	Costs incurred for service provisioning, direct and indirect costs
Target margin	How much turnover each transaction should yield to achieve desired profit levels
Resource velocity	How quickly resources need to be used to support target volume

3.4 Customer value proposition

Target customer: 4C clients

We see a 4C as an intermediary service provider that provides logistics-based services to one or more supply chain actors, such as shippers/receivers, logistics service providers, terminal operators, freight forwarders and other. In the FMCG supply chain shippers consist mainly of consumer packaged goods manufacturers and retailers. Logistics service providers typically operate manufacturer-dedicated warehouses and run fleets of trucks. In many other industries, raw material suppliers and wholesalers are common supply chain actors that can become clients of a 4C.

Figures 3.3, 3.4 and 3.5 show a generic supply chain, in which we have scoped three types of roles a 4C can play. For instance, a 4C may enable vertical supply chain collaboration among an LSP and a distribution warehouse. Alternatively, the 4C can focus on establishing, coordinating and managing a horizontal collaboration among LSPs. Or the 4C can manage a whole network, across multiple supply chains, with its client base consisting of manufacturers, wholesalers, LSPs, and other. Note that the contracted client may be different from the firms for whom the 4C services are run.

Job to be done: improve supply chain performance of 4C clients

Companies continuously strive to increase economies of scale and economies of scope in their supply chain operations, in order to improve service levels and fulfillment, reduce supply chain costs and lower environmental impact. Often, they are confronted with a glass ceiling, in which the boundaries of their own firm do not allow further optimization of their supply chain performance.

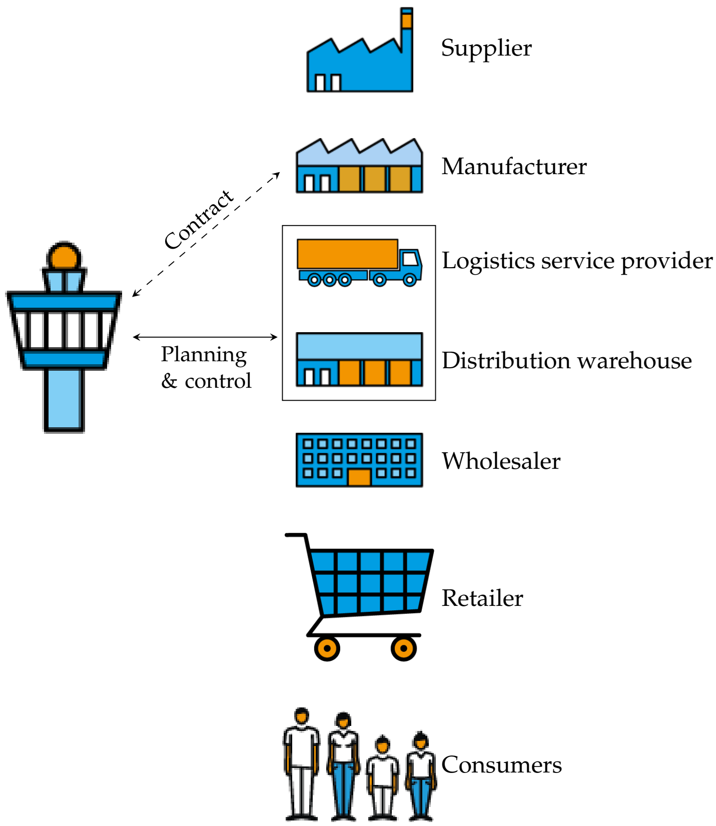


Figure 3.3: Vertical supply chain collaboration

Consequently, they are required to consider consolidating their activities with supply chain partners in order to make a next step in the optimization of their supply chain performance. A 4C can facilitate the forming of collaborative relationships among the supply chain actors and foster the formation of alliances. Also, as noted in chapter 1, deeper collaboration among all supply chain actors yields superior network density. A denser network lowers the costs of supply chain execution, decreases environmental impact, and improves service levels due to more frequent deliveries and responsiveness, thus ultimately improving supply chain performance. In short, a 4C solves the job of its clients by bringing parties together to improve network density, exploit economies of scale and scope, and increase supply chain performance.

Offering: unique competences to exploit latent strategic and operational synergies among clients

To get the job done, the 4C offers unique competences to uncover the latent strategic and operational synergies present in the supply chain networks of

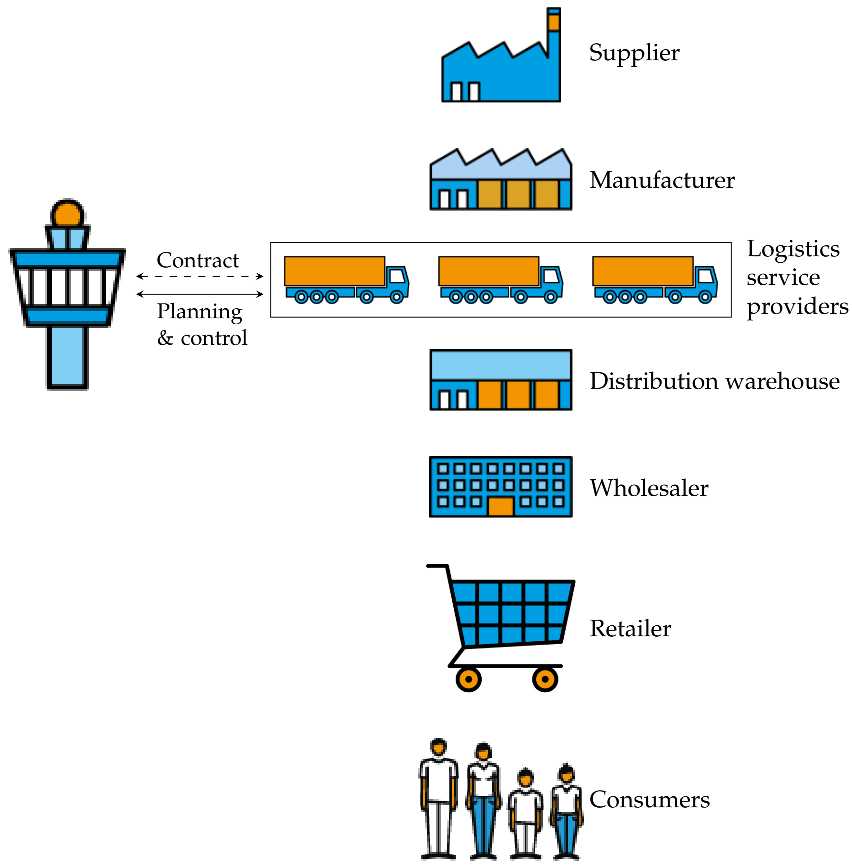


Figure 3.4: Horizontal supply chain collaboration

manufactures, LSPs, retailers and other parties, in order to increase network density. By consolidating networks, slack and waste in the network are reduced, network density improves and economies of scale can be reaped. At the strategic level, the 4C can advance complementary fit between various partners who can then intensify collaboration in order to gain more benefits – a manifestation of economies of scope. For instance, the transition from dedicated warehouse to category warehouses (De Kok, 2015) can be a major operation where a 4C can prove valuable.

Offering: ICT data sharing and safeguarding

A typical challenge in supply chain collaboration exists in safely sharing data between the involved parties (Samaddar et al., 2006). The 4C can offer the required ICT infrastructure and aid in data sharing. The 4C should facilitate data sharing and guard against unintended information spill-overs among compet-

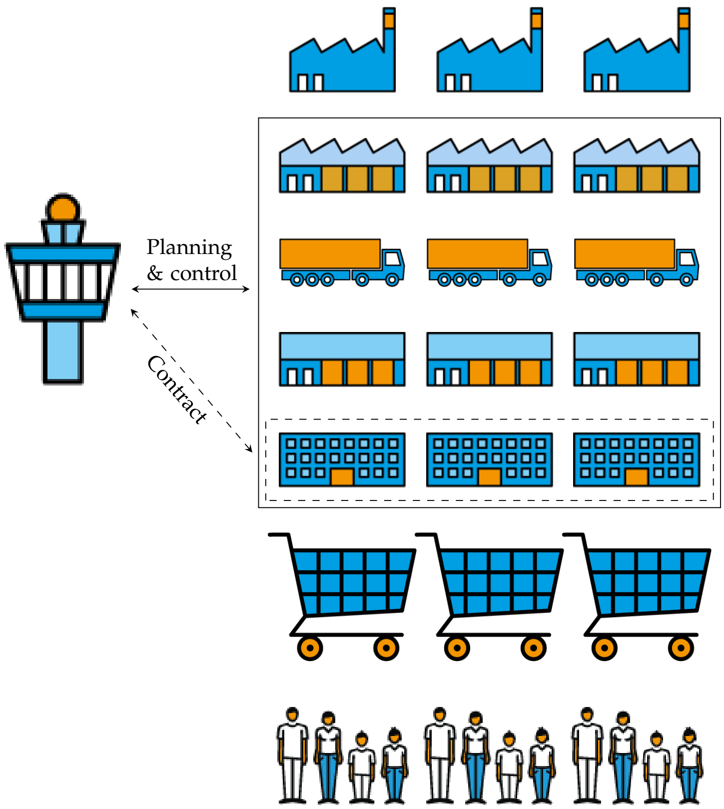


Figure 3.5: Supply network collaboration

ing clients (Klein Woolthuis et al., 2013), which is key for ensuring legal compliance, especially with regard to competitive information.

Offering: neutral collaboration-facilitation and transaction efficiency

Clients of the 4C will not automatically integrate their supply chains (Flynn et al., 2010). Part of the work of a 4C resides in being able to ensure a climate in which all clients pro-actively collaborate. As a trusted third party, the 4C can take care of forming and managing alliances among its clients. The 4C can contribute to partner selection and implement fair allocation of benefits and costs. In this sense, the 4C is similar to the trustee introduced in the CO3-project (Cruijssen, 2012). The 4C will be judged on its ability to build the desired relationships and to process transactions in a fast and efficient manner, from an independent, neutral standpoint.

3.5 Key processes

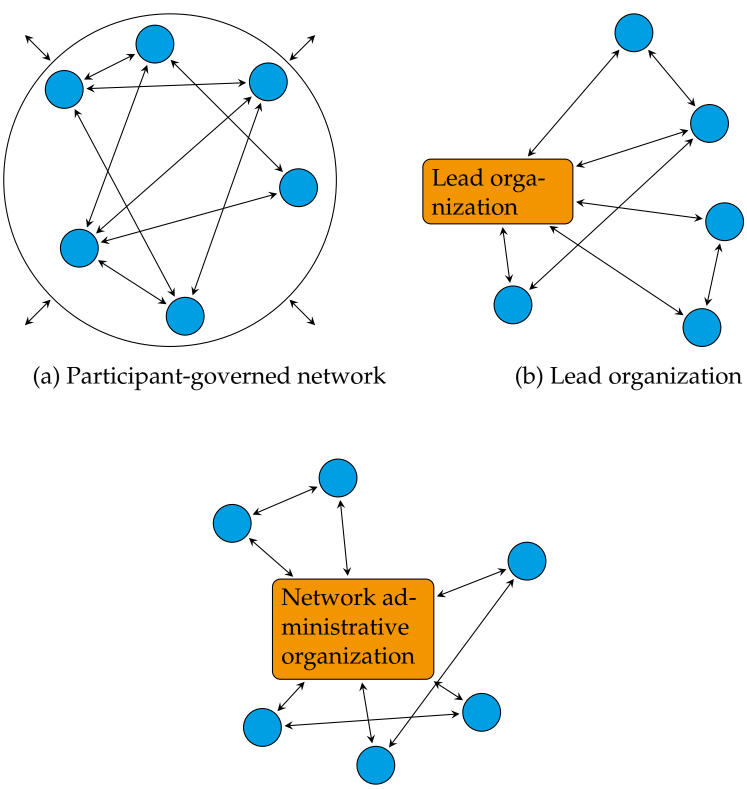
Operational network coordination

Operational network coordination is perhaps the key process and competence of a 4C, consisting of network coordination, consolidation and synchronization to improve network density and supply chain performance for its clients. Put simply, the 4C takes care of transportation or warehousing operations, ensuring that shipments arrive at their destination on-time, in full with no errors (OTIFNE) against lowest costs and minimal environmental impacts, with highest possible service levels for its clients. For instance, the 4C can improve load rates or offer smaller deliveries more frequently, while maintaining acceptable load rates through the bundling of shipments from multiple shippers, i.e. consolidation. The 4C can also help improve service levels, lower costs and decrease environmental impact by synchronizing shipments from multiple shippers over time. For instance, if two less-than-truckload shipments from different shippers are scheduled for Monday and Tuesday deliveries, the 4C might pro-actively try to synchronize the delivery dates, sharing the gains obtained from this transaction – and in effect uncover and exploit the latent operational synergies in the supply chain networks.

Finally, network coordination means that the 4C aims to combine the resources, i.e. vehicles, warehouses, equipment and other, and processes, i.e. sourcing, distribution, inventory control and other, of the client firms in the sense that a 4C can take of managing the underlying alliances of the client firms (Skipper et al., 2008). Apart from operational coordination, at a more strategic level network coordination is very much a governance decision. Figure 3.6 shows three modes for coordination of collaborative networks (Provan and Kenis, 2007). First, the 4C network can be coordinated by the participants themselves, i.e. participant-coordinated; see figure 3.6a. A decision to consolidate or synchronize shipments within the network – or any other operational or strategic decision – would be made by all the participants together. Second, a lead organization can assume the coordination role; see figure 3.6b. Usually, this would be one of the larger firms in the network, or a firm with very specific resources and competences. Third, the 4C can be characterized as a network administrative organization (NAO); see figure 3.6c. The 4C takes care of coordination of the network as a delegate, i.e. a specialized service provider. The differences between the three modes actually exist in a make-or-buy decision. Should one outsource the network coordination to a specialized 4C/NAO, or instead develop the required resources and capabilities oneself, among all the participants in the network, or at an appointed lead organization?

Alliance management

Alliance management is also part of the key activities of a 4C to ensure long-lasting value-creating relationships among the client firms – this is especially true if the 4C manages an alliance among competitors (Wilhelm, 2011). The 4C can form collaborative alliances among client firms following a structured



(a) Participant-governed network

(b) Lead organization

(c) Network administrative organization

Figure 3.6: Various supply chain coordination mechanisms

step-based approach (Tjemkes et al., 2012), managing the alliance lifecycle. As an independent neutral party, the 4C can mitigate power play behavior of a dominant client firm in the alliance by instituting the appropriate alliance governance mechanisms (Lavie, 2007), and safeguard confidential data exchange (Klein Woolthuis et al., 2013). As part of alliance management activities, the 4C can offer auxiliary services such as fairly allocating benefits and costs among the client firms (Vanovermeire and Sörensen, 2014), perform partner selection for expanding the operational network involving partner acquisition and retention (Albers et al., 2013), and educate client firms in developing alliance capabilities to work more effectively together (De Man, 2005).

Project management and consultancy

Improving network density by combining multiple supply chains and forming alliances requires a keen sense of project management amongst other skills. Previous cases of horizontal supply chain collaboration, such as the example of Kühne+Nagel, Nabuurs, and Bakker, have shown that the formation process can easily take up multiple years, which cuts the momentum required to effectively setup a working collaboration. The 4C can fill this void by managing the whole formation process, skillfully employing their highly-educated workforce's hard or soft skills. Beyond mere project management, the 4C can offer non-operational consultancy and fulfill ad-hoc analysis demands. At a strategic level, the 4C can accomplish network design, mode selection and routing studies for its client firms (Schmid et al., 2013).

Administrative handling

In the basic business model, the 4C performs administrative control of their services provided, e.g. handling all transactions, invoicing, or debt and credit settlements. At a more advanced level, the 4C can incorporate specialized supply chain finance concepts, such as debt management and facilitate supply chain finance factoring; see chapter 4 about supply chain finance. Note that administrative handling is not limited to finance-related processes, but can also include other handling responsibilities, such as legal assistance, alliance organization administration, communication and public relations or sales support.

3.6 Key resources

Operational capacity

One of the main resources of a 4C comprises its access to operations and logistics capacity, e.g. vehicles, vessels, trains, warehouses, equipment and systems. In order to execute the operations across the managed network for its client firms, it can use their existing service contracts, such as volume-based contracts tendered annually to LSPs. In this sense, the 4C role equals the role of a typical shipping-agent (Ashenbaum et al., 2009). As the scale and scope of the 4C services increase, it may develop and maintain private contracts with LSPs and shippers (Olander and Norrman, 2012), based on aggregated volumes, capturing volume discounts in the process. It is important that a 4C can make combinations of freight over more multiple LSPs, terminals and freight forwarders. It will not be bound to a single LSP, such that new value-creating alternatives come within reach. For instance, the 4C may be able to consistently bundle sufficient freight to allow a mode shift from road to rail, or to combine shipments from multiple warehouses under a single roof, changing the fundamental structure of the supply chain operations of its client firms.

ICT infrastructure and telematics

Usually, network coordination is enabled by ICT-technology (Skipper et al., 2008), like interfaces between transport management systems (TMS), warehouse management systems (WMS), and enterprise resource planning (ERP) systems, with the goal of providing seamless data exchange in order to improve decision-making. With this in mind, a 4C needs an extensive information system architecture to coordinate multiple supply chains. Even more so, the 4C can strive to make operational information available in real-time employing telematics infrastructures and using predictive analytics and big data to improve forecasts and operational decision support; see chapter 5 about forecasting, chapter 6 about analytics, and chapter 8 about ICT.

Client supply chain network

The 4C can access potential partners in the extended supply chains of their client firms. Initially, a 4C may focus on coordinating simple bi-lateral vertical or horizontal collaborations, such as those between the manufacturer and an LSP, or between two LSPs. The 4C could search within the same supply chain for additional partners to improve economies of scale from consolidation and synchronization. However, the full potential of 4C coordination is unleashed when multiple supply chains are considered. By actively searching for complementary supply chain networks among its clients (multi-echelon), the 4C can grow its managed network and improve economies of scale and scope (Wind et al., 2009).

Client alliances portfolio

The portfolio of alliances forged among client firms is another important resource. This alliance portfolio (e.g., Ozcan and Eisenhardt, 2009) may contain an additional level of latent operational and strategic complements that can be unlocked by fusing all the client firms' supply chain networks. Also, the client alliances will ensure recurrent payments to the 4C for their management and administrative support. The more alliances are formed and managed, the stronger the total managed network supporting the customer value proposition. The 4C can even be asked to lead and chair the client firm alliances in order to provide stability and longevity, and ensure continuous legal compliance, as survey research shows (Janssen et al., 2015).

Partner network

Genuinely living in the network economy, a strong resource of the 4C can be its partner network. Initially, the 4C will provide referrals to complementary advisory/consulting firms on different topics, e.g., HR, project management, finance and legal, on an ad-hoc basis. However, as time passes, the 4C can develop itself as knowledge broker (Klein Woolthuis et al., 2013) by establishing and maintaining a network of preferred advisory or consulting firms and being the 'channel' through which all inquiries to the partner advisory network flow, effectively reducing transaction costs and improving efficiency.

Personnel

The 4C will typically employ highly-skilled personnel able to navigate the complexity associated with combining multiple operational supply chain processes, administering alliance management processes, and using advanced ICT and collaborative decision-support tools; a requirement for a potent mix of hard or soft skills. At a basic level, the 4C personnel should support operational coordination and execution, resolving conflicts. Yet, at a more mature level, the 4C can leverage their employees' analytical competencies to maximize gains from coordination, consolidation, and synchronization across supply chains.

3.7 Profit formula

Revenue model

The revenue model of a 4C is typically a policy choice. For instance, the 4C can choose to be reimbursed by a periodic management fee for providing its services. Alternatively, the 4C can seek to be compensated on a per-transaction basis, e.g. based on the number of orders or shipments executed. 4Cs with a stronger risk appetite can even engage in revenue sharing based on the savings obtained for its clients (Bhaskaran and Krishnan, 2009). If, for example, the 4C is able to contract a new partner that contributes significantly to the performance of the network and improve network density, the 4C should be able to negotiate a premium for this service, as it serves as an incentive to align the interests of the 4C with its client firms.

Cost structure

The 4C, as a service provider, will typically have high direct costs associated with the operational network coordination. As with most intermediary, asset-light models, indirect costs are usually relatively low and the lion's share of total costs are incurred from the direct costs attached to running the operations.

Most indirect costs will be associated with forming alliances among its clients – a cost hard to get reimbursed as it could be seen as generic everyday acquisition business for a 4C. Alternatively, a 4C could assume a more entrepreneurial approach and co-invest in the formation of client alliances and become shareholder in those alliances, letting the costs of formation activities be reflected on the balance sheet of the new alliances as subordinated loan. This gives a cost structure involving high sunk costs and deferred remuneration. However, it may provide dividends and sought after decision-making rights in the future.

Target margin

The risk appetite or entrepreneurial attitude will also influence the way a 4C goes about policy choices regarding target margin levels. Questions need to be answered relating to how much turnover each transaction should yield to achieve desired profit levels. For instance, a 4C can charge a fee per transaction, perhaps at break-even-point with an additional profit surcharge. Alternatively, it can lower the risk for its clients to try its services by temporarily charging under break-event-point in order to gain market share and aim for future revenues. It is key here to develop a sound business case, to help in weighting these options; see chapter 2 for an elaborate motivation of a business case.

Resource velocity

The larger and more comprehensive the client network, the better the 4C is able to provide value to its target customers and earn money. At the basic level, the 4C would orchestrate the supply chain execution of its clients as independent networks and operations. However, by integrating these independent networks, the total managed network grows resulting in an exponential growth in number of transaction, thus increasing profitability and developing significant entry barriers for potential competitors.

3.8 Business model experimentation and configuration

Having discussed the main elements of a template 4C business model, figure 3.4 shows two further elaborations of 4C business models: a basic 4C business model and a more extensive 4C business model. Note that we do not attach any normative judgment to these levels – they merely serve to distinguish between the two models. It cannot be said that the extensive model is better than the basic model, which is just a matter of which model suits the customer better, i.e. provides better value creation through the customer value proposition.

Sinfield and Calder (2012) point out that it is key to experiment with various configurations of the developed business model in order to arrive at the final business model that will be implemented. For example, a 4C will typically not fully fit either the basic or extensive configuration. A business modeler for a 4C might mix some elements from both, such that unique business model configurations are obtained. For example, in the mature FMCG supply chain, a prospective 4C might not be permitted to pro-actively identify potential new partners for its client network (extensive model) and focus on mainly providing efficient transactional support for the operational execution (basic model). Still, the same 4C might really improve its customer value proposition by searching for data re-use opportunities and support advanced analytics (extensive model), effectively mixing basic and extensive business model elements.

Table 3.4: Illustrative 4C business models: mixing low and high levels of service provisioning

Business model element	**Basic 4C service**	**Extensive 4C service**
	Customer value proposition	
Target customers	One or more shippers and/or one or more LSPs	Cross-chain cross-channel actors, e.g., shippers, LSPs, terminals, freight forwarders, retailers
Job: Improve supply chain performance of 4C clients	Combine supply chains of a limited number of partners on a peer-to-peer basis within a single industry	Foster large open distribution networks in which cross-chain cross-channel collaborations take place
Offer: Exploit latent strategic and operational synergies among clients	Focus on operational execution (coordination, bundling, synchronization)	Operational execution and strategic development, e.g. network design, LSP selection and mode changes
Offer: ICT data sharing and safeguarding	Allow data interchange between all parties, and guard against spill-overs from classified information	Pro-actively identify data re-use opportunities and complementary data sources for improved decision support and analytics
Offer: Neutral collaboration-facilitation and transaction efficiency	Efficient transactional support of operational execution, from neutral position	Pro-actively identify potential new partners, building and extending the network. Provide tri-lateral governance and perform conflict resolution

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Table 3.4 – *continued from the previous page*

Business model element	**Basic 4C service**	**Extensive 4C service**
	Key processes	
Operational network coordination	Bundle freight volumes of multiple shippers. Create new matches in origin-destination flows. Source required transport/warehousing capacity	Plan and control a network of shippers and LSPs, ensuring maximum bundling, also through order synchronization
Alliance management	Form collaborative partnerships among client firms following a structured process, mitigating power play behavior	Fairly allocate benefits and costs, and manage network membership acquisition, retention and termination (partner selection). Develop alliance capabilities among clients
Project management and consultancy	Actively guard the collaborative project using project management tools and perform ad-hoc analysis	Strategic supply chain consultancy, e.g, network design, mode selection
Administrative handling	Transactional invoicing and financial controlling	Manage cash-to-cash cycle, invoicing, debt management for clients, facilitate supply chain finance factoring
	Key resources	
Operational capacity	Utilize existing LSP contracts for operational execution	Develop and maintain private contracts with LSPs and shippers, based on aggregated volumes
ICT infrastructure and telematics	Enable TMS/WMS/ERP interfacing and execute collaborative planning	Employ real-time data availability and provide decision-support from predictive analytics solutions using telematics infrastructures

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Table 3.4 – *continued from the previous page*

Business model element	**Basic 4C service**	**Extensive 4C service**
Client supply chain network	Focus on first echelon operational partners to build the managed network	Search actively for complementary organizations in the extended supply chains (multi-echelon) in order to grow the managed network and improve economies of scale and economies of scope
Client alliances	Provide administrative support to the client firm alliances	Lead and chair the client firm alliances in order to provide stability and longevity, and ensure continuous legal compliance
Partner network	Ad-hoc referral to complementary advisory/consulting firms	Establish and maintain network of preferred advisory/consulting firms in different fields, e.g., HR, project management, finance and legal
Personnel	Operational execution support and capable alliance management, resolving conflicts	Leverage highly-skilled and analytical personnel in order to maximize bundling and synchronization gains across supply chains
	Profit formula	
Revenue model	Fixed periodic management fee, or management fee based on orders/shipments executed	Revenue sharing based on annual savings obtained for clients, with premiums based on marginal contribution of newly contracted partners

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Table 3.4 – *continued from the previous page*

Business model element	Basic 4C service	Extensive 4C service
Cost structure	Low sunk costs, and high portion of direct costs from transaction-based operations	Co-invest in the formation of a client alliance and become a shareholder in the alliance, letting the costs be reflected on the balance sheet as subordinated loan – high sunk costs, deferred remuneration
Target margin	Charge per transaction at break-even-point with additional profit surcharge – risk at the clients	Temporarily charge under break-event-point in order to gain market share and aim for recurrent revenues – risk at the 4C
Resource velocity	Orchestrate the supply chain execution of clients as independent networks/operations	Integrate independent networks to grow the network. With network size increasing, the number of transactions grows exponentially, increasing profitability and preempt competition

3.9 Conclusions

While there is much research in the Netherlands on the Cross-Chain Control Center (4C) concept, this chapter started from the proposition that there is a lack of a broadly-agreed upon definition of a 4C. Many short-hand descriptions have been offered, such as the control tower metaphor. In order to illuminate the 4C concept, we have adopted concepts from the business model literature to develop a template business model for the cross-chain control center. Using Johnson et al.'s (2008) business model framework, we explained the four key elements of a 4C business model: the customer value proposition, profit formula, key resources and key processes. Across these business model elements, we framed the 4C as a trusted third party providing supply chain coordination services to a collaborative network of shippers, logistics service providers and other supply chain actors, with the ultimate goal of improving supply chain performance. As part of this conceptualization, we identified basic and more extensive 4C service provisioning levels, which can be configured and experimented with in order to arrive at the final 4C business model. Subsequent steps in research towards the conceptualization of the 4C concept lie in validating our 4C business model template by studying real 4C firms in actual practice.

Of course, our study has limitations. First, we did not attempt to discriminate the 4C concepts from other related concepts like Third-Party Logistics (3PL), Fourth-Party Logistics (4PL), or even Fifth-Party Logistics (5PL), as these discussions are quite lingering and inconclusive. Second, our 4C business model has not been validated with real 4C firms. Therefore, the 4C concept remains elusive – as long as there are no real firms offering services to coordinate a broad portfolio of supply chain networks, the concept will not gain ground beyond academic explorations.

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Chapter 4

Supply Chain Finance for 4C

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As a result of global competition and sourcing, outsourcing, and shortening life cycles, supply chains have become complex the last decades (Wagner and Bode, 2008; Blackhurst et al., 2011). Not only has the operational management of supply chains become more challenging, but also the associated financial management. For instance, due to global sourcing firms are more vulnerable to exchange rate movements of buying versus selling products and services in different currencies. On top of this, the financial crisis of 2008 exposed the goods and cash flows of many firms to increased volatility. So, operations and finance managers are increasingly driven to interact with each other. Otherwise, for example, while the operations manager may want to cope with demand uncertainty by investing cash in safety stocks, the financial manager strives to preserve cash to try to cope with cash flow uncertainty. Risk management is thus a complicated and sometimes contentious matter. It is not always clear what actions are more beneficial, e.g. investing or preserving cash, or even what the key underlying trade-offs for value creation may be.

Supply Chain Finance (SCF) is an emerging area that aims to deliver value through concepts and applications that considers both the operations and financial management of supply chains. Indeed, researchers increasingly stress that, while the goods and information flows are well studied in supply chain management, the financial flows have often been neglected so far (Gomm, 2010; Gupta and Dutta, 2011; Wuttke et al., 2013; Silvestro and Lustrato, 2014) According to a recent Aberdeen survey (Pezza, 2011) among professionals, the three primary reasons to consider supply chain finance are: ‘demand volatility’s impact on available cash’, ‘risk of trading partner default’, and ‘difficulty obtaining financing on acceptable terms’. While some have explored problems related to this in a supply chain, important challenges that can result from the inter-firm nature of a financial arrangements remain largely unexplored. The potential complexity of these arrangements is evident from the general definition of SCF proposed by Pfohl and Gomm (2009):

> *"[SCF] is the inter-company optimization of financing as well as the integration of financing processes with customers, suppliers, and service providers in order to increase the value of all participating companies."*

Thus, supply chain finance involves making a choice of performance criteria to represent the interests of stakeholders and making trade-offs such that the best outcome for the supply chain is realized (Van der Vliet et al., 2013b).

The goal of this chapter is to introduce the concept of supply chain finance (SCF) and present some insights on the trade-offs of an SCF-application called reverse factoring. Specifically, we show that interactions between operations and finance influences trade-offs regarding this application and that opportunities yet exist to create value from applying supply chain finance. Furthermore, based on our insights we are able to indicate some fruitful directions for the implementation of supply chain finance in 4C.

The remainder of this chapter is structured as follows. In section 4.1, we first provide a more detailed understanding of supply chain finance, and explain a particular SCF-application called reverse factoring. In section 4.2, we present a framework that considers the value dimensions and trade-offs of supply chain finance implementations. In section 4.3, we present the main insights of three studies in which trade-offs concerning reverse factoring are analyzed. In section 4.4, we conclude with managerial recommendations on implementing supply chain finance in a 4C.

4.1 Supply chain finance

In this section, we provide (subsection 4.1.1) a framework that highlights the source of value creation from financial cooperation within the supply chain. Subsequently, we illustrate (subsection 4.1.2) the potential scope of supply chain finance. In section 4.1.3, we zoom in on a particular SCF-application, reverse factoring.

4.1.1 A supply chain finance framework based on information asymmetry

Pfohl and Gomm (2009) introduce a framework for explaining how supply chain members can create value from facilitating financing to each other as opposed to leaving individual members to arrange financing through conventional channels. We will explain their framework shortly here.

The framework is based on the concept of information asymmetry, which entails that one party has more or better information than the other. Information asymmetry makes transactions *inefficient* in the sense that they become more expensive or less effective when the information would be readily available or perfectly transferable between parties. In the context of the proposed framework, information asymmetry exists between companies *within* and *outside* the supply chain. Indeed, companies within a supply chain may have superior information about the status or the risk of supply chain investment due to their direct involvement. This implies that opportunities may arise in which firms, through cooperation, finance supply chain operations more efficiently. This is illustrated in figure 4.1.

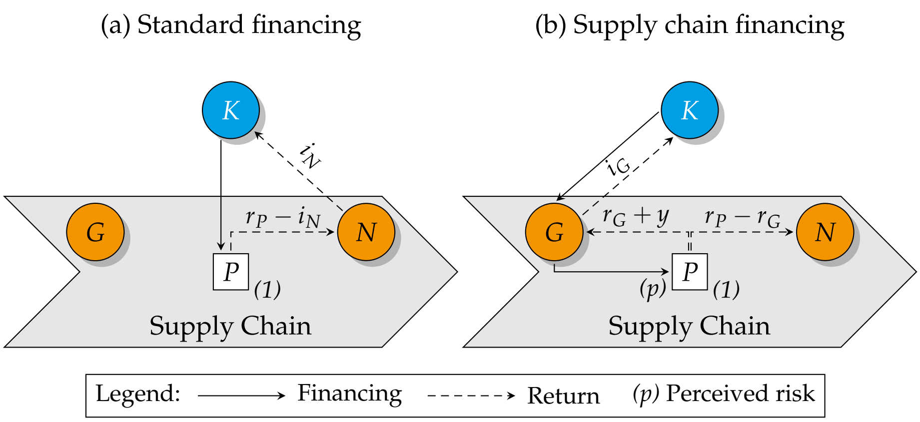

Figure 4.1: Two alternative financing methods: (a) standard financing; and (b) supply chain financing (source: Pfohl and Gomm, 2009)

In this figure, G and N are companies within the same supply chain, e.g. a supplier and a customer, or a shipper and its logistics service provider. K is a financial institution, such as a bank, or investor outside the supply chain. Company N has an investment project P that yields a return r_P to N. While the financial institution K can assess the general risk of the companies G and N, it cannot assess the risk of financing P. Based on this risk, it charges an interest rate i_G and i_N for G and N, respectively. Due to its creditworthiness G has access to a lower rate than N, i.e. $i_G < i_N$. To finance project P, firm N has two options: (*i*) standard financing; and (*ii*) supply chain finance.

If company N uses standard financing it gets funding from the financial institution K. As the interest for company N is i_N and the return of the project is r_P, the net return of N is $r_P - i_N$. If company N uses supply chain financing (SCF), it gets funding from its supply chain partner G. Due to its access to information about P, G may facilitate a better financing deal than K. Indeed, G may be a supplier or a customer of project P thus can assess the risk more efficiently. In addition, project P may indirectly benefit G. For instance, it may increase its sales to N or to other customers. Let us call this benefit 'y'. Supply chain financing boils down to the following: G attracts cheap funding from K and directs this funding to N. G asks a compensation r_G for its role; r_G is such that G makes a positive return ($r_G + y > i_G - y$), and N gets cheaper funding than with standard financing ($r_G < i_N$). While K makes indeed less return ($i_G < i_N$), it benefits from lending to a less risky counterpart.

Thus, firms within the supply are capable of offering better financing terms due to their inside knowledge of or direct involvement in the investments that are made in the supply chain. This idea proves to be powerful to explaining many SCF applications that are emerging.

4.1.2 The potential scope of supply chain finance applications

When firms conduct transactions, it is customary for the seller to give 'trade credit': the seller provides goods or services in return for a payment in the near future. Estimates suggest that around 80-90% of the world trade is facilitated by trade credit (Casterman, 2013). The types of terms at which trade credit is mediated is extensive and it has been shown that the terms can vary significantly between countries and industries. Facilitation of credit to suppliers, in contrast to facilitation to customers, is scarce in industry. Examples of pre-payment, however, can be found in the construction industry (Ferris, 1981). Indeed, as (sub)contractors may have difficulty pre-financing the raw materials of a large project, they can require clients to make partial payments before or during the execution of a project.

Conventionally, the firm finances trade credit, i.e., receivables, just as it finances inventory or other assets required to run its operation: from its own capital sources. Due to information asymmetry between the firm and its providers of capital, capital may be sometimes more expensive or more restricted than when information of these assets would be accessible to capital providers. For instance, when a firm needs financing for buying a certain machine, information about the contractual deals that the firm has made with its customers may be relevant to the capital provider to assess its financial risk. Hence, the premium and maximum amount of financing it is willing to give to the firm. Even better would be if these customers would confirm their intentions to buy the items that will be produced by the firm's machine to the capital provider. In supply chain finance, these informational events are offered to capital providers, such that the latter can reconcile their financing offers.

Supply chain finance applications can be divided in post-shipment and pre-shipment finance solutions (Casterman, 2013). In post-shipment solutions financing is offered based on the completion a physical transaction and a confirmation corresponding payment obligation. Reverse factoring, a scheme that allows a seller to sell its payment entitlements, i.e. receivables, for a creditworthy customer, is a prime example of this. In pre-shipment solutions, financing is offered before the completion of the physical transaction. Examples are purchase-order financing and inventory financing. In these solutions, financing is offered based on the receipt of a buyer-backed purchase order or a receipt of raw materials, respectively.

However, the earlier financing is granted before the actual physical transaction, the greater the risk; see figure 4.2. Indeed, several events before or during a transaction may trigger a delay or even a default in payment. For instance, a customer may cancel its future intended purchase due to a lower end-customer demand than anticipated. As a result, the inventory that is financed may perish or needs to be salvaged. Moreover, estimating the likelihood of disrupting events require detailed knowledge or data on operations. It is therefore understandable that pre-shipment financing applications, like purchase order financing, are (yet) less developed or even offered in an ongoing manner like post-shipment financing applications by intermediaries.

New industry standards, such as the Bank Payment Obligation (BPO) from the Society for Worldwide Interbank Financial Telecommunication (SWIFT), should ease the facilitation of both pre-shipment and post-shipment applications (Casterman, 2013). The BPO enables firms to more easily communicate payment commitments in the supply chain to financial intermediaries. While intermediaries can offer suitable financing solutions more efficiently, these standards, suggest that firms still need to be able evaluate when to engage in supply chain finance and what type of arrangements to make in the supply chain. Indeed, SCF implementation may entail a higher cost or risk exposure for the initiating firm. In section 4.2, we will provide a framework that highlights this trade-off.

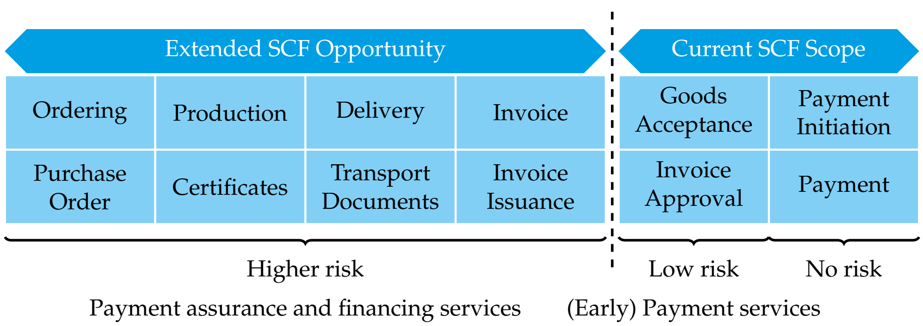

Figure 4.2: Various stages of supply chain finance (source: Casterman, 2013)

4.1.3 A supply chain finance application: reverse factoring

Reverse factoring is a development of factoring, an arrangement where firm independently sells one or more of its receivables to a financier, called factor. The factor subtracts a premium from the nominal receivable amount, and collects the full amount at when the receivable becomes due. Factoring differs from traditional sources of financing as more emphasis is placed on the risk and value of the asset, i.e. the receivable, as opposed to the credit applicant's creditworthiness in general. Thus, when the debtor of a receivable is a transparent creditworthy firm, the factor incurs little risk of default and so the premium imposed for the factoring transaction can be low.

Whereas factoring is initiated by the selling party, reverse factoring is initiated when a creditworthy debtor notifies and promises a factor of the forthcoming payment of a receivable. In this way, the primary process is 'reversed'. The process illustrated in figure 4.3. Since the creditworthy debtor explicitly confirms the corresponding payment, the factor is supplied with better information to assess its risk. Indeed, in 'traditional' factoring the factor may not know whether delivery of goods actually took place or whether the buyer is satisfied with the quality. Furthermore, in reverse factoring the factor is excluded from payment disputes that may arise between buyer and supplier. Hence, it will not need to exercise any effort to collect its money.

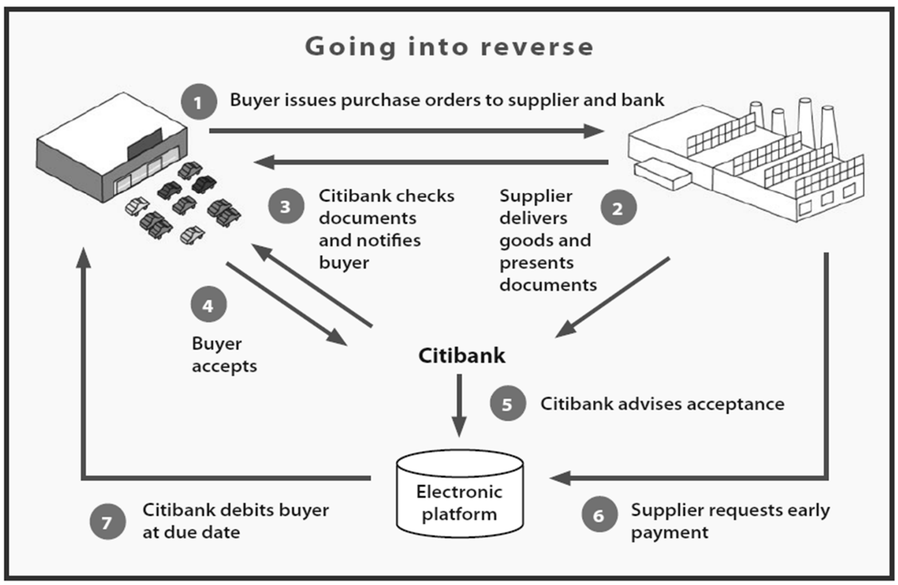

Figure 4.3: Successive actions in a reverse factoring scheme (source: Seifert and Seifert, 2011)

Both buyer and supplier can benefit from reverse factoring in several ways. The supplier can access its money earlier. Hence, it can increase its liquidity position. The cost of financing the transaction is lower than what it normally would be when using an alternative short-term financing method, such as a bank overdraft. Indeed, the spread of short financing rates between investment grade and non-investment grade SME firms can be significant. Many buyers perceive reverse factoring as a mechanism to improve also their own working capital (Seifert and Seifert, 2011). Indeed, in return for offering attractive early payment options they can extend their payment terms.

4.2 Maximizing the value of supply chain finance

In this section, we present a framework that helps firms to formulate a strategy that maximizes the value of an SCF-initiative. The framework allows an initiating firm to formulate an SCF-strategy and tactic that maximizes its value. The framework has already been applied Van der Vliet et al. (2013a,b).

4.2.1 A supply chain finance framework

We identify two dimensions and accompanying trade-offs for SCF implementations: a strategic, and a tactical dimension; see figure 4.4 for a visualization. Along the strategic dimension, we distinguish transaction-oriented supply chain finance at one extreme from competence-oriented supply chain finance at the other. In transaction-oriented supply chain finance, the initiating firm aims to improve transactional efficiency through the collection of working capital benefits or reduction in financing cost. In competence-oriented supply chain finance, the initiating firm aims to enhance a supply chain competence, such as supply base agility. Thus, while in transaction-oriented supply chain finance the transactions itself are the main source of benefit to stakeholders of an SCF initiative, in competence-oriented supply chain finance the investments made to achieve a particular competence are the source of benefit.

Along the tactical dimension, we distinguish uniform implementations from customized implementations. In a uniform implementation, the initiating firm follows more or less a single specification for SCF arrangements, while in a customized implementation the firms adjusts the type and terms the agreement to fit the nature their supply relationships. Customization can occur both at the transactional and competence level; firms can adjust terms to financing characteristics or to operational characteristics of supply relationships. The choices made on each dimension affects the initiating firm's expected size and uncertainty of cash flows that result from an SCF implementation. Therefore, the firm needs to make a tradeoff between these criteria to formulate an SCF strategy that maximizes value.

Strategic Trade-off: the marginal revenue versus marginal risk from solving supply chain underinvestment

Many investments in supply chains, such as inventory or capacity, are often made based on a trade-off between return and the financing cost at the respective tier of the supply chain. Investments made at a certain tier may thus neglect the value of the investment for the downstream supply chain member. In some cases, a downstream firm could generate additional revenue or reduce the cost, if upstream supply chain members increase their investment level in certain assets, such as capacity and inventory. Based on their cost of capital, these upstream members may be unable to generate value from additional investment, however. Due to credit constraints they may not even be able to invest at all. This agency phenomenon is called 'underinvestment'. When

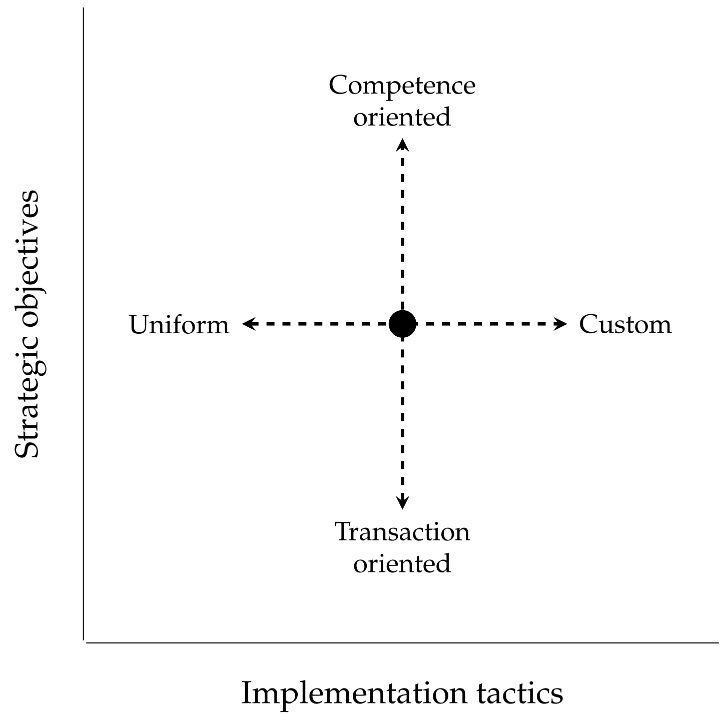

Figure 4.4: Supply chain finance implementation framework

underinvestment is substantial, firms should benefit from taking competence oriented approach in supply chain finance.

While pursuing additional investment in an SCF-arrangement may generate greater expected returns it exposes an initiating firm to greater risk. Indeed, supply chain members may divert financing from SCF and not commit to the required investment level. As the risk of pursuing a competence oriented approach becomes substantial, the net return of this strategy may prove inferior to the returns from a transaction oriented strategy. The latter would then be preferable.

Tactical Trade-off: the marginal return versus marginal cost of customization

Accounting for the specific nature of a supply chain relation in an SCF-implementation may generate additional return. For instance, by identifying the financing cost of each member in the supply chain, the amount of transactional benefits to be potentially collected from supply chain finance can be specified. Alternatively, by identifying the required investment for each supply chain member to improve a supply chain competence, the terms of particular SCF arrangements can be adapted such that these investment are actually made.

Customization, however, may require substantial investments in information systems or organizational and contracting processes. The level of investment required will depend on a firm's existing capabilities. For instance, firms are not always capable of assessing the cost of capital or capacity or inventory level of supply chain counterparts. The effort needed to gather this information may depend on several characteristics of their respective supply chain relationship, such as the level of systems integration, and the level of trust between each other. Hence, the marginal return of investing in customization measures must be balanced with the marginal cost of customization.

The expected additional benefit from customizing supply chain finance to each supply chain relationship thus also depends also on the heterogeneity of the target group. In some instances, the target group of supply chain finance may be homogeneous, in the sense that they experience similar financial or operational conditions. For instance, the target group has limited access to sufficient funds to commit investment, hence the offering of supply chain finance automatically raises the investment level. Customization would then yield little additional value.

4.3 Summary of three projects about reverse factoring

In the following three subsections we provide a short summary of the findings of three research projects conducted on reverse factoring. Each summary addresses the motivation of the project, the research questions explored and the insights obtained.

4.3.1 The price of reverse factoring: financing rates versus payment delays

Motivation: Reverse factoring is increasingly popular in industry. Many investment-grade buyers use the scheme to induce their suppliers to grant them more lenient payment terms. By increasing the payment term, the buyer improves its working capital position. While literature suggests that payment terms can be reconfigured in a collaborative spirit, the approach of some buyers appears to neglect this perspective. Indeed, Aberdeen's survey findings that 17% of its respondents experienced 'pressure' from trading partners to adopt supply chain finance (Pezza, 2011). This suggests that the benefit of a reverse factoring arrangement for suppliers may in some cases be open to question. Even if there is an extension in *contractual* payment terms, the supplier can use reverse factoring to obtain early payment cheaply. Thus, a trade-off between 'longer' and 'cheaper' arises. This provides the central motivation for our study.

Research Questions: (*i*) What is the impact of a payment term extension on the cost of managing a stochastic inventory operation? (*ii*) What extensions of payment terms allow the supplier to benefit from reverse factoring?

Main Insights: We model a periodic review base stock model that includes alternative sources of financing and obtain solutions by means of simulation optimization. We find that an extension of payment terms induces a non-linear financing cost for the supplier, beyond the opportunity cost of carrying additional receivables. Longer payment terms exposes a supplier's cash position to increased volatility. Furthermore, we find that the maximum size of the payment term extension that a supplier can accommodate, depends on the demand uncertainty and the cost structure of the supplier. The greater the demand uncertainty or the greater the proportion of variable cost, the smaller the maximum extended payment term. Overall, our results show that the financial implications of an extension of payment terms needs careful assessment in stochastic settings.

4.3.2 Reverse factoring and service levels: let it happen or make it work?

Motivation: While literature increasingly suggest that improved delivery performance is a by-product of offering reverse factoring to a supplier, we aim to explore whether this is the case and how much more 'performance' can be contracted by the buyer. Our study is inspired from a case study an OEM that introduced a reverse factoring program to suppliers improve their resilience to demand uncertainty. Despite the significant transaction cost, the OEM did not enforce any contractual changes on service levels from its suppliers before or after the implementation of reverse factoring. The OEM, however, was convinced that their reverse factoring program would result in a more reliable supply chain as high cost of capital and shortfalls in liquidity as a result of the 2008 crises, have impeded many suppliers to sustain healthy levels of investment.

Research Question: (*i*) Is it in the supplier's benefit to provide a higher service level to a retailer that offers reverse factoring, or does this need to be contractually agreed by the retailer? (*ii*) What is the maximum service level improvement that a retailer can ask, given the terms of the reverse factoring offer?

Main Insights: We consider a scenario where a supplier uses a base stock inventory system to serve demands from two retailers. One of the retailers (A) facilitates early payment to the supplier through reverse factoring; the other (B) pays the supplier with a fixed payment delay. We find that the optimal base stock decreases as a function of the reverse factoring rate, hence, a supplier does not 'naturally' offer a better service level for reverse factoring, but rather collects the financial savings. However, we find that a significant service level improvement can be contractually required by retailer A but the maximum service level is conditioned on the relative mean demand size of A, the demand uncertainty of both retailers, the deviation between the supplier's lead time and its payment terms. Overall, our results suggest that if buyers aim to pursue a more reliable supply chain from implementing reverse factoring, they ought to consider contractually requiring a higher service level rather than leaving it up to their supplier to decide whether to offer a higher service.

4.3.3 On the interaction between pooling receivables and pooling investment

Motivation: The indivisibility a reverse factoring transaction influences the potential value it can deliver to the firm. Indeed, while reverse factoring allows firms to obtain cheaper financing from selling its receivable, it typically must sell the *whole* receivable when it chooses to sell it. This friction can become costly as firms may need more granular financing for their investment. Pooling receivables with other entities mitigates the adverse impact of indivisibility. In a setting in which firms can pool their investments operational assets to reduce unit cost, such as labor or R&D equipment, we answer the following question:

Research Questions: (*i*) If firms can invest to increase margin, what is the impact of pooling investment, pooling receivables and pooling both on the optimal investment level? (*ii*) Is the benefit from pooling both investment and receivables super or sub-additive?

Main Insights: In a stochastic make-to-order setting in which firms make a cost reducing investment subject to diminishing returns, we compare investment level, profit, and return on investment (ROI) when firms (a) operate independently, (b) pool investment, (c) pool receivables, or (d) pool both. We find that pooling receivables may lower as well as increase the optimal investment level depending on how production unit cost is to additional investment. Furthermore, the benefit from pooling both investment and receivables can be sub-additive as well as super-additive. When production cost is sensitive (insensitive) to investment the benefit from pooling is sub-additive (super-additive). Overall, our results indicate that simultaneous evaluation of operational and financing pooling concepts is warranted.

4.4 Conclusions and implications

Supply Chain Finance (SCF) is a concept that aim to bring value to the supply chain by integral perspectives and cooperative applications on financing. Reverse factoring is an SCF-application that allows suppliers to obtain cheap financing based on their receivables from creditworthy buyers. We find that the benefits and trade-offs concerning reverse factoring are conditioned on the firms' operations, such as the buyer's demand uncertainty and the supplier's cost structure. In addition, we find that firms can enhance the performance of their supply chain through the scheme, but the firms involved must contractually agree this to realize it. Indeed, contracts are needed to align the operational and financial incentives of the firms. Lastly, we find that the pooling of receivables in addition to pooling investments may yield synergistic benefits to the pool. This suggest that the Cross-Chain Control Center (4C) concept, which offers firms the opportunity to engage in multiple pooling initiatives both on the operational and finance level, allows firms to obtain a competitive edge compared to firms that only engage in a single type of pooling initiative. More research is needed to quantify this synergy benefit in detail and to come up with policy recommendations on the operational and tactical level, however. The fact that multinational firms increasingly recognize the benefit of a tighter cooperation between their treasury, finance, procurement and supply chain functions in supply chain finance provides further evidence of this.

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Chapter 5

Collaborative Forecasting

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Several concepts have arisen in supply chain management over the last few decades, which have been made possible by the availability of data and standards to share data, such as through electronic data interfaces (EDI). Many of these concepts are based on collaboration practices in which there is a match between the firms' interests which leads to inventory savings. With vendor-managed inventory (VMI) the supplier of the products has access to inventory information and is responsible for making sure that the product is in stock, without intervention of the buyer. With efficient consumer response (ECR) more demand information is given to the supplier so that orders and expected consumer demand are better managed. Quick response (QR) relies on fast sharing of the electronic data so that response times are reduced. Accurate response aims to improve operations by reducing manufacturing and distribution lead times and by obtaining market information earlier. Many of these concepts share either some means or goals, or both. A more recent addition, Collaborative Planning, Forecasting and Replenishment (CPFR), further aims to integrate supply chain operations so that they are managed in collaboration based on shared information. Collaborative forecasting partly overlaps with some of these earlier concepts, and is at the very least complementary to them (e.g. Aviv, 2001). Collaborative forecasting is the use of shared or obtained information to improve the forecasts with the goal of increasing effectiveness and efficiency in the use of scarce resources in supply chain management.

This chapter introduces the theoretical attractiveness of collaborative forecasting and describes the gap in its empirical evaluation in academic literature. A case study is then examined of collaboration within the firm, in which much of the same issues, such as trust and incentives, are crucial factors, and of which much more is known.

5.1 Theory of collaborative forecasting

Forecasting is necessary for the activities in a supply chain – inventory control, production and distribution planning – due to uncertainty and lead times. Retailers use a forecast as input for sales, inventory and order decisions, suppliers for production and procurement decisions, and distributors for capacity allocation decisions. The forecast horizons and units are different for these forecasts: retailers have to forecast consumer demand for short-term stocking decisions, whereas manufacturers have to forecast the actual orders placed by the retailer for long-term production decisions. Errors in a forecast can propagate upstream, distorting the basis on which decisions are made. Even if no errors are made, demand variability increases upwards in the chain – the bullwhip effect (Lee et al., 1997).

5.1.1 Inside the chain: information sharing

The bullwhip effect can be reduced by centralizing demand information (Chen et al., 2000). If not only demand information is shared, but also the forecasts themselves, Aviv (2001) concludes that the forecasting strength of a collaborative forecasting process is at least as good as the best individual forecasting strength. Much research has found substantial savings, mainly in terms of reduced inventory, from information sharing (Huang et al., 2003). However, it is questionable whether many of these findings can be generalized due to their dependence on 'implausible assumptions', which 'lack any empirical foundation' (Fildes et al., 2008, p. 1162).

The most common choices entail that the analyses do not take the uncertainty inherent in forecast modeling into account. Even if, ideally, this assumption accurately captures a base case, the question rises as to how representative this is in the fast moving consumer goods chain, which is characterized by large volumes, high competitive pressure and many promotions (Wiehenbrauk, 2010). Though some conjecture that 'information sharing can have a significantly greater value in environments with unknown demand' like during 'promotion[s]' (Cachon and Fisher, 2000, p. 1046), little evidence supports this. This issue is salient as scholars widely conclude that the benefit of information sharing is highly dependent upon, or sensitive to, the demand process (Ali et al., 2012; Babai et al., 2013; Bourland et al., 1996; Gaur et al., 2005; Lee et al., 2000; Zhao et al., 2002).

5.1.2 Forecast capability

In much of the research on collaborative forecasting, the information shared is the private demand information from the retailers, as the manufacturers supposedly have no knowledge about demand (e.g. Ha and Tong, 2008; Jain et al., 2011). Even if only retailers have information about demand, this situation can change when (competing) retailers share their information with the manufacturer: the manufacturer can become more informed than the separate retailers (Li and Zhang, 2008). In the case of Aviv (2001, 2007), forecast information and forecast capability are conflated, so that the value of collaborative forecasting depends on who has 'the largest relative explanatory power': this value is highest when the manufacturer has the largest explanatory power (Aviv, 2007, p. 792).

However, the difference between information and capability is important because in practice retailers have limited forecasting capabilities, in terms of forecast model formulation and estimation, and so cannot adequately handle all the information at their disposal (Smaros, 2007). Not only do manufacturers and retailers have different forecasting needs due to a difference in planning horizons and aggregation levels, the long production intervals and lack of internal integration make it difficult for manufacturers to use the information from the retailers (Smaros, 2007).

5.1.3 Outside the chain: information acquisition

Collaborative forecasting has been examined over various types of supply chain structures, broadly classified as either dyadic, serial, divergent, convergent or network (Huang et al., 2003). These structures are identified based on the physical flow of goods, rather than on the flow of information. Given that collaborative forecasting is most beneficial when the manufacturer has the best forecasting capabilities (Aviv, 2007) and when there is high diversification of forecasting capabilities across the chain (Aviv, 2001), the improvement of forecasting capabilities of the manufacturer not only benefits its own forecast but can also affect the gain of the collaborative forecasting within the whole chain. Huang et al. (2003) observe that an interesting avenue of research is to explore the impact of the neighborhood in which information is shared.

Companies are ever more operating in an information-rich environment, in which much more information pertaining to demand can be acquired and used than electronic point of sales (EPOS) data. Aviv (2007, p. 778) generally considers 'information signals' to which companies have access, and which can be 'any sort of data, other than past demand realizations, that correlate with future demand.' Unfortunately, in the research of Aviv (2007), this is implicitly modeled as the explanatory power that a firm has, so that this only remains an abstract notion. Fildes et al. (2008, p. 1168) consider that 'models linking novel sources of information' provide 'major research opportunities': however, the examples they give of these novel sources of information are 'EPOS data' or unspecified opportunities arising from a 'collaborative forecasting relationship.'

5.1.4 Channel coordination

In the earlier research on collaborative forecasting, firms are assumed to be cooperative (Aviv, 2001, 2007) and information to be shared truthfully (Cachon and Fisher, 2000), though conflicting interests can lead to non-cooperative behavior. The effects of collaborative forecasting can be severely undermined as the buyer has an incentive to inflate the forecast for its future orders when the buyer shares its forecast with the supplier, whereas the supplier is aware of the bias and so may not trust the forecast (Cachon and Lariviere, 2001). In practice, suppliers penalize buyers for unreliable forecasts by providing lower service levels, and buyers penalize suppliers that have a history of poor service by providing them with overly inflated forecasts (Terwiesch et al., 2005). Most of the research ignores effects of trust building and reputation (Terwiesch et al., 2005). Whereas earlier literature on forecast sharing and supply chain coordination implicitly assumes that supply chain members either absolutely trust each other or do not trust each other at all, in practice a continuum exists (Özer et al., 2011).

5.1.5 Tacit information and judgmental forecasting

Much of the information valuable for forecasting can be tacit. Sometimes the most important information, such as during promotions, can be tacit (Fildes et al., 2008). As tacit information can often not be captured by forecasting models, the practice of judgmental forecasting, or judgmental adjustment of a forecast, prevails at many companies. According to Lawrence et al. (2006, p. 493) judgment is now seen as an 'indispensable component' of forecasting, and much research has been done to understand and improve its use. In a collaborative setting, the availability of important tacit information is increased so that the use of judgmental forecasting can be central to the possible benefits collaborative forecasting can provide. However, there are still many questions as to how to use judgmental forecasting best, as the use of judgment invites various heuristics and biases which can deteriorate the forecast more than the use of tacit information can improve it (Lawrence et al., 2006).

Much research has focused on eliciting biases of forecasters and estimating the effect of particular information cues – such as the characteristics of a promotion – on forecasters (Goodwin and Fildes, 1999; O'Connor et al., 2000; Massey and Wu, 2005). The two most important biases are anchoring and insufficient adjustment (Schweitzer and Cachon, 2000). The success of judgmental forecasting has often been shown to depend on the characteristics of the series and the presentation of the task (Lawrence et al., 2006). The success is also conditional on the nature of the adjustment: small adjustments are much less likely to improve accuracy than large adjustments (Fildes et al., 2009; Syntetos et al., 2009). The bias and inefficency in judgmental forecasts can be so strong as to 'mask any contribution of contextual information to accuracy,' possibly due to information overload and anchoring (Lawrence et al., 2000, p. 161).

5.2 Forecasting for sales and operations planning

Forecasting is an important part of Sales and Operations Planning (S&OP) in companies, a process in which decisions on sales and production planning are made based on the expected demand. In large organizations, such as Unilever, SCA, Diageo, L'Oréal and Danone, this process is supported by advanced information systems and various managers are involved in the formulation of demand forecasts. Despite the resources and commitment, these forecasts often vary widely and differ substantially from the final demand realizations. Bad forecast performance leads to inefficient production, with substantial financial ramifications.

The forecasting process in an organization is not a simple matter of extrapolating a trend, but a carefully orchestrated business process involving different business units. Oliva and Watson (2009) and Oliva and Watson (2011) use Leitax, a manufacturer of consumer electronics,[1] as an example, which is described here.

The forecasting process at Leitax changed drastically in 2002. In the old situation sales managers made demand forecasts in different regions worldwide. These forecasts were informally communicated to the operation managers and the financial department of the company. Operations used the forecasts for purchasing and production decisions and the financial department for financial planning and management. The quality of demand forecasts, however, was seen as flawed, with the result that these departments each made their own demand forecasts. Eventually, this led to inefficient business processes and failed product introductions, which had large financial consequences.

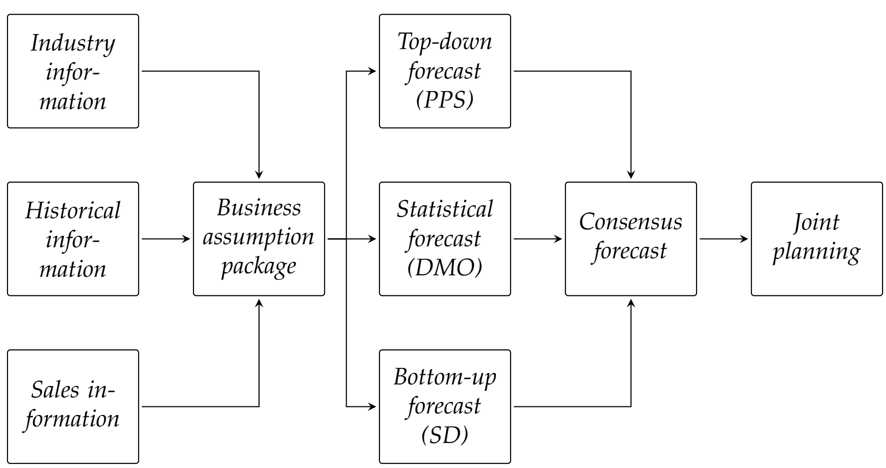

Figure 5.1: Consensus forecasting at Leitax (source: Oliva and Watson, 2009)

[1]See for example the commercial website `http://leitax.com/` and the historical overview on the site `http://www.overgaard.dk/leica_history.html`.

In 2002, the forecast process at Leitax was completely changed. A new business unit was set up, Demand Management Organization (DMO), which was responsible for creating statistical demand forecasts and to centralize the information needed for forecasting. Figure 5.1 illustrates the changed structure of the forecast process. Central to the process is the Assumption Business Package (BAP) that brings together the information that stakeholders consider relevant for forecasting demand developments. After preparing the relevant information the various parties in the organization, especially Product Planning and Strategy (PPP), Sales Directors (SD) and DMO, create their own demand forecasts at the product group level. These are called functional forecasts. The PPP forecast has a top-down character, in which forecasts of global demand are made on the basis of historical information about market developments of the current product range. The SD forecast has a bottom-up character, based on locally available knowledge of sales directors and account managers on planned promotions and inventory in the distribution channel. The DMO forecast is based on statistical analysis of available information. The three forecasts are combined to form a so-called consensus forecast. In a monthly forecast meeting they look for support for the consensus forecast, with ample attention to the motivations of the different demand forecasts. The final demand forecast is presented to the financial department to assess the consequences for the financial objectives of the company.

The changed structure has had a major impact on the operations of Leitax. The forecast accuracy increased by about 30 percentage points from 58% in 2002 to 88% in 2003. The current inventory in stock was reduced from $55 million in 2002 to $23 million in 2003. The depreciation on obsolete stock has decreased by $3 million to virtually zero in 2003. The adjusted forecast process may seem cumbersome, but it has had a substantial impact.

5.2.1 Forecast methods

There are numerous forecasting methods for forecasting consumer demand, or of process outcomes in general. Examples are: linear regression models, Box-Jenkins and Arima models, Holt-Winters models, Croston models, seasonal models, state space models and other. Some forecast methods are very sophisticated, others are relatively simple.

A widely used forecast method is simple exponential smoothing (*SES*). This method provides a forecast $F_{t+1|t}$ for the process outcome in a subsequent period $t+1$ on the basis of information available in the current period t, as a weighted sum of the realized process outcome in the current period, D_t, and the forecasted process outcome for the current period, $F_{t|t-1}$:

$$F_{t+1|t} = \alpha D_t + (1-\alpha) F_{t|t-1} = F_{t|t-1} + \alpha (D_t - F_{t|t-1}) \quad (5.1)$$

The second notation shows that the forecast is obtained as the sum of the forecast for the current period and a correction that consists of a weighted forecast error $D_t - F_{t|t-1}$. The parameter α determines the weight given to forecast errors. The larger the α, the more weight is given to the realized process outcome in the current period. The smaller the α, the less weight is given to deviations between actual and forecasted process outcomes. Suppose, for example, that the actual process outcome for the current period is equal to 1000 units (D_t), while 1100 units were predicted ($F_{t|t-1}$). With a low coefficient, say $\alpha = 0.10$, the forecasted process outcome is equal to $F_{t+1|t} = 1090$ $(= 1100 + 0.10[1000 - 1100])$. With a high weight, say $\alpha = 0.90$, the outcome is equal to $F_{t+1|t} = 1010$ $(= 1100 + 0.90[1000 - 1100])$. In the first case the forecasted outcome stays relatively close to the earlier forecast for the current period, whereas in the second case the forecast is relatively close to the realized process outcome in the current period.

Formal forecasting methods, such as simple exponential smoothing, have the pleasant property that they are fully defined, and thus available in automated information systems, such as SAP and others. Large companies, such as Unilever, SCA, Leitax and L'Oreal, have such forecast methods available to support planning activities. However, it often happens that these system forecasts are adjusted for various reasons or even ignored by planners.

5.2.2 Explanations of systematic forecast errors

Operating systems, such as factories, supply chains and product development organizations are characterized by social complexity: human behavior plays a major role. Even to the extent that models and methods for operational issues, which ignore the consequences and limitations of human behavior, only have limited use (Gino and Pisano, 2008). Much of the behavioral research in operations management is about heuristics and biases in information processing, leading to deviations from optimal decisions. Gino and Pisano (2008) give an overview of cognitive abnormalities that may affect operational systems and processes.

Forecast errors can be intentional or unintentional. A well-known example of unintentional errors is given by Schweitzer and Cachon (2000). With a laboratory experiment they show that anchoring, i.e. the phenomenon that people are influenced by an initial value, and adjustment errors can have a great impact on stock decisions. Decision makers used the expected demand as an anchor for their order decision without sufficiently taking the optimal order quantity into account. Gino and Pisano (2008) observe that 'future research might explore the role of this bias in forecasting. It could well be that sales forecasts are anchored to previous years' sales, with just a small, insufficient adjustment – thus resulting in systemically inaccurate predictions. Similarly, sales forecasts might be anchored to an estimate generated by a rational quantitative model and managers might adjust too little when making revisions to their initial forecasts' (p. 686). The experiment led to several follow-up studies, such as Bolton and Katok (2008) and Bostian et al. (2008).

Groups of individuals, such as organizational departments, e.g. sales, marketing, operations, and finance, can be exposed to the same routines and systematic decision errors as individuals, leading to sub-optimal group decisions. This sub-optimal group decisions can also have an intentional character. An example is given by Nauta and Sanders (2001). They argue that opposing interests are common to negotiations between organizational departments. Operations can find efficiency and costs relatively more important, while sales attaches relatively more importance to customer service and sales development. The interests of the department may affect the way individual decision makers forecast future demand. Similarly, different incentive schemes of departments, and the degree of alignment, influence forecasting behaviour (Oliva and Watson, 2009, 2011). Different organizational departments will want to influence the forecast in accordance with their own agenda (Oliva and Watson, 2009, p. 140). Intentional forecast errors can be a result of incentive schemes.

Demand forecasting, as an organizational activity, naturally entails the need for cooperation between individuals. This means that demand forecasting can also be influenced by the confidence that co-workers have in each other and each other's decisions, by social values and the way they deal with conflicting interests.

Özer et al. (2011) show that trust and trustworthiness greatly affect the sharing of demand forecasts between firms in supply chains. They describe an example in which raw material suppliers try to get information on demand forecasts from a manufacturer. In this situation, trust refers to the willingness of the supplier to depend on the forecast of the manufacturer for its own capacity planning. A fully trusting supplier believes the demand forecast with certainty. A non-fully trusting supplier will completely ignore forecasts of the manufacturer or only use them to adjust its own forecasts. The extent to which this happens will depend on the confidence the supplier has in the information of the manufacturer. Trustworthiness determines the tendency of the manufacturer to share information with the supplier. A fully trustworthy manufacturer experiences such an aversion to misinformation that it will provide credible demand forecasts to the supplier. A non-trustworthy manufacturer will share manipulated demand forecasts without any reluctance (Özer et al., 2011, p. 1112).

5.3 Illustration

We conducted several laboratory studies where participants take on the role of a company forecaster. After studying a time series of historic demand they have to provide a forecast for the next period. All the available information is then updated, and participants can see the outcome. They iterate through these steps a number of times. The forecast is neutral and has nothing to do with actual quantities produced. The process is as follows: participants privately forecast demand for the next period (not shared) and separately propose a production quantity. Their proposal is shared with other managers and together they negotiate about the final quantity. The idea is that the biases are divided over the two steps: the forecast will reveal the participants' unintentional biases, whereas the production quantity will reveal the intentional biases.

Table 5.1: Average forecast accuracy

Group	MSE	MAPE	Bias
Forecast	16453.60	0.16	-0.06
Operations	14732.43	0.15	-0.07
Sales	16363.64	0.16	-0.03

The participants were given different roles and incentives. The operations department is focused on production and inventory levels, which may result in lower proposed production quantities. The sales department is concerned with sufficient product availability so that there are no lost sales, which may result in higher proposed production quantities.

What we show here is an excerpt of one of our studies, based on a small sample of the participants. The participants selected were either in the operations department or the sales department. They were specifically instructed to focus on company goals and measures, such as profit and accuracy, so there were no incentives specific to their department. They saw the historic demand displayed in figure 5.2. They then had to provide a forecast for the next period and a production quantity. After entering these numbers, they continued to the next period where they would see the result of their actions. The graphs and measures, such as profit, would all be updated, and participants would then have to repeat the process for the subsequent time period. In the example displayed here, they did this ten times.

Table 5.1 summarizes the average forecast accuracy of sales and operations as compared to the optimal forecast, simply labeled *Forecast*. MSE is short for Mean-Square Error and is calculated by squaring the forecast errors for each time period before taking the mean. MAPE is short for Mean Average Percentage Error and is a popular metric in practice. It is calculated by dividing the sum of the absolute forecast errors over the periods by the sum of the total demand in those periods. The Bias is calculated almost in the same way as MAPE, but now the absolute of the forecast errors is not taken, so that errors can cancel out. The Bias shows that all three forecasts suffered from a negative bias, which means that the forecasts were, on average, too low.

For the unintentional biases, table 5.1 shows that, on average, the participants were close to the optimal forecast, and even slightly outperformed it, so they were doing a good job. However, as figure 5.3 shows, their forecasts clearly reflect the role they were given in the experiment, even though the forecast is free from intentional biases. For the participants selected here, there was no reason to inflate or deflate the production quantity as they were supposed to focus on company objectives. Even if this were the case, there would still be no reason to inflate or deflate the private forecast.

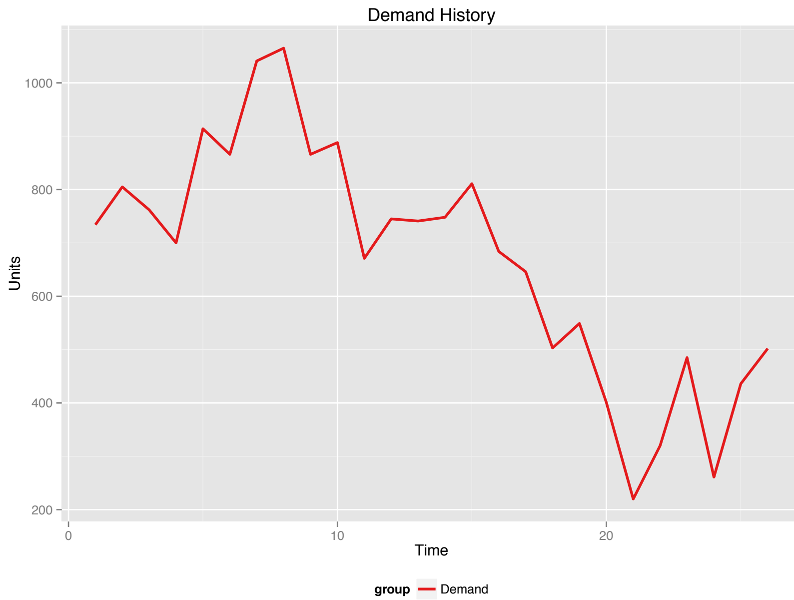

Figure 5.2: Demand history of the experiment

Figure 5.3: Forecasts of the operations and sales managers

This shows that people's role affects their unintentional biases. The role already influences them to be more optimistic or pessimistic about future demand. These unintentional biases can appear to be intentional, which affects trust and other aspects which can have severe consequences for collaboration.

5.4 Conclusion

Whereas the literature on collaborative forecasting shows large possible gains and benefits for supply chains in stylized models, the situation in practice is more complicated. Trust requires to share information and coordinate processes, but can be difficult to evaluate as uncertainty is central to forecasting. Promotions, competitors' promotions, product dependencies and stockouts make modeling demand more difficult, which makes it challenging to judge the actions and quality of information of other firms. Many firms simply lack the capability to take advantage of all of the information at their disposal, and already face difficulties having different departments collaborate within their own firm. The interaction between unintentional and intentional biases, also illustrated here, shows that a close collaboration within the forecast process is needed, and that firms have to expand their forecasting capabilities.

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Chapter 6

Methods for Making Predictions in Cross-Chain Contexts

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Supply chain generate massive amounts of data, ranging from GPS position traces from trucks, to bills of lading, to purchases at retail outlets. All this data is potentially at the disposal of the Cross Chain Control Center (4C). The question is: how do partners collaborating in the 4C benefit from this cornucopia of data? Stated differently, how can this data be turned into value for the 4C stakeholders? In this chapter, we will discuss the use of predictive analytics, and show its value and potential applications for 4Cs. Examples of these applications are: the synchronization of arrival times between transports, assessing how 'future proof' collaboration partners are, and forecasting next months demand. For each of these applications, we will apply Shmueli and Koppius' (2011) framework, involving the identification of relevant literature and the choice of methods, to systematically discuss relevant stages of predictive analytics.

6.1 Explanatory analysis and predictive analytics

Exploiting available data for gaining insights and developing business applications, typically follows one of two directions. The first is trying to understand the data and the phenomena or processes they represent, like understanding the behavior of the market or keeping tabs on the performance of suppliers.

This type of analysis is know as explanatory analysis, and is limited to looking back: it makes no claims about the future. A good explanatory model has high explanatory power: it should explain the data as good as possible. The second direction is the use of predictive analytics. Unlike explanatory analysis, predictive analytics is not just about understanding the past. Rather, it is about understanding the past to predict the future. So, predictive analytics uses knowledge of the past, like a supplier's performance, to predict future results or events.

A good predictive model has high predictive power, but not necessarily a high explanatory power. To clarify this distinction, consider the plot in figure 6.1, which shows quarterly earnings on the y-axis, and the fiscal quarter on the x-axis. Each point represents the quarterly earnings of a fictitious company. Using regression analysis, a model has been 'fitted' to these points, in such a way that the distance between the points and the line is minimized. In terms of explanatory power, this is a very good model: its R^2, a measure of the quality of the fit, is 0.97, on a scale of 0 to 1. Now consider the plot in figure 6.2, which shows new data for the quarters after 2008. Looking at the fit of the blue line, the model does not explain the new data very well: it assumes that earnings would go up indefinitely. By contrast, the green plot has a much better fit with the new data, though it is not as good as an explanatory model for the past period. So, good explanatory power and good predictive power not always go hand in hand.

Proper use of predictive analytics in practical domains requires a systematical approach in its own right. We will use the method proposed by Shmueli and Koppius (2011) to demonstrate the use of predictive analytics in cross-chain collaboration. The steps of the method are illustrated in figure 6.3. The first step is goal definition, which means deciding the desired outcome of the model: should it be numeric or categorical? The second step, data collection, is about establishing (*i*) what data is necessary for the predictive model, (*ii*) how much data is necessary; and (*iii*) deciding how this data is to be collected. Data preparation, the third step, deals with determining the strategy to deal with missing values, and preparing the data for analysis. Next, the exploratory data analysis establishes the correlations between the predictors (independent variables) and the predictand (dependent variable) by using visualizations, for example. This leads to the choice of variables: determining which variables are available at the time of prediction and which are likely to be strong predictors. Choice of potential methods, the sixth step, is about the algorithms to use for creating the model, such as decision trees, neural networks or ensemble methods. The two final steps evaluation, validation and model selection and model use and reporting are about determining the actual predictive power of the model, and comparing the model's performance with other approaches.

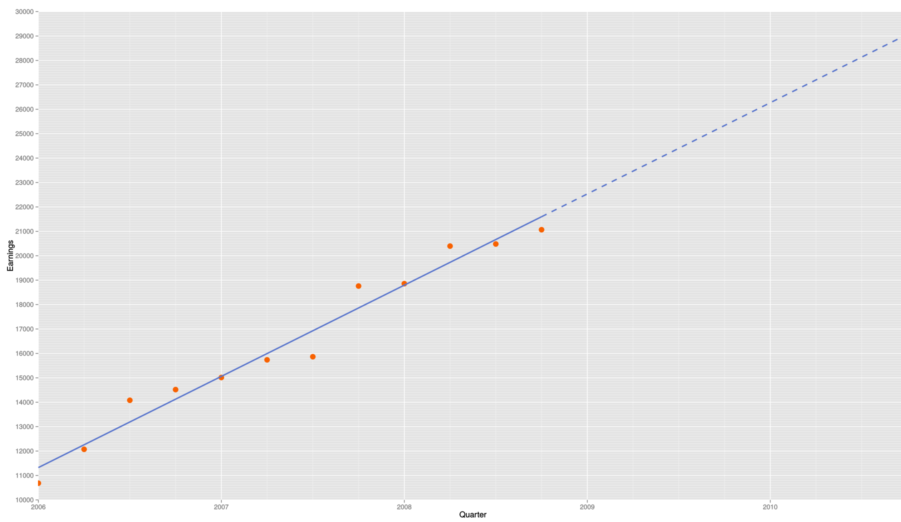

Figure 6.1: A model with high explanatory power: the ’distance’ between the points and the line is small

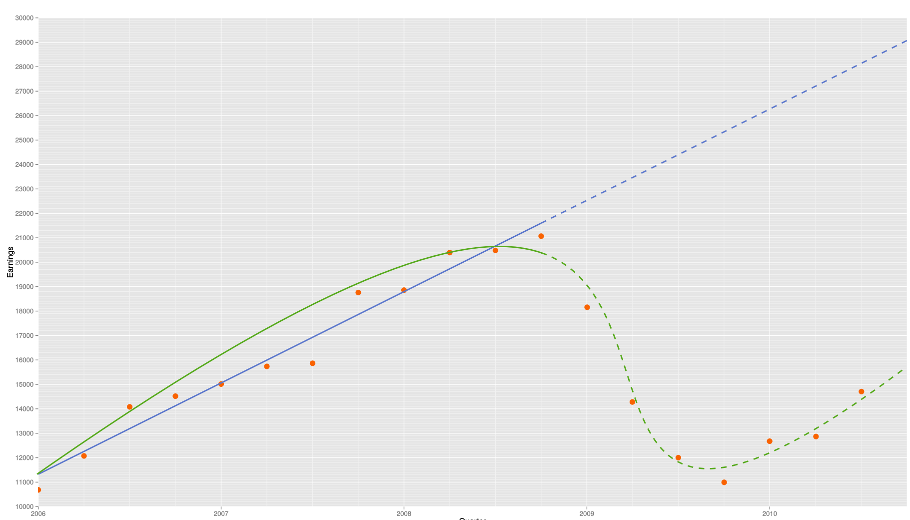

Figure 6.2: A model with high explanatory power (in blue) and a model with high predictive power and low explanatory power (in green).

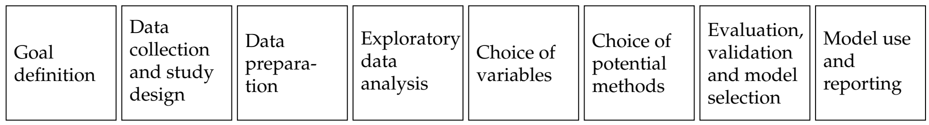

Figure 6.3: The Shmueli and Koppius method for predictive analytics (source: Shmueli and Koppius, 2011)

6.2 Synchromodality and arrival time prediction

Synchromodality is the current trend in supply chain transport.It entails that the means of transportation may be switched ad-hoc: if other means seem more effective or efficient, even during execution, switches can be made. This requires, amongst other things, that arrival times are known ahead of time.

A quick example may clarify the idea. Suppose a truck leaves from Rotterdam carrying one container bound for Hengelo. Based on its arrival time, a barge in Gorinchem from a 4C partner decides to wait for the truck, and takes the container from the truck the rest of the way over water. This benefits the trucking company: it can use the truck to do more work in and around the port. This also benefits the barge company: the barge is now used more efficiently. This only works when the barge operator knows when the truck will arrive. For example, it may not be possible to leave half an hour later, due to lock planning and so on.

Besides synchromodality, arrival time prediction can benefit down-stream supply chain partners. If these partners know when their cargo is due to arrive, they can plan for the available personnel to deal with this cargo. More generally, they will not be surprised by an unexpected late or early arrival. In summary, arrival time prediction is one ingredient in making better, more efficient plannings across the 4C partners, both horizontally and vertically.

There are multiple ways an arrival time estimate or prediction can be made. A trucker could be well aware of the time it takes to reach a certain area, based on experience. A problem could be that these predictions are unreliable, or that it is to difficult to send the trucker's arrival time prediction to anyone who can benefit from this prediction, like a planner. Therefore, we propose predictive analytics methods for predicting truck arrival times.

Below, we describe the steps of Shmueli and Koppius' method applied to arrival time prediction, and provide general answers to the questions posed by the method where applicable.

Goal definition

The goal definition part of Shmueli and Koppius' method is about establishing the desired outcome of the analysis. That can be one of two things: numerical, such as exact arrival time, or categorical, such as which quarter or even hour the truck will arrive. This choice impacts the methods used to build the actual model.

Data collection and study design

Next, the necessary data needs to be collected. This requires knowledge about the research domain, in this case road transport. Having a clear picture of the relevant data, one can proceed to finding sources for these data. For an overview of the relevant data for truck arrival prediction, it is important to look at previous literature and research practice: what data have others used, and were they successful in their study? This requires a structured literature review, following, for example, the steps proposed by Webster and Watson (2002). We have performed this review, resulting in a list of 45 papers about predicting travel times. The findings of this review are summarized in table 6.1. Based on these findings, traffic, including incidents, and weather data are identified as important sources for predicting travel times. Combined with GPS positions of trucks and truck destinations, these data constitute the basis for arrival time prediction.

Data preparation

Data preparation deals with missing values and missing data. Shmueli and Koppius (2011) suggest several techniques for dealing with missing values, e.g. removing values, taking a mean value where meaningful, or replacing the missing value with a dummy value. For arrival time prediction, it seems to make sense to remove missing values, i.e. to drop the rows that have missing traffic or weather data. Considering the findings of the literature review, replacing missing weather or traffic values with mean values is likely to have negative effects on the performance of the model – these are important predictors.

Exploratory data analysis

Exploratory data analysis (EDA) is an initial analysis of the data, to better understand the relations between predictors and between predictor and dependent variable. Shmueli and Koppius suggest to use EDA for dimensionality reduction. We have collected data from Rijkswaterstaat (Rijkswaterstaat, 2014), the Dutch agency for roads and water, consisting of congestion information for all Dutch highways, and data from KNMI (Royal Dutch Meteorological Institute, 2014), the Royal Dutch Meteorological Institute, consisting of several weather variables, e.g. temperature, precipitation, wind, and visibility. A simple Pearson's correlation test shows that weather and traffic conditions are dependent, but that the associations are not very strong: correlation coefficients are in between 0.05 and 0.07

Choice of potential methods

Based on previous research (Van der Spoel et al., 2013) clustering and regression trees (Breiman et al., 1984), support vector machines (Cortes and Vapnik, 1995), Adaboost M1 (Freund and Schapire, 1995, 1996) and random forests

Table 6.1: Key variables for arrival time prediction and selected references

Variable	Description	$x^{a.}$	Selected references
Congestion	Number of vehicles on a road per time unit	38	Sheu and Ritchie (1998); Yang (1998); Golob and Regan (2001); Hollander and Liu (2008); Van Lint et al. (2008); Figliozzi (2010); Jula et al. (2008); Chen and Zhou (2010); Ng and Waller (2010); Yu et al. (2011); Khosravi et al. (2011); Li and Rose (2011); Fei et al. (2011); Lederman and Wynter (2011); Jenelius (2012); Hofleitner et al. (2012); Peer et al. (2012); Zhan et al. (2013); Antoniou et al. (2013); Yildirimoglu and Geroliminis (2013); Celikoglu (2013); Li and Zhiheng (2013); Van Lint et al. (2008)
Time	Time of day, week, month, year	20	Amini et al. (1998); Bates et al. (2001); Fowkes et al. (2004); Wu et al. (2004); Hollander and Liu (2008); Yeon et al. (2008); Lam et al. (2008); Van Lint et al. (2008); Jula et al. (2008); Nie and Wu (2009); Chen and Zhou (2010); Ng and Waller (2010); Li and Rose (2011); Lederman and Wynter (2011); Jenelius (2012); Peer et al. (2012); Zhan et al. (2013)
Weather	Weather conditions	15	Wu et al. (2004); Clark and Watling (2005); Golob and Regan (2005); Hollander and Liu (2008); Yeon et al. (2008); Lam et al. (2008); Li et al. (2010); Chen and Zhou (2010); Khosravi et al. (2011); Jenelius et al. (2011); Peer et al. (2012); Antoniou et al. (2013)
Incidents	Collisions, road work, outages	15	Hall (1996); Sheu and Ritchie (1998); Rietveld et al. (2001); Wu et al. (2004); Clark and Watling (2005); Golob and Regan (2005); Lo et al. (2006); Lam et al. (2008); Li et al. (2010); Chen and Zhou (2010); Ng and Waller (2010); Khosravi et al. (2011); Zhan et al. (2013)

[a.] 'x' represents the number of times that variable occurred.

(Breiman, 2001) are good candidate predictive algorithms. In addition, the literature suggests the use of neural networks as well.

6.3 Partner selection

Perhaps more than synchromodality and arrival time prediction, the selection of partners is a key component for effective and efficient cross chain collaboration, and therefore of a 4C. Of course, there is no free choice of partners for a 4C: the candidates need to be upstream or downstream in the same chain for vertical collaboration, or in the same or similar segment for horizontal collaboration. Even within these limits, the choice of candidates is difficult. A new collaboration requires investments of time and effort, and it is not certain beforehand whether or not the collaboration will eventually be fruitful. Various factors can cause a collaboration to fail: from an insurmountable difference in organizational culture to financial shortcomings of one of the partners. A key question is if the success of collaboration is predictable; and, if so, what are the quantitative or qualitative factors that determine the future success of a collaboration?

Goal description

The goal description part of Shmueli and Koppius' method is about determining the desired outcome of the predictive model: numerical, categorical, or perhaps even something else. For the case of partner selection, either numerical or categorical makes sense, although the latter seems a better fit. After all, success of a collaboration is difficult to quantify, so a more qualitative outcome, e.g. 'likely to succeed' or 'very unlikely to succeed', seems more relevant.

Data collection and study design

Just as for the arrival time prediction data collection, we have performed a structured literature review of the data, necessary for partner selection. We identified two distinct streams in supply chain partner selection: corporate failure prediction and supplier selection. The first, corporate failure prediction, is about using financial ratio's, such as assets to liability, earnings before taxes to total assets, and sales to total assets (Li et al., 2012; Sun et al., 2014). The second, supplier selection, is about qualitative factors, like satisfaction, and organizational factors (Monczka et al., 1998; Jain et al., 2007; Cao and Zhang, 2010; Kone and Karwan, 2011). Table 6.2 summarizes the findings from the literature review.

Choice of potential methods

In the literature, different categories of prediction algorithms are distinguished. Li et al. (2012) and Sun et al. (2014) – the latter in an especially in-depth review

Table 6.2: Variables used for partner selection

Variable	Description	References
Financial ratios	Earnings, growth, asset-liability ratio etc	Li et al. (2012); Sun et al. (2014)
Relationship	Flexibility, durability, ISO9000	Monczka et al. (1998); Jain et al. (2007); Cao and Zhang (2010)
Satisfaction	Satisfaction with other alliances	Monczka et al. (1998); Jain et al. (2007)
Performance	Efficiency and effectiveness	Monczka et al. (1998); Jain et al. (2007); Cao and Zhang (2010); Kone and Karwan (2011)
Cost	Logistics cost, operating costs etc.	Jain et al. (2007); Cao and Zhang (2010); Kone and Karwan (2011)
Organization	Innovativeness, management, ISO14001, HRM	Jain et al. (2007); Cao and Zhang (2010)

of applicable algorithms – mention the use of case-based reasoning, which is itself related to machine learning, but takes a different form of data. Sun et al. (2014) review various classification algorithms: machine learning, like decision trees; ensemble methods, like forests, bagging and boosting; and neural networks. Just as case-based reasoning, these approaches fit a qualitative outcome oriented approach, as discussed in the literature review. Monczka et al. (1998) and Cao and Zhang (2010) use regression and related algorithms, such as structural equation modeling. These algorithms do not result in qualitative outcomes, but rather produce continuous results. Their applicability therefore depends on the choices made in the goal definition. Finally, Jain et al. (2007) suggest the use of association rule mining, and Sun et al. (2014) mention clustering and support vector machines. These approaches are unsupervised learning methods, and are more applicable to qualitative than quantitative goals. These methods group or cluster similar cases.

6.4 Inventory planning and demand forecasting

Inventory planning is the final application of predictive analytics of this chapter. The use of predictive analytics in this domain lies in vertical collaboration, where downstream partners communicate demand upstream, so that upstream partners can anticipate. Still, vertical collaboration is an important part of cross-chain collaboration. An in-depth discussion of the specifics of forecasting in collaborative settings is deferred to chapter 5. Here, we apply Shmueli and Koppius' method to forecasting.

Goal definition

For forecasting, the question of the desired type of outcome is more clear-cut than for the previously discussed applications: it should be numerical. A forecast is meant to show the predicted demand for the next period, so this amount can in fact be produced – something that cannot be captured with a categorical outcome.

Data collection and study design

Once more, we conducted a literature review to determine the quantities that are used for forecasting demand. Table 6.3 gives an overview of relevant studies and quantities. The majority of studies use demand in previous periods, though some use inventories or the economic regime. The choice depends on the goal definition: if the prediction goal is inventory, it makes sense to take inventory levels from previous periods into account.

Table 6.3: Variables used for forecasting

Variable	Description	References
Historical demand	Demand in previous periods	Lau et al. (2013); Williams et al. (2014); Warren Liao and Chang (2010); Chen and Zhou (2010); Moon et al. (2013); Kapuscinski et al. (2004); Doganis et al. (2008)
Regime	The current or previous economic regime	Korpela and Tuominen (1996); Ketter et al. (2009)
Inventory	The amount of inventory in previous periods	Wu (2013); Oke and Szwejczewski (2005)
Economic indices	Macro-economic indices like GDP	Cheng et al. (2010)

Choice of potential methods

The algorithms used in the review forecasting literature paint a roughly similar picture to that of partner selection. Machine learning algorithms, like neural networks and decision trees are used extensively, in addition to heuristics and time-series forecasting. An overview of the methods is in table 6.4.

Table 6.4: Methods used for forecasting

Method	References
Neural networks	Lau et al. (2013); Moon et al. (2013); Cheng et al. (2010)
Heuristics	Wu (2013); Chen and Zhou (2010); Kapuscinski et al. (2004)
Time-series forecasting	Williams et al. (2014); Doganis et al. (2008)
Regression	Oke and Szwejczewski (2005); Moon et al. (2013)
Decision trees	Moon et al. (2013); Cheng et al. (2010)
Markov prediction	Korpela and Tuominen (1996)
Gaussian mixture model	Ketter et al. (2009)
Ant colony optimization	Warren Liao and Chang (2010)
Rough set theory	Cheng et al. (2010)

6.5 Summary

In this chapter, we have presented some applications for predictive analytics in 4C. Using Shmueli and Koppius' (2011) method for creating predictive models, we have discussed the goals, variables and methods that are applicable to three applications of predictive analytics in 4C: arrival-time prediction, partner selection and demand forecasting. Although the variables used for the different applications are quite different, the methods show marked similarities. Especially, data mining and machine learning methods are well-represented in the literature, but also regression is used in various applications.

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Chapter 7

Human Factors of a 4C

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Among the different initiatives for the horizontal integration of supply chain, one of the most critical is the integration of planning and scheduling functions by the co-location of schedulers and planners in a single facility. As a trend consolidates, the question arises if the productivity of planners and schedulers can be enhanced. Productivity increases can be achieved through a more focused recruitment and training processes, extended learning opportunities and the possibility to monitor and devise incentive schemes by comparing the performance of different schedulers. However, for such initiatives to be effective better understanding the schedulers' actual job and work-related behaviors. Although there is a vast literature regarding scheduling problems and algorithms (cf. Pinedo, 2005), the literature about the study of the very scheduler is scarce. In the emerging field of Behavioral Operations, certain scheduler decisions have been studied though.

An important aspect in which the scheduler is poorly understood is how he makes use of time, i.e. its main resource for his job. Time is essential to understand the job of a scheduler and its productivity. For one, understanding the schedulers' use of their time, can be critical to know the kind of deliverables other than schedules the scheduler produces for an organization. Jackson et al. (2004) advance that schedulers not only contribute by producing schedules, but also by providing information for the organization. However, the relative weight of these other functions in the consumption of the scheduler's use of time is unknown.

In addition, the behavior of schedulers in managing their own time is worth studying as it may influence their productivity as well as their responsiveness to external disruptive events that need their attention. In contexts where uncertainty was judged as high, De Snoo et al. (2011) find that among planners and schedulers, 55% of respondents consider being responsive more important than optimizing schedules.

The purpose of this chapter is to review insights obtained from different studies that conform the human factors of the 4C4More work package. The common theme of all the studies is the time dimension of the scheduler's job. This chapter is organized as follows. In section 7.1, we develop a theoretical work-flow model to describe the scheduler's job from the point of view of his time usage. Next, in section 7.2 we present the results of a field study to identify emerging trends as regard to time usage of the scheduler. In section 7.3 we present further empirical analysis of the field study focusing on the determinants of self-interruption. This is followed in section 7.4 by an evaluation on the impact of self-interruption on the scheduler's performance. We conclude in section 7.5 discussing briefly managerial implications of the studies reviewed for the management of schedulers' control towers.

7.1 Functional work-flow models of the scheduler

Most of the research into the scheduling function has been carried out from an operations research perspective (Dessouky et al., 1995). However, there has been a growing interest for the human aspect of scheduling (Crawford and Wiers, 2001; Fransoo et al., 2010). Models that describe the scheduling task have been proposed by various authors, such as Jackson et al. (2011); Wiers (1997); Wiers and Van Der Schaaf (1997); McKay and Buzacott (2000) and Jackson et al. (2004). Cegarra and Van Wezel (2011) present a review of models from the perspective of the objective of the model – either for designing decision support or training.

The functional model presented by Jackson et al. (2004) is of particular interest for understanding the scheduler's use of time; see figure 7.1. Jackson et al. (2004) make a distinction between three kinds of scheduling activities or functions that a scheduler serves: goal-oriented, enabling and monitoring activities. Goal-oriented activities include the formal tasks described on the scheduler function, i.e. scheduling itself, as well as maintenance tasks, e.g. data maintenance, and compensatory tasks, e.g. rescheduling, which support the formal tasks. At the same time, they propose that to enable the goal-oriented activities, the scheduler also fulfills enabling activities in a number of roles. These include a decision role, e.g. production orders, use of extra time, a role in which information is received, used, researched and disseminated and an interpersonal role where relationships are built for gaining access to information, being able to relax constraints and ease implementation of schedules. Finally, they propose that schedulers engage in monitoring, anticipating any problems and the need for rescheduling. To the best of our knowledge, the model by Jackson et al. (2004) is the most comprehensive description of the scheduling task that has been empirically validated. However, the description is primarily qualitative and conceptual, and does not take the perspective of time into account. Nevertheless, some of the qualitative descriptions in their work do suggest that the decision role, often perceived to be the dominant scheduler's activity, occupies a relatively small share of the time spent.

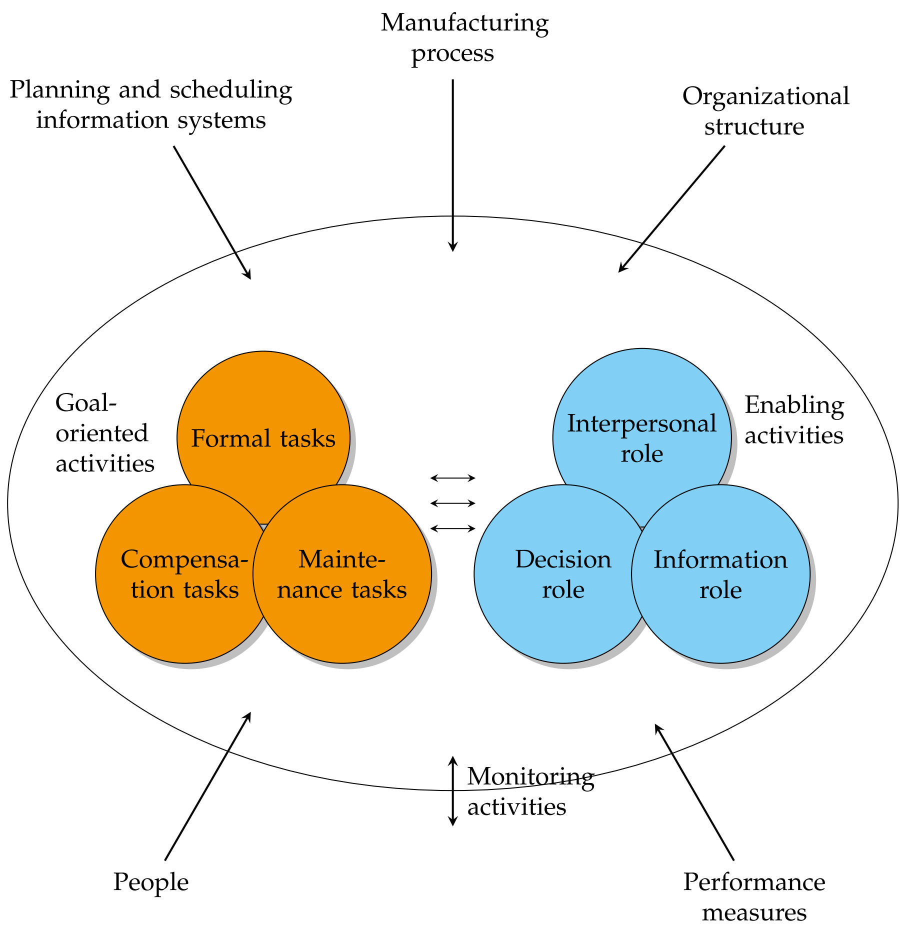

Figure 7.1: Model of scheduling tasks and roles. (source: Jackson et al., 2004)

Jackson et al.'s (2004) model suggests that the scheduling job consists of several tasks and roles that simultaneously require attention by the human scheduler. Some of these are initiated by the scheduler himself, while others are triggered by other persons or events. Conducting endogenously triggered activities and responding to exogenous requests compete for the same scarce time of the scheduler. The existing models do not make clear how schedulers deal with this time management issue, in particular in the presence of stochastic events, e.g. resources failure, unexpected customer orders or interruptions by colleagues in other organizational functions, that may alter the scheduler's work-flow. In other words, time-management in the scheduling task is an unexplored domain.

The second model of interest is the framework by Hopp et al. (2009), which models time-related aspects of white-collar work, e.g. average waiting time, throughput. The framework is applicable to the scheduling job as it fits their description of white-collar work, i.e. work that requires intellectual, problem-solving skills and often creativity. Indeed, schedulers have been described by McKay and Wiers (1999) as problem-solvers that anticipate problems and often seek non-conventional solutions to problems that have not been faced before.

In Hopp et al.'s (2009) framework, tasks, or work packages, are triggered by either of two types of entities: exogenous entities and endogenous entities; see figure 7.2. Trigger entities are not the tasks themselves, but are the initiators of the tasks. Exogenous entities are external requests to the individual by any of his stakeholders. For example, in the scheduling context, an exogenous entity may be a request by a sales representative to be informed about the status of a customer order. Endogenous entities are internally generated items that are done at the initiative of the white-collar worker himself. An example of an endogenous entity is the initiative of a scheduler to conduct a check on the progress of the released production order to avoid any future capacity problems.

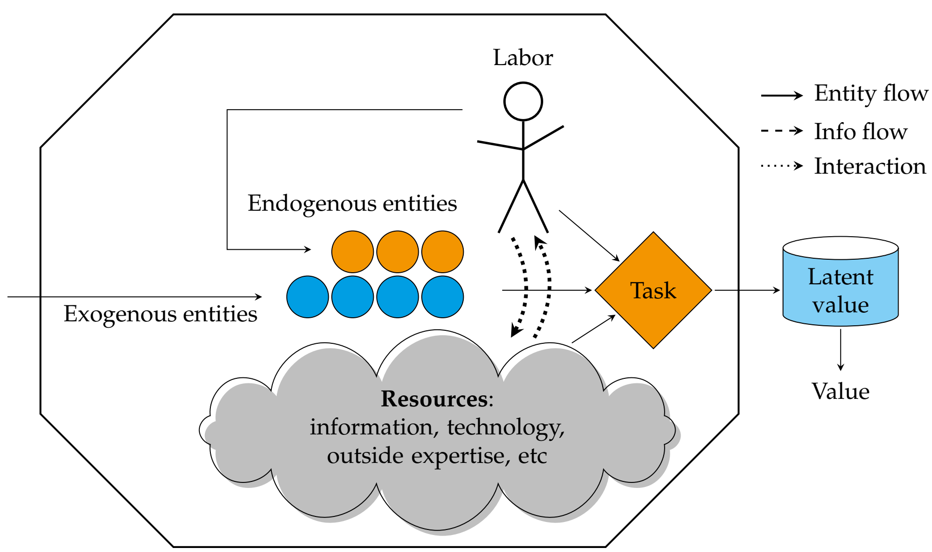

Figure 7.2: Individual white-collar framework (source: Hopp et al., 2009)

Figure 7.3 presents an extended version of the model by Hopp et al. (2009). Task triggers can be endogenous or exogenous. They can interrupt a task, which is then put in a work-in-process queue to be finalized later. Exogenous triggers can either forcibly or non-forcibly interrupt the scheduler. For example, requests that arrive by e-mail are non-forcibly interrupting tasks as the scheduler may decide when to read e-mails and when to react to it. However, if a planner phones a scheduler, the scheduler is forced to interrupt a current task. In addition, it may occur that the scheduler decides to start new activities even if he has not finished the current one.

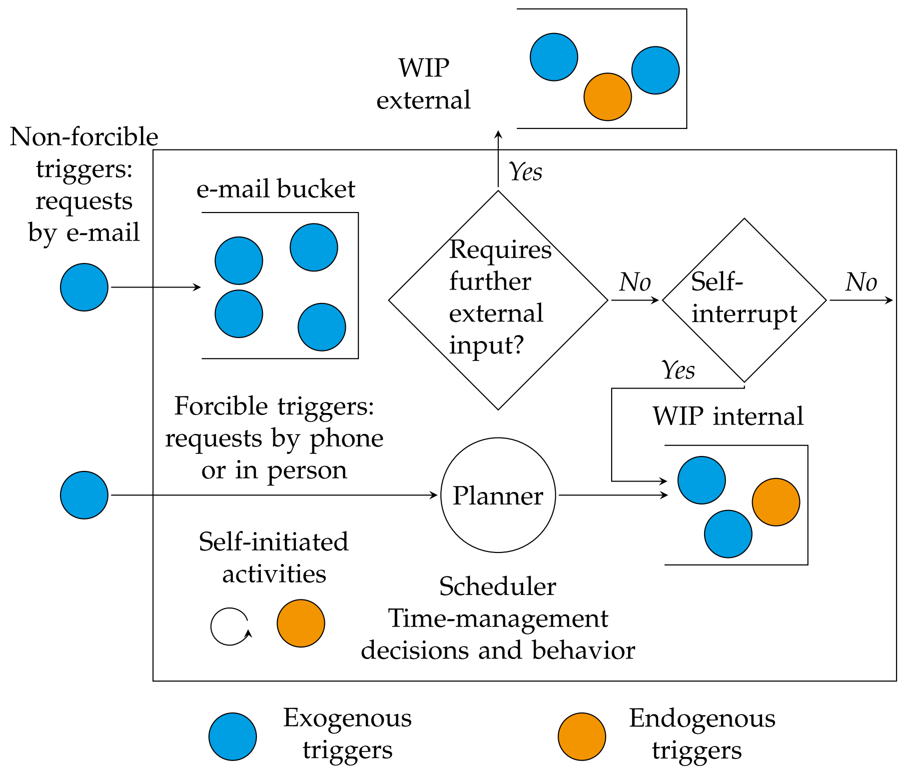

Figure 7.3: Work-flow scheduling framework

The internal work-in-progress of tasks increases with one unit when the scheduler is forcibly interrupted, decides to allow to be interrupted by non-forcibly interruptions, or starts another self-initiated activity before finishing the current one. It is also possible that the scheduler cannot finish a task because he requires input from another party in which case, he needs to wait for a response from the other party in order to resume such a task.

7.2 Time usage scheduler study

To investigate on the time usage of the scheduler a field study at a planning department of a Fortune 500 chemical corporation was conducted. The goal of the study was two-fold: first, to investigate the amount of time the scheduler spends in each role; and, second, to investigate the interruptions behavior of scheduler's.

In the planning department, 12 planners and 36 schedulers are co-located in a single facility. The planning department is a separate entity in the chemical corporation that provides planning and scheduling services to all European production and distribution facilities. The planning department is an example of the trend to centralize planning and scheduling operations, by co-locating personnel in a single so-called Control Tower.

The sample consisted of 19 scheduler-days performed by eight subjects, each with a different context as shown in table 7.1 Three schedulers worked in a predominantly make–to–order environment. There was diversity also in terms of the number of products, or stock keeping units (SKUs), scheduled by the eight schedulers studied, ranging from 20 to 500. In addition, the number of plants scheduled by the observed scheduler was diverse, ranging from one to four production plants. The geographical scope of the customer base addressed by each scheduler also varied widely from regional to global. The diversity of scheduling contexts provided some potential to generalize the results obtained.

Table 7.1: Production environment of the eight schedulers

Scheduler	Number of SKU's	% Make to order	% Make to stock	Plants	Planning scope
1	500	25	75	4	European
2	200	0	100	1	Global
3	40	75	25	1	Global
4	20	50	50	1	European
5	130	80	20	4	Global
6	50	60	40	2	Western Europe
7	500	10	90	4	European
8	60	10	90	1	Global

The four researchers involved in the study were assigned to a particular scheduler to observe its job as a pilot observation day, using a preliminary coding scheme. The last three hours of the pilot day, the four researchers tested the applicability and completeness of the preliminary scheme. This scheme had been developed by the lead researcher on the first visit during a debrief session with the scheduler involved, and subsequently with the other researchers. During the debrief session, the completeness of the options, the ease to fill in the scheme in a spreadsheet and the definition of what a task is, were all discussed and modifications were agreed upon.

From the number of interruptions reported in table 7.2, it becomes clear that about one quarter of the tasks are interrupted, either by the scheduler himself, or by being forcibly interrupted by others. From this finding, we conclude that a significant fraction of tasks is interrupted. Following this result, we conclude

Table 7.2: Trigger frequency per type

	Exogenous triggers					
	Forcible	Non-Forcible	Total	Endogenous	Total triggers	% in control
Max	9	23	27	20	44	1.00
Min	0	2	7	3	10	0.50
Mean	3.9	13.9	17.8	10.9	28.7	0.85
Stdev	2.7	6.5	5.7	4.8	8.0	0.13

that time-management is a critical skill for the productivity and response time of a scheduler, as it is the scheduler who decides in most cases what task deserves attention.

Indeed, table 7.2 shows that most interruptions were self-initiated. Exploring the personality factors and other determinants of self-interruptions may be important to recommend best recruiting and communication policies in the scheduling function. Most of these effects are framed negatively, and are labeled as switching costs by the cognitive systems community (Monsell, 2003).

Table 7.2 also shows that for an average of 84.5% of the triggers, the scheduler can decide when to start a task, counting all endogenous triggers and exogenous triggers of a non-forcible nature (via e-mail). For the schedulers involved in the study, it was counter-intuitive that in most occasions the scheduler can control his work-flow.

Table 7.3: Summary of the time spent on different roles

	Informational	Decisional	Monitoring	Transactional
Max	76.9%	53.8%	39.2%	19.7%
Min	23.1%	6.0%	2.2%	0.0%
Mean	50.5%	27.1%	10.6%	4.6%
Stdev	17.6%	14.6%	9.0%	5.3%

Another important result is that in the case studied, more time is spent on the information role than on the decision role, as shown in table 7.3. This result is important, as scheduling has been studied mainly from the point of view of the decision role. Similarly, most efforts for improving the scheduling function have been focused on the scheduling role itself. Underpinning the task model presented by Jackson et al. (2004) with quantitative data provides both academia and practice with the important finding that efforts to improve scheduling should include the informational role.

Table 7.4: Determinants of self-interruption: a mixed logit model

Variable[b]	Estimate	S.E.	Odds ratio[a]	
Intercept	-4.809	0.523	0.008	***
CATAR	0.819	0.237	2.268	***
Time Zone 2	-0.981	0.329	0.375	**
Time Zone 3	-1.665	0.397	0.189	***
Time Zone 4	-1.936	0.337	0.144	***
WIP	1.437	0.397	4.207	***
TimeLast	0.111	0.022	1.118	***
TaskDuration	-0.073	0.038	0.929	.

[a] Significance levels: *** p<0.001, ** p<0.01, * p<0.05, . p<0.1

[b] CATAR: trigger indicator, 1 if exogenous, 0 otherwise; Time Zone 2: 1 if 10:00-12:00, 0 otherwise; Time Zone 3: 1 if 13:00-15:00, 0 otherwise; Time Zone 4: 1 if 15:00-17:00, 0 otherwise; WIP: unfinished tasks; TimeLast: time elapsed since last interruption; TaskDuration: minutes.

7.3 Self-interruption determinants

Using the empirical data from the prior section, further analysis was conducted in two directions: identifying the determinants of self-interruptions; and evaluating the impact on the schedulers' performance. For analyzing self-interruption determinants, we construed the tendency to self-interrupt as the probability that a task that has started will be self-interrupted. This became the dependent variable to be explained in our analysis.

The main explanatory quantities of interest were: (*i*) the initiating cause of the task, i.e. exogenous or endogenous triggers; (*ii*) the time of the day represented by four time zones, 8:00–10:00 AM, 10:00 AM–12:00, 1:00–3:00pm, and 3:00–5:00pm; (*iii*) the number of tasks that were left unfinished before the start of a new task, i.e. work-in-progress (WIP); (*iv*) the time elapsed since the last interruption at the start of the task; and, (*v*) the total duration of the task.

To analyze whether the above-mentioned factors are related to the probability to self-interrupt the next task, a mixed logit model was used. A mixed model was used, because the data in our sample ($n = 1595$ entries) are clustered within scheduling days and schedulers, which violates the basic principle of independence that regular OLS (Ordinary Least Square) techniques have. At the same time, mixed modeling allows us to evaluate differences across schedulers.

Among the results in table 7.4, a notably significant effect is that the larger the work in progress, the higher the probability to self-interrupt. This is important as it means that self-interruption is a feed-forward phenomenon. This effect may be explained by the fact that unfinished tasks create thoughts that are potential triggers to self-interrupt again. Another important result from table 7.4 is that there is a significantly higher tendency to self-interrupt more when the tasks have been triggered exogenously than endogenously. Finally, it is noteworthy that the later in the day, the more the self-interruption tendency seems to be mitigated, which may reflect a desire to get things done towards the end of the day.

7.4 Interruptions and scheduler performance

To evaluate the influence of interruptions on schedulers' performance, we conducted a simulation study based on the work-flow model presented in figure 7.4 and the empirical data collected with the field study presented in section 7.2.

One important aspect modeled by the simulation is that it recognizes that for the scheduler to do his job, he needs to sense what is happening in the world. There are two ways in which he can do this; either by checking his e-mail or by checking the systems to monitor stocks and production orders. Critical events that need his reaction may be reflected in any of these ways. In the case of e-mail, the scheduler can rearrange his queue of tasks to attend first critical tasks. This also means that a scheduler has to balance two performance measures: (*i*) the response time to external requests that are communicated via e-mail; and, (*ii*) the response times to disruptive events that can only be perceived via the monitoring stocks and production orders systems.

Table 7.5 summarizes the data used as input for the simulation. The data were observed in the field study described in the prior section. A distinction has been made between characterizations of the scheduling environment and the scheduling behavior. For each scheduler, simulations were run to obtain two long-run average parameters: the response time to external requests via e-mail, and the response times to disruptions that can only be perceived via the monitoring stocks and production orders systems. Two key parameters were varied: (*i*) the probability that after finishing a given task, the scheduler will engage in checking his e-mail; and, (*ii*) the probability of engaging in a monitoring task after finishing a task. Both parameters are proxies for the frequency of e-mail checking and monitoring checking. By varying these two parameters, non-dominated solutions that generate an efficient frontier balancing both response times, were obtained.

Furthermore, the actual performance in terms of response times was compared with the efficient frontier as shown in figure 7.4. The deviance of the actual response times from the efficient frontier stems from two factors: the scheduler selects a non-optimal probability to check-email after finishing a task, and the scheduler actually self-interrupts a task. Simultaneously comparing these solutions, yields horizontal and vertical distances to the efficient frontier. These distances, or gaps, are available per scheduler, as illustrated in table 7.6. Whenever the simulation has unstable results that lead to infinite response times, the distances are marked as infinite.

Table 7.5: Simulation input summary

	1	2	3	4	5	6	7
Scheduling environmental parameters[a.]							
Mean time between arrivals of requests via e-mail	5.86	14.78	7.58	12.63	15.55	22.74	23.96
Mean time between arrivals of (no-email communicated) disruptions	524.00	480.35	750.00	192.14	480.36	510.35	740.00
Fixed duration of e-mail processing	1.00	2.00	1.50	2.50	2.00	2.50	3.00
Variable duration of e-mail processing (per request in e-mail checked)							0.90
Mean duration of request processing	3.75	7.35	3.89	5.65	8.13	7.79	7.73
Mean duration of (non-email) monitoring activity	8.41	16.00	7.96	15.50	6.60	6.50	7.88
Proportion of urgent requests overall requests	0.20	0.10	0.20	0.20	0.20	0.10	0.10
Behavioral parameters[b.]							
Probability of checking e-mail after a non e-mail task	0.69	0.21	0.67	0.23	0.15	0.47	0.46
Probability of engaging in monitoring activity after a non e-mail task	0.10	0.10	0.16	0.27	0.10	0.08	0.04
Probability of preempting a task for checking e-mail	0.25	0.26	0.33	0.21	0.13	0.03	0.25
Probability of preempting a task for a monitoring task	0.25	0.26	0.33	0.21	0.13	0.03	0.25
Probability of self-interrupting a task for switching a task	0.08	0.15	0.07	0.13	0.05	0.03	0.05

[a.] All scheduling parameters are measured in minutes, except the proportion of urgent requests
[b.] All behavioral parameters are probabilities

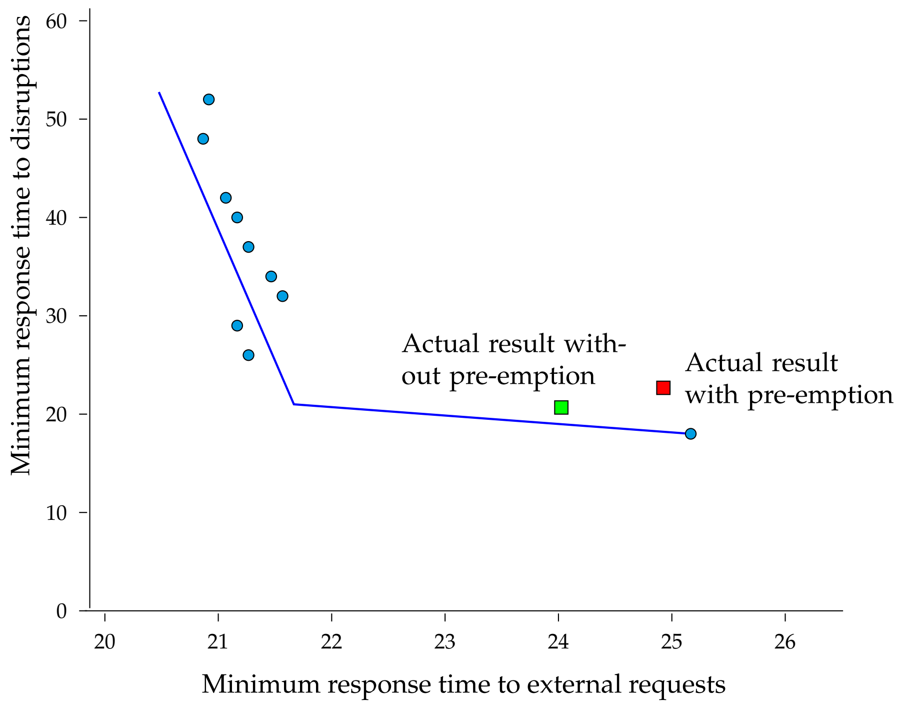

Figure 7.4: Efficient frontier of minimum response times to disruptions and to external requests

The distances observed in table 7.6 show that it tends to be more difficult to be close to the efficient frontier in the dimension of responsiveness to disruptions than in the dimension of response to external requests. The former entails a slower arrival process with more variability. Engaging in checking e-mail often implies marginal benefits for the response to urgent requests, but this must be traded-off with significant responsiveness to possible disruptions.

At the same time, table 7.7 shows that five out of seven schedulers checked e-mail more than needed for minimizing response time of urgent requests. Two had avoidable instability problems. They also engaged in the preemption of tasks (self-interruptions), which further decreases the multi-dimensional responsiveness performance. This, however, has a less important effect.

7.5 Managerial implications

The studies reviewed in this chapter demonstrate the importance of analyzing the time dimension of the scheduling job. First, because as any white-collar work, time is the main resource of a scheduler, and thus a basic factor to mea-

Table 7.6: Efficient frontier gaps in responsiveness

	Hypothetical without pre-emptions		Real with pre-emptions	
	GAP H e-mail	GAP V disruptive	GAP H e-mail	GAP V disruptive
Scheduler 1	Inf	Inf	Inf	Inf
Scheduler 2	4%	124%	5%	125%
Scheduler 3	Inf	Inf	Inf	Inf
Scheduler 4	1%	98%	1%	112%
Scheduler 5	9%	121%	9%	124%
Scheduler 6	6%	113%	6%	116%
Scheduler 7	14%	41%	19%	41%

'Inf' means that the system becomes unstable with actual behavioral parameters

Table 7.7: Deviations of optimal e-mail checking probabilities.

	Optimal e-mail checking prob	Actual e-mail checking prob	Deviation	Observation
Scheduler 1	0.6	0.7	+0.1	Unstable
Scheduler 2	0.2	0.2	+0.0	Stable
Scheduler 3	0.1	0.7	+0.6	Unstable
Scheduler 4	0.5	0.2	-0.3	Stable
Scheduler 5	0.5	0.2	-0.3	Stable
Scheduler 6	0.0	0.5	+0.5	Stable
Scheduler 7	0.0	0.5	+0.5	Stable

sure productivity. Second, the scheduling job by its own nature is time-critical and thus require timely-responses.

Contrary to general belief, the study showed that schedulers spend less time on decision making tasks and more time in distributing information. Managers of control towers should then question themselves what part of such information distribution tasks should be part of the job description, and if some of it could be automated or mitigated by more training. For example, users of the information delivered by schedulers, such as customer services, could be trained to find the information by themselves in an ERP-system.

One of the main messages is the need for managers to implement policies to mitigate self-interruptions. Self-interruptions have been shown in empirical studies to be significant and to affect the responsiveness of the scheduler. On top of this, the rate of self-interruptions has been shown to increase, as more tasks are left unfinished. However, towards the end of the day, there was a tendency to self-interrupt less. Hence, planning managers should avoid scheduling meetings towards the end of the day, as this seems to be the time that the schedulers are most productive.

Similarly, and more importantly, according to the simulation studies, the frequency of e-mail checking should be curtailed, as it can distract schedulers from reacting to other critical events that may be sensed only through other information systems. For example, a potential stock-out may be overlooked, because attention is paid to e-mail checking, as shown in the simulation study.

At the same time, in the recruitment of schedulers, special emphasis should be on time-management skills including the ability to reserve special times of the day for certain tasks and to regulate adequately their frequency to check their e-mails.

The simulation also showed the sensitivity of the time to respond to external tasks to the speed at which incoming requests arrive and the working rate of the schedulers. Hence, it may be useful to make a list of work in progress at the working day and monitor if the lists gets longer. If it is, then corrective measures, including increasing the number of schedulers may be considered.

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Chapter 8

Towards an Information Architecture to enable Cross-Chain Control Centers

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Cross-chain control centers (4C) have received increasing attention. Operating at the intersection of science and practice, Dutch logistics top institute Dinalog positioned the so-called 4C centrally in its research agenda. 4Cs could either be physical ('an overall supply chain cockpit'), fully virtual, or a mix of physical and virtual. However, their large scale implementation is hindered by several barriers including the lack of effective governance mechanisms, potentially conflicting goals, limited willingness to share data and unclear or ill-defined business models and gain-sharing mechanisms. Moreover, the lack of proper ICT support can be a key hindrance to the feasibility of a 4C. While ICT today offers many paradigms and technologies to support internal process automation or static business-to-business integration, the creation of a 4C requires far more advanced IT architectures. Current ERP systems are not fit to this task. Key requirements for ICT architectures in a collaborative setting are: (*i*) modularization of services, product, process services; (*ii*) coordination and collaboration capability; (*iii*) quick connect capability; (*iv*) relationship management capability; and (*v*) risk management capability. In this chapter, we describe these requirements and zoom in on ICT capabilities for swift business to business integration.

8.1 Inter-firm collaboration challenges traditional ICT support

Traditional ICT support for supply chain management has been limited to, often cumbersome, static horizontal and vertical integration of enterprise systems. The IT links established are usually limited to coordination and control at the operational level in the context of fixed collaboration patterns. This enables useful functionality, such as tracking and tracing of goods, exceptions and alerts in case of delays and so on. Already in 1966, Felix Kaufman published an article in Harvard Business Review that called for experiments with ICT that would cross organizational boundaries (Kaufman, 1966). Decades later, however, studies have shown that ICT can be both an enabler and a disabler to agile business networks. Enterprise systems integration projects may take years and huge investments to complete. Connecting legacy and ERP systems of various partners is technically highly complex. The resulting 'hard-wired' links often do not enable agile business networks that allow business partners to quickly connect their business processes.

Various authors have investigated this issue. For example, a Delphi study by Akkermans et al. (2003) revealed the following key limitations of ERP systems in providing effective supply chain management support: '(1) their insufficient extended enterprise functionality in crossing organizational boundaries; (2) their inflexibility to ever-changing supply chain needs, (3) their lack of functionality beyond managing transactions, and (4) their closed and non-modular system architecture'. In a more recent Delphi panel, Daniel and White (2005) investigate the potential of improved support of inter-organizational linkages by emerging ICT. Their findings suggest that 'ERP systems may be reaching a structural limit concerning their capabilities and adjunct technologies will be required to integrate multiple inter-organisational operations'. These include a combination of electronic hubs, web services, widespread adoption of common enterprise resource planning (ERP) systems and enterprise portals.

Van Hillegersberg et al. (2004) develop a typical virtual organization scenario using web services and conclude that the technology provides clear benefits: 'Webs ervices will truly allow straightforward B2B integration using standard and low-cost internet technology. This is a major advantage in enabling business networks, as small companies within these networks usually do not have the knowledge, time and money to implement traditional and complex enterprise integration technologies. (...) Network orchestration could be designed mostly separately from the various systems available in the business network'. However, the authors stress that the orchestration technologies may have scalability and security issues. Furthermore, to truly design a collaborative and intelligent network integration, contracting and collaboration tools are required as well.

Inflexible and cumbersome integration of ICT systems does not empower a true strategic 4C, in which flexibility is a key issue. Therefore, we focus on ICT support for agile business network integration. Such ICT platforms will enable a strategic 4C in which business services of 3PLs can be found in advanced registries, evaluated and seamlessly integrated and deployed into supply chains.

Our proposed ICT architecture departs from the traditional static ICT architectures and makes use of mechanisms that enable swift service integration. Such an ICT architecture enables the 4Cs concept at both the operational level, e.g. tracking, tracing, planning and execution, and at the tactic and strategic levels, e.g. business network formation, alliance building, service pricing and evaluations.

8.2 Requirements of an architecture to support 4C

Cross-chain control towers basically enable and facilitate inter-organizational relationships between actors in the supply chain. In general, inter-organizational relationships require careful governance. A comprehensive set of joint processes and practices is needed to achieve a successful sourcing relationship. We focus here on capabilities that are key to achieving agile business networks. Several capabilities of agile business networks have been described in literature: (*i*) modularization of services, product, process services; (*ii*) coordination and collaboration capability; (*iii*) quick connect capability; (*iv*) relationship management capability; and (*v*) risk management capability.

Modularization of services, product, process

Products and services offered, and the business processes supporting them, have a modular structure. Such a modular structure enables effective sourcing, coordination and integration of logistics services (Tanriverdi et al., 2007). Quality of the services can be precisely specified and assessed. Pricing schemes allow for price comparisons (Hoogeweegen et al., 1999).

Coordination and collaboration capability

Coordination and collaboration are key in agile business networks. As defined by Thompson (2011), coordination comprises the protocols, tasks and decision-making mechanisms designed to achieve concerted actions between interdependent units. Dekker (2004) outlines that both formal and informal control mechanisms can be applied to coordinate the inter-organizational relationship; see table 8.1.

Quick connect capability

Support integration and quick-connect and quick-disconnect capabilities to external partners include searching, contracting, monitoring and enacting services. These capabilities are needed from the business contract level to the tech-

Table 8.1: Formal and informal control mechanisms (source: Dekker, 2004)

Outcome control	Behavior control	Social control
	Ex-ante mechanisms	
Goal setting: incentive systems, reward structures	Structural specifications: planning, procedures, rules and regulations	Partner selection: trust, goodwill and capability, interaction, reputation, social networks
	Ex-post mechanisms	
Performance monitoring and rewarding	Behavior monitoring and rewarding	Trust building: risk taking, joint decision making, problem solving, partner development

nical infrastructure level (Goldman et al., 1995; Konsynski and Tiwana, 2005; Van Heck and Vervest, 2007).

Relationship management capability
In agile networks, there is little time to build subjective loyalty between network partners. Therefore, according to Mowshowitz (1997) there is only room for 'objective loyalty that is based on reasoned self-interest'. Trust cannot be based on long term relationships and past performance either. Therefore, agile business networks need to find alternative mechanisms to ensure trust and loyalty. Aziz and Van Hillegersberg (2010) point out that capabilities such as high quality and formal communications between partners, adaptation of processes, and conflict resolution to higher performance in an inter-organisational relationship.

Risk management capability
The dynamically formed reciprocal relationships in agile business networks often do not have a stable history. Both at an organizational and technical levels building networked relationships are high risk activities (Kumar and Van Dissel, 1996). At both technical and organizational levels semantic misunderstandings easily occur. The lack of high quality semantic standards in many industries increases this risk (Folmer et al., 2011).

8.3 An integration architecture to enable 4C

In this section we focus on two requirements for the ICT architecture to support 4C: (*i*) coordination and collaboration capability; and (*ii*) quick connect capability. Traditionally, closed and proprietary IT systems have hindered effective collaboration between business partners (horizontal collaboration) and between suppliers and customers (vertical collaboration). Recently, standard API-based integration has emerged in other areas, such as social media, e.g Twitter, LinkedIn, Facebook, as a rapid way to integrate services crossing inter-organizational boundaries. APIs also serve as a basis for new innovative initiatives. For instance, we see the phenomenon that businesses give to the consumer or user a so called application-programming interface (API). This is a set of routines and protocols, so that programmers can write applications using information from the business services, e.g. Twitter API – querying a certain hash key via programmable routines instead of using the mobile app by hand. In practice, the adoption of business-to-consumer applications appears to be comparatively easy due to the extra functionality of using the offered services. Therefore, there is more space for innovation, e.g. connecting Twitter with Facebook, and LinkedIn and doing data analysis. APIs seem to be much more than a technical issue. Still, research into their nature and impact is very scarce. Here, we illustrate how APIs can contribute to rapid and successful innovation use. We illustrate how setting up collaboration through joint API design can facilitate information sharing agreements among supply chain partners and enable effective 4C.

A case study will be presented of two logistic service providers (LSP) that are willing to collaborate instead of compete with each other. In practice, setting up a horizontal collaboration appears to be challenging (Cruijssen et al., 2006). Still, nearly 70% of LSPs in the Benelux indicate that they have either implemented horizontal collaboration or plan to do so within the next four to five years (Muir, 2010).

8.4 Ecosystem enabling supply chain collaboration

In optimizing supply chains, sharing data and information should be actively supported. A virtual ecosystem, in which each organization uses procedures, rules, and standards for sharing information, could provide a solution to these challenges.

The virtual ecosystem supports cross-chain collaboration in the transportation of containers and products, see figure 8.1. It is possible for one or more containers to create a digital shadow that virtually categorizes relevant information. This virtual container uses an e-dossier, which contains the characteristics of the load, the location, but also the limitations or boundaries of the cargo, such as the requirement to maintain constant temperature and humidity. Supply chain partners are allowed to access the data, depending on their access rights in the dossier or certain parts of the dossier. This digital shadow can also be used for trucks and ships. This means that organizations have the control

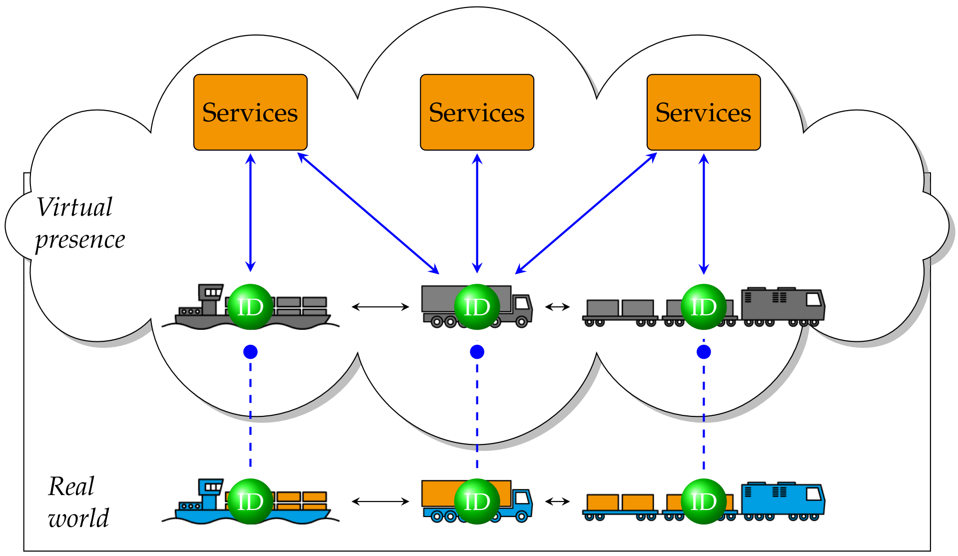

Figure 8.1: Virtual ecosystems

of who may view or access their data, while preventing their information from falling into the wrong hands.

An advantage of this entity-centric approach is that it is about controlling physical freight flows instead of focusing on all kind of processes. By organizing information in a smarter way, there is only one version of the 'truth' about the status of the container, truck or ship. Organizations can themselves subscribe to and unsubscribe from a digital shadow, whereby the owner of the data can give this organization access or not. This stands in contrast to current information sharing mechanisms, in which many organizations manage the same order, but the data is redundant and inaccurate. Companies have the ability of sharing crucial information through the ecosystem. This information can be used to make better decisions in optimizing the supply chain. For example, when it comes to truck utilization and CO2 reduction across organizational boundaries.

In the Netherlands, LSPs search for opportunities to collaborate with each other. The main reason for collaboration is to achieve higher sustainability and increased profit margins. In practice, this means that LSPs can reduce empty trips, improve vehicle utilization, lower handling time and costs, and increase on-time performance, so there is less waiting time by the truck drivers. Figure 8.2 gives an illustration of horizontal collaboration, where normally LSP A is executing its own trip, and the same for LSP B. By combining these trips, less kilometers are necessary and the truck utilization will be increased.

LSPs have gained functionality over the years, besides transporting orders. The two companies offer services, like warehousing (management), vendor-managed inventory (VMI) and outsource orders to charters. The core function

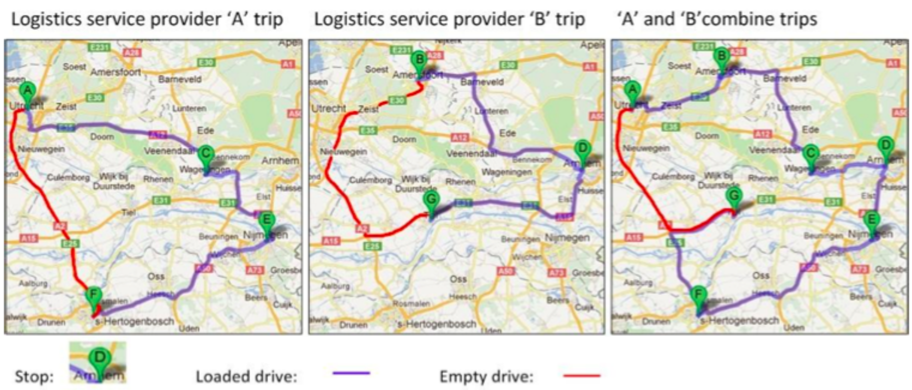

Figure 8.2: Single LSPs and horizontal collaboration

of an LSP is planning orders into trips and executing these trips in the most efficient and effective way, while respecting the quality of service.

We studied an effort of the two LSPs to start a collaboration using control towers concepts. Due to the complexity and the organization having cold feet about horizontal collaboration, the companies started with setting up a foundation, so information could be exchanged based on trust and commitment. In the design, there was a particular challenge caused by anti-trust regulation, which does not allow to directly share information, such as prices, between competitors.

The first step towards horizontal collaboration the LSPs initiated was to jointly plan transportation. Collaborative planning is a flexible, complex process, because orders have to be translated into a trip. A single trip can consist multiple orders. When orders are executed at day X, the intake takes place at day $X-1$, $X-2$ or before that period, where $X-1$ refers to the execution day minus 1 day. Collaborative planning will have a big impact on the planning process of both organizations, because trips are set up in the warehouse for a truck driver one day before execution ($X-1$). During day $X-1$, both companies need to upload their data to the platform. The planning algorithm will plan the trips at $X-1$, and at twelve o'clock both organizations need to give an acknowledgment about the new trip planning. This requires a collaborative planning-platform. This platform has to be able to import trips from both organizations. All trips will be incorporated into a new, overall transportation plan. Where trips are shared, organizations become more efficient and effective.

We identified the following four main functionalities for this platform: (*i*) trip and equipment intake; (*ii*) input data checker; (*iii*) collaborative trip planning; and (*iv*) sharing the collaborative trip planning. Trip and equipment intake means that the system must be able to import trips and equipment such as trucks and drivers from both organizations. Each organization should provide the data to the system. Due to cartel agreements, it is not allowed to share data among each other. The system must be able to handle data in a secure and confidential manner. Input data checking is needed as all the data should checked on completeness and errors. Otherwise the planning algorithm will use the wrong input. Collaborative trip planning means that the system must be able to produce a combined trip planning where all trips are assigned to a truck and driver. Sharing the collaborative trip planning indicates that the system must be able to export the new trip planning where each company receives its own trip planning. It is not allowed for both organizations to see the whole trip planning. In practice, organization *A* sees its own trip planning, including its own trips and the newly shared trips from organization *B*.

In addition to the functional requirements, several non-functional requirements apply: (*i*) extensibility; (*ii*) scalability; and (*iii*) security. First, the system must be extensible, i.e. adding new features should be possible. At present, trips are shared among the partners via this system. But in the future, it is desired to share orders instead of trips. The system should be capable of adding new or improved planning algorithms when available. Second, the system should be scalable in the sense that multiple partners can join the platform, and that the planning algorithm can handle big chunks of data. Third, the system must be secure in a way that data is encrypted. Organizations that have access to the platform are not allowed to see each others data, except the exchanged trips.

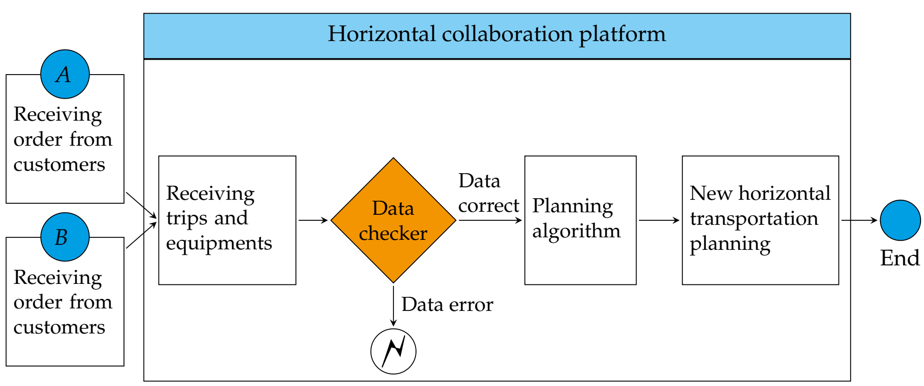

Figure 8.3: Process overview of the horizontal collaboration platform

Planning algorithms need certain parameters to plan. These parameters have been designed using knowledge from different planning departments. Figure 8.3 gives an overview of offering data to the platform and creating a planning. The outcome, a planning, must be incorporated in the existing transport managements systems (TMS) or advanced planning systems (APS) of both companies. Currently, both companies use different systems. We have investigated how to return the planning back to the IT systems of both organizations. We found that both systems were not able to import trips back into the system. The current functionality of the local systems can handle orders as input data, but not a complete trip planning. Furthermore, the local systems were not able to import trucks and driver data linked to a trip. Besides these challenges, all data have to be input manually. At present, there is no interface for automatic input. An important lesson learned by all participants is that the current IT system lacks functionality to achieve the benefits of flexible horizontal integration.

8.5 API-based integration

A main challenge of the new system, or platform, is its extensibility. This is due to the form of collaboration, where both companies have cold feet and a lack of knowledge about the new processes and required tools. Therefore, the platform needs to provide functionality and information in an agile, flexible manner. This can be realized via APIs. Further enabling of supply chain innovation can only be done via non-functional requirements.

At this point, the platform should provide the following POST routines, where POST stands for sending data to the horizontal collaboration platform: (*i*) available equipment; (*ii*) location information; (*iii*) trips for a specific date; and (*iv*) acknowledgments of transfers. Likewise, the following GET routines are supported, which facilitate the retrieval of information about: (*i*) trip planning including assigned equipment; and (*ii*) location information about incoming trips of the other organization. Details are in table 8.2.

By setting up an API, the participating LSPs were forced to think differently. People were mainly thinking in existing processes for transportation planning. Creating an API is all about thinking what information is important for the platform, and the other way around. It was an eye-opener for the participating planners that they had to think about services, and about the information needed to set up collaborative transportation services.

Via an iterative approach and added functionality, supply chain collaboration could be enhanced. The people involved were not aware of the complexity of combining two similar processes into a single overall process. Using an agile design approach helped people to change behavior and be aware of how IT can support collaboration. Current and future supply chains will change and the business networks should become more agile. They have to be able to add or remove existing functionality, e.g. changing trips or orders among partners within an ecosystem.

It is all about connectivity in a flexible and secure manner and about connecting organizations who are willing to collaborate. Connectivity is the main precondition for cooperation and collaboration between organizations. In practice, this appears to be difficult. The discussion goes beyond lack of functionality of IT systems. For example, the interpretation of data is also key. Organizations that want to collaborate should be aware of how to present their data. Plain examples are the precise definitions of an order, the size of the pallet – Chep or EURO, and the expected time of arrival (ETA), as the time that an order arrives at the location or that it is unloaded. Other examples relate to

Table 8.2: Basic functionality of the horizontal collaboration platform

POST

- CP1.0/vehicles_drivers_by_date: available equipment
- CP1.0/locations: location information, required by the organization who will execute the trip
- CP1.0/trips_by_date: send trips for a specific date, e.g. execution date X
- CP1.0/trips_acceptance: give an acknowledgment, formal check – auditable

GET

- CP1.0/planning_trips_by_date: trip planning included assigned equipment for execution date X.
- CP1.0/plannings_locations_by_date: retrieve location information for execution date X, this is only required for the incoming trips of the other organization.

the accessibility of data, the formatting of the data, and the authorization of the data usage. A final example concerns the organization of the data, the frequency of data backups, and the storage of the data for later use.

8.6 Conclusions

There is a need for coordination in supply chains and 4C is a promising concept in this respect. However, current IT systems are not suitable to enable 4C effectively. We know that IT investments are often lost, as creating a 4C on top of current legacy systems and methods is challenging. Key requirements for the ICT architecture are support for: (*i*) modularization of services, product, process services; (*ii*) coordination and collaboration capability; (*iii*) quick connect capability; (*iv*) relationship management capability; and (*v*) risk management capability. In this chapter we focused on the second and third requirements by illustrating how APIs can be used for faster and more controlled integration.

Future IT systems or platforms can support APIs to achieve more flexibility and extendability. Using APIs will help organizations to implement their information needs for their own process, instead of building hard to maintain point-to-point interfaces. We have seen that there is no silver bullet for collaborative planning. Here, we only discussed trip planning. However, the system should also be able to plan orders, or to start to re-plan at day X, for example. This will require more flexibility of the current IT infrastructure. The future supply chain processes will become more agile, and by using APIs this can be a first step in becoming more flexible

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This edited book is the culmination of almost five years of industry-university collaboration in the context of Cross-Chain Collaboration Centers, funded by Dinalog's 4C4More program. In this book, the researchers in the 4C4More program jointly explore what Cross-Chain Collaboration Centers (4C) in the Fast-Moving Consumer Goods supply chain look like and how they create value for all companies participating in the collaboration.

We combine insights from strategy, finance, operations research, and ICT domains to provide a broad account of Cross-Chain Collaboration Centers. **Ton de Kok** (TU/e) explains the origin and application of Cross-Chain Collaboration in detail. **Robbert Janssen** (VU, TNO) and his co-authors develop business models that enable collaboration between the different actors in the supply chain. **Kasper van der Vliet** (TU/e) and his co-author discuss supply chain finance concepts that can lower the cost of capital for collaborating companies. **Clint Pennings** (RSM) and his co-author discuss the benefits of collaborative forecasting, emphasizing the need to include behavioral aspects of collaboration. **Sjoerd van der Spoel** (UT) applies predictive analytics for forecasting showing how currently available transactional data on quantity, quality and location enables more effective collaboration in supply chains. **José Larco** (TU/e) and his co-authors discuss the nature of planning and scheduling jobs in control towers, which is quite important for effective implementation of 4C concepts. Finally, **Simon Dalmolen** (UT) and his co-authors translate the 4C concept into intercompany ICT requirements and information architecture.

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