4C4more R&D: Project Plan

Summary

Introduction

The R&D project 4C4more addresses one of the three main themes of the Innovation Program Logistics and Supply Chains: Cross Chain Control Centers, in short 4C. The key idea behind 4C is to create economies of scale and scope through inter- and intra-supply-chain collaboration. Economies of scale refer to more efficient use of scarce physical resources and materials, whereas economies of scope refer to more effective use of scarce human resources. Creating such economies of scale and scope boosts profitability of companies involved in 4C activities, while more efficient use of scarce resources and materials contributes to a sustainable planet. It is our vision that 4C activities are essential for coping with ever more demanding customers, ever complex product offerings to the market and ever more complex manufacturing and distribution networks.

The idea of inter- and intra-supply-chain collaboration is not new, but effective and sustainable forms of such collaboration are scarce. This is mainly for two reasons: sharing benefits of collaboration in a fair way is far from trivial, and operational collaboration requires sharing very sensitive data about sales and orders. We start from the conjecture that 4C activities are orchestrated by legally independent companies that provide these activities as a service to the participating companies. This implies that our research should lead to knowledge that can be exploited by new businesses that create high-skill work.

Work Packages (synonym in this proposal for Activites)

Cross Chain Control Centers can be established for multiple types of services. Clearly, transportation and warehousing services can benefit from more volume to be serviced. We intend to set-up demo projects for these services that are closely linked to our research project, i.e. with the same partner companies. Within scope of our research project is the careful study of the process of developing the business models, finance structures and associated ICT in the work packages (WP) Business Models, Finance and ICT. Thus, these three WP's will be closely linked to the demo projects we intend to set-up with the same partners. In WP Finance, WP Forecasting and WP Planner Productivity we develop (part of) the content of the service. The WP Finance focuses on the leverage created by a 4C service to mitigate risk and thereby the reduction of the cost of investments. Alternative models and methods will be developed and tested in both the modeling environment and the 4C demo environments. Forecasting is a process that relies on both historical demand data and market intelligence. In both aspects we conjecture that having data from multiple companies enables more accurate forecasts. In WP Forecasting we develop new forecasting methods based on appropriate demand models. We exploit both econometric modeling and agent-based modeling. The latter directly represents the nature of cross chain collaboration, i.e. multiple independent companies collaborating to reap benefits for themselves. In WP Planner Productivity we focus on productivity of planners and schedulers. To date no formal measurements exist to determine productivity. As measurement precedes understanding, we first develop the measurement principles and tools needed. Based on measurements on different planners in different, yet through our measurement framework, comparable 4C situations, we develop a conceptual model and associated directions for best practices to enhance planner productivity in later projects. Given the complex nature of the subject we have chosen to appoint a postdoc on this WP and substantial involvement of senior research faculty.

The WP Business Models and WP ICT intend to fill gaps in existing knowledge due to the fact that knowledge on Business Models, and to a large extent for ICT as well, has been developed from a single company's perspective. The WP Business Models uses the case study method to develop the required knowledge as appropriate given the complexity of the situation at hand. As stated above, we use the demo projects as case material. Similarly, the WP ICT uses the design research methodology, i.e. prototyping, to answer a comprehensive set of ICT related research questions. In the WP ICT we can extensively exploit the state-of-the-art BPM tools developed by Cordys as well as the knowledge software developed by ITUDE.

The WP Forecasting will be strongly linked to the demo project with Unilever as the lead company. The software of Cordys is used to develop the tools. The WP Finance project will be linked to the demo project with ING as the lead company.

The WP MSc student pool is a key enabler of both research and demo projects (albeit outside the scope of this research project). Under supervision of the researchers involved in the PhD and postdoc projects and other university faculty, these students perform literature research, in-depth case studies, modeling with the tools provided by the ICT companies and implementation of the knowledge developed. Each MSc project consists of half a year preparatory work (one day a week) and half a year full-time, partly at the host company, partly at Dinalog. Each company hosts two students per year, so that a student is permanently available. In order to coordinate the MSc projects as they are supporting the research projects and link research projects to demo projects (to be defined), we have a separate work package Student Pool. To ensure dissemination of the project results we explicitely have a work package on Knowledge Dissemination. Furthermore, we carefully developed the valorization process.

Goals

The research should yield more efficient transport and warehousing processes (WP Business models, WP Planner Productivity, WP Forecasting, WP ICT), and thereby lower costs, lower usage of scarce resources and lower emissions. The project also leads to more effective use of human and physical resources (WP Planner Productivity, WP Forecasting). Furthermore the WP Finance yields a substantial capital cost reduction. In total we expect a short-term revenue improvement of 10% for the companies involved, both shippers and service providers, 25% reduction in emissions in transport, and 100 new jobs created on the supply chain campus, of which 50% did not exist before the project. Our valorization strategy thus is based on attracting more added value towards the campus from companies involved in the project thereby also targeting for 8 new companies (start-ups) resulting from actively stimulating the 40 MSc students from the MSc student pool to start 4C activities.
Through our concept of a student pool of about 40 students the project also contributes to the development of human capital in logistics and supply chain management. We also aim at active involvement of SME's in our research (ITUDE is already a project participant) and we expect more involvement of SME's when demonstration projects are started.

A.Orientation and Project Goals

Motivation

The 4C4More project is initiated by Unilever and Kuehne & Nagel as a direct consequence of their involvement of the 4C concept as described in the “Rapport Commissie Van Laarhoven”. It is clear that in order to make the step towards € 10 B of GDP contribution by supply chain control and logistics, The Netherlands should offer supply chain talent and innovative concepts and tools to multinational companies. In essence we need to create new business as well as attract existing supply chain control companies. (Note: these companies are now primarily in Switzerland and Poland for tax reasons and lower wages, respectively). Our research project contributes to the establishment of 4C business with respect to its ICT infrastructure, its service content and its organizational set-up.

Relation to Dinalog innovation themes

As stated above the research in 4C4More is one-to-one related to the focus area Cross Chain Control Centers.

Objectives and goals

1) The project contributes substantially to the development of scientific knowledge in various scientific domains, ranging from operations management, computer science to labor psychology and enterprise law.
2) The project should yield more efficient transport and warehousing processes (WP Business models, WP Planner Productivity, WP Forecasting, WP ICT), and thereby lower costs, lower usage of scarce resources and lower emissions.
3) The project leads to more effective use of human and physical resources (WP Planner Productivity, WP Forecasting) as well as substantial capital cost reduction. In total we expect a short-term revenue improvement of 10% for the companies involved, both shippers and service providers, 25% reduction in emissions in transport, and 250 new jobs created on the supply chain campus, of which 50% did not exist before the project.
4) The project targets for 8 new companies (start-ups) resulting from actively stimulating the 40 MSc students from the MSc student pool to start 4C activities.
5) Through our concept of a student pool of about 40 students the project also contributes to the development of human capital in logistics and supply chain management.
6) We also aim at active involvement of SME’s in our research (ITUDE is already a project participant) and we expect more involvement of SME’s when demo projects are started.

We have summarized the above in the table on the next page.

Expected results

	Specific	Measurable	Acceptable	Realistic	Timing
4C	Knowledge on forecasting, planning, finance, business models and ICT infrastructure and support tools	At least 8 new companies and 250 new jobs		The new company goal assumes strong support from Dinalog and university staff	Start-ups created from 2 years onwards, as students graduate and start businesses with support of Dinalog. The 250 jobs are realized by 2015
Human Capital	Pool of MSc students developing and acquiring 4C skills	≥ 40 supply 4C workers	This number of highly skilled workers can easily be absorbed by industry; yet we focus on 4C roles	The MSc supervision team is very experienced and has deliverer hipo's in logistics and SCM over 20 years	Every year 8 students become available, starting from 2011
Sustainability	Less energy usage and emissions due to less trucks; less waste due to less rework	25 % less trucks doing the same volume	This is an ambitious goal	The ambition is based on the tacit knowledge of innovative logistics service providers	Assuming a demo project starts by the end of 2010 we expect the first results by 2012 and the objective is met in 2014..
Accessibility	Less congestion leads to better accessibility	Hard to measure as congestion is a contingency phenomenon. We refer to sustainability goal	Sustainability	See sustainability	
SME Involvement	ITUDE and future SME	At least 5 SME companies involved	We build on the foreseen demo projects linked to 4C4more to get more SME involved	The companies involved are committed to get demo projects started as they see a more immediate impact thereof	2 SME's from the kick off and at least 3 more in 2012
Science	Publications in scientific journals	≥ 25 scientific papers of which 5 in top journals	Given the practical orientation, we cannot aimed at much more	The faculty involved has shown its capability to get industry-driven research in top journals and others	Given the time lags between submission and publication, we expect the first papers in scientific journals in 2013 and top journal publications in 2014.

Relation to government policy

All the objectives of the project strongly support government policy, not in the last place The Netherlands being the leading supply chain country in the world.

Orientation

In the work packages below, the innovativeness of the research is described in detail. Each project is embedded into existing literature, so that the contribution to the state-of-the-art in the scientific domain of interest can be stipulated.

Researchers in the consortium have participated in earlier public-private collaboration projects such as KLICT and Transumo. In these projects some ground work has been done under the heading of supply chain synchronization. The focus in these projects was primarily on planning concepts and implementation at individual companies, primarily. No attention has been paid to business models, which may have been a reason why some projects with the aim to implement supply chain collaboration, have not resulted in sustainable relationships. The principal applicant was involved in a

intra-supply-chain collaboration project at Philips Semiconductors and their customers and customers' customers, showing the sustainability of the approach developed for more than five years and with a great financial impact (7% of revenue additional profit contribution due to far more effective control than before). With our focus on business models, the 4C concept sold as a service, three research projects aimed at developing 4C service content and one on ICT as enabler, we expect to remove obstructions that have been faced in earlier research.

Another reason why we expect to be successful is that all researchers belief in industry-driven research. The groups from EUR, UT and TUE have a strong track-record on publishing practically relevant research in top journals. Unilever and Kuehne & Nagel can be seen as industry champions of the 4C concept, if not the inventors.

B.Activities and Work Packages

R&D project 4C4more		
Phase 1: Research and Development	Activity 1: PhD project 4C business models	4 years
	Activity 2: PhD project 4C forecasting	4 years
	Activity 3: PhD project 4C finance	4 years
	Activity 4: PhD project ICT for 4C	4 years
	Activity 5: Postdoc project 4C planner productivity	2 years
	Activity 6: MSc student pool	4 years
Phase 2: Implementation and Dissemination	Activity 7: Implementation and knowledge dissemination	2 years
Deliverables/ Milestones:	Papers in scientific journals, conference contributions; PhD theses; workshops and presentations for practitioners; new companies; new jobs; 4C professionals	

Activity 1: 4C business models
Description: **Title of research proposal** "Developing joint business models for 4C's" Research question: which joint business models are suitable for 4C cooperation in logistics? What are the characteristics of these joint business models and what development methods can be used to generate successful joint business models? **1.2 Abstract** In this proposal the central research questions is formulated as follows: 'Which joint business models are suitable for 4C cooperation in logistics?' and 'What are the characteristics of these joint business models and what development methods can be used to generate successful joint business models for a 4C?' A business model should outline how a business enterprise delivers value, considering the revenues, costs and profits. Business models can contribute to the understanding of the business logic of a firm. Most business model literature focuses on only one focal company and does usually not describe the business models of collaboration or alliances, let alone of a 4C. In this research we use the existing literature to see if the existing business model elements could be used for 'joint business models' as well. Extra elements on collaboration, such as gain sharing, risk sharing, investment sharing, profit sharing should be considered then as well. The legal construction

of the collaboration is another element that is not included in most business models for one focal company. Interestingly, the Dutch legislator is currently modernizing private company law and alternative entity law. In addition to studying joint business models in static situations, the dynamics of how to develop and evolve a joint business model over time are interesting as well. Developing business models across organizational boundaries involves a number of additional challenges over developing them inside one firm. This extends the business model literature with an interorganizational focus and it extends the literature on alliances and collaboration with a business model focus.

As our research topic aims to study both statics and dynamics and aims to build theory in the unexplored area of joint business modelling, we propose to follow the case study method. In the cross-case analyses different cases are compared in order to develop differentiated approaches to set up successful 4C. Next to extending the literature on business models, this research answers questions on how to set up a successful 4C in practice, considering different situations.

1.3 Research proposal

Business models: definition

A business model can be defined as the way an enterprise creates and delivers value to customers, and then converts payments received to profits (Teece, 2010). According to Teece (2010) a business model should outline how a business enterprise delivers value, considering the revenues, costs and profits. Figure 1 shows the elements that need to be determined in a business model design.

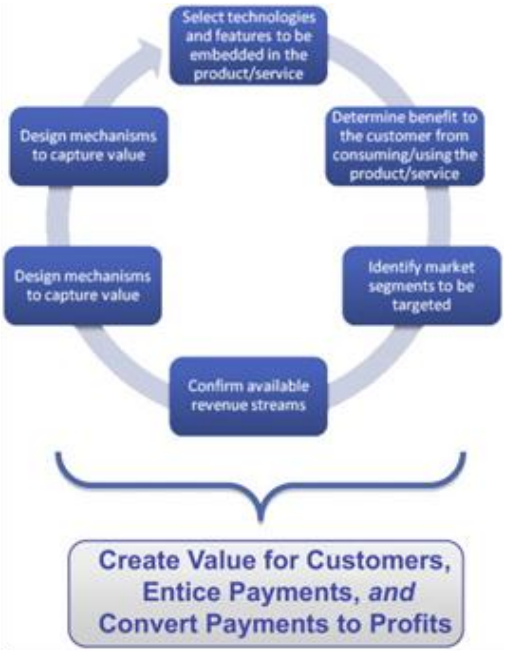

Figure 1 Elements of business model design (from Teece, 2010)

There are many different definitions in literature on business models. Based on an extensive literature research, Osterwald (2004) distinguishes four areas (including nine building blocks) that a business model must address. Chesbrough (2010) argues that this approach to construct maps of business models (see Figure 2) is useful to experiment with different business models.

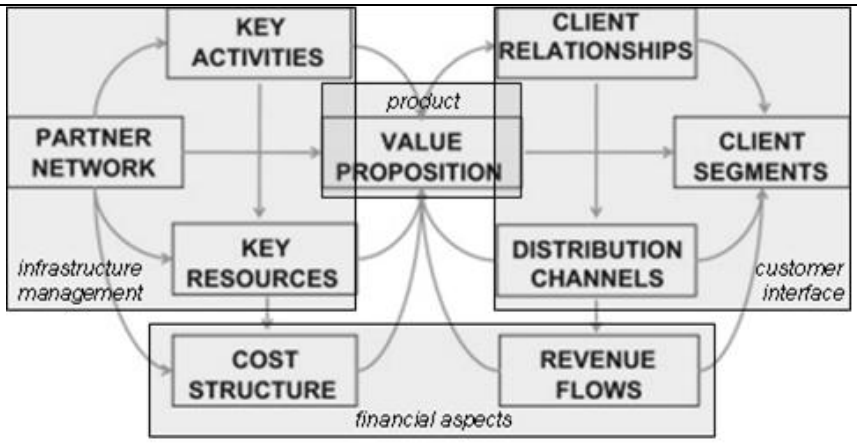

Figure 2 Osterwalder (2004)'s 9 point decomposition of a Business Model (Chesbrough, 2010)

The four areas that have to be considered in a business model are: product, customer interface, infrastructure management, and financial aspects. These areas are composed by the nine building blocks presented in Figure 2. The value proposition of a business model shows the overall view of a company's offered products and services that are of value to a customer. Osterwalder (2004) defines the client segment as the group of customers to whom the company aims to offer value. The distribution channel is the way the company gets in touch with its customers, the link between the company and the customer is described as client relationship. Figure 2's left-hand side shows the key activities (value configuration) which describe the activities and resources necessary to create value, the key resources (capability) which is the ability to execute a repeatable pattern of actions necessary to create value and the partner network which is defined as the "voluntarily initiated cooperative agreement between two or more companies in order to create value for the customer" (Osterwalder, 2004). Finally, at the bottom of Figure 2 there are two building blocks that describe the financial aspects of a business model; i.e. the cost structure that represents the money of all means in the business model and the revenue flows that represent the way the company makes money through a variety of revenue flows. Osterwalder's building blocks show the relevant parts that have to be considered in developing and comparing business models, as well as their relations.

Literature on business models

The previous section discussed elements to design business models. Next, we discuss the use of business models in literature. Usually, the business model literature focuses on only one focal company. Business models are usually not used to describe collaboration or alliances. This does not imply that the world external to this focal company is not considered; see e.g. the partner network or clients in Figure 2. The different business model's elements are usually seen from the focal company, but these could be used for 'joint business models' as well. Extra elements on collaboration gain sharing, risk sharing, investment sharing, profit sharing should be considered then as well. The legal construction of the collaboration is another element that is not included in most business models for one focal company, neither as other typical cooperation issues such as an entry strategy for new entrants and an exit strategy to leave the collaboration (see Van der Ham et al. 2006; Vos et al. 2002). Examples of this use of business models are found in Osterwalder (2004). The use of business models is a relative young research domain and therefore business models are not widely used in academia yet (Osterwalder, 2004), but the use is recently increasing (see McGrath, 2010). Business models can be used for several functions. Business models can contribute to the understanding of the business logic of a firm. This implies that business models can be helpful in capturing, visualizing, understanding, communicating and sharing the logic behind a business. Next, a business model can be used to analyze the logic of a business, e.g. these models can improve the way business logic is measured, observed and compared. Business models can also improve the management of the business logic of a firm; the models make it possible to conceptualize (and then compare) the design, planning, changing and implementation of different ways to organize (new) ways of value creation and its business implications (based on Osterwalder, 2004).

Gaps in literature

The current literature on business models mainly considers business models internal to the firm. Joint business models have scarcely received attention, despite the fact that an increasing number of business models cross organizational boundaries. For example, the increase in alliances (Hagedoorn,

2002) shows that collaboration has become an integral part of modern business. This also means that joint business models are created. Some examples include the Philips-Sara Lee alliance around Senseo (De Man and Roijakkers, 2009), the RIB-NMA alliance (Dekker, 2004) and the Bayer-Millennium alliance (Ziegelbauer and Farquhar, 2004). Intriguingly, the cases mentioned are described in the literature, but there is limited attention for the way the business model is constructed. Instead the literature focuses on alliance governance, control in interorganiational arrangements and learning between partners, and hardly on the way value is created in the market place by innovative joint business models. The question whether joint business models are in anyway different from business models developed by individual organizations is not addressed.

This gap in the literature raises two questions. The first question is if there is anything specific to business models of an interorganizational nature. Do joint business models include other elements than those defined by Osterwalder (2004) or Chesbrough (2006)? Are some elements of joint business models more important than others? How are both partners incentivized in joint business models by gain sharing, risk sharing, investment sharing, profit sharing etc.? Is it more effective to 'split' business models between partners or to ensure that all partners are involved in all elements of the business model? These questions refer to the 'static' of joint business models: the way they look at one point in time. The answers to these questions will contribute to both the literature on business models and to the literature on alliances. The literature on business models may be extended to incorporate elements or guidelines for joint business models. Integrating business modeling in the alliance literature may among others shed more light on alliance stability (Das and Teng, 2000), as the choice for the right business model may increase alliance stability.

An additional issue in this regard is what may be termed business model fit. How does a collaborative business model fit with the business models of the individual partners. If for example one partner has a business model focusing on low cost, whereas the other partner focuses on customer intimacy, the business model of the alliance may not fit with one or both of the partners. As the incentives in the partners internally may diverge from what is optimal for the alliance, the alliance may be set up for failure. Is it necessary for a collaborative business model to work that both partners adapt their internal organization to that business model? What other solutions are possible when an alliance business model does not fit with one of the partners (e.g. set up a separate business unit around an alliance)?

In addition to studying joint business models in static situations, the dynamics of how to develop and evolve a joint business model over time are interesting as well. The process in which two or more partners develop new business models has not yet been studied. Who is involved in that process? What external factors shape joint business model development? To what extent is it possible to test new business models across organizational boundaries? How can the acceptance of business models across organizational boundaries be ensured? What processes and procedures are used in developing joint business models? And once the business model is in place: what happens when changes to the model affect partners differently? How do companies deal with that? In addition one may wonder whether there is a fixed process for developing business models or whether it is a more messy process or even one determined by luck and coincidence. Can we find commonalities in the development process of collaborative business models? Or is it highly alliance specific? Are there certain steps that are always applied? Is there a fixed order or not? If it is a matter of coincidence, than what are the implications for setting up new alliances?

These questions address a second gap in the literature. Developing business models across organizational boundaries involves a number of additional challenges over developing them inside one firm. It needs to incorporate the views and interests of several independent firms, requires sharing of information and knowledge which may be thought of as proprietary and requires bridging different company cultures. These elements may cause a different dynamic in the development process of a joint business model. Techniques to overcome barriers to joint business modeling and to avoid classic hold up and prisoner dilemma situations may need to be implemented to reach a satisfactory result. Again, the literature is silent as to how this may work.

Further to the above, questions arise as to the legal implications of cross-organizing business models. Typically, two organizations teaming up in one business will do so in the form of a joint-venture, often a private company with limited liability (Raaijmakers 1976). The two partners, who will provide the joint-venture with funding, know-how, labor etc., will have to make various choices when setting up their joint-venture vehicle (Van Duuren 2002). Important questions cover the nature of the vehicle,

also for tax purposes (legal entity or alternative entity?), the locus of the business and the function of the vehicle (e.g., one business in the vehicle?; the vehicle as holding, heading a group of sub-vehicles that run the various sub-businesses?), the corporate governance framework of the vehicle (e.g., who decides what and when?), the necessity of separate and additional contractual arrangements between the partners (e.g., anti-competition clauses) (Rensen 2005) and a solution framework for possible disagreement between the partners. Interestingly, the Dutch legislator is currently modernizing private company law (making it more flexible and less complex in its application) and alternative entity law.

In short, the theoretical contribution of this research project is its focus on the static and dynamic of joint business models, also incorporating relevant legal aspects of setting up joint ventures. This extends the business model literature with an interorganizational focus and it extends the literature on alliances and collaboration with a business model focus.

1.4 Approach

As our research topic aims to study both statics and dynamics and aims to build theory in the unexplored area of joint business modeling, we propose to follow the case study method as put forth by Eisenhardt (1989), see also Voss et al. (2002). Specifically the application of this method in dynamic situations (Ozcan and Eisenhardt, 2007) is a relevant example here. By tracing a number of cases over time the dynamics of joint business modeling may be analyzed.

We will follow an embedded multiple case design. The companies involved in the 4C4more project will set up a number of collaborations in a 4C context. Each collaboration will be one case study. This case study design allows for comparison within the firm context, which should enable us to find why variations in business models, including legal aspects, emerge within a similar organizational setting. By including a second focal firm, we will also be able to find variations across companies. The collection of multiple data ensured by a multi-case design is likely to yield more accurate and generalizable theory (Ozcan and Eisenhardt, 2007). As we aim to study cross chain collaboration in an early set up phase, we will also be able to trace the dynamics. Changes over time can be monitored real time, real life, avoiding any ex post facto rationalizations that may occur when interviews take place long after the fact.

The procedure we envision is to select the producer as focal company (e.g. Unilever). Next, with the focal company we will select potential partners for a 4C (e.g. Kuehne & Nagel or Hero). For this we will need to develop selection criteria following Douma (1997). This will involve finding partners with a strategic, operational and cultural fit with the focal company. Alternatively, if a company already has selected a partner before the involvement of the researchers, the relationship with that partner will be taken as point of departure. Next, we will study how the focal firm and the partner(s) set up of 4C alliance. By registering the process and steps they take to develop the business model for the alliance we gather our material.

The main source of information will be observation through involvement in the meetings between focal firm and partners and interviews for which a case study protocol will be developed. The interviews will be fully transcribed and analysed using a programme like Atlas or similar. Informants will be sought from all partners involved in a case and at different hierarchical levels in the organizations, in order to ensure that a variety of perspectives is covered. Triangulation of data can be had by making use not only of interviews, but by observation/participation in meetings and document study as well.

We expect data gathering to take place over a two year period. This period is necessary because it will on average take about one to 1.5 years to set up collaboration. The final half year of data collection will be directed at changes in the business model and at studying the success of the collaboration. Case study writing will start after all data are collected. This prevents that any emerging theorizing will start to influence the data collection process and hence avoids researcher bias. The case study write ups will be sent to respondents for verification. Case studies will be written on a case per case basis first, before cross-case analysis will take place.

The final phase of the project will be devoted to the cross-case analysis. Through coding of the interviews we can identify any steps, mechanisms, conflicts, idea generating mechanisms or other noteworthy points in and across cases. This involves confronting any emerging theory with the data and vice versa. These data could include answers to a range of questions of different scenarios and

various business cases, for example the overall cost savings, the value proposition for individual partners in a 4C, the organization criteria of different participants (e.g. maturity of processes or the professionalism of personnel), and the logistical criteria (e.g. the type and characteristics of combined good flows). This iterative process follows Eisenhardt (1989). We will first study the business model static in this way and next the dynamics. For the cross case analysis, models will be developed based on interview coding. Confrontation with the other data sources will lead to refinement of the model per case. Next the models per case will be confronted and major points of similarity and differences identified. Following Yin (1989), through replication logic we may find why models are similar or different across cases. Final interpretations may again be checked by respondents to enhance the validity of the findings.

The case study procedure could turn out as follows: first a producer is selected as focal company (e.g. Unilever). The idea is that the setting up of a 4C will be done in a related Dinalog demonstration project. Next, the partners in a 4C are selected (and criteria are developed, e.g. client locations, logistics processes, maturity of processes, culture etc.). This group of companies starts to setup of 4C (alliance), develops a business model and computes the savings in a business case and develops a juridical format. Another 4C demonstration project could be setup with the same approach with Logistics Service Provider as focal company (e.g. Kuehne & Nagel). In the cross-case analyses these different cases can be compared in order to develop differentiated approaches.

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Planning:
Start: 2010
Completion: 2014
The research trajectory will take four years. During the first year, interviews with legal experts will be held to gain a thorough understanding of the possible legal structures for a 4C, their advantages and drawbacks, their consequences for participating companies. Also, this period will be used to get a deep insight into the relevant literature and to develop specific research questions. During the second year, data sources will be explored and the empirical framework will be developed. Also, initial research results will be collected to set up an initial paper. Elaborating the research projects will continue throughout the third year, while part of the fourth year will be specifically devoted to writing the thesis. In the case of a PhD, the first two years will be used to attend courses on the relevant subjects.

Work distribution:
PhD student: to be determined
Researcher 1: prof. L. Hagdorn (VU Amsterdam)
Researcher 2: prof. A.P. de Man (VU Amsterdam)
Researcher 3: Prof. B. Assink (EUR)
Researcher 4: dr. H. Quak (TNO)

Expected results/deliverables/milestones:
Conference contributions (1 or 2 per year); journal articles (3), PhD thesis (1); workshops and presentations for practitioners.

Activity 2: 4C Forecasting

Description:

2.1 Title of research proposal
Assessing the gain of sharing demand forecasts in FMCG supply chains

2.2 Abstract

The value of sharing demand information is highly dependent on the forecast methods used and the representativeness of the forecasts for the actual ordering behavior. The objective of the presently proposed research is to empirically assess the value of sharing market demand information for decision making by manufacturers, suppliers and distributors in a fast moving consumer goods (FMCG) supply chain. The research project includes the development and evaluation of different forecasting methods, with a specific interest in auto regressive demand patterns and in dependencies among product categories sharing common resources. The latter will be particularly relevant for procurement decisions by manufacturers. Moreover, the application of multi-agent modeling will be considered to gain insight into the possibly distorting behavior of non-participating supply chain members as well as to simulate the effectiveness of different strategies to cope with observed and forecasted demand as well as order variations.

2.3 Research proposal
Forecasting demand provides important information for inventory control, ordering, and production and distribution planning throughout the supply chain. Retailers use this information as input for sales, inventory and order decisions, suppliers for production and procurement decisions, and distributors for capacity allocation decisions. However, errors in demand forecasts can have serious consequences for the optimality of upstream decision making and for the supply costs as a whole. This holds particularly for non-cooperative supply chains in which demand information is communicated indirectly through frequency and extent of order placement. In this respect, {Lee1997} introduced the notion of the bullwhip effect which refers to the tendency that the variation of orders observed by suppliers is larger than the variation in the demand experienced by the buyer. Moreover, they show that the resulting demand distortion is amplified when it is propagated upstream from retailer to distributor,

manufacturer and other suppliers. {Chen2000} show that the resulting costs can be significantly reduced when demand information is shared along members of the supply chain.

However, the value gain of sharing demand forecasts is highly dependent on the quality of the information and its representativeness of the behavior of supply chain participants. {Cachon2000} demonstrate that sharing demand forecasts may even have adverse effects when these forecasts reveal little or unrepresentative information of a buyer's behavior as reflected by the information already contained in the orders. Information about a retailer's demand is only informative when it actually triggers orders, and is not confounded with excessive retail inventories {Cachon2001}. Likewise, {Zhao2002} demonstrate that the value of demand forecasts depends on the forecasting methods employed and the tightness of capacity, in addition to demand patterns. As for the latter, {Aviv2001} presents a model that combines the joint information from orders received and demand forecasts with auto regressive behavior of the demand. In like spirit, {Raghunathan2007} demonstrates that the benefits of collaborative forecasting is more pronounced when the auto regressive behavior of demand can be exploited. In a previous paper, {Raghunathan2001} showed that the gain of collaborative forecasting is dependent on the participation of supply chain members in the information sharing effort.

In addition, the ability to accurately forecast consumer demand depends on the volatility and dynamics of consumer demand as well as on the retailer's capability to capture market share. In the highly dynamic settings of today's consumer markets, this ability to come up with accurate demand forecasts and statements about the optimal supply chain response is challenging. In such contexts, multi-agent modeling may be useful to assess the consequences of different forecasting methods for inventory control, ordering and production strategies, as advocated by {Huang2003}. A marked application of agents in supply chains is TAC/SCM, which mimics a three-layer supply chain for PC's, in which competing manufacturers (agents) have to make daily decisions about pricing, production and procurement in the face of uncertain demand and supply {Ketter}. The TAC/SCM has been successfully applied to evaluate different forecasting methods {Kiekintveld2009}.

The objective of the presently proposed research is to empirically assess the value of sharing market demand information for decision making by manufacturers, suppliers and distributors in a fast moving consumer goods (FMCG) supply chain. The research project includes the development and evaluation of different forecasting methods, with a specific interest in auto demand patterns and in dependencies among product categories sharing common resources. The latter will be particularly relevant for procurement decisions by manufacturers. Moreover, the application of multi-agent modeling will be considered to gain insight into the possibly distorting behavior of non-participating supply chain members as well as to simulate the effectiveness of different strategies to cope with observed and forecasted demand as well as order variations.

2.4 Approach

The research methods intended for this proposal are econometric time series models and agent-based modeling. Econometric time series models are applied to analyze the characteristics of market demand, and the joint behavior of market demand and retail orders. Agent-based modeling will be applied to evaluate the possibly distorting behavior of non-participating supply chain members and to evaluate the effectiveness of different strategies to handle variation in the observed and forecasted demand, and orders.

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Planning:
Start: 2010
Completion: 2014
The research trajectory will take four years. During the first year, interviews with stakeholders in the selected FMCG supply chain will be held to gain a thorough understanding of the peculiarities of market demand developments, order strategies, production and distribution schedules, behavioral responses to unexpected features of the shared forecast information. Also, this period will be used to get a deep insight into the relevant literature and to develop specific research questions. During the second year, data sources will be explored and the empirical framework will be developed. Also, initial research results will be collected to set up an initial paper. Elaborating the research projects will continue throughout the third year, while part of the fourth year will be specifically devoted to writing the thesis. In the case of a PhD, the first two years will used to attend courses on the relevant subjects (e.g., supply chain analysis, econometric modeling, agent-based systems).

Work distribution:
PhD student: to be determined
Researcher 1: prof. J. van Nunen
Researcher 2: prof. A.G. de Kok
Researcher 3: dr. J. van Dalen

Expected results/deliverables/milestones:
Conference contributions (1 or 2 per year); journal articles (3), PhD thesis (1); workshops and presentations for practitioners.

Activity 3: 4C Finance

Description:
3.1 Title of research proposal
Financial Benefits of Collaboration between Supply Chains

3.2 Abstract

Research and practice show that firms within a supply chain benefit by collaborating with each other, instead of competing as adversaries. We consider the following corollary: supply chains will benefit by collaborating, rather than competing. In particular, we explore the financial implications of a Cross-Chain Collaboration Center (4C). The 4C mechanism will improve cash flow conditions for participating firms, reduce informational asymmetries, and facilitate the implementation of advanced financing arrangements. We aim to provide a thorough characterization of these prospects, so that 4C partners can participate equitably in the mechanism and realize long-term economic benefits.

3.3 Research proposal
Supply chain management appears today to be a natural feature on the landscape of business research and practice. Less than two decades has elapsed, however, since Christopher (1992) predicted that future competition would take place between supply chains, rather than between individual firms. Developing the supply chain argument further, Christopher and Ryals (1999) explain

that firms can create more shareholder value by collaborating (both financially and operationally) in a supply chain, instead of competing individualistically. The logic of this argument leads inevitably to a hypothesis of contemporary importance: that supply chains themselves may create more shareholder value by working collaboratively, rather than competing against each other.

Christopher and Ryals (1999) discuss how supply chain strategies may be employed to enhance shareholder value using the analytical framework of Srivastava et al. (1998) which has originally developed to assess the impact of market-based assets on shareholder value creation. The key concept in this framework is free cash flow. The authors identify four possible cash effects that increase shareholder value:

(1) Acceleration of cash flows.
(2) Reduction in the volatility of cash flows.
(3) Increase of cash flows.
(4) Increase of residual value, i.e., the value of free cash flows beyond a given planning horizon.

We claim that each of these cash effects can be further enhanced by vertical and horizontal collaboration of supply chains. In addition, supply chain coordination and collaboration provide opportunities to reduce informational problems between the firms and the financial resource providers, and implement novel financing arrangements, such as reverse factoring. The realization of this potential requires, however, the existence of a more general entity: some sort of cross chain collaboration center (4C).

The precise nature of the 4C entity – whether it is real or just a virtual service available through an appropriate IT platform – is of secondary importance to the concept. In what follows, we explain how each of the cash flow effects that create shareholder value may arise in the 4C context. Our research will develop a rigorous quantitative framework to understand, evaluate and communicate the benefits of 4C from this perspective of shareholder value creation.

Through a series of related studies, we will explore the financial implications of 4C implementation from the perspective of each involved party. In order to motivate the need for this research and indicate the directions we expect it to follow, Section 3a below explains the underlying research problem in greater detail and states the resulting research questions. Section 3b then states our initial observations on each research question and describes the approaches that we expect to employ in conducting our investigations.

Research topic

Many specific operational configurations may be possible for the 4C concept, but consolidation of shipments is the fundamental aspect of any implementation. This consolidation means that the parallel transportation networks of multiple supply chains are effectively replaced by a single infrastructure. Such a system realizes a greater economy of scale than any individual supply chain, although the capital base of the 4C implementation is less than the combined capital base of a set of individual supply chains.

A consolidated transportation network yields savings in costs for each 4C participant. Savings are expected both in operating costs, such as personnel and transportation, and capital expenditures on supply chain infrastructure. In effect, the participants in the 4C concept outsource their supply chain requirements, but to an entity that is their own collaborative undertaking. Provided revenue is not reduced (in fact, it should increase, as we will discuss shortly), reduction in costs entails an increase in free cash flows for the 4C participants.

Many other potential benefits are available, since a 4C implementation should in fact entail pooling of goods and information at each point in the consolidated network. Indeed, under the 4C concept, the availability of any specific good at any point in the (consolidated) supply chain should be as great as or greater than what it would be without the 4C concept. Likewise, the supply chain information available to any 4C participant should be as great as or greater than the information without the 4C concept. These increases of goods and information are realized through greater capacity and efficiency of the physical and informational systems. Increased capacity, efficiency, and the concomitant pooling of goods and information within these systems are the factors that enable 4C participants to realize all of the cash flow benefits identified in the framework of Srivastava et al.

(1998), rather than simply reduction of costs.

The 4C concept promises to accelerate cash flows and further reduce costs by mitigating the effects of demand uncertainty. The need to reconcile order quantities with unknown future demand is fundamental problem for businesses, and one that the length of supply chains tends to exacerbate. It is difficult and costly to accelerate the delivery of new goods when demand unexpectedly increases, and similarly problematic to retard pre-existing orders when demand proves to be less than expected. With the pooling of goods and information that is essential to the 4C concept, decisions about quantities and destinations can be delayed until goods are closer to the final market. The 4C can rapidly reconfigure transportation schedules, diverting goods away from destinations with lower demand and toward destinations with greater demand. When faced with a global increase in demand, the scale of the consolidated supply chain means that it is better able to respond. Customers will experience a higher service level, and this entails an acceleration of cash flows, since fewer customers will be forced to delay purchases because of stock-outs. Conversely, if faced with a global reduction in demand, the cost of storing excess inventory is less under the 4C concept that it would be for multiple individual supply chains.

Increased responsiveness to customer demand in the 4C context also reduces the severity of the bullwhip effect, whereby the variability in demand of the final market is amplified further back in the supply chain. These amplifications translate into greater variability of cash flows. While the 4C framework can do little to reduce underlying demand uncertainty, it can minimize the effect of this uncertainty on the cash flow of supply chain participants. Less volatile cash flows are preferable to firms since they enhance shareholder value through reducing the expected financial distress costs and tax payments (Smith and Stulz, 1985, Froot et. al., 1993).

Notwithstanding the immediate operational and financial benefits resulting from a 4C implementation, long-term economic viability of a supply chain saliently depends of the efficiency of its members' access to capital markets. In particular, small and medium sized enterprises in a supply chain are notoriously vulnerable to credit restrictions. The recent financial crisis, wherein a significant amount of capital has been lost in the global capital markets, has lead to a situation where much of private equity and venture financing seems to have dried up. Small businesses have been hit particularly hard by this credit squeeze because many of them, if not most, depend on financing from banks or other institutions to fund their capital outlays and operations (Berger and Udell 2003). Supply chain managers are exploring alternative operational and financial strategies to overcome the effects of this squeeze. We suggest that supply chain finance, implemented in conjunction with a 4C mechanism, would allow firms not only to weather credit restrictions, but also provide them with competitive benefits in normal business environments, i.e., higher survival and growth rates. In this regard, financial resource providers should be an integral part of a successful 4C implementation.

A 4C mechanism can be employed to lower informational gaps not only among the supply chain members, but also between the supply chain and the financial resource providers. Informational problems and the allied financial constraints can be especially severe for small and medium sized enterprises (SMEs) in a supply chain, since small firms are usually characterized by highly uncertain prospects and high informational opacity, compared to their larger, well established counterparts (Shane 2003). We claim that, in an implementation of a 4C mechanism, it is desirable to reduce informational problems, thus further increasing cash flows and residual value.

In the 4C context, supply chain finance is an effective way of translating reduced informational problems into financial benefits. It requires that supply chain partners and financial resource providers collaborate on financing arrangements, in order to improve the efficiency of their transactions, reduce costs, and obviate operational roadblocks. These outcomes are desirable under any circumstances, but they are particularly needed in the current economic context, where even established firms may face the type of financial difficulties that are typically encountered only by SMEs. During the credit crisis, firms reduced inventories by $207 billion, in order to conserve cash (WSJ, January 2010). Replenishing these stocks requires a correspondingly large inflow of funds, yet access to capital from banks and private investors continues to be relatively restricted. At this point financial and operational coordination within the supply chain becomes critical to successfully manage the business processes.

In an uncoordinated setting, when traditional credit lines are limited, an external financing option may lie in factoring of accounts receivable. Here, the firm sells its receivables to a third party (the "factor").

The factor makes an interest charge, based on the time to maturity, and may also impose a transaction fee, but pays the remaining value of each receivable in cash. Factoring of receivables is a large and established practice (Klapper, 2006), but may still be less than satisfactory for small firms. Interest rates and charges from a factor may be very high. Also, corporate customers (OEMs) may forbid their suppliers to factor receivables, because factors are inflexible about payment terms.

In the 4C context, when small or medium-sized suppliers sell regularly to a large corporation, reverse factoring arrangements may offer a better solution to the financing problem. In contrast to normal factoring, where supplier and factor are the only active players, the large corporate customer is an integral part of a reverse factoring arrangement. Hence, there are less informational problems from the perspective of the financial resource providers regarding the value of the supplier's invoices. The corporate customer notifies the factor of approved invoices, so that suppliers can borrow against their accounts receivable at a preferential rate of interest. The loan from the factor is repaid by the customer when the account receivable comes due (see Figure 3).

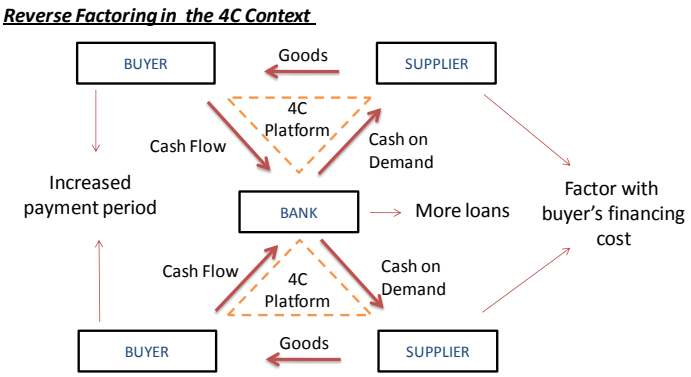

Figure 3: Demonstration of Reverse Factoring in a Supply Chain in the 4C Context

Finally, with a long-term perspective, we note that the direct financial and operational benefits of the 4C concept, along with supply chain financing, create even more involved (and even more important) third order strategic benefits. Stylized economical models are required to quantify these benefits and derive managerial insights. Aside from the current financial crisis, ever intensifying competitive pressures suggest that a successful implementation of 4C is essential and may draw the very thin line between the survival and failure of a supply chain in the long-term.

In summary, the 4C concept prompts the following four research questions:

How does the 4C mechanism can be employed to create shareholder value? And, how should the 4C implementation distribute its benefits among participants, in order to compensate them for the risks incurred by their collaboration? For instance, the 4C might optimally charge participants different rates for their usage of its services, instead of a uniform rate per transaction handled.
How can reverse factoring be incorporated in the 4C concept? We might expect the collaboration between supply chain partners to facilitate the implementation of reverse factoring, but the involvement of OEMs may in fact compromise their credit rating, undermining the premise of a reverse factoring arrangement.
Given the findings in (1) and (2), how should partners for a 4C implementation raise capital for the necessary investments? Do collaboration and the resulting reduction in overall risk make it easier to issue new equity/long term debt, or is the complexity of the system likely to deter investors?
What are the long-term economic benefits of a 4C implementation on the individual firms, supply chains and on the overall economy? In particular, how do the survival and growth of small and medium sized members of the supply chain is affected, and what are the reflection of these effects on the supply chains and overall economy?

3.4 Approach

(1) Distribution of benefits

A firm's inventory policies must provide efficient protection against the negative effects of demand uncertainty: lost demand or postponed satisfaction of demand. A firm could obviate these negative effects by holding enough inventory to make the probability of a stock-out negligible, but this is likely to be an inefficient approach: the opportunity cost of the capital, holding costs, and spoilage costs all

increase with inventory.

Uncertainty of demand is not, however, the sole cause of the inventory problem. Rather, it results from the combination of demand uncertainty and impediments to the replenishment of inventory, such as lead times and set-up costs. If the firm could obtain new inventory instantly from suppliers with no transaction costs, then inventory would be unnecessary and all demands would be satisfied, no matter how erratically they might arrive. Instead, inventory theory offers a range of models, from the deterministic EOQ to general (r, q) policies, that quantify the relationship between demand uncertainty, lead time, set-up, and holding costs, in order to provide optimal solutions for scenarios of increasing complexity.

The 4C concept offers a different solution to the inventory problem. It promises to adjust the supply chain mechanism, in order to yield more favorable inputs to inventory models. Specifically, under the 4C concept, the logical and physical infrastructure of multiple supply chains is consolidated, in order to create a larger apparatus that is more efficient and effectively brings the ends of the consolidated chain closer together.

Implementation of the 4C concept entails capital investment and ongoing operational expenditures. Assuming that participants' cost of capital remains constant, these cash outflows will be more than offset by the reduction of existing operational expenses (e.g., transportation costs) and acceleration of cash inflows that would otherwise be delayed by supply chain inefficiencies. In order to obtain an adequate financial perspective on the 4C concept, however, we cannot consider only these direct costs and benefits. We must also consider the risks associated with them, and ultimately the change in volatility of participants' earnings. These risks will influence 4C participants' cost of capital, thus potentially changing the value of the 4C concept (for better or worse).

(2) *Implementation of reverse factoring:*
In the 4C context, reverse factoring mechanism creates value by increasing the generated cash flows in two ways. First, small and medium sized suppliers in the supply chain enjoy a reduction in the cost of external capital which in turn reduces the expected cost of financial distress. Lower financial costs translate into higher cash flows. Second, due to reduced cost of financial distress and cost of capital, suppliers may also experience increased levels of output and investment (Tanrisever and Gutierrez, 2010 and Erzurumlu et. al., 2010) which leads to higher cash flows and shareholder value. In addition, financial coordination and cooperation established through 4C and reverse factoring, help to build closer relationships between the supply chain members and financial institutions. These intangible benefits translate into more residual value for the shareholders.

On the other hand, the OEMs in the supply chain strategically benefits from the improved financial stability of their suppliers since this would help the OEM to secure supply at a more economic cost in the future. OEMs also directly benefit from reverse factoring, by asking for an increase in the payment period in exchange of the offered low interest rate. This effectively leads to a decrease in the working capital employed by the OEMs. In addition, improved supplier relations help the OEM generate more residual value. In this process, banks also benefit by issuing more loans. Projected benefits of reverse factoring in the 4C context are detailed in Table 1.

	Supplier (SME)	**Buyer (OEM)**	**Financial Institution (Bank)**
Direct Financial Benefits	Reduced external financing cost for financially distressed suppliers.	Reduction in working capital due to increased payment periods to the suppliers.	Increased volume of loans.
Direct Operational Benefits	Increased output levels and more efficient operating plans due to reduced cost of capital.	Reduction is supply chain disruptions due financial distress.	Decreased cost of issuing loans due to reduced credit checking requirements.
Long-term Strategic Benefits	Survival and growth.	Secured economical supply.	Increased market share.

Table 1: Projected benefits of reverse factoring in 4C

The 4C implementation creates shareholder value through four main cash flow effects discussed in the introduction: (1) acceleration of cash flows, (2) reduction in the volatility of cash flows, (3) increase of cash flows, and (4) increase of residual value. Our objective is to create a rigorous framework to quantify how these cash flow effects can be created through the 4C mechanism in supply chains. We also aim to demonstrate how benefits can be distributed among the participating firms providing guidelines to managers and policy makers who implement and create incentives for 4C. Since scientific models for the operational and financial decisions of a single firm are generally distinct, yet in themselves complex, novel models are needed to allow a joint optimization of benefits across two disciplines (operations and finance) and three or more partners (OEM, supplier, and bank).

The theoretical challenge of the required models is commensurate with the scope of provisions that characterize commercial contracts. Direct financial benefits create a complex second order effect on the operations and shareholder value; in order to understand such benefits, we must define a detailed operational model and establish its linkage to the supply chain finance arrangement.

(3) *Raising capital:*
A complete 4C implementation may involve significant initial capital outlays as well as operating and maintenance costs over the life-time of the project. Raising this initial capital for the project can be a major obstacle for the implementation of 4C at the very beginning of the project cycle. It is necessary to understand how the 4C collaboration affects the perceived risks of individual firms and supply chains by the financial institutions and other investors. The overall risk may make it easier to issue new equity/long term debt, or the complexity of the system may deter investors from investing.

(4) *Long-term benefits:*
Finance and entrepreneurship literature have long argued that financial constraints due to capital market imperfections hold back innovation and growth (Rajan and Zingales, 1998; Hubbard, 1998; Hyytinen and Toivanen, 2005). Further, financial constraints for SMEs may lead to severe financial distress, bankruptcy and even an immature liquidation of the business. Tanrisever et. al. (2010) provide an analytical model for value-maximizing debt-financed SMEs under a survival constraint. In their model, external financing cost is exogenous and they provide survival rates for the firm under different operating and investment scenarios. In our context, 4C implementations help to endogenize the external financing costs and reduce SMEs probability of immature liquidation while enabling the firm to invest more in growth opportunities.

In the long-term, we conjecture that, 4C would lead to higher survival rates for economically viable small suppliers, more economical supply for the OEMs, and more sustainable and competitive supply chains. We plan to explore this impact by extending the analytical framework of Tanrisever et. al. (2010) to cover endogenous external financing costs through 4C.

3.5 References

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Planning:
Start: 2010
Completion: 2014
We plan to complete work on the four research questions in the order they are listed and an approximate rate of one question per year. We expect each research question to generate a scientific paper for submission to an ISI journal.
Accordingly, during the first year, we will develop a quantitative model of the financial and operational aspects of the 4C mechanism. Taking external financing costs to be exogenous, we assess benefits at the firm-level and show the conditions for an optimal 4C implementation. In the second year, we will add the supply chain finance perspective to our foundational model. Supply chain financing is expected to relax financial constraints, particularly for small and medium-sized enterprises, so we expect the optimal 4C implementation to be different in this case.
The final two years of the project address the broader context of a 4C implementation. Given the financial impact of the 4C mechanism, as elaborated in the first two studies, we consider how firms should raise the necessary capital for investment in 4C infrastructure. In the final phase of the project, we synthesize the preceding work and explore the broad economic benefits of 4C mechanisms. This perspective will be achieved by extending the analytical framework of Tanrisever et. al. (2010), in order to allow for endogenous external financing costs in the 4C context.

Work distribution:
PhD student: to be determined
Researcher 1: prof. J.C. Fransoo
Researcher 2: dr. F. Tanrisever
Researcher 3: dr. M.J. Reindorp

Expected results/deliverables/milestones:
Conference contributions (1 or 2 per year); journal articles (3), PhD thesis (1); workshops and presentations for practitioners.

Activity 4: ICT for 4C

Description:
4.1 Title of research proposal
Design and deployment of effective IT support for 4C's

4.2 Abstract
The key research question of this PhD project within the 4C4More program is: How can ICT enable effective Cross Chain Control Centers? The research will result in methods and tools to analyze, design and implement automated support for 4C's in practice. Methods/tools will be developed and tested in real-life applications address 4C information architecture with a focus on information sharing practices, information integration, business intelligence and mining. Key technologies that this project will incorporate to establish effective 4C's are software services composition and deployment in a cloud infrastructure setting. A number of 4C demonstration projects will be developed in collaboration with the ICT and logistics/shippers partners in the project. Architecture-based integration of approaches, models and technologies is a major aspect in this phase – this will enable the research to reuse results of prior research activities as (partial) building blocks, hence keeping complexity within bounds. These projects will test the applicability and validity of research results in real life situations.

4.3 Research proposal

Research topic

The key research question of this PhD project within the 4C4More program is: How can ICT enable effective Cross Chain Control Centers? The research will result in methods and tools to analyze, design and implement automated support for 4C's in practice. Methods/tools will be developed and tested in real-life applications to:

I. Analyze *current* and *future* requirements for 4C information architectures

This regards:

- A. Coordination and control mechanisms
- B. Interorganisational business processes
- C. Joint and conflicting goals
- D. Financial and value flows
- E. Information architecture (including current enterprise systems, infrastructure)
- F. Information sharing practices, information integration, abstraction and aggregation
- *G.* Business performance, intelligence and mining (including uncertain and fuzzy data)

II. Design and implement and operate 4C architectures

- H. Transformation from current to target IT architecture
- I. Servicitization of current legacy components and enterprise systems
- J. Software services Composition and Deployment in the cloud

We recognize that this is an extensive list of topics to cover in a single PhD research project. However, to design and implement successful 4C's, effective ICT support is vital and earlier research has demonstrated that the topics listed should be included in a comprehensive approach to realizing 4C's. To meet both the requirements of practical value of this research and theoretical contribution and soundness, the focus of this research will be on:

- I.F. Information sharing practices, information integration, abstraction and aggregation
- I.G. Business performance, intelligence and mining including uncertain and fuzzy data
- II.C. Software services Composition and Deployment in a cloud infrastructure setting

This focus is chosen as these areas are both of great importance and highly innovative in a 4C context. The remaining aspects will also be part of the research but here the research is limited to applying and translating ongoing research to the 4C context. The research groups collaborating in the project have a long tradition in covering theories and practical applications of supply chain control. Knowledge from earlier and related projects can be applied to the 4C context. Next, we will elaborate on our view of the 4C concept and the role of ICT architectures to improve supply chains through 4C's. Next, we will discuss the three focus areas of this research.

ICT enabling 4C's

Today's supply chains need to be increasingly agile and responsive to thrive in dynamic and competitive markets (van Oosterhout et al., 2006, Grefen et al. 2009a, Grefen et al. 2009b, Mehandjiev and Grefen 2010). To address this challenge, static supply chains have transformed to dynamic business networks with an increasing number of highly specialized and globally distributed actors. Such business networks cannot effectively function without effective ICT support. We illustrate various ICT architectures to support supply chains using Blumenthal's control model as a basic building block (Grefen 2010a). Figure 4 shows a basic supply chain control model without explicit information passing (only produced goods are passed between respective transformation systems). This may seem an extreme case, but some current supply chains operate similarly. The information system (IS) is fed by the environment and by using events from the transformation system (TS) (the goods being shipped, tracked, stored, etc.). The aggregated information from the IS is used by the control system (CS) to steer the operations in the TS (sending execution plans, transport orders etc.). Both the IS and CS can use highly advanced algorithms and ICT such as sensors and wireless communications to get feedback from the Environment and TS. However, as long as IS and CS between various participating organizations in the supply chain are not connected, the result is sub-optimal.

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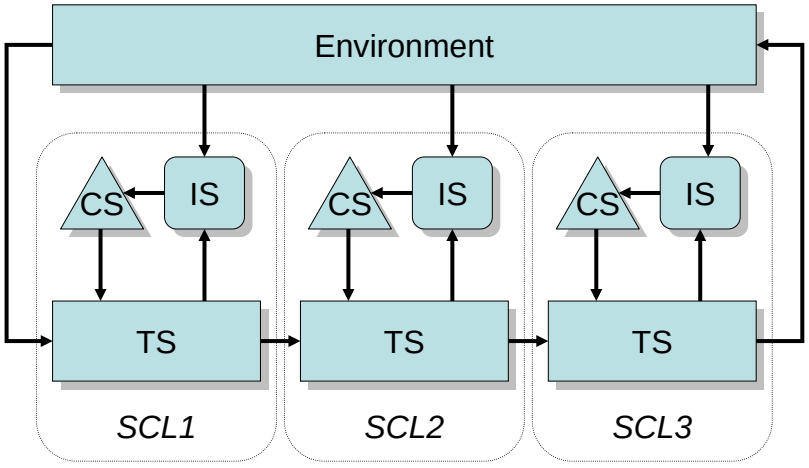
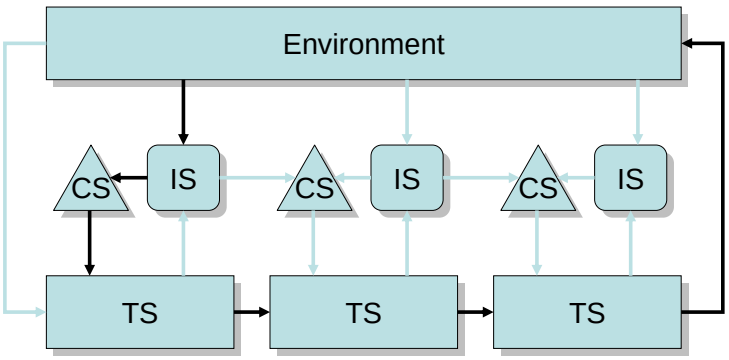


Figure 4: basic supply chain control model without information passing

Recent efforts have explored two solution directions illustrated in Figure 5 (Grefen 2010a). In supply chain integration efforts, supply chain information systems are linked (shown in the top half of the figure). This can lead to dramatic improvements but creating these links has proven to be cumbersome. Current links are usually limited to exchanging operational data using proprietary technologies. Semantic integration at a tactical and strategic level is a scarcity. An even more serious limitation of this approach is that information needs to flow from one tier to the next through the supply chain. As a result, chain wide coordination is practically impossible. No single actor in the supply chain oversees the functioning of the network of businesses. The alternative solution shown in the bottom half of figure 2 aims at a fully central control. The solution can work in rare situations were one party can control the entire set of chain activities through a centralized information and control system. In today's complex logistics settings, only a few of such cases can be found. Usually multiple powerful actors are involved that are not willing to accept such a central authority (Van Hillegersberg et al., 2000).



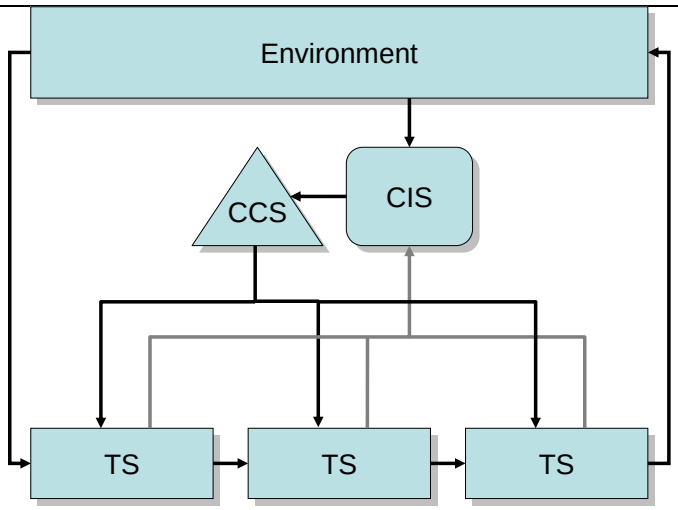


Figure 5: Information passing and central control

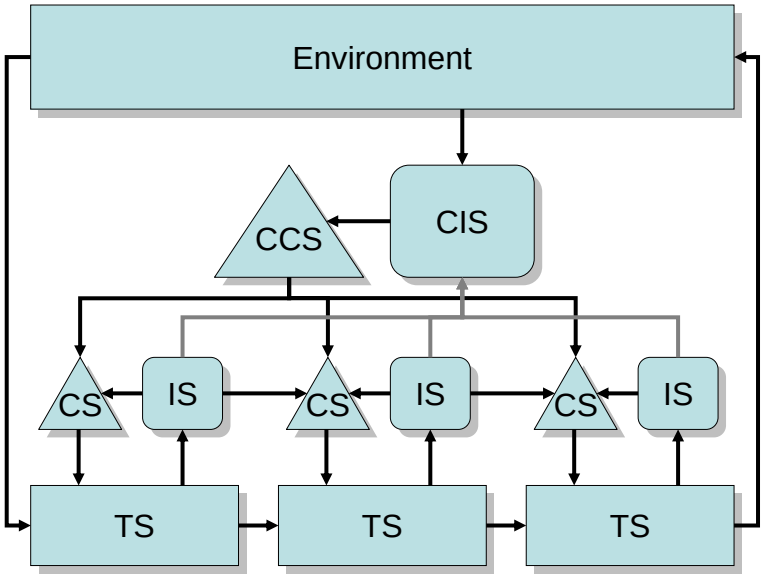


Figure 6: superimposed centralized control

Figure 6 illustrates a hybrid scenario were CCS and CIS represent the 4C information and control system (Grefen 2010a). In this architecture, operational integration between direct partners is handled through bi-directional integration and only more tactical and strategic information is handled at the central level. In addition, decisions that require chain wide insights and cooperation are coordinated at the 4C level. Examples of such decisions are minimizing total stock in the chain, synchronizing deliveries and creating joint forecasts.
This 4C architecture recognizes the reality of cooperation and competition in business networks. Information is not automatically shared, but only exchanged when joint benefits can be gained and equally shared. Actors usually do not wish to give up their autonomy. They do wish to share information in a coordinated way which is facilitated by this 4C scenario.
Benefits of a well-functioning, chain-wide information and control center are countless. For example, better chain coordination can eliminate extensive buffers, wrong deliveries, waste, etc. Studies of the US automobile sector, for example, estimate that imperfect interoperability in the supply chain adds at least $1 billion in additional operating costs, of which 86% is attributable to data exchange problems.

However, achieving the 4C scenario requires several challenges to be met. In this proposal we focus on ICT related topics, with the focus on the three areas identified earlier. We briefly explain the practical and theoretical gaps below:

Information sharing practices, information integration, abstraction and aggregation
As can be seen in Figure 6, supply chain information is collected and processed both distributed and centrally, in the 4C. How this sharing should be organized is an important issue to address. What are proper levels of abstraction and aggregation of both information elements and control actions needed to benefit fully of the 4C concept? In other words, what type of information is needed at the 4C level to improve the chain performance? Collecting too much detailed information can be threatening to the individual parties and put an information processing burden on the 4C. This research therefore addresses the proper sharing, abstraction and aggregation levels of the 4C information and control systems

Business performance, intelligence and mining (including uncertain and fuzzy data)
Traditional supply chain information systems focus mainly on transactional operational data. While basic performance management and data warehousing facilities are available in current systems, these mechanisms are insufficient to benefit from the wealth of information that will be available in a 4C. For example, simple alert messages with standard thresholds are ineffective in a 4C where information is arriving from a variety of dynamic sources. Moreover, information that arrives at the 4C is often uncertain and fuzzy. For example, information may come from sensors that have a certain reliability dependent on their GPS location, information on estimated arrivals may depend on customs delays or road congestion. Forecasts may vary depending on their source. 4C systems need to be able to deal with such uncertain and fuzzy data. This requires a depart from existing monitoring and business intelligence systems. This research therefore addresses mechanisms to deal with fuzzy and uncertain data from supply chain sources (Lenz and Muller, 2000).

Software services Composition and Deployment in the cloud
Traditional ICT support for SCM 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. Supply chain 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 do not enable agile business networks that allow business partners to quickly connect their business processes (Kumar and Van Hillegersberg, 2000) (van Hillegersberg et al. 2004) (Grefen 2006).
Therefore, we focus in this project on ICT support for agile business network integration (Grefen et al. 2009a). Such ICT platforms will enable a strategic 4C that allow for example business services of 3PL’s to be found in advanced registries, evaluated and seamlessly integrated and deployed into supply chains. The platform departs from the traditional static ICT architectures and makes use of scalable virtual “clouds” that host 4C services. As such, the 4C infrastructure flexibly integrates ICT elements from enterprise information system, service-oriented computing (Eshuis and Grefen 2009) (Grefen, Ludwig, Dan and Angelov 2006) (Grefen 2008), dynamic business process management (Grefen 2006) (Grefen 2008) (Grefen 2009c) and e-business (Grefen 2010b). These ICT developments hold high promises for realizing the 4C’s concept at both the operational level (tracking, tracing, planning and execution) as well as the tactic and strategic levels (business network formation, alliance building, service pricing and evaluations). A 4C can only function if business processes can be quickly linked up and proved information to the control center (van Hillegersberg et al. 2004)
This research will address how service composition and deployment in the cloud can enable the 4C concept.

4.4 Approach
The PhD researcher will closely collaborate with the other members of the 4C4more team to develop and test theories, methods and sound ways of working in practice for ICT enabling 4C’s.
The research project will start with a combination of studying running examples of state of the art ICT coordination in supply chains and a systematic literature review in the three foci area.
As a result of this phase, an overview of the state of practical and theoretical possibilities is obtained.
In the next phase of the research, a number of 4C demonstration projects will be developed in collaboration with the ICT and logistics/shippers partners in the project. Architecture-based integration of approaches, models and technologies is a major aspect in this phase – this will enable the research to reuse results of prior research activities as (partial) building blocks, hence keeping complexity within bounds. These projects will test the applicability and validity of research results in real life situations. This phase progresses through a number of design-evaluate-build iterations to ensure that solutions can grow and be adapted to better fit the context. In addition, this approach enables us to contribute early results to a wider audience and include new insights while developing and testing

In the final phase the experiences from the various demonstration projects will be jointly evaluated. Knowledge obtained will be grounded in methods and tools for use in future 4C development projects.

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- P. Grefen et al., 2009a, Dynamic Business Network Process Management in Instant Virtual Enterprises, Computers in Industry 60(2):86-103, Elsevier.
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- P. Grefen, 2010a, Operational Control of Supply Chains: a Structured Exploration from an Information Systems Perspective, Working Document, Eindhoven University of Technology.
- P. Grefen, 2010b, Mastering e-Business, Routledge.
- N. Mehandjiev and P. Grefen (eds.), 2010, Dynamic Business Process Formation for Instant Virtual Enterprises, Springer.

Planning:
Start: 2010
Completion: 2014
Year 1: PhD student will focus on creating an overview of the state of theory and practice related to the design and deployment of IT support for 4C. The PhD student will create and test an initial method to support 4C with integration and informing technologies.
Year 2 & 3: PhD student will work closely with knowledge and industrial partners to design, implement and evaluate the methods, tools and technologies in a series of 4C cases.
Year 4: More in depth evaluations will be held and a final version of the theories, methods and practices to design and deploy IT support for 4C's will be included in the PhD thesis.

Work distribution:
PhD Student: to be determined
Researcher 1: prof. J. van Hillegersberg (UT)
Researcher 2: Prof. P. Grefen (TU/e)

Expected results/deliverables/milestones:
Conference contributions (1 or 2 per year); journal articles (3), PhD thesis (1); workshops and presentations for practitioners.

Activity 5: 4C Planner productivity

Description:

5.1 Title of research proposal

Measuring and improving the productivity of planners

5.2 Abstract

While substantial emphasis in the planning process and related IT support has been focused on improving the outcome of the planning process (higher service levels, lower inventory, etc.), relatively little is know about the productivity of planners. The number of planners related to the amount of work to be conducted has seen little improvement over the past decade. In this study, we will develop a

clear measure for planner productivity, validate this measure empirically, and develop a methodology to improve planner productivity. Continuous improvement of planner productivity is essential to maintain competitiveness in a cross chain control center.

5.3 Research proposal

In cross-chain control centers, human decisions makers will be co-located that make operational decisions on parallel supply chains. This could be joint forecasting, joint production planning, or joint transportation planning and scheduling. Apart from aligning algorithms and decision models, this will also require the alignment of business processes in the planning and scheduling task. It is well-known from the empirical planning and scheduling literature (see, e.g., Jackson *et al*., 2004; McKay and Wiers, 2004) that the planning and scheduling task is a comprehensive task that is only partially involved with the actual planning and scheduling decisions. Jackson *et al.* (2004) observe that *"businesses have historically invested heavily in computer-based support mechanisms for scheduling task and monitoring activities, such as expert systems, decision support systems, and advanced planning systems. In relation to supporting scheduler roles, there are fewer support mechanisms in use or even available. Generally, computer-based support focuses on only the decision making component of scheduling, typically resource allocation decisions."* The work by Jackson *et al.* (2004) clearly shows that this is not the main scheduling function activity.

While the other studies in the project proposal focus on performance enhancement due to cross-chain control, we take a longer term perspective as there is a need to have continual productivity increase. If productivity increases are not attained, the inherent benefit of positioning cross chain control centers in a knowledge-intensive developed country like the Netherlands may not be sustainable in the long term, as it may be cost-effective to transfer these activities to low-cost countries such as India.

Moreover, we hypothesize that the actual productivity increase due to wide deployment of planning, scheduling, and forecasting tools single-chain control centers has been limited, and the focus has been primarily on performance enhancement rather than productivity enhancement. In this study, we will focus on the productivity aspect of operational decision making processes, such as S&OP, production planning and scheduling, demand forecasting, sourcing, etc, rather than on the performance aspect of these processes.

Productivity is generally defined as the quotient of the output of a particular process and the input needed to produce this amount of output. Most of the research on productivity is based on an economics approach at the level of an economy or a firm (see, e.g. Coelli *et al*., 2005). In this study, we are interested in measurement and analysis at the business process level. While planning and scheduling processes have been widely studied (see, e.g., the edited volumes by McCarthy and Wilson (2001) and by Fransoo *et al.* (2010) for recent overviews), the aspect of productivity is absent in these studies. The difficulty of studying productivity at the process level is that it needs to be measured in general under a quality constraint (as in manufacturing), since we are interested units rather than in value I do not understand this sentence. In planning processes this would imply that it would require study under a performance constraint. Since performance is likely to vary and be strongly dependent upon exogenous characteristics of the planning problem, this poses a serious problem in measuring productivity, let alone identifying the explanatory variables for productivity differences. In order to provide a proper framework for productivity measurement and improvement in cross-chain control center, we will in this 2-year study address the following research issues:

1. Development of a methodology to measure productivity in planning, scheduling and forecasting settings.
2. Empirical productivity measurement of planners, schedulers and forecasters in a number of companies to validate the feasibility of the methodology developed under 1
3. Develop a conceptual model that explains productivity differences between individuals, and can serve as a basis for a follow-up study to enhance productivity.

5.4 Approach

Productivity is the ratio of outputs and inputs. We expect measurements of input to be fairly straightforward if you mean nr of orders, machines, yes. But complexity and uncertainty are difficult to quantify. In terms of the type of roles and activities involved with planning and scheduling, we will use the model developed by Jackson *et al.* (2004), which has been reproduced in Figure 7.

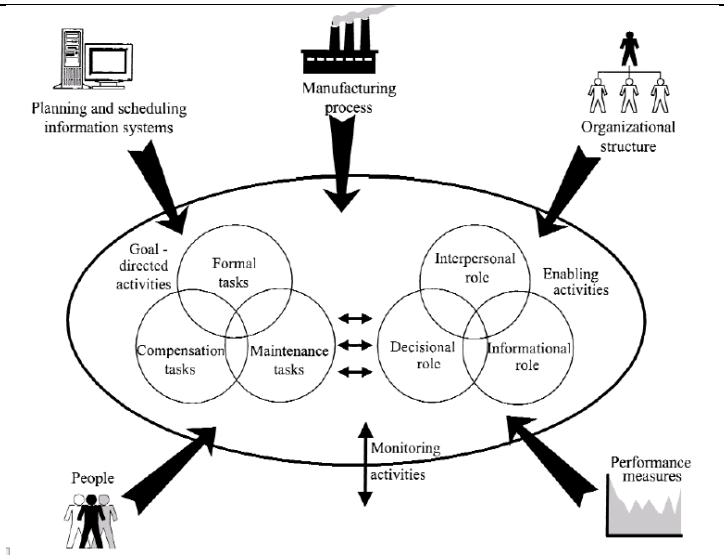

Figure 7. Tasks, roles, and monitoring activities of schedulers (Jackson et al., 2004).

For measuring the output of the planners' and schedulers' activities, we need to establish a measure that is robust, and both internally and externally valid. It is likely that we will end of with a composite measure, that will take into account items such as number of orders, complexity of the orders, and the level of uncertainty. Some initial work on measuring the complexity of the planning task empirically has been conducted by Fransoo and Wiers (2006), yet the work here will be largely exploratory. The quality of the measures can be indicated by common practices in empirical work, such as Roth *et al.* (2008).

In the second part of the study, we will use the measure develop in the first part and conduct three empirical studies in different environments to validate the proposed approach. The case studies will be conducted in a subset of the companies taking part in the 4C project. The measurement validation study will be complemented by an extensive task analysis that will enable us to develop a conceptual model that link the characteristics of the task, the task design and the task support (both organizational and information technology).

5.5 References

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Planning:
Start: 2010
Completion: 2012

Work distribution: Postdoc: To be determined Researcher 1: prof. J.C. Fransoo Researcher 2: prof. A.G. de Kok Researcher 3: Prof. W.P.M. Nuijten Researcher 4: dr. V.C.S. Wiers
Expected results/deliverables/milestones: Conference contributions (1 or 2 per year); journal articles (3), workshops and presentations for practitioners.

Activity 6: MSc student pool
The student pool is the linking pin between science and practice. MSc students acquire scientific knowledge under the supervision of senior researchers and PhD's. They support the development of scientific knowledge by gathering data, developing tools and doing research themselves. They implement research results in practice in the context of demo projects set up by the companies participating in this research project. Students from the participating universities must be selected, prepared and allocated to the research projects and the demo projects. This is a substantial effort. The assistant project manager acts as student pool coordinator. This enables her/him to have direct contact with all participants on a regular basis.
Work distribution: Student pool coordinator: to be determined.
Expected results/deliverables/milestones: 40 4C MSc projects

Activity 7: Implementation and knowledge dissemination
The results of the research projects must be translated into working 4C solutions at participating companies and into parts of the services provided by the new 4C companies. We expect that the MSc students either are hired by the participating companies or themselves start-up a 4C company. We need to facilitate this process. Here we want to involve Dinalog as well as institutions at universities such as the TU/e Innovation Lab. The assistant project manager and overall project manager are responsible for setting up the relationships with these "incubator institutes". In order to act as a catalyst for increasing the total Netherlands GDP contribution in supply chain control we want to develop a best practices book, called the 4C bible, where we consolidate all the findings of our research project. The 4C bible comes with prototype tools, working procedures and case materials.
Work distribution: Prof. A.G. de Kok: overall project manager Dr. H. Quack: representative WP 4C Business Models Dr. J. van Dalen: representative WP 4C Forecasting Dr. M. Reindorp: representative WP 4C Finance To be determined: representative WP ICT for 4C Dr. V.C.S. Wiers: representative WP Planner Productivity
Expected results/deliverables/milestones: Implemented solutions, at least 8 new 4C companies, 4C bible.

Planning

In Figure 8 below we give an overview of the project plan.

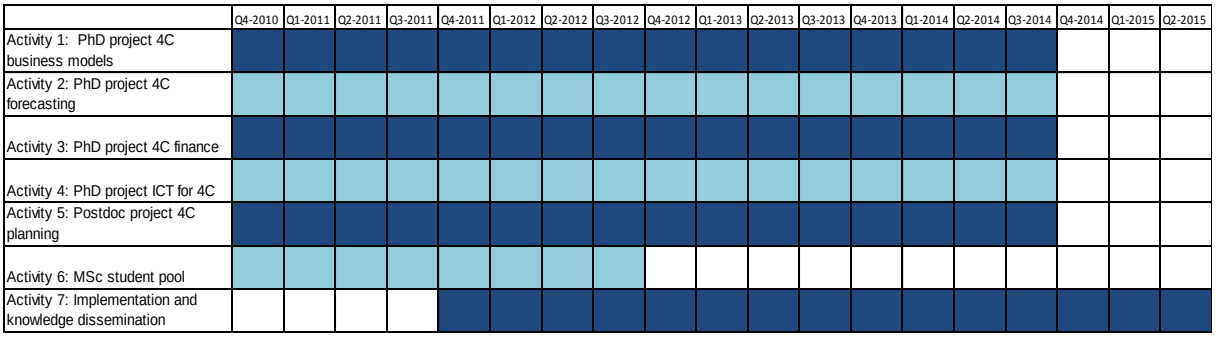

Figure 8 – Overview of the project plan.

All relevant more detailed information can be found in the work packages descriptions above. We also refer to the project organization described below as well as the evaluation and monitoring process that is aligned with this project plan.

C. Consortium and Project organization

Research team (see Appendix: 4C4more R&D: Researchers for short CV and publications)

Name partner	**Role and input**	**Specific competence**
Prof. A.G. de Kok (TU/e)	Overall project manager	Participated in this role in KLICT and Transumo
To be determined	Assistant project manager	Project management expertise, communication skills, expertise in logistics and SCM
Prof. L. Hagdorn (VU)	Researcher 1 Business models	Professor of Transport, Distribution and Logistics, expert on innovation at companies for improvement of Rotterdam harbor
Prof. A.P. de Man (VU)	Researcher 2 Business models	Professor of Knowledge Networks and Innovation, expert on collaboration, alliances and innovation
Prof. B. Assink (EUR)	Researcher 3 Business models	Professor of Corporate Law, and active as a practicing lawyer (corporate litigation)
Dr. H. Quak (TNO)	Researcher 4 Business models	Expert on logistics in urban areas and sustainable logistics
Prof. J. van Nunen (EUR)	Researcher 1 Forecasting	Professor of Decision and Information Sciences, researcher on close loop supply chains and ICT applications in logistics

Prof. A.G. de Kok (TU/e)	Researcher 2 Forecasting	Professor of Quantitative Analysis of Logistcs Systems, has recently supervised PhD project on forecasting
Dr. J. van Dalen (EUR)	Researcher 3 Forecasting	Associate professor of statistics, researcher on quantitative analysis of information and logistics-related processes
Prof. J.C. Fransoo (TU/e)	Researcher 2 Finance	Professor of Operations Management and Logistics, conducted dozens of projects with industry. Member of various governmental and nationwide committees in the Netherlands.
Dr. F. Tanrisever (TU/e)	Researcher 3 Finance	Expertise on Chain Risk Management, Operations-Finance Interface and Supply Chain Financing.
Dr. M. Reindorp (TU/e)	Researcher 4 Finance	Expertise as a Funding Specialist and Settlement Officer at a financial group
Prof. J. van Hillegersberg (UT)	Researcher 1 ICT	Professor of Business Information Systems, research on the effects of new IT services on supply chain integration
Prof. P. Grefen (TU/e)	Researcher 2 ICT	Professor of Information Systems, research interests include architectural design of complex information systems, interorganizational workflow management, and high-level transaction management.
Prof. J.C. Fransoo (TU/e)	Researcher 1 Planner Productivity	Professor of Operations Management and Logistics, conducted dozens of projects with industry.
Prof. A.G. de Kok (TU/e)	Researcher 2 Planner Productivity	Professor of Quantitative Analysis of Logistcs Systems, extensive research on APS systems, implemented APS system and work processes at Philips.
Prof. W.P.M. Nuijten (TU/e)	Researcher 3 Planner Productivity	Professor of Intelligent Information Systems, research into modeling and solving real-life planning and scheduling problems.
Dr. V.C.S. Wiers (TU/e)	Researcher 4 Planner Productivity	Industrial Fellow at TUE, School of IE, has numerous publications on human factor in planning.

Mrs. J. van Andel	Unilever Benelux	Supply Chain Development Manager with a shipper company, member of the Van Laarhoven Committee
Mr. B. Becker	Bakker Logistiek Groep	Commercial Director of a Logistics Service Provider
Mr. K. Kinds	Control Pay	Chief Executive Officer
Mr. H. de Visser	Cordys	Manager with an ICT company developing software systems for Supply Chain Management
Mr. M. Steeman	ING	In charge of business development at a financial company
Mr. W. Lammerse	ITUDE	Director Logistics with an ICT company focussing on ICT, planning and finance
Mr. T. Beckmann	Kuehne+Nagel	Director Contract Logistics with an Logistics Service Provider
Mr. T. Nabuurs	Nabuurs	Member of the Management Board with an Logistics Service Provider
Mr. R. Strik	SCA	Regional director logistics Region North-West (benelux, Scandinavia, Baltic States)

Project organization

The R&D project here proposed, is a part of a larger project in which also demonstration projects play an important role. Figure 9 indicates the relationship in terms of timing between the R&D project and 4 demo projects that provide data and absorb the knowledge developed.

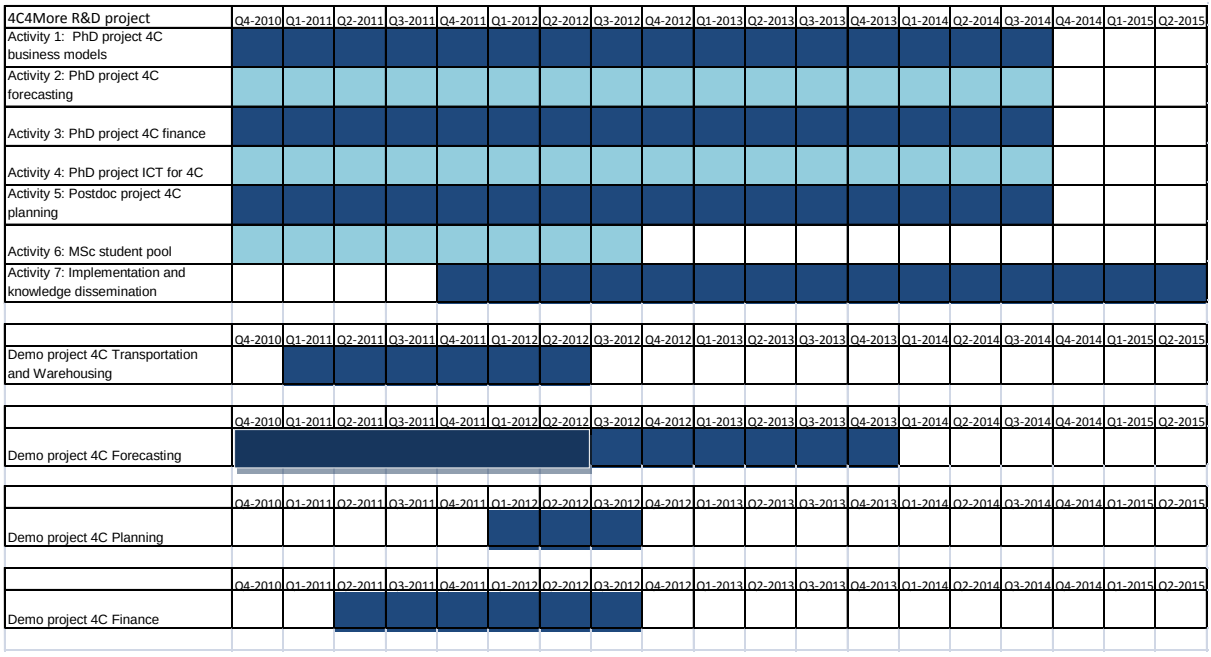

Figure 9. Overall 4C4more project plan.

The partners in the 4C4more consortium can be grouped according to their specific competences. Their relationships and roles can be seen in Figure 10.

Role	Transport warehouse	Finance	Forecasting
Leading company	Kuehne+Nagel	ING	
Core members	Unilever ITUDE	Unilever	Unilever Cordys
Other partners	Bakker Logistiek Groep Nabuurs	Control Pay Claudius Prinsenlaan 138a 4818 CP Breda Netherlands	SCA
Research partners	PhD Business Models Postdoc Planner Productivity	PhD Finance	PhD Forecast Postdoc Planner Productivity

Figure 10 – Overview of 4C4more partners and their role

The various work packages will be carried out by 4 PhD students at the knowledge institutes and 1 postdoc student, under the supervision of senior researchers. It is these students' task to achieve the goals set in their research proposal. But they can only do so in close collaboration with the companies in the consortium. There they find data, expertise, knowledge about practical situations which give them inspiration about research topics and the best way to tackle them. In this way, researchers also obtain a feeling for the impact of their results in the logistics supply chain, and hence their significance for the 4C concept. Parallel to these research activities, master students will execute demonstration projects at the companies. These companies are subdivided into an "Inner Circle" of core companies (being the participants mentioned in this project proposal) and an "Outer Circle" of companies (who will get involved during the project): see figure 11.

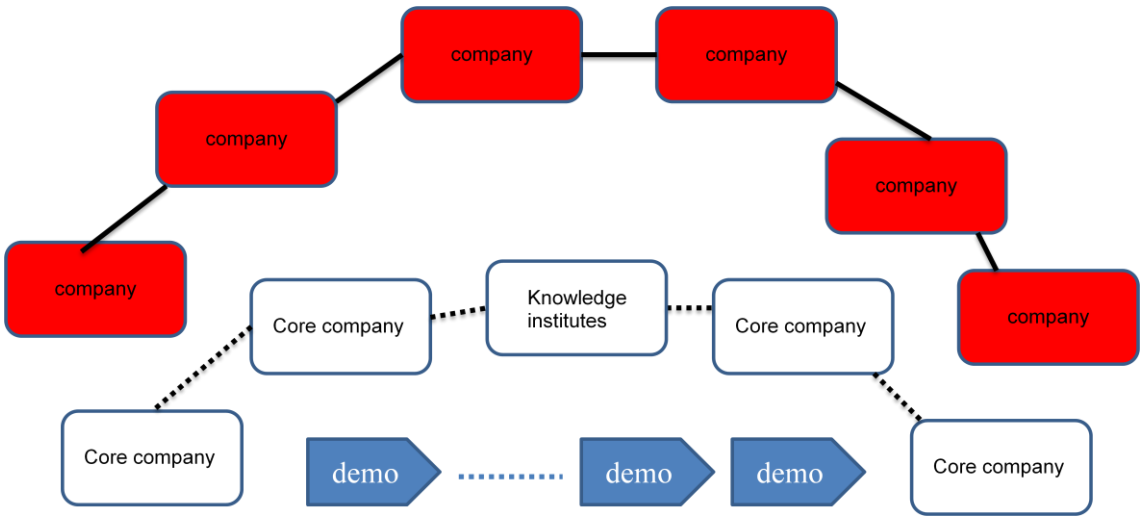

Figure 11 – Demonstration projects with their Inner Circle (white) and Outer Circle (red)

Researchers will regularly meet to discuss their findings, exchange ideas, problems encountered and solutions developed; in other words: see where their activities can enhance each other. They will support each other, whereby co-authorship of scientific papers is to be considered as a feasible option.
The applicant, TU/e, will appoint a project leader. His task will be to overview the project and take all measures necessary to realize its goals. To this end he regularly will be briefed by the researchers and keep in contact with their supervisors at the knowledge institutes. Where necessary, he also will contact project partners in the "inner circle" as well as those of the "outer circle".

D.Evaluation and monitoring

Evaluation

The project will be evaluated on the measurable outputs described above. Each PhD project follows the evaluation process that is standard at universities. The postdoc is evaluated each year. On top of that, we evaluate the progress against the targets every quarter during our quarterly project meeting at Dinalog. This quarterly meeting ensures that the individual projects are aligned, relevant information can be exchanged, in particular with respect to empirical data for case studies and tools that can be implemented. This evaluation process starts in Q4-2011, i.e. after a year. The 4C4more quarterly meetings start in Q4-2010 with two kick-off meetings to assess our SMART objectives and to refine and adjust when needed.

We will set up a steering committee with representatives from the companies and universities involved, and the two directors of Dinalog. The steering committee meets 4 times a year shortly after the quarterly project meetings. The key role of the steering committee is to ensure that the Dinalog objectives are met.

E.Valorization and implementation strategy

Valorization and knowledge dissemination

This section describes the valorization processes the consortium will put in place to create a constant awareness for:

a) the activities and results of the research programs,
b) the potential spin-off projects coming out of the cooperation between knowledge institutions workers and professionals from industry
c) the identification of commercial potential and development of valorization projects which will lead new products and services to markets.

The focus will be on short-term successes and long-term changes in culture and organization, organized in multidisciplinary project teams and valorization teams (out of the box thinking and paradigm shift).

Secondly we describe the structure and organization of the valorization process in the 4C4more program.

Our aim is to create added value by connecting the partners in the program together with professional business developers from the Innovation Lab (TU/e), facilitated by the infrastructure and commercial network the Innovation Lab has developed over the last 6 years. We will work together with already existing structures and entities such as other Technology Transfer offices in participating universities to realize the maximum of added value by the lowest cost.

It is our strong believe that business development will be the linking pin between theory, education and application in the market. The commitment and focus of professional business development to the program will create an ecosystem which will be directed to immediate contribution to the economy and the objectives Dinalog has.

The result of this added value is quantified and prognosed as follows (next page):

Subject	Results
Research results	proof of concept
Research/market cooperation	mixing theory and practice
Researchers in the program	20 fte
Innovative leads	90
Business projects	60
Business cases	40
Research/market cooperation in the business case	40
Patents/protection of ideas	10 out of 40
Implementation in product/service pipeline	5 out of 40
Licensing	20 out of 40
Spin-offs/Start-ups	8 out of 40
Labor places as spin off of the program (incl. researchers and spin-off/start-up)	100
Education/students involved in the program during the entire program	100
Contribution to GDP	€ 50 million

Context
The program 4C4more is focused on interdepartmental, interuniversity research in cooperation with commercial professional parties in transport, logistics service providers and supply chain management (shippers). The result of this cooperation will directly be applicable in commercial markets.

The knowledge of supply-chain cooperation is not new and the proof of principle is already there. The problem is not in the knowledge but in the application in the market. We see that the momentum for a breakthrough in this field can be made. The market is eager, the proof of principle already exists, the technology in ICT and business development is available and can be further developed to market proof of concept. This explains our focus on business models, finance and ICT, accompanied by functional innovation.

Through jointly developing processes, systems and viable business cases we will be able to build up a system of trial and error (virtual incubator) in which the research results, knowledge and knowhow can be put to the (commercial) test through projects and business cases.

We will organize a virtual incubator supervised by Innovation lab/TU/e where we can use results in a commercial setting facilitated by stakeholders and other (potentially) involved knowledge-centers, market parties and governmental entities.

Valorization process and organization

<u>The process</u>
1. The TU/e Innovation Lab, the technology transfer office (TTO) of the TU/e will facilitate as the valorization officer (VO) for the 4C4 program.
2. The 6 activities/work packages will lead to measurable results. The results in the specific work packages will be scouted by the valorization officer (VO) and joined with results from other packages. In this way a constant overall view over the results will be in place.
3. The VO will, in close cooperation with the parties working in the work packages be responsible for economic and business screening of the ideas. Go-no go decisions to go forward with a specific valorisation project will be made on commercial and business parameters.

4. Project teams will be formed (business, universities and other knowledge institutions) to build up a specific business case.
5. A important role will be played by students who will join the project and act as assistant business developer. We believe that the existing education programs within the TU's have a unique form in which beta students are offered a business and entrepreneurial program beside their beta-/technical program. These students form the basis of future projects because of their multifocal attitude(technical/economical).
6. The business case will be reviewed by a valorization committee which will be formed by representatives of the 4C program and professionals (market, investor, entrepreneurs).
7. The business case will be the bases for starting new valorization projects and/or new businesses.
8. The VO will be in the lead to bring the business further and will be responsible to bring parties together who have the highest added value for the success of the specific project.
9. The business case will be continually reviewed. Our strategy is that all effort, money and attention which will be put in the project is seen as an investment in the project which will have to be paid back in future.
10. Upfront the VO will be responsible to develop a consortium agreement which will make clear what effort every party is obliged to make in the valorisation project and what commercial rights they will have.
11. The VO will use her facilities and network to bring in finances and new interested parties to guarantee that the best added value come out of the project

<u>Process summary</u>

In short, the process will contain the following steps and activities:

- research in work packages
- constant review with stakeholders in work package committee, i.e.
    - structural meetings to evaluate findings
    - identifying ideas
- scouting by professional business developers, i.e. bringing the idea to a business lead
- screening of the scouted lead, to answer questions such as:
    - is there a potential product or service?
    - is there a market?
    - can the knowledge be patented/protected?

REVIEW: GO – or NO GO

- organizing the valorization team
    - connecting business, research and entrepreneurial student
- building the business case:
    - what is the product/service?
    - what is the target group/market, who are the buyers
    - status quo of research and steps to be taken to develop a marketable product
    - who can be partners?

REVIEW: GO – or NO GO

- financing the business case
    - preseed
    - subsidies
    - seed
- teaming up partners
    - development of the project in a commercial environment
- licensing the knowledge to market parties
- developing a business plan for a spin-off company
- incubator facilities for spin-off companies

Organization
Next, we provide an outline of the orgaization of the valorization process:

1. Program management
   1.1 Work package committee
   1.2 Project Manager 4C

2. Work packages
   2.1 Work package manager Business models
   2.2 Work package manager Forecasting
   2.3 Work package manager Finance
   2.4 Work package manager ICT
   2.5 Work package manager Planner Productivity

3. Valorization
   3.1 Valorization committee
   3.2 Valorization officer/Innovation Lab
   3.3 3+ Incubator
   3.4 Valorization teams

Facilitation of the valorization process

- Student pool of entrepreneurial (beta)students - Brabant Centre of Entrepreneurship (BCE)
- Strong relationship between Erasmus University/Rotterdam, University Twente, VU/Amsterdam, TNO and TU/Eindhoven which gives the opportunity to involve other research groups in valorization projects.
- Innovation Lab TU/e :
    1. contract and subsidy unit (legal- and subsidy) support
    2. network support and relations (government, big industry and SME)
    3. professional business development
    4. patent and IP fund
    5. preseed funds/proof of concept-facilities
    6. financing and venture funds

Implementation

The implementation process is strongly linked to the described valorization and knowledge dissemination process. Therefore we refer to the above section.