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Lotta Lind

IDENTIFYING WORKING CAPITAL MODELS IN VALUE CHAINS: TOWARDS A GENERIC FRAMEWORK

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ABSTRACT

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Emerging research stream of financial supply chain management emphasizes inter-organizational perspective to the optimization of working capital in order to increase the competitiveness of the whole value chain. To achieve this target, it is required to recognize the working capital positions in the value chain. In this thesis, these positions are mapped by studying working capital models applied by companies in the value chain context. Consisting of the management of inventories, accounts receivable and accounts payable, the concept of working capital model brings together perspectives from two research streams (finance and operations management), and provides a holistic view to working capital. The purpose of this thesis is to provide a novel perspective to the timely discussion of financial supply chains by identifying different working capital models in the value chain context, and by developing a framework for working capital models.

This study employs grounded theory research method. The empirical archival data of the research is collected from the official financial statements of companies operating in the automotive, ICT and pulp and paper industries. Quantitative data is analyzed with the financial value chain analysis and statistical cluster analysis. The results of the study indicate that value chain stages have a typical working capital model, but it is not applied by all companies within the stage. Similar working capital models were found in all studied value chains, but the value chains differ in how the working capital models are emphasized. Based on the empirical findings, a generic framework for working capital models is introduced. The framework consists of six working capital models: Minimizers, Aiming-at-Minimum, Moderates, Inventory holders, Financiers and Underperformers. Additionally, sub-model Trade credit users is included in the framework.

This thesis contributes to the literature of financial supply chain management by building theoretical foundation for different working capital models in the value chains. It introduces a novel approach for the value chain wide working capital management and supports the sustainable reduction of the cycle times of working capital. The results deepen the understanding of the current state of working capital management in the value chains, and encourage and support managers in the collaborative management of working capital and financial supply chains.

Keywords: working capital model, working capital management, financial supply chain management, value chain

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I never thought that I would be in this situation. As a child, I planned on becoming a flight attendant and a cross-country skier, and later, I was completely sure of making a living playing the violin. Today I am here as a consequence of several lucky coincidences, but when I look back, it all actually makes sense and I know that this is how it was all supposed to be. My academic journey has been a rewarding and amazing adventure, and I have enjoyed every minute of it. It has given me what I needed: I have been able to challenge myself, collaborate with talented people, live abroad, achieve goals and set new ones, travel and, above all, learn – not only about working capital or doing research, but about myself, other people, and life in general. However, completing a PhD would not have been so much fun – or even possible – without help and support from several quarters. Here I finally have the chance to direct my warmest thanks to everyone involved.

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Thank you, all, for believing in me.

Lotta Lind
October 2018
Hyvinkää, Finland

“’When we take people,’ thou wouldst say, ‘merely as they are, we make them worse; when we treat them as if they were what they should be, we improve them as far as they can be improved.’” *(J.W. von Goethe)*

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LIST OF PUBLICATIONS

This thesis is based on the following papers. The rights are granted by the publishers to include the papers in the dissertation.

Publication I

Lind, L., Pirttilä, M., Viskari, S., Schupp, F., and Kärri, T. (2012). Working capital management in the automotive industry: Financial value chain analysis. *Journal of Purchasing & Supply Management*, 18 (2), pp. 92–100.

The author was responsible for collecting the data and writing the original version of the publication. The study was planned and the data analyzed jointly with the co-authors.

Publication II

Viskari, S., Lind, L., Kärri, T., and Schupp, F. (2012). Using working capital management to improve profitability in the value chain of automotive industry. *International Journal of Services and Operations Management*, 13 (1), pp. 42–64.

The author was responsible for collecting the data and writing part of the paper. The study was planned and the data analyzed jointly with the co-authors.

Publication III

Lind, L., Monto, S., Kärri, T., and Schupp, F. (2016). Detecting working capital models in the ICT supply chains. *International Journal of Supply Chain and Inventory Management*, 1 (3), pp. 233–249.

The author was responsible for collecting the data, writing the publication and revising the paper during the journal review process. The study was planned and the data analyzed jointly with the co-authors.

Publication IV

Monto, S., Lind, L., and Kärri, T. (2013). Working Capital Models: Avenues for Financial Innovations. *Proceedings of The XXIV ISPIM Conference – Innovating in Global Markets: Challenges for Sustainable Growth, June 16–19, Helsinki, Finland.*

The author was responsible for collecting the data and writing the results section. The study was planned and the data analyzed jointly with the co-authors.

Publication V

Lind, L., Monto, S., and Kärri, T. (2017). Mapping working capital models in the automotive industry. *Paper presented at the 26th IPSERA conference, April 9–12, Balatonfüred, Hungary.* Revised and further submitted version.

The author planned the study and collected the data. The data was analyzed jointly with the co-authors. The author wrote the paper and is responsible for revising the paper during the journal review process.

Publication VI

Lind, L., Kärri, T., Virolainen V.M., and Monto, S. (2018). Working capital models: A generic framework. *Paper presented at the 27th IPSERA conference, March 25–28, Athens, Greece.* Revised and further submitted version.

The author was responsible for collecting the data, writing most of the publication, and revising the paper during the journal review process. The study was planned and the data analyzed jointly with the co-authors.

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NOMENCLATURE

AP	Accounts payable
AR	Accounts receivable
CCC	Cash conversion cycle
C2C	Cash-to-cash cycle
COGS	Cost of goods sold
DIO	Days inventory outstanding
DSO	Days sales outstanding
DPO	Days payables outstanding
EOQ	Economic order quantity
GDP	Gross domestic product
FSCM	Financial supply chain management
ICT	Information and communications technology
INV	Inventories
JIT	Just-In-Time
OEM	Original equipment manufacturer
ROC	Return on capital
SCF	Supply chain finance
VMI	Vendor-managed inventory
WCM	Working capital management

1 INTRODUCTION

This thesis concerns working capital models detected in the value chain context. The first chapter of the thesis introduces the background and motivation for the research, and presents the objectives and scope of the study. In addition, key concepts discussed in the thesis are defined. The final part of the chapter illustrates the structure of the thesis.

1.1 Background

Working capital is an asset that keeps the firm's operations running, and an essential element of the short-term finance of the firm. While being an investment in inventories and an effort to find the desired balance between the payment periods towards suppliers and customers, operational working capital (in this thesis: working capital) is a combination of material and financial flows in the value chain. On the one hand, it is about managing the inventories of raw materials, work-in-progress and finished goods, which has been discussed widely in the literature of operations and supply chain management (e.g. Claycomb et al., 1999; Chen et al., 2005; Eroglu and Hofer, 2011; Ancarani et al., 2016), and on the other hand, it concerns the management of trade credit, i.e. accounts receivable and accounts payable, which has been studied in the literature of finance (e.g. Petersen and Rajan, 1997; García-Teruel and Martínez-Solano, 2010; Garcia-Appendini and Montoriol-Garriga, 2013).

Working capital is capital tied up in the operations of the company. An annual working capital study of the 1 000 largest European nonfinancial companies by REL consultancy revealed that the total amount of tied-up excess working capital of these companies reached over one trillion Euros. The amount is equivalent to 7% of the GDP of the area. (REL, 2017) Also, the working capital management report by Ernst&Young (2016) indicated similar opportunities for improvement in the working capital management of US and European companies. The findings suggest a remarkable potential for more efficient working capital management in companies in order to release cash for other objectives.

Interest in working capital management research has been increasing during the last decade. Rapid changes in the business environment, as well as challenging financial conditions have made companies focus on efficient asset management (Mullins, 2009). The global financial crisis, through tightened opportunities to get external financing, had its effect on the increased attention. However, at least in the automotive industry, the financial crisis starting in 2007 only boosted the effects of the inability to manage cost and working capital in a value-adding way (Brandenburg, 2016). Thus, there has been real need for the attention on the working capital management.

The emergence of the research stream of financial supply chain management (FSCM) has raised the management of financial flows into discussion next to the effective material and information flows along the supply chains. This has led to an increased number of

scientific articles focusing on the topic during the last decade (Gelsomino et al., 2016). At the same time, companies have also started to pay more attention to working capital management. Its relevance has been shown e.g. by raising improved working capital rotation as one of the main financial targets (KONE Corporation, 2017) or by highlighting the financial model based on negative working capital as one of the corner stones supporting the strategy (Valeo, 2014). Also, companies such as Adidas and BMW emphasize focusing on strict working capital management, and see it as one of the drivers towards increased shareholder value (Adidas Group, 2016) and, overall, as a key element for managing business (BMW Group, 2010).

Earlier studies on working capital management have relied strongly on the perspective of a single company. The benefits of a small amount of working capital have been discussed in many studies, and several researchers have provided evidence on the negative relation between profitability and the cycle time of working capital (e.g. Jose et al., 1996; Shin and Soenen, 1998; Deloof, 2003; Lazaridis and Tryfonidis, 2006; Talha et al., 2010; Viskari et al., 2011a; Enqvist et al., 2014). Companies have aimed at shorter cycle times of working capital by reducing inventory levels, shortening the terms of payment towards customers and doing the opposite towards suppliers.

However, in today's networked environment, where competition is more and more based on the functionality and effectiveness of inter-organizational value chains instead of individual companies, taking the single company perspective to working capital management is fairly blinkered. Companies have different premises depending on their position in the value chain, bargaining power, business model, production processes, and financial conditions which all have their effect on working capital management. Additionally, especially actions related to the financial flows of working capital (i.e. trade credit) affect the working capital of the value chain partners as well. Thus, improvements in working capital management should not be done at the expense of other companies by passing the negative effects to suppliers and customers; instead, the issue should be considered from the wider perspective of the value chain (e.g. Hofmann and Kotzab, 2010; Grosse-Ruyken et al., 2011; Vázquez et al., 2016).

If working capital management is a complex issue within a company, and requires support and commitment from several functions such as production, finance, purchasing and sales, how can the even more challenging task of optimizing the working capital management of the value chain be accomplished? At least more knowledge about different working capital models or strategies would be needed to analyze the present state of working capital management in the value chain. Depending on the company's business environment, the way the company's working capital is constituted from the material and financial flows may differ remarkably. Two companies with exactly the same cycle time of working capital may have arrived there with totally different choices of working capital strategy. The identification of the working capital models applied by companies in the value chain can be seen as a prerequisite for optimizing the working capital management of the value chain. In order to make the value chain work efficiently, it should be ensured by each firm that their cycle times of working capital are in line with

the structure of the value chain (Grosse-Ruyken et al., 2011), and the positions in the value chain should be understood before making decisions related to financial supply chain management (Wuttke et al., 2013). Analyzing the working capital models applied by the value chain companies, which also reveals the structure as well as positions in the value chain in terms of working capital management, is a starting point for the collaborative working capital optimization of the value chain.

Working capital management practices have been studied in previous research, and scholars have presented classifications for working capital management routines by applying survey methodology to collect data. The studies have observed practices of working capital management in top companies within certain geographic areas such as the United States (Ricci and Morrison, 1996) and United Kingdom (Ricci and Di Vito, 2000), compared working capital management practices between different countries (Belt and Smith, 1991; Khoury et al., 1999), and focused on the small firms (Howorth and Westhead, 2003; Padachi and Howorth, 2014). However, previous research on different working capital models is scarce even if the working capital model has been defined as an important component of the business model beside the revenue model, gross margin model, operating model and investment model (Mullins and Komisar, 2009). Additionally, previous research on working capital management and financial supply chain management lacks the framework for positioning and categorizing the companies of the value chain on the basis of their working capital management even though the need to understand the working capital environment has been recognized.

The research presented in this thesis advances the knowledge of working capital management practices, but it differs from the previous research on this topic in two ways. First, it uses quantitative data based on official annual financial statements and thus provides a perspective of realized working capital models to support the survey-based results of companies' own perceptions. Second, it brings the perspective of inter-organizational value chains to the discussion of working capital models and provides support for the optimization of working capital management at the value chain level.

This dissertation continues the research on analyzing working capital management in inter-organizational value chains studied in the dissertations by Monto (2013) and Pirttilä (2014), as well as touches on the research of different strategies on (financial) working capital management studied by Talonpoika (2016). The thesis differs from the above dissertations by focusing on the working capital models in the value chains.

1.2 Objectives and research questions

This thesis studies different working capital models of companies existing in the value chain context. The main objective of the study is to develop a framework for working capital models in the value chains. As working capital models have not been widely studied before, this study aims at adding to the understanding of these different models applied in the companies, as in the value chain perspective, aiming at minimum working capital is not possible for all actors.

Figure 1 describes the objectives and research questions of the thesis. The links between the individual publications and related research question(s) are also shown.

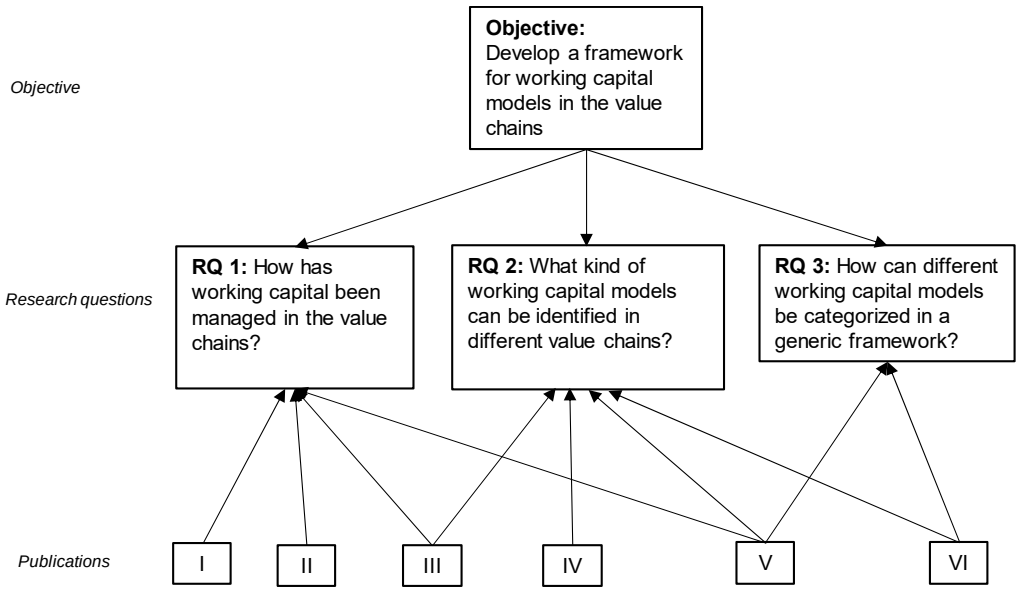


Figure 1. Objectives, research questions and individual publications of the thesis.

The study aims at answering three research questions. The first research question takes the cycle times of working capital under examination, and it is studied in publications I, II, III and V. The results related to the first research question provide background information regarding the current state of working capital management in the value chains. The second research question is studied in publications III, IV, V and VI. The research question focuses on the identification of different working capital models in the value chains. RQ1 and RQ2 differ from each other in terms of the methods used: in the first research question, only the cycle times of working capital have been under examination. When studying the working capital models (RQ2), the data has been analyzed more deeply by using e.g. statistical methods. The third research question relates to framework development, and it is investigated in publications V and VI. The research question seeks ways for categorizing the working capital models in the value chains. The results related to the third research question provide a generic framework in order to understand the phenomenon, and conclude the findings of the research.

1.3 Scope of the research

This thesis concerns the working capital models applied by different value chain actors. The scope of the thesis is in the intersection of the research streams of finance and operations management as described in Figure 2. Additionally, the research presented in the thesis has a connection to the literature of strategic management and especially business models, as a working capital model is seen as a part of a business model (Mullins and Komisar, 2009). Also, as discussed earlier, companies have started to pay attention to working capital management as an important part of their strategy. However, strategic management is included in the Figure 2 with a dotted line as the topics of strategic management and business models are not widely discussed in this thesis, but they are considered more as an underlying supportive framework and as a significant area for future research.

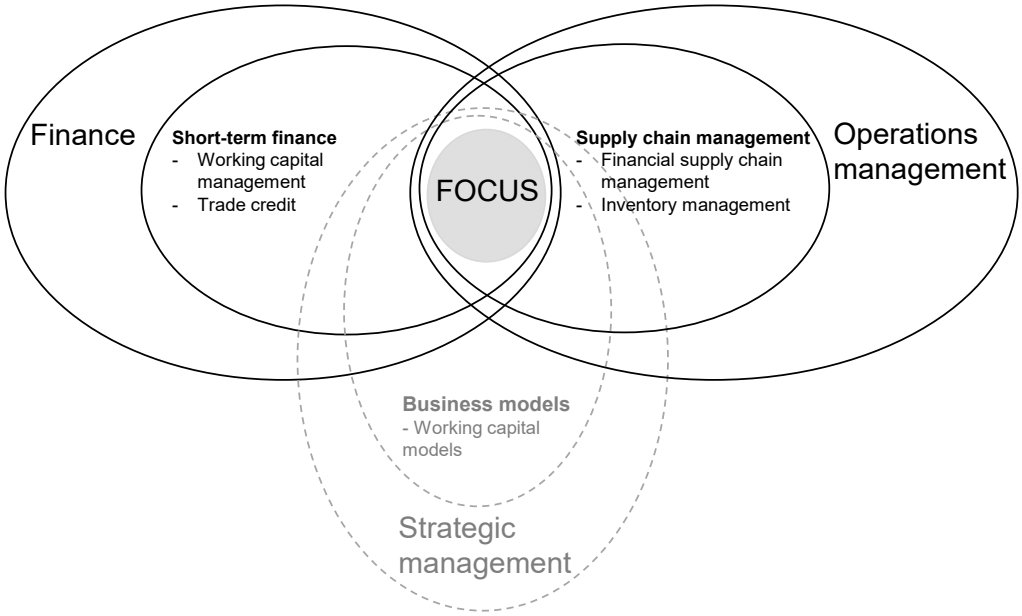


Figure 2. The scope of the thesis.

Working capital itself is already a concept that contains components from both research streams: accounts receivable and accounts payable, i.e. trade credit, is a topic discussed in finance literature concerning short-term finance, and inventory management is a part of operations and supply chain management. Working capital management as a whole has been studied in both environments, but with different focuses. Finance literature has concentrated on profitability and liquidity issues (e.g. Jose et al., 1996; Shin and Soenen, 1998; Deloof, 2003; Charitou et al., 2010), while recent research under the supply chain management stream has taken the collaborative perspective on working capital management and emphasized the holistic view of the whole value chain (e.g. Hofmann

and Kotzab, 2010; Grosse-Ruyken et al., 2011; Viskari and Kärri, 2012). This research contributes to the emerging literature of financial supply chain management, which has brought the financial flows into the discussion of efficient supply chains, along with efficient material and information flows.

1.4 Key concepts

Working capital

This thesis focuses on the management of operational working capital, consisting of inventories, accounts receivable and accounts payable. Operational working capital (in this thesis referred to as working capital) is defined as follows:

$$Working\ capital = Inventories + Accounts\ receivable - Accounts\ payable \quad (1)$$

Another perspective on working capital is to define it as current assets less current liabilities (e.g. Mullins and Komisar, 2009). This view considers all short-term balance sheet items. However, in this thesis, the interest is in the working capital tied-up in the company's operations and related to its processes, and therefore other items of current assets and current liabilities – that are rather financing-related issues – are not taken into account in this study.

Working capital model

The working capital model is the main topic of this thesis. Mullins and Komisar (2009) defined the business model being a combination of five smaller sub-models: revenue model, gross margin model, operating model, working capital model, and investment model. This thesis takes the working capital model as part of the business model under examination. As suggested by Farris and Hutchison (2003), companies should find the unique combinations of all working capital components to optimize their working capital, instead of individual attempts by managers to decrease inventories, reduce receivables, and extend payables. In this thesis, these "unique combinations of all working capital components" are called working capital models. By analyzing the working capital models, a more specific view is taken on how the working capital of a company is constituted of inventories and trade credit. The working capital model of a company describes the balance between the working capital components in relation to each other.

Working capital model as a concept is close to working capital strategy. In this thesis, working capital strategy as a term is considered to indicate that there are conscious decisions related to the management of working capital and its components behind the working capital performance of a firm. However, the data from financial statements used in this thesis does not reveal whether the working capital performance of a company is the consequence of a defined working capital strategy, or whether it is a result from a passive drifting towards a certain working capital model if working capital related issues are not actively managed within the company. It might also be that the company has failed

in the implementation of the selected strategy. Thus, the term working capital model is used in the study instead of working capital strategy.

Value chain

This thesis studies working capital models in the value chain context. The traditional definitions of the supply chain (see e.g. Croom et al., 2000) focused mainly on the material flow in the chain from suppliers to end customers. To highlight the importance of financial flows along the chain in addition to material flows, the value chain is used as a concept in this thesis. In this study, the value chain describes the value creating steps from raw material suppliers to end customers by following the material flow, but also takes into account the opposite financial flow. According to the definition by Al-Mudimigh et al. (2004), the focus in the value chain is on the customer and the information flow including the financial aspects, whereas Tan (2001) defines the supply chain focusing on the operations, material and logistics. Al-Mudimigh et al. (ibid.) see the supply chain as a sub-set of a wider value chain. Of course, the recent discussion on supply chains has recognized the need to consider the financial flows in addition to effective material and information flows, and thus the supply chain has been used as a term in this context as well (e.g. Hofmann and Kotzab, 2010; Gomm, 2010; Grosse-Ruyken et al., 2011; Brandenburg, 2016). Also, the concepts of financial supply chain management as well as supply chain finance (SCF) have become idioms in the research field. However, when starting the research for this dissertation, research considering financial issues in the supply chains was limited, and the term value chain was seen as a more holistic approach to the topic. The related research has also still used the term value chain (e.g. Lorentz et al., 2016).

Financial supply chain management and supply chain finance

Financial supply chain management and supply chain finance are often used as synonyms, but depending on the source, they may also have different definitions. In this thesis, the definition for the term financial supply chain management is adopted by Wuttke et al. (2013, 773), who described financial supply chain management as “optimized planning, managing, and controlling of supply chain cash flows to facilitate efficient supply chain material flows”. They see supply chain finance as one FSCM practice along with buyer credit and reverse factoring, for example. Gelsomino et al. (2016) found two differing streams within the research in the area of financial supply chains: the finance-oriented perspective, focusing on trade credit and including external providers of supply chain finance solutions, and the supply chain oriented perspective, which takes into account all working capital components (inventories in addition to trade credit), emphasizes the collaboration between the supply chain members, and does not necessarily include financial institutions. In this thesis, the supply chain oriented perspective by Gelsomino et al. (2016) is adopted and referred to as financial supply chain management. Supply chain finance, in turn, is seen as a sub-part of financial supply chain management, as a tool which can provide solutions to the problems in the financial supply chains. This thesis focuses on the collaboration and optimization related to working capital management in

the value chains, and the supply chain finance solutions are not widely considered nor discussed.

1.5 Structure of the thesis

This thesis consists of two parts. The first part is the introductory part, which provides an overview of the research. The introductory part is comprised of five chapters which introduce the background and objectives for the research, previous literature, research methodology and design, research contributions, and conclusions. The second part is formed by six individual publications, which provide a more detailed view of the research.

Figure 3 shows the structure of the thesis. The first chapter introduces the background and objectives for the research. The second chapter provides the description of the research environment and previous research by reviewing prior literature on financial supply chain management, management of working capital and its components, and discusses the working capital models as part of business models. The third chapter presents the methodological choices and research design, as well as describes the used data and measures. The fourth chapter summarizes the main results of the individual publications and answers the research questions. The fifth chapter concludes the thesis by providing the theoretical contributions and managerial implications of the research and, finally, suggests directions for further research.

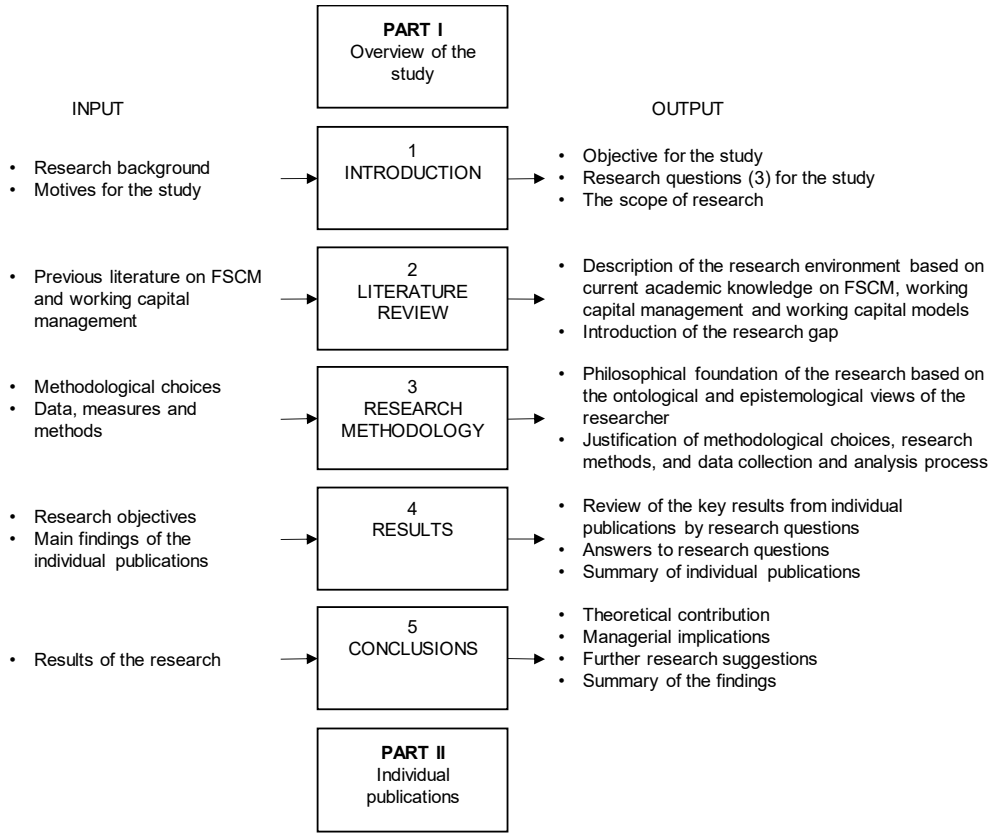


Figure 3. Outline of the thesis.

2 LITERATURE REVIEW

In this chapter, the theoretical background of the dissertation is described by reviewing previous literature relevant to the research of this thesis. The chapter begins with the description of the research stream of financial supply chain management, the literature of which provides the main framework for the study. After that, previous research on working capital management, including inventory and trade credit management, is reviewed. The chapter continues with literature related to the core concept of the thesis, working capital models, and different working capital management practices found by previous research are introduced. The chapter ends with the description of the research gap, the bridging of which is the objective of this thesis.

2.1 Financial supply chain management

The supply chain, consisting of several actors working together in order to acquire raw material, produce goods, and deliver them to the end customer, has traditionally been seen delivering material flow from upstream to downstream and information flow from downstream to upstream (Beamon, 1998). Formerly, research on supply chain management focused on individual processes until the interest in the supply chains as a whole increased in the 1990s. Mentzer et al. (2001, 4) defined the supply chain as "a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer". This definition also brings up the financial aspects in the supply chain, which can be seen as a requirement for an effective supply chain system (Gupta and Dutta, 2011). In the past years, the concept of financial supply chain management has emerged and gained increasing interest among researchers. In addition to material and information flows in the supply chain, financial supply chain management acknowledges the inventory financing costs together with the financial flows towards upstream and downstream (Lee and Rhee, 2010; Protopappa-Sieke and Seifert, 2010; Wuttke et al, 2013). Efficient working capital management, consisting of the management of inventories and trade credit through the whole chain, is a key element of financial supply chain management. As discussed in chapter 1.4, this thesis refers to the value chain instead of the supply chain. Nevertheless, financial supply chain management is seen as a relevant theoretical background for the research.

As an emerging research stream, the key definitions of the research area have not been established, which has led to difficulties in forming a proper view of the topic from previous literature. According to Gelsomino et al. (2016), the research area lacks a general framework, and different perspectives on the topic have resulted in contrasting – and even conflicting – definitions. For example, the terms "financial supply chain management" and "supply chain finance" have been used in similar contexts as synonyms, whereas some researchers define these as different concepts. An example of the different definitions for the terms related to financial supply chains is presented in Table 1.

Table 1. Definitions for financial supply chain management and supply chain finance in previous literature.

Concept	Definition	Source
Financial supply chain management	"A specific set of solutions and services to expedite the flows of money and data between trading partners, i.e. buyers and suppliers, along the supply chain."	Sugirin (2009, 237)
	"Optimized planning, managing, and controlling of supply chain cash flows to facilitate efficient supply chain material flows."	Wuttke et al. (2013, 773)
	"Financial Supply Chain Management (FSCM) consists of the holistic and comprehensive activities of planning and controlling all financial processes, which are relevant within a company and for communication with other enterprises."	Popa (2013, 142)
Financial supply chain	"The set of processes and information that determines the value of liquidity, of the accounts and of the company's working capital."	Camerinelli (2009, 121)
	"A financial supply chain is the network of organisations and banks that coordinate the flow of money and financial transactions via financial processes and shared information systems in order to support and enable the flow of goods and services between trading partners in a product supply chain."	Blackman et al. (2013, 133)
Supply chain finance	"Located at the intersection of logistics, supply chain management, collaboration, and finance, Supply Chain Finance is an approach for two or more organizations in a supply chain, including external service providers, to jointly create value through means of planning, steering, and controlling the flow of financial resources on an inter-organizational level"	Hofmann (2005, 3)
	"The set of products and services that a financial institution offers to facilitate the management of the physical and information flows of a supply chain."	Camerinelli (2009, 122)
	"Supply chain finance (SCF) is the inter-company optimisation of financing as well as the integration of financing processes with customers, suppliers, and service providers in order to increase the value of all participating companies."	Pfohl and Gomm (2009, 151)
	"Optimising the financial structure and the cash-flow within the supply chain"	Gomm (2010, 135)
	"An automated solution that enables buying firms to use reverse factoring with their entire supplier base, often providing flexibility and transparency of the payment process."	Wuttke et al. (2013, 774)
	"Managing, planning and controlling all the transaction activities and processes related to the flow of cash among SC stakeholders in order to improve their working capital."	More and Basu (2013, 625)
	"Using the supply chain to fund the organization, and using the organization to fund the supply chain."	Huff and Rogers (2015, 5)

Gelsomino et al. (2016) discovered that research on the area of financial supply chains has been divided into two different domains: into 1) finance–oriented, and 2) supply chain–oriented perspectives. The finance-oriented perspective focuses on the financial solutions offered by external financial institutions, and the studies applying this perspective consider working capital mainly in terms of trade credit, i.e. accounts receivable and accounts payable. A considerable amount of studies on this topic has been conducted lately. The key concept in this research area is reverse factoring (see e.g. Seifert and Seifert, 2011; Tanrisever et al., 2012; van der Vliet et al., 2015; Lekkakos and Serrano, 2016). In some contexts, reverse factoring may even be used as a synonym for supply chain finance (Iacono et al., 2015; Grüter and Wuttke, 2017). Reverse factoring is initiated by buyers mainly to extend the accounts payable periods, but the reasons to its use also cover the willingness to reduce the supplier default risk and to simplify processes (Liebl et al., 2016). The arrangement benefits the suppliers as well, as they have the possibility to receive the due amount immediately from the financial institution with an interest based on the buyer's credit rating (Wuttke et al., 2016). Differing from traditional factoring, in which the firms sell their creditworthy accounts receivable, often from several customers, to a factor to receive immediate cash (Klapper, 2006), reverse factoring is buyer-centric and thus causes less risks for the factors, and lower interest rates can be charged (Seifert and Seifert, 2011). In this thesis, the finance-oriented perspective is referred to as supply chain finance, following the definition by Wuttke et al. (2013), which sees supply chain finance as a sub-concept within financial supply chain management.

The second perspective presented in the study by Gelsomino et al. (2016) is described as the supply chain–oriented perspective. This view emphasizes the collaboration between the supply chain actors, and takes a holistic view on working capital optimization, also considering inventory management in addition to trade credit. In the supply chain–oriented perspective, it is not mandatory to consider the financial institutions, and many studies have provided a comprehensive view on the financial supply chains without discussing any specific supply chain finance solution or practice. The studies applying the supply chain–oriented perspective have discussed for example the optimal working capital management for the supply chain (Grosse-Ruyken et al., 2011), developed models for working capital management in intra- and inter-organizational value chains (Monto, 2013), analyzed the cycle times of working capital in different industry value chains (Pirttilä, 2014), and observed the relationship between the changes in working capital management and financial performance (Huff and Rogers, 2015). In this thesis, the supply chain–oriented perspective is applied, and referred to as financial supply chain management. The division into finance-oriented and supply chain–oriented perspectives follows the traditional fragmentation of working capital management research: trade credit issues, liquidity, and profitability were discussed mainly in the literature of finance (Charitou et al., 2010; Deloof, 2003; Enqvist et al., 2014; García-Teruel and Martínez-Solano, 2007; Jose et al., 1996; Shin and Soenen, 1998), whereas the literature on operations management has focused on efficient material flows and inventory management (Chen et al., 2005; Claycomb et al., 1999; Gunasekaran et al., 2001; Hofer et al., 2012; Johnson and Templar, 2011). This shows that there is need for studies that

view working capital from the holistic perspective, as well as combines the two different perspectives on financial supply chains.

The number of studies discussing financial issues in the supply chains has increased remarkably during the past decade. The first remarks about the relevance of considering the perspective of the supply chain when managing working capital were presented by Farris and Hutchison (2002, 2003). Their papers concerned measuring working capital management with the cycle time of working capital, cash conversion cycle (CCC), and introduced it as a new supply chain management metric. They highlighted the opportunities that this measure provides for collaboration in supply chain management, as the CCC serves as a bridge for the processes into and out of the firm. The article by Hutchison et al. (2007) continued the research with the same measure. The authors argued that the supply chain approach to working capital management could lead to overall efficiency and improved profits for all parties. Randall and Farris (2009) showed that collaborative strategies for financial supply chains may improve the profitability of all supply chain partners. In some cases this may even require companies to accept the deterioration in its own cycle times to gain benefits for itself and the supply chain partners (Hutchison et al., 2009). The central paper in the research of financial supply chains adopting the supply chain–oriented perspective is the study by Hofmann and Kotzab (2010). The authors compared the single-company and supply chain perspectives on working capital management, and built a conceptual model for a collaborative approach to CCC. Their findings indicated that minimizing working capital from a single company perspective does not add value to all supply chain partners. The authors note, however, that a certain balance between trust and power is required, and remind as well that to gain long-term benefits from the collaborative working capital management, some supply chain members may experience short-term deteriorations in the cycle times of working capital.

Working capital management literature from the single company perspective has traditionally emphasized that companies should aim at minimizing their working capital by reducing their inventories and accounts receivable, and by extending their payment periods towards suppliers (e.g. Farris and Hutchison, 2002; Mullins, 2009). However, Wuttke et al. (2013) stress that working capital situations in the supply chains should be analyzed by companies before making decisions related to financial supply chain management. The supply chain–oriented approach, focusing on collaborative working capital management within the supply chain, highlights that working capital should not be managed at the expense of the supply chain partners, but the decisions should be done in accordance with the structure of the chain (Grosse-Ruyken et al., 2011). Large and powerful companies could take advantage of their position and negotiate payment terms in a way most beneficial for themselves. However, studies have provided evidence for the fact that this kind of behavior only provides short-term benefits, but may harm the companies in the long run (e.g. Huff and Rogers, 2015; Kroes and Manikas, 2014; Grosse-Ruyken et al., 2011). This was also highlighted in the study by Vázquez et al. (2016), who showed that there was no collaboration in the working capital management between the first- and second-tier suppliers in the automotive industry. They found that the first-

tier moved all the harm in terms of inventories and trade credit backwards in the chain. The authors demand the role of OEMs as promoters of collaborative working capital related actions throughout the chain. Lorentz et al. (2016) also emphasize the value chain perspective on working capital management because of its sustainability and economic sense, but they note that improvements might be difficult to achieve as real operational changes would be needed.

The target of collaborative working capital management is to optimize the material and financial flows in the supply chain. However, previous literature on working capital management and financial supply chain management has not been able to define exact values for the optimal amount of working capital management due to the different premises of companies and supply chains. Grosse-Ruyken et al. (2011) note that the optimal cycle time of working capital of a company depends on its business model, supply chain design and risks. Different characteristics in different industries have their effect on the optimal amounts of working capital of companies as well as supply chains (Filbeck and Krueger, 2005; Pirttilä et al., 2014). Also, the size of the firm has been found to impact cash conversion cycles: in the study of Moss and Stine (1993), results showed that larger firms managed their working capital more efficiently than smaller ones. These characteristics need to be taken into account when optimizing working capital in the supply chain context. According to the results by Hofmann and Kotzab (2010), the optimal way of managing working capital in the supply chain context minimizes the costs of tied up capital and maximizes the received cash among all supply chain members.

Earlier studies on working capital management often focused either on the financial flow (trade credit) or the material flow (inventories) of working capital. The studies in the area of financial supply chain management have tried to tackle this division by developing models that consider both flows simultaneously. Protopappa-Sieke and Seifert (2010) linked the financial and material flows by treating the financial flows as constraints on inventory decisions, while creating a mathematical model to determine the optimal purchase order quantity. The working capital model by Viskari and Kärri (2012), considering all working capital components, was developed to analyze the efficiency of working capital management at the company level and to observe the financing costs of tied-up working capital at the value chain level.

Singh and Kumar (2014) argued that prior literature on working capital management lacks survey-based approaches and systematic theory development studies. Gelsomino et al. (2016) note that general theory development studies considering both the finance- and supply chain–oriented perspectives, empirical studies on the application of supply chain finance solutions, studies analyzing the effect of financial supply chain management on the financial performance, as well as the development of practical tools to support the managerial decisions, are directions for future research in financial supply chain management.

2.2 Working capital management

Companies have limited amounts of resources. Therefore, it is essential to take care of the allocational efficiency of capital markets, and make sure that resources will be organized in the most productive way (Arnold, 1998). This is a common view in the literature of finance, and even if the statement originally concerned stock markets, the same idea serves as a foundation behind the management of working capital in companies and financial supply chains: working capital should be allocated in the most optimal way, and released in order to use it for more productive objectives. This calls for the reasonable reduction of working capital in the supply chains, but also for the optimization of the working capital inside the value chain. This would improve financial flexibility, as well as decrease financing costs (de Almeida and Eid Jr., 2014).

Research in the area of working capital management has increased recently. The origin of the research is in finance. However, working capital is not a mere financial concern: the key to its improvement lies in the operative actions behind the financial results (Reilly and Reilly, 2002). Thus, during the past decade, working capital studies under the research stream of supply chain management have increased as well. The bibliometric study by Viskari et al. (2011b) showed that, in the studied databases, the number of articles concerning working capital management was 23 during 1990–2010, and the number of annual studies increased in the last years of the observation period. The findings by Pirttilä (2014) confirmed this trend, as during the following 3-year period (2011–2013), 39 articles were published. Despite the increased number of scientific articles in general, the findings by Viskari et al. (2011b) and Pirttilä (2014) demonstrate the grown academic interest in working capital management. Although, it should be noted that only articles considering working capital management as a whole were included in the analyses, and papers concerning inventory management or trade credit alone were excluded. One reason for the grown interest in the working capital was the financial crisis of 2008, as it decreased the availability of trade credit (Kestens et al., 2012) as well as external financing from banks. The situation led to the increased interest in the opportunities to release working capital from the supply chain (Polak et al., 2012). Another trend causing the increasing focus on the working capital issues are the new technologies enabled by the digitalization. It has been shown that high level of digitalization in companies enable the use of innovative supply chain finance solutions, which are more flexible and provide benefits for all participants (Caniato et al., 2016). Digitalization can support the synchronization of material, information and financial flows in the supply chains, which provides benefits for the supply chain partners (Omran et al., 2017). With strong probability, the development of blockchain technology will affect the management of financial flows in the future (Iansiti and Lakhani, 2017).

Many researchers have studied the connection between effective working capital management and firm performance. The contexts of the studies have varied: in many studies, the sample has been restricted to a specific country or geographical area (e.g. de Almeida and Eid Jr., 2014; Padachi, 2006; Sharma and Kumar, 2011), certain industry sector (e.g. Shah and Sana, 2006; Viskari et al., 2011a; Tahir and Anuar, 2016), or to

manufacturing (e.g. Raheman et al., 2010) or service (Marttonen et al., 2013) companies. Several studies have concentrated on the relation between working capital management and profitability in small and medium sized companies (e.g. García-Teruel and Martínez-Solano, 2007; Tauringana and Afrifa, 2013; Tran et al., 2017). Reasons for this particular interest may be the limited access of small firms to external finance (Tran et al., 2017), limited resources in terms of equipment and technology to manage working capital components effectively (Tauringana and Afrifa, 2013), and the crucial role of efficient working capital management in the growth and long-term survival of small firms (Pais and Gama, 2015). Generally, most studies about the connection of working capital management and firm performance have reported a significant negative correlation between working capital and profitability (e.g. Jose, 1996; Shin and Soenen, 1998; Deloof, 2003; Lazaridis and Tryfonidis, 2006; Mojtahedzadeh et al., 2011; Marttonen et al., 2013; Enqvist et al., 2014; Yazdanfar and Öhman, 2014; Lyngstadaas and Berg, 2016). The same result was confirmed by Singh et al. (2017). In their research, they conducted a meta-analysis of 46 articles studying the relationship between working capital management and profitability to synthesize the previous quantitative research findings. The results support the traditional view that aggressive working capital management minimizing the inventories and accounts receivable, and maximizing the accounts payable, would lead companies to the best profitability.

However, opposite findings have been presented as well. The results by Abuzayed (2012) indicated that more profitable firms in Jordan were less motivated to manage working capital. The studies in India (Sharma and Kumar, 2011) and Pakistan (Nazir and Afza, 2009; Tahir and Anuar, 2016) also found a positive relation between working capital and profitability. This could indicate that the operating logic in regard to working capital management is different in the emerging markets. Baños-Caballero et al. (2012, 2014), Aktas et al. (2015) and Pais and Gama (2015) have provided evidence for the existence of an optimal level of working capital. The results showed that companies can maximize their profitability with a certain level of working capital, but moving away from the optimal level by decreasing or increasing the tied-up working capital deteriorated profitability. The results presented above indicate that even if demonstrated with several studies and datasets, the positive correlation between profitability and working capital efficiency is not unambiguous. Individual companies have to take into account which working capital management practices improve their profitability and not simply blindly aim at decreasing their working capital.

2.2.1 Inventory management

Especially in a manufacturing company, inventories may tie up remarkable amounts of cash into the inventories of raw material, work-in-process and final goods. Thus, efficient inventory management is a highly important part of working capital management, and the component of working capital that can mostly be affected by the company itself. On the other hand, it can also be seen as the most difficult working capital component to manage as it requires involvement from several functions, such as production, purchasing,

finance, management, sales and engineering (Björk, 2000). Rafuse (1996) argues that companies should direct their working capital management attention particularly on the reduction of inventories, as the benefits gained via more efficient inventory management are real and substantial, and not caused by re-allocating working capital in the value chain. The optimal amount of inventory is balancing between the disadvantages of inventories too large and too small. Carrying large inventories requires a lot of physical space, ties up working capital, and increases the risk of damage, spoilage, and loss, whereas inventories that are too small may cause production stops and lead to negative effects on customer service (Koumanakos, 2008) and further, to lost sales (Shin et al., 2015).

Traditionally, studies on inventory management have concentrated on the efficient operations and correct sizing of inventory in relation to economic order quantity (EOQ), management philosophies like just-in-time (JIT) and lean, and issues in demand characteristics and marketing environment (Koumanakos, 2008). Logistic researchers have developed models for inventory control and studied collaborative inventory management (Williams and Tokar, 2008). One of the collaborative tools for inventory management is the vendor-managed inventory (VMI), which has been the topic of several studies (e.g. Yu et al., 2012; Mateen and Chatterjee, 2015). The VMI is based on a collaborative strategy and information sharing between a customer and supplier, and it is a process in which the supplier manages and replenishes the raw material inventory of the customer at the warehouse level (van Weele, 2010). VMI is used to optimize the availability of material at minimal cost for both actors, and its benefits are the reduction of total inventory costs and the ability to manage the bullwhip effects in the supply chain (Karimi and Niknamfar, 2017). In an individual company, inventory management can be made more efficient by short- or long-term actions (Steinker et al., 2016). Short-term actions include the optimization of inventory policies, reduction of obsolete stocks, and enhancement of forecasting processes. Re-designing the manufacturing network, reduction of portfolio complexity, and supplier integration are considered as long-term actions. The study by Steinker et al. (ibid.) showed that companies under financial distress use short-term inventory adjustments to free tied-up working capital.

While the principles of lean and JIT have become more popular, the value of more efficient inventory management has been understood in companies and thus, inventories have decreased during the past decades. Chen et al. (2005) studied the changes in inventory management with a large dataset consisting of American manufacturing companies, and found a significant reduction in the cycle time of inventories, which decreased by 15 days over the observation period from 1981 to 2000. The reduction was mainly due to reductions in the work-in-progress inventories, whereas the inventories of finished goods remained at the similar level. Additionally, the authors found abnormally high inventories leading to abnormally poor long-term stock market performance, while abnormally good stock market performance was achieved by companies with low, but not too low, inventories. A similar finding was made by Eroglu and Hofer (2011), who suggest that going too lean on inventories (i.e. reducing inventories too much) is not beneficial, but may turn negative. They found evidence for the existence of an optimal

degree for inventory leanness, and when the inventories are reduced beyond that limit, it has a negative effect on firm performance.

Many other researchers have studied the relation between inventory management and financial performance as well. Claycomb et al. (1999) concluded that companies following JIT gained improved financial performance in terms of profitability and return on investment and sales. Capkun et al. (2009) found a significant positive correlation between inventory and financial performance. According to their findings, there are industry-specific differences in the impact of different inventory types on operating profit. Their findings indicate that while in the assembly-related industries operating profit is improved by reducing all types of inventories, processing industries or basic commodities do not benefit that much from the reduction of raw material or work-in-process inventories. Another positive relation was found by Shin et al. (2015), whose findings also indicate that small companies were able to gain even more advantage of reduced inventories than medium and large sized companies. Negative relation between inventory efficiency and financial performance has been found as well. Balakrishnan et al. (1996) analyzed the annual reports of 92 manufacturing companies and studied the relation between different inventory types and profitability. Their results showed that efficient inventory management was not associated with a superior return on assets. Cannon (2008) found only a little or no link between the improvements in inventory management and overall financial performance in his study of 244 firms over a 10-year observation period. He points out that improved inventory performance should not be considered as the only indication of improved overall performance.

2.2.2 Trade credit management

The other part of operational working capital, trade credit, consists of the financial flows towards the supplier (accounts payable) and customer (accounts receivable). Trade credit has been recognized as an important source of short-term finance (Nadiri, 1969; Petersen and Rajan, 1997; Seifert et al., 2013), and it has been widely used in practice (Luo and Zhang, 2012). Trade credit arises when goods are sold on credit. The use of trade credit creates accounts receivable for the supplier which is equivalent to the amount of accounts payable created to the customer. The reasons for the use of trade credit are various: competitive and industry pressures, substitution or complementation of bank credits, or reduction of transaction costs (Petersen and Rajan, 1997; Seifert and Seifert, 2008; Seifert et al., 2013). The study by García-Teruel et al. (2014) showed that SMEs use trade credit to finance their sales growth. Mateut et al. (2015) found evidence that firms with large raw material inventories used trade credit to sell goods to their customers in order to reduce inventory costs. The study by Ng et al. (1999) revealed that credit terms seem to differ between industries, but within the industries only a little variation was found. There are also country-specific differences in the use of trade credit (Seifert et al., 2013).

A major part of previous research on trade credit comes from finance (see e.g. Petersen and Rajan, 1997; Molina and Preve, 2009; Fabbri and Klapper, 2016), but recently, studies in the area of operations and supply chain management have also been made (see

e.g. Lee and Rhee, 2011; Luo and Zhang, 2012). As trade credit is a component affecting more than one company – accounts payable of the buying company are accounts receivable of its supplier – it makes sense to view the situation from the supply chain perspective as well. Also, Seifert et al. (2013) highlighted the relevance of the supply chain perspective and raised a question of how to use trade credit for allocating capital through the supply chains. Lorentz et al. (2016) studied trade credit dynamics in the context of a value chain. Their findings show that the change in the cycle times of trade credit components seems to react to the economic situation, and they found evidence of passing extensions in the cycle time of accounts payable upstream along the value chain. This affects the cycle time of accounts receivable in the value chain as well. Their finding supports the previous results by Bastos and Pindado (2013), which indicated that companies carrying large amounts of accounts receivable delayed their payments to suppliers in order to avoid the risk of insolvency.

Lorentz et al. (2016) suggested collaborative cash management to be considered as a way of improving the value chains as a whole. This view is shared by other researchers as well. The collaborative perspective emphasizes that large companies should not use their power to stretch the accounts payable periods at the expense of suppliers – the behavior that was identified in the study by Fabbri and Klapper (2016) – but instead, consider the advantage of the supply chain as a whole. Kroes and Manikas (2014) found that the reduction of accounts receivable was positively associated with firm performance, but changes in the accounts payable are not related to changes in performance. They argue that the increase of accounts payable only offers improvements to immediate liquidity, but on the long-term it may have a negative impact on the firm. Huff and Rogers (2015) made a longitudinal study on the relationship of the working capital components and financial performance of a firm. They found that payment term adjustments only give short-term benefits, but improvements in inventory management offer longer-lasting advantages for a company. Similarly, Grosse-Ruyken et al. (2011) and Wandfluch et al. (2016) also stated that by forcing supply chain partners to accept longer payment terms a firm can only achieve short-term success.

2.3 Working capital models

The business model is the economic foundation of a firm, and it consists of five sub-models: revenue model, gross margin model, operating model, working capital model, and investment model (Mullins and Komisar, 2009). In this thesis, the focus is on the working capital model. Farris and Hutchison (2003) stated that instead of individually attempting to reduce inventories and accounts receivables and increase accounts payables, companies should find their own unique combinations of all three components to optimize their working capital. This is the starting point for studying the working capital models in this thesis.

Previous research related to working capital models has mainly approached the topic by studying what kinds of working capital management practices and policies are applied in

the companies. These studies have mostly used surveys to discover the policies regarding working capital management. One of the earliest academic journal papers of this type was the one authored by Belt and Smith (1991), in which working capital management practices were compared in Australia and the United States. The questions of the survey concerned the overall working capital policy (e.g. the existence and review regularity of the working capital policy), the management of working capital (e.g. measures and most important actions of working capital), and the management of the components of working capital (e.g. policies regarding inventory replenishment and cash discounts offered by the suppliers). The results showed that the companies in the two countries differed in the practices related to inventory management and credit collection, but they faced similar problems regarding working capital in which they responded in a relatively similar manner. Later, Khoury et al. (1999) conducted a similar study in Canada. The studies by Ricci and Morrison (1996) and Ricci and Di Vito (2000), in turn, focused on the impact of international business on the practices related to the financial flows of working capital. However, these studies mainly reviewed the practices that companies reported to use, and did not particularly identify or categorize any specific working capital models based on the results.

A step towards working capital models was taken by Howorth and Westhead (2003), who analyzed the working capital management routines of a large sample of small companies. They collected data via a structured questionnaire and received 343 valid responses, in which companies reported the frequency of 11 working capital management related routines. Table 2 describes the routines and the proportion of companies that reported reviewing the routine in question. The most reviewed routine was the creditor payment periods, whereas inventory management related routines (stock levels, stock reorder levels and stock turnover) were among the less reviewed routines.

Table 2. Working capital management routines and their use in the companies. (Howorth and Westhead, 2003).

Working capital management routine	% of companies reviewing the routine
Payment period to creditors	75 %
Customer credit risk	71 %
Cash budgeting	70 %
Customer credit periods	70 %
Doubtful debts	68 %
Finance of working capital	68 %
Stock levels	64 %
Bad debts	61 %
Stock reorder levels	60 %
Stock turnover	59 %
Customer discount policy	30 %

The results of Howorth and Westhead (2003) showed that the majority of the small companies focused on one area of working capital management instead of the holistic view. The authors identified four distinctive types of companies via cluster analysis: 1) companies were either focused on cash management routines, 2) inventory management routines, 3) credit management routines, or 4) did not use any working capital management routines. Additionally, characteristics regarding e.g. the age and size of the firm, level of sophistication of financial skills, and the use of external finance, for each cluster were studied. The results revealed that larger and younger firms focused on cash management and had more external finance, whereas smaller and younger companies concentrated on stock management. They also used less external finance and had longer production cycles. Companies focused on credit management routines were less profitable, and purchased more on credit and had fewer customers paying on time than other clusters. The companies with no working capital management routines had less sophisticated financial skills, less external finance and higher profitability.

The study of Howorth and Westhead (ibid.) was the first to provide categorization for the working capital models. Padachi and Howorth (2014) followed a similar approach in their study of Mauritian small and medium sized firms. They also identified four clusters which were described as follows: 1) no working capital management routines, 2) debtor and stock review, 3) stock review, and 4) all working capital management routines. Both studies were limited to small and small and medium sized firms, and the results by Howorth and Westhead (2003) indicate that the lack of resources may make companies concentrate on only one aspect of working capital. Therefore, identifying working capital models in a different context may bring up deviating findings.

While other studies on working capital management practices were based on the data collected via surveys, Meszek and Polewski (2006) used quantitative financial data in

their study of working capital management strategies in the construction industry. The authors presented a framework for the working capital management strategies in a company (Figure 4) which introduced aggressive, moderate and conservative working capital strategies. According to the authors, an aggressive working capital management strategy is based on the large amount of current liabilities and small amount of current assets. In this strategy, income and risk are high. The conservative strategy is the opposite: it is based on the small amount of current liabilities and large amount of current assets. The conservative strategy leads to a low income and has a low risk. The moderate strategy is located between the aggressive and conservative strategies, and its income and risk are on an average level. The results showed that five out of the six analyzed companies applied the moderate strategy, whereas one company followed the conservative policy.

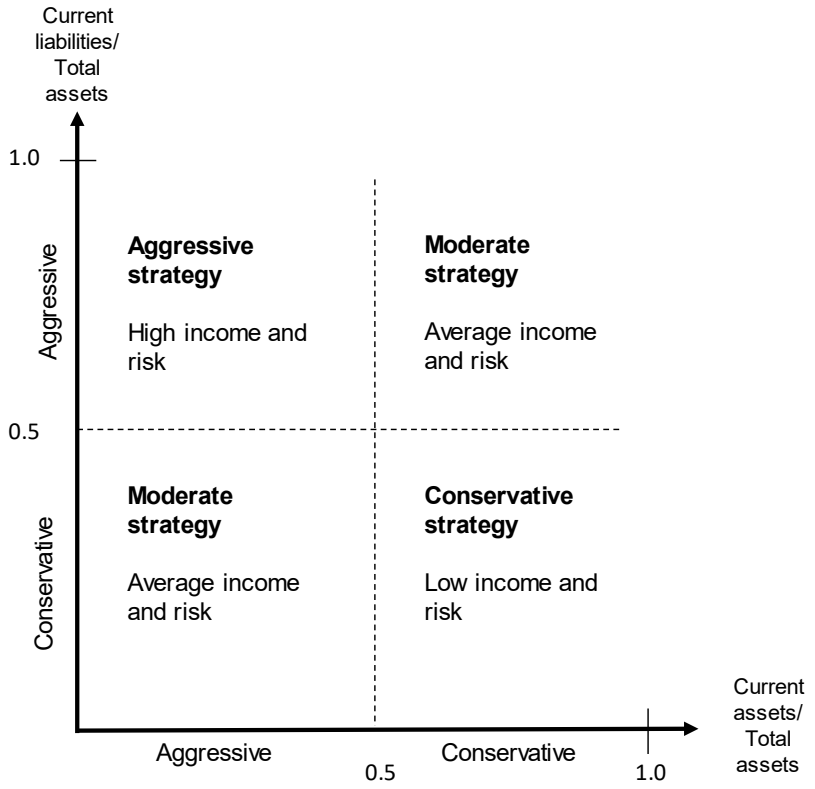


Figure 4. Working capital management strategies in a company. (Meszek and Polewski, 2006)

Farris and Hutchison (2003) have also introduced a matrix to map different working capital management approaches. In their paper, they introduced a taxonomy to classify industries by their working capital performance. The authors used this cash-to-cash map

(see Figure 5) to categorize different industries into groups on the basis of their accounts receivable (AR), accounts payable (AP), and inventory levels.

	High inventory	Low inventory
High AR	**High AP** (e.g. Chemicals and allied products, Industrial commercial machinery computers)	**High AP** (e.g. Oil and gas extraction, Communications, Business services)
	Low AP (e.g. Real estate)	**Low AP** (e.g. Health services, Engineering and accounting services)
Low AR	**High AP** (e.g. Forestry, Electronic and other electrical equipment)	**High AP** (e.g. Motion pictures)
	Low AP (e.g. Metal mining, Rubber / miscellaneous plastics, Auto dealers and gas stations)	**Low AP** (e.g. Paper and allied products, Printing Publishing, Food stores)

Figure 5. Cash-to-cash map (adapted from Farris and Hutchison, 2003).

The authors (ibid.) divided the industry sectors into different categories of their cash-to-cash map by using median values of each sample to characterize the level of working capital components in each industry. Then, the total sample was split into two halves according to high and low categories. The purpose of the matrix is to provide an opportunity to identify possible benchmark industries in terms of working capital management.

2.4 Research gap

Previous research on working capital models has been scarce. The topic is of interest for a few reasons. First, at the beginning of this dissertation process, the findings of Publication II suggested that in the value chain context, companies should have different strategies for working capital management, as all companies do not benefit from similar working capital actions. Second, as suggested by Farris and Hutchison (2003), companies should define their own unique combinations of all working capital components instead of managing all of them individually. This statement calls together the fragmented academic literature of working capital management, as in prior literature, inventory management and trade credit are studied extensively but, for the most part, separately. Less studies have taken the holistic view on working capital, and even the studies concentrating on working capital management often focus on either the material or financial flows of working capital. In the automotive industry, Publication II found that the most efficient option for improving the profitability of the value chain by working

capital management is the simultaneous management of all working capital components, and the findings by Brandenburg (2016) indicate that automotive companies have not had this comprehensive view on working capital. Thus, research on working capital models is highly relevant. Third, prior research on working capital models has mainly studied different working capital practices with data gathered by surveys. The literature lacks studies based on numerical financial data, which reveal the realized working capital models that companies have applied. In addition, previous studies on working capital management practices, models, and strategies have not taken the perspective of the value chain but mainly compared similar type of companies. The research gaps presented above are narrowed down in this thesis by examining the working capital models, consisting of both the inventories and trade credit, applied by companies in the value chains.

The review of previous literature on working capital and financial supply chain management reveals that several researchers have stressed the need to manage working capital at the value chain level (e.g. Hutchison et al., 2007; Randall and Farris, 2009; Hofmann and Kotzab, 2010; Huff and Rogers, 2015; Vázquez et al., 2016; Lorentz et al., 2016). Financial supply chain management aims at the optimization of the working capital of the value chain in a way that benefits all participants. In order to reach this target, the positions of the companies in the chain should be recognized. Scholars have emphasized that the working capital decisions made by companies should be in line with the structure of the value chain (Grosse-Ruyken et al., 2011; Wuttke et al., 2013). However, previous research has provided only few suggestions on how to map these positions in the value chains. In addition, the emerging research stream of financial supply chain management still does not have an established theoretical foundation, and it lacks e.g. systematic theory development studies and generic frameworks (Singh and Kumar, 2014; Gelsomino et al., 2016). These recognized research gaps motivated the development of the generic framework for working capital models presented in this thesis.

This thesis contributes to the literature of financial supply chain management by providing support for the optimization of working capital at the value chain level. A taxonomy for the working capital models, based on quantitative, empirical data, is presented. The matrixes presented in the previous literature (Meszek and Polewski, 2006; Farris and Hutchison, 2003) provide possibility for categorization of working capital management of companies. However, their suitability for the analysis of working capital models at the value chain level is limited. First, the framework by Meszek and Polewski (ibid.) concerns current assets and liabilities as a whole, but does not separate the components of operational working capital. Thus, it is not visible what characteristic of the working capital management directs the firm to a certain category of working capital strategy. Additionally, the number of different working capital strategies is too low for analyzing the working capital models in the value chains. The cash-to-cash map by Farris and Hutchison (ibid.) concerns the management of operational working capital. However, the comparison of the categories in terms of the efficiency of working capital management is difficult as the map was not designed to analyze and compare the working capital positions in the value chains. The framework presented in this thesis advances the

knowledge of different working capital models and their use by companies in the value chains. It has been constructed from the perspective of the value chain, and it enables the systematic analysis of working capital models in this context. This is an important, non-researched area. In addition, the research provides a holistic view to working capital consisting of both material and financial flows, and thus, combines the research streams of finance and operations management.

3 RESEARCH METHODOLOGY

This chapter introduces the research methodology of this thesis. It starts with a discussion of the philosophical foundation of the research and a description of the methodological framework. Then, the methods, measures, and data used in the research are introduced in detail. The purpose of this chapter is twofold: first, it gives the reader an understanding of the philosophical standpoint of the researcher, and second, it introduces the research design in such detail and transparency that the research could be replicated by other researchers.

3.1 Philosophical foundation

Research is influenced by the philosophical worldview of the researcher. Even if this philosophical foundation often remains in the background and is not usually reported in the research as it is, it is important to understand what kind of a philosophical orientation of the world and nature of research is brought to a study by the researcher (Creswell, 2014). Thus, it is necessary to discuss the philosophical stance of the study in terms of two main concepts, ontology and epistemology. Ontology represents the study of being. It concerns the nature of reality, and the central question is whether the reality is external or constructed by the minds of individuals (Jonker and Pennink, 2010). Epistemology indicates the theory of knowledge. It deals with the issue of what is – or should be – considered as an acceptable knowledge in the discipline (Bryman and Bell, 2011), and it defines the ways in which the knowledge can be produced and argued for (Eriksson and Kovalainen, 2008). Reasoning on these two concepts plays a remarkable role in the theoretical and methodological choices made by the researcher, and they need to be consistent with each other. Ontological and epistemological issues are seen as built-in factors in the understanding of the researcher, rather than choices made by the researcher. Next, ontology and epistemology are discussed in relation to the research of this thesis.

Ontological issues concern the way the researcher views the reality to be constructed. This topic is discussed here from two perspectives: first, it is considered how the reality can be discovered, and second, the reality is pictured through the nature of social entities. When discovering the reality, the distinction can be made between rational thinking and empirical perceptions (Markie, 2017). Additionally, the reality may be constructed as a combination of these two approaches. This thesis studies working capital models, which strongly lean on empirical perceptions and therefore, describe the reality through perceptions instead of rationality. However, in this discussion it is important to consider the preconceptions of the researcher and whether they guide the results into a certain direction. Even if the study strongly focuses on the empirical findings, in truth all former knowledge and rational thinking cannot be excluded when conducting the research. However, there was only minor bias regarding the results due to the fact that previous research on the studied topic as such is extremely scarce. The issue whether the reality is viewed as external (objectivism) or considered as constructions of individuals (constructionism) is twofold. This thesis studies a phenomenon in companies and value

chains. In this sense, the reality is viewed through constructionism: the research samples are constructed by individuals and thus, they describe the reality as products of individual consciousness. On the other hand, the main concept under scrutiny in this thesis is the working capital model. As a concept, it is uncontradicted and universal, and therefore it has an objective nature.

Epistemological discussion deals with the question of what is knowledge and what are its sources and limits (Eriksson and Kovalainen, 2008). Ontological and epistemological issues typically emerge together (Crotty, 1998). Therefore, the discussion here continues the themes from the ontological reasoning. As discussed above, the study on working capital models in this thesis strongly focuses on empirical observations. Thus, the research of the thesis is based on positivism, which is the philosophical position associated with empiricism (Eriksson and Kovalainen, 2008). In positivism, knowledge is created via careful observation and measurement of the objective reality (Creswell, 2014), and the purpose of the research is to produce facts that correspond to independent reality (Eriksson and Kovalainen, 2008). In this thesis, knowledge is produced by measuring the working capital management of companies with empirical quantitative data. The main result of the thesis, the theoretical framework, describes the objective and independent reality.

3.2 Methodology

Methodology is a concept which explains the way in which the research is conducted (Jonker and Pennink, 2010). The methodological foundation of this thesis is based on grounded theory, introduced by Glaser and Strauss (1967) as an alternative for the traditional view in social sciences which used to focus on the testing and verification of existing theories rather than generating new theory. The main idea of this general methodology is developing a theory from systematically gathered and analyzed empirical data (Strauss and Corbin, 1994). Two key concepts of the methodology are constant comparison, which includes the simultaneous collection and analysis of data, and theoretical sampling, which contains the decision of the data that will be collected next. This decision derives from the theory being constructed. (Suddaby, 2006) According to Mello and Flint (2009), the objective of grounded theory researchers is to develop theories providing explanations for behavior and hypotheses to be verified. Theories are also expected to be applicable in practice. Additionally, they should be easily understood by other academics as well as practitioners (Glaser and Strauss, 1967).

Grounded theory is a suitable methodology in situations where the research aims at generating new theory, existing theories are not enough for the research inquiry, and/or the researcher wants to open up new directions of research in a particular field (O'Reilly et al., 2012). Grounded theory has been extensively used by scholars in management and organization studies (Locke, 2001; Welch et al., 2013). It is often considered as an approach of qualitative research (e.g. Locke, 2001; Creswell, 2014), most likely due to the subtitle of the original publication by Glaser and Strauss (1967), which indicated

grounded theory being a strategy for qualitative research. However, the authors (ibid.) discussed the use of quantitative and qualitative data in their original publication, and noted that each form of data can be used for verification as well as for the generation of theory, and the primacy of the used data depends on the interests and background of the researcher as well as on the type of material needed for generating the theory. This was also stressed later by Glaser (2008). He noted that even if grounded theory has mainly been used with qualitative data, it can be used with any data, and underlined the inductive nature of the methodology. In this respect, the type of data has no meaning, and it can be either solely qualitative or quantitative, or a combination of both.

A common discussion in relation to the use of inductive methods (i.e. observations and/or findings are used to generate a theory) is the role of former, a priori, knowledge of the researcher. The basis of inductive research is the data collected by the researchers which is used to explain the studied phenomena and create new theories. The inductive approach may enable the researcher to be free from all a priori knowledge and rely only on the data, which raises the question of whether the researchers can be totally apart from a priori information when analyzing the data. Is it possible to shut out all bias? Could it be that subconscious targets may lead the analysis of the data towards a desired direction? Suddaby (2006) notes that even though grounded theory is an inductive research methodology, it is not an excuse to ignore previous literature from the research area. He reminds that the purpose of grounded theory has never been to ignore the existing empirical knowledge. Instead, researchers should be careful in order to avoid ending up testing hypotheses rather than observing. He noted that researchers should find a balance between a pure theoretical view and extreme empiricism, and be conscious of the possible bias of individual humanity. In this thesis, the prior research on the area of study is extensively reviewed in order to describe the theoretical background of the study and to address the research gaps. However, it is assumed that the role of bias in the analysis of data is minor. In this research, the analysis of data leads to certain conclusions and describes the reality in the way that it is described in the results and conclusions sections of the thesis. Nevertheless, given the above discussion about the philosophical foundation and methodological choices in this thesis, it is possible that the described ontological and epistemological views have affected the conduction of the research in different phases of the research process.

In this thesis, quantitative data is used to create a theoretical framework about a certain phenomenon. The data for the grounded theory research has been gathered by using an archival research approach. Moers (2007, 399) defines the archival study as follows: “an empirical study that uses archival data as the primary source of data applying quantitative methods to analyze these data”. He defines the archival data as data which was not originally gathered for the purposes of archival research, and divides them into two distinguished types: public and proprietary data. The first type of data is accessible for anyone regardless of the reason, and the latter type of data is confidential, and its use requires access from the owner of the data. Financial statement data, which is used in this thesis, is considered public data. Moers (ibid.) notes that easy access to publicly available databases has led to the uncritical use of archival data. In this thesis, the problem has been

avoided by collecting the data from the official financial statements of companies. This was a time-consuming process, but adds to the reliability, correctness and traceability of the data.

This grounded theory research was conducted in order to fill a gap in the existing literature of financial supply chain management and working capital models. The data has been analyzed systematically with a defined method, and comparisons have been conducted in order to define the categories of working capital models. Different data samples have been added for comparison during the research process, which led to the proposed theoretical framework. The framework supplements the existing academic literature, but it is applicable in practice as well. In the next chapters, the research methods regarding the data collection and analysis, as well as the used measures and data are presented in more detail.

3.3 Methods

Financial value chain analysis

The main research method used in this research is the financial value chain analysis. The method is developed and introduced in Publication I of the thesis. It consists of seven consecutive steps as described in Figure 6. The purpose of the method is to provide a holistic view of the financial phenomenon in a broad value chain consisting of different value chain stages from raw materials to end customers. In this thesis, it is used in the context of working capital management and it has been applied as a research method in all publications.

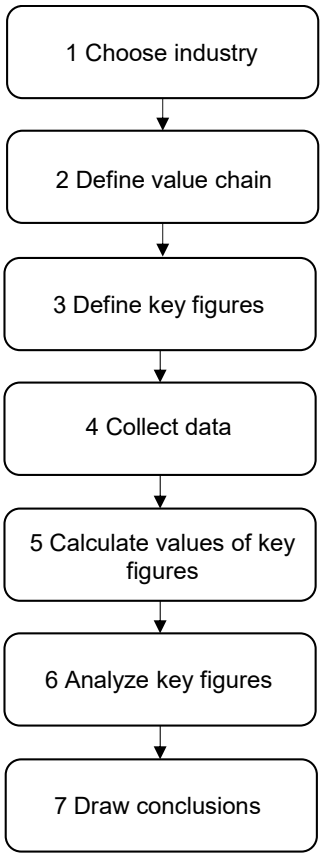


Figure 6. Financial value chain analysis method according to Publication I.

The financial value chain analysis is based on the analysis of financial statements. The purpose of the financial statement analysis is to process the data in a way that best fulfills the needs of the analyst (Yritystutkimusneuvottelukunta, 2005). The data sources of the financial statement analysis cover the official financial statements, notes to the official financial statements, or other available information. In this thesis, official consolidated financial statements were used as the data source in all publications. The figures were collected from the balance sheets, which describe the financial position, i.e. the total investments made (assets) and how they have been financed (liabilities and equity), of the company at a specific moment, and from the income statements, where the company's earnings for a predefined period are reported (Petersen and Plenborg, 2012). The used financial statements have been audited and thus, the data is expected to be reliable and describe the accurate financial position of the company. The limitation of the method is that the financial statements are only published annually, and the figures in the balance sheet only demonstrate the values of working capital and other key figures on one day during the fiscal year. It is not known whether the year-end balance sheet figures describe

their typical working capital levels, or whether there are remarkable changes in the figures during the year for example due to seasonal fluctuation.

Cluster analysis

Statistical K-Means cluster analysis has been used in Publications III, IV and VI to categorize different working capital models from the datasets. Clustering was conducted with SPSS. K-Means clustering divides the data into a particular number of clusters which is defined before the analysis. The suitable number of clusters was tested iteratively by adding and removing clusters, and measuring the difference between the clusters with ANOVA. The method moves the observations from onecluster to another during the process according to their distance to the cluster mean vectors. The target of the method is to minimize the variability within and maximize the variability between the clusters. (Landau and Everitt, 2004) Because of this, the method is sensitive to the case order of the sample, and the analysis may result in differently organized clusters if the analysis is conducted with a different order of cases. This characteristic of the method is recognized as a limitation in this study. Therefore, it should be noted that the cluster analysis provides one, but not the only, possibility to formulate the clusters from the sample. This was considered when analyzing the results of the cluster analysis. The relatively small sample size may also have an additional effect on this behavior. The number of observations in each data set analyzed with cluster analysis is around 50, which is the requirement for conducting the cluster analysis (Nummenmaa, 2009).

WCM matrix

In Publication V, the WCM (working capital management) matrix was introduced as a tool to analyze working capital models and working capital positions in the value chain. The development of the WCM matrix was motivated by the results of Publications III and IV, as the results indicated that working capital models often differed in regard to the material and financial flows. This led to the definition of the axes of the matrix: The Y-axis describes the efficiency of the material flow of working capital with the cycle time of inventories, and the X-axis combines the components of trade credit (i.e. accounts receivable and accounts payable), and describes the balance between them. This way, it was possible to construct a matrix that considers all three working capital variables. The WCM matrix complements the financial value chain analysis by providing a further tool for visualizing the working capital models in the value chain or in a certain value chain stage. Figure 7 illustrates the WCM matrix.

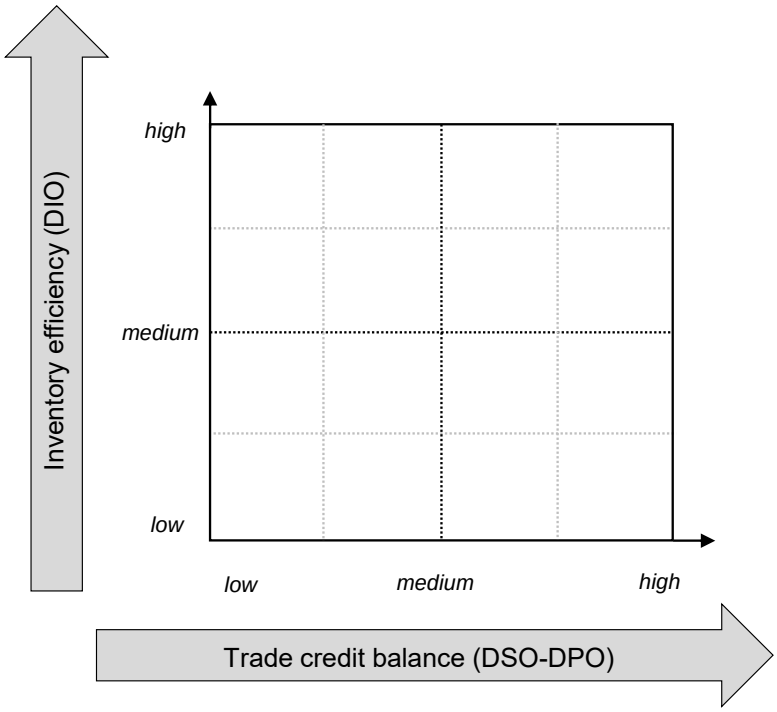


Figure 7. WCM matrix (adapted from Publication V).

The WCM matrix was used to support the analysis of working capital models in Publications V and VI. Initially, the WCM matrix was divided into four categories on the basis of the average values of the samples (Publication V). In further use, a more detailed analysis was conducted in a 4x4 matrix (Publication VI). The use of the WCM matrix is not locked up to a certain approach: the variables as well as the boundaries of different categories can be defined according to the needs and requirements of the analysis.

3.4 Measures

In this thesis, the management of working capital and its components is measured with cycle times. Richards and Laughlin (1980) developed the Cash Conversion Cycle (CCC) as a new, improved measure for the liquidity of a firm. They argued that instead of focusing on the analysis of static balance sheet liquidity ratios, such as current and quick ratios, the measurement could be developed by taking into account some income statement values that measure the operating activity of the firm. They shifted the attention to the accounts receivable and inventory turnovers, constituting the operating cycle, which provided a more realistic view of the liquidity position of the firm than the traditional measures. By adding the accounts payable to the measurement, they extended the operating cycle to consider all relevant in- and outflows of operational working

capital. This measurement also raises the element of time to the measurement of working capital by indicating the number of days a firm has funds committed to working capital. In the literature of supply chain management and logistics, the cycle time of working capital, i.e. CCC, has also been known as Cash-to-Cash cycle (C2C). Farris and Hutchison (2002) highlighted the relevance of the CCC measurement in the supply chain context as it bridges the inbound material activities with the suppliers, internal production processes of a company, and the outbound material flow and sales activities with the customers. This supports the relevance of the chosen measurement for this research. The CCC in the context of a value chain of three companies (C1, C2 and C3) is illustrated in Figure 8. The figure shows the components of working capital: inventories (INV), accounts receivable (AR), and accounts payable (AP), and describes their linkages between the companies.

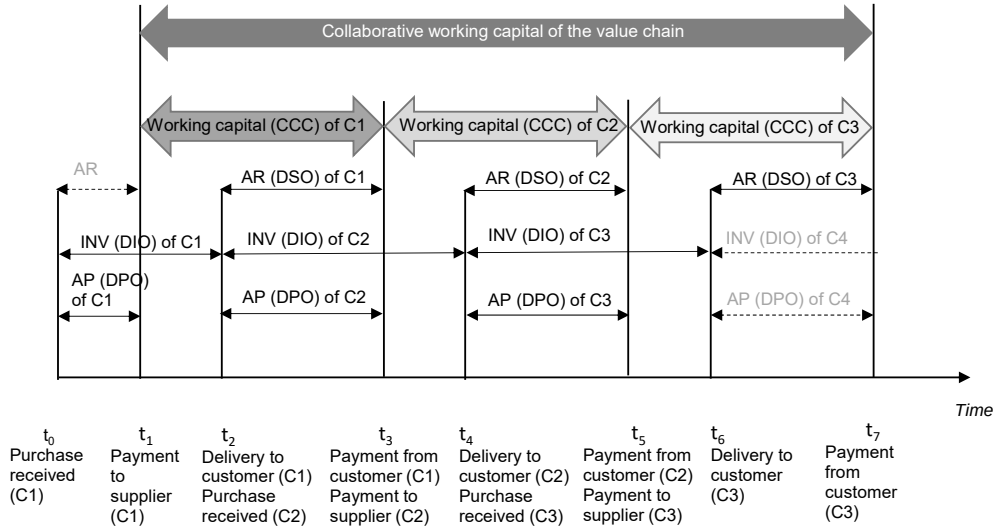


Figure 8. Working capital and Cash Conversion Cycle in the value chain context (adapted from Hofmann and Kotzab, 2010).

As described above, the CCC consists of three components: the cycle time of inventories (DIO), the cycle time of accounts receivable (DSO), and the cycle time of accounts payable (DPO). The components describing the financial flows of working capital, i.e. accounts receivable and accounts payable, can be combined and determined as net trade credit (DSO-DPO) (Nadiri, 1969). This variable has been used in Publications V and VI, in which the working capital models consisting of the management of financial and material flows was in focus. Publications II and III also consider the connection between profitability and working capital management. In these studies, profitability is measured

by the return on capital employed (ROC%). The definitions for all used measures are presented in Table 3.

Table 3. The determinants for the used variables.

Variable	*Abbreviation*	*Definition*
Cycle time of inventories	DIO	DIO = (Inventories/Sales)*365
Cycle time of accounts receivable	DSO	DSO = (Accounts receivable/Sales)*365
Cycle time of accounts payable	DPO	DPO = (Accounts payable/Sales)*365
Net trade credit	DSO-DPO	DSO-DPO = ((Accounts receivable-Accounts payable)/Sales)*365
Cycle time of working capital	CCC	CCC = DIO + DSO - DPO
Return on capital employed	ROC%	ROC% = EBIT/((Equity$_t$+Equity$_{t-1}$)+ (Long term liabilities$_t$+Long term liabilities$_{t-1}$))/2

There have been slight differences in the calculation of the cycle times of working capital components in previous literature. Some authors, such as Farris and Hutchison (2003), Viskari and Kärri (2013) and Brandenburg (2016) have used cost of goods sold (COGS) from the income statement as a denominator when defining the DIO and DPO, whereas Shin and Soenen (1998) and Talonpoika et al. (2016), for example, have used sales instead of COGS in all working capital components. In this thesis, the latter approach is used in order to ensure the uniformity of the data of different companies. This is particularly important when using public sources. The use of sales ensures that the cycle times are comparable and similarly calculated for all companies, as the definition of COGS is not necessarily defined similarly, or available, in all sources. When calculating the cycle times in relation to sales, the cycle times are shorter than they would be by using COGS in the formula.

3.5 Data collection

The empirical data of the research consists of financial figures gathered from official financial statements. The datasets are formed around three industry value chains: automotive, ICT, and pulp and paper. The value chains employed in this study are constructed to describe the material flow through the value chain stages from raw material suppliers to end customers. The financial flow, in turn, goes upstream in the value chain. The value chains consist of stages which group similar companies together at the same part of the value chain. The companies within the stages may share the same customers and act as competitors to each other. However, it should be noted that the value chains are not meant to be all-inclusive, and they do not include all business relationships that companies have, but they provide a broad view of the industry and include several supply chains of three or more tiers that exist in real life. Another limitation is that, especially at the upstream part of the value chains, many companies also operate in other industries,

and therefore only a part of their working capital is tied up in the specific value chain of this study. For example, in oil and iron ore companies only a minor portion of sales comes from the automotive industry. Therefore, their working capital is widely affected by the other industries as well. However, the companies' shares in the certain industries were not considered in the analysis, as this data was not reliably available for all firms.

The value chains of the automotive and pulp and paper industries were defined with the help of literature and discussions with experts working in the industries. The professional insights helped in ensuring that the value chains are realistic and reasonable. The value chain of the ICT industry differs slightly from the automotive and pulp and paper value chains. The structure of the chain is more like a network, partially due to the variety of its end products, whereas the other two value chains consist of consecutive value-adding stages. Of course, this difference should be noted as a limitation, when comparing the value chains. The ICT value chain was formed without professionals, for example with the help of companies' annual reports and ICT related news in the media. Four of the publications in this thesis concentrate on the value chain of the automotive industry alone, one publication studies the ICT industry, and the last article uses the data from all three value chains.

The companies selected for the sample had to meet two criteria: the financial statements had to be publicly available, and the sales of the company had to exceed the minimum of 100 million Euros. The financial statements have been downloaded mainly from the company websites. For the automotive sample, some financial statements were picked from the German company register (Bundesanzeiger), which is a public and free of charge online database. The data of the automotive and ICT industries has been collected solely by the author: the automotive data was first collected for the period 2006–2008 in the fall of 2010, and the dataset was updated in the fall of 2011 and 2016, whereas all ICT data was collected at once during the fall of 2011. The data from the pulp and paper industry was collected by another researcher in the same research group, and the same data has been used in the study by Pirttilä et al. (2014). Table 4 shows the details of the sample by the publication. The number of companies in the value chain of the automotive industry has changed due to the availability of the data, as all annual reports for the companies in the original sample were not accessible. In addition, Publications II and V have a different value chain structure.

Table 4. Details of the sample by the publication.

Publication	Industry	Number of companies in the value chain	Number of stages in the value chain	Observation period
I	Automotive	65	6	2006–2008
II	Automotive	48	4	2006–2009
III	ICT	61	9	2006–2010
IV	Automotive	57	6	2006–2009
V	Automotive	41	5	2006–2015
VI	Automotive	56	6	2006–2010
	ICT	61	9	
	Pulp and paper	45	8	

The findings by Capkun et al. (2009) and Eroglu and Hofer (2011) show that industry-specific factors should be considered when studying the relationship between inventory management and financial performance. This has been noticed also in the field of working capital management. The study of Pirttilä et al. (2014) showed that the cycle times of working capital differ in the different industries mainly due to different requirements for inventories. These findings suggest that it would be reasonable to approach working capital management, as well as inventory management, one industry at a time instead of using large, multi-industry datasets. Thus, in this study the working capital models are identified in the context of different industries, which all have their own features regarding the manufacturing processes and end products that characterize their working capital management as well. The choice of industries was expected to provide insight into different working capital management needs as well as to enable the identification of different kinds of working capital models.

Three different value chains for this study were selected in order to provide different insights to working capital models. The value chains differ especially by the production type, capital-intensity, and type of end products and customers. It was assumed that these characteristics could bring out different ways of building working capital models. The value chain of the automotive industry is a representative of batch and serial production. The pulp and paper industry, in turn, represents the process industry. The automotive and pulp and paper industries are traditional, capital-intensive manufacturing industries where business practices and production processes force companies to tie up certain amounts of working capital in order to run their businesses. Therefore, a good contrast in terms of working capital is the ICT industry which is characterized by fast technology development, use of contract manufacturers, low inventory levels, and effective management of working capital overall. Contrary to automotive and pulp and paper industries, physical assets do not play so significant role in the ICT industry, but in turn, know-how and innovative ability are crucial factors. The value chains with the companies forming the sample are described next.

The value chain of the automotive industry

The automotive industry was hit by the financial crisis, but the industry faced serious problems due to raised pressure on costs and competition already before the crisis. As a trailblazer in lean management, the industry has a strong orientation towards effective working capital management, which the companies also see as an elementary part of their businesses (e.g. BMW, 2010; Valeo, 2014). Figure 9 describes the value chain of the automotive industry used in the study. The automotive industry was studied in Publications I, II, IV, V and VI. There were slight differences in the number of firms in the publications. While Figure 9 shows the companies forming the value chain in Publication I, Appendix A describes in more detail which companies were included in the sample in each individual publication. The differences in the samples were mainly due to missing data: the annual reports were not available, or the data reported was incomplete to conduct all analyses. In Publication II, the stage of raw material suppliers consisting of oil and iron ore companies was excluded from the study in order to concentrate on the core automotive industry, as only a minor portion of the sales of raw material suppliers actually comes from the automotive sector. In Publications II and V, the stage of car dealers was excluded from the sample. This decision was made on the basis of previous findings, which indicated that end customers have a remarkable, direct relationship with the car manufacturers through their leasing and financing services. Additionally, the unavailability of the data and the regional nature of the car dealers contributed to the decision. The value chain starts with the stage of raw materials, oil and iron ore, which are used as a raw material for plastics, steel and metal. Refined raw material is delivered to component suppliers, who supply small parts such as sintered components, springs, bearings, and gaskets to system suppliers. System suppliers manufacture complete systems, such as clutch systems, to car manufacturers, who take care of the final assembly of the car. The final product is often delivered to the end customer via car dealers, but as discussed above, the end customers may also have direct relationships with car manufacturers via leasing or financing contracts.

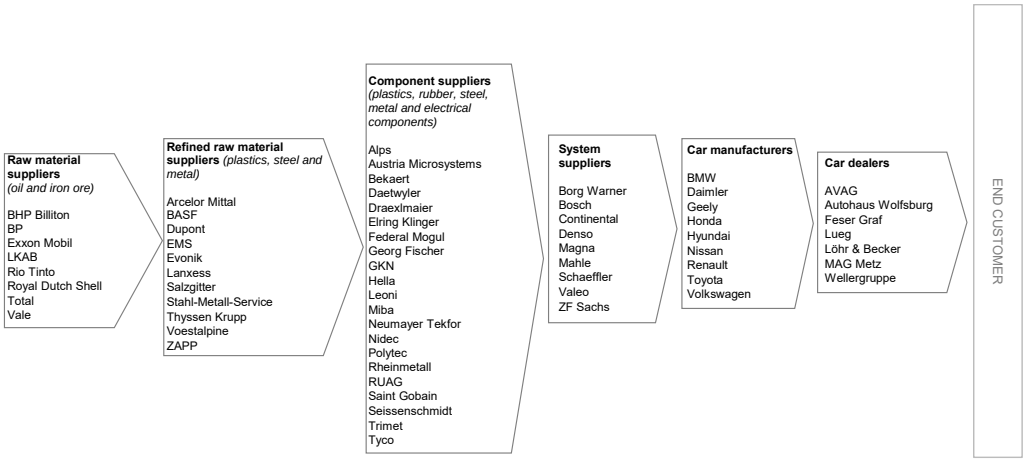


Figure 9. The value chain of the automotive industry used in the research.

The research sample for the value chain of the automotive industry was constructed in collaboration with professionals working in a company in the stage of system suppliers. This brought the industry perspective to the study, and ensured that the sample also included actual supply chains. The sample was extended for example by reviewing the global ranking of automotive suppliers (Automobilproduktion, 2010). As the research was done in Europe and the sample was constructed with the support of professionals from the European automotive industry, the value chain has a strong regional focus. This can be seen especially within the supplying stages of the value chain (i.e. refined raw material suppliers, component suppliers and system suppliers) and car dealers. Additionally, the availability of official financial statements for American and Asian companies from public sources was limited, and it affected the sample as well.

The value chain of the ICT industry

The value chain of the ICT industry is illustrated in Figure 10. The value chain is not as straightforward as in the automotive industry. The ICT industry, as well as the companies operating in the industry, have a variety of end products of different types, i.e. physical goods and services. The value chain consists of nine stages: Component manufacturers, contract manufacturers, network hardware, computers, mobile phones, network operators, IT services, software, and internet software and services. It should be noted that the value chain was constructed in 2011, and does not describe the present state of the industry. Due to fast technology development, the market has changed rapidly. For example, the value chain includes companies that are not active anymore (e.g. Elcoteq), and it could be considered whether some companies, such as Apple and Huawei, should be moved to another stage instead of their current one. Additionally, the stage of internet software and services has grown remarkably during the last years.

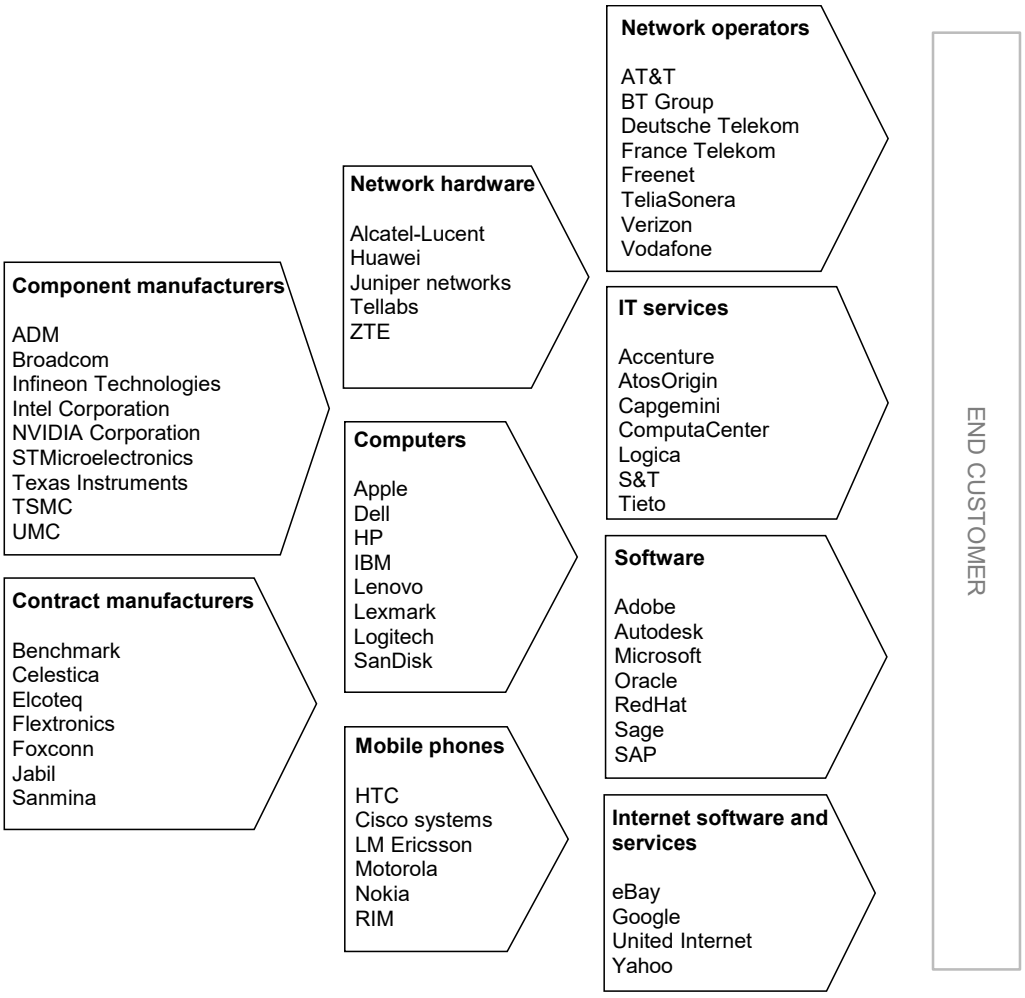


Figure 10. The value chain of the ICT industry used in the research.

Sample selection for the value chain of the ICT industry was slightly different in comparison to the automotive industry, as there were not any experts from the industry supporting the construction of the sample. The sample was constructed with the help of different sources: internet searches, consultancy reports (i.e. working capital studies by REL consultancy), ICT companies' annual reports, and other ICT related news in the media. These sources provided details on the existing business relationships within the value chain, as well as information about the most remarkable actors in each stage of the chain.

The value chain of the pulp and paper industry

The third sample of the study is formed by companies in the value chain of the pulp and paper industry. It is known that in the pulp and paper industry, the return on capital employed is very sensitive to the amount of working capital tied up in the inventories of raw material and finished products. This has led companies to focus more and more on reducing their working capital (Carlsson and Rönnqvist, 2005). In addition, the structural change of the industry has motivated companies, such as UPM, to focus on the efficient management of working capital (Töyssy, 2016). The value chain of the pulp and paper industry in this study (Figure 11) begins with the stages of machinery and chemicals, which act as suppliers for market pulp producers, but also to paper and board manufacturers. The downstream part of the value chain consists of merchants, printers, brand owners, and publishers. The end customers receive the end products of the value chain in the form of packages or books, for example. The pulp and paper industry has faced changes in the last years as well. For example, M-Real and Metsä-Botnia are part of the Metsä Group nowadays, and in the paper and board stage, Myllykoski was merged with UPM.

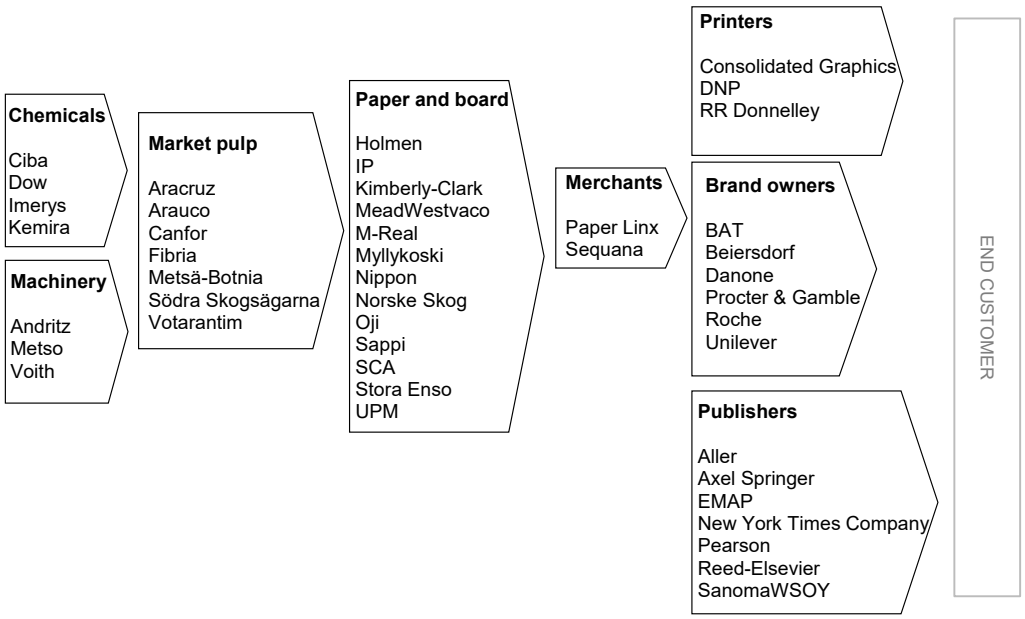


Figure 11. The value chain of the pulp and paper industry used in the research.

The value chain of the pulp and paper industry was used in Publication VI to add new perspectives on working capital models in addition to the automotive and ICT industries. The value chain and the companies are similar to the studies by Pirttilä et al. (2010) and

Pirttilä et al. (2014). The authors (ibid.) have constructed the sample by reviewing industry rankings, consultancy reports and databases of financial data. In addition, industrial insights were brought by practitioners working in a paper and board company.

4 RESULTS

The thesis consists of six complementary publications. This chapter introduces the main findings of these individual publications. The chapter starts with an overview of the individual publications forming the thesis. This includes a summary table of the individual publications, which sums up the objectives, research questions, details of data, main results, and main contributions of the original publications. Then, the chapter continues by focusing on the first research question, i.e. on the analysis of the cycle times of working capital in the value chains. Then, different working capital models are identified in the value chains of the automotive, ICT, and pulp and paper industries. This is followed by the introduction of the generic framework for working capital models in the value chains. At the end of sub-chapters 4.2–4.4, a short summary concludes and discusses the main results of the individual publications in relation to the specific research question.

4.1 Overview of individual publications

In this thesis, six complementary publications form the foundation of the research. Their main results will be presented in the following sub-chapters in more detail and in accordance with the objectives and research questions of the thesis. The main objective of the thesis was to develop a framework for working capital models. The objective was further divided into three research questions: 1) How has working capital been managed in the value chains?, 2) What kind of working capital models can be identified in different value chains?, and 3) How can different working capital models be categorized in a generic framework? The first research question was studied in Publications I, II, III and V. The second research question was addressed in Publications III, IV, V and VI. The third research question was in focus in Publications V and VI.

Table 6 presents a summary of the individual publications including the objectives, related research questions, main methodological choices, used data, main results and main contribution for the thesis.

Table 5. Summary of the individual publications of the thesis.

	Publication 1	Publication 2	Publication 3	Publication 4	Publication 5	Publication 6
Title	Working capital management in the automotive industry: Financial value chain analysis	Using working capital management to improve profitability in the value chain of automotive industry	Detecting working capital models in the ICT supply chains	Working Capital Models: Avenues for Financial Innovations	Mapping working capital models in the automotive industry	Working capital models: A generic framework
Objective	To examine working capital management in the value chain of the automotive industry in the years 2006–2008 by using financial value chain analysis	To study the possibilities of improving profitability through working capital management in a four-tier value chain	To identify different working capital models companies in the different parts of ICT supply chain operate with	To detect different working capital models used in the value chain of the automotive industry and to connect working capital models to profitability of companies	To study the different patterns of managing working capital applied by companies in the automotive industry	To explore working capital models in three large industry value chains representing the automotive, ICT and pulp and paper industries.
Methodology	Archival research	Archival research	Archival research	Archival research	Archival research	Grounded theory
Methods	Financial value chain analysis	Financial value chain analysis, Correlation and regression analyses	Financial value chain analysis, Cluster analysis	Financial value chain analysis, Cluster analysis	Financial value chain analysis	Financial value chain analysis, Cluster analysis
Data	Financial statements of 65 automotive companies	Financial statements of 48 automotive companies	Financial statements of 61 ICT companies	Financial statements of 57 automotive companies	Financial statements of 41 automotive companies	Financial statements of 161 companies
Main results	The change in the CCC follows the change in the DIO while the changes in the DSO and DPO offset each other. Car manufacturers tie up large amounts of working capital due to long DSO caused by their financing and leasing services.	Statistically significant relation between the CCC and relative profitability was not found at the value chain level. Companies benefit from different working capital strategies. The profitability of the value chain could be improved by simultaneous management of all working capital components, or by radical reduction of payment terms.	Each branch has a typical working capital model, but it is not applied by all companies within the branch. Some companies operate with a negative CCC which was achieved by having low DIO and longer than average DPO.	Companies that successfully minimized their working capital were most profitable in the value chain. Working capital model may vary yearly. The results indicated that most companies prefer shorter cycle times but success of achieving them varies.	Different working capital models are applied within the value chain stages. Working capital reduction seems to be a clear trend in the automotive industry. Changing working capital model is a long-term process and sustainable reduction of working capital is conducted in small steps.	Companies have different working capital models. Similar working capital models were identified in all value chains. Value chains differ in how the working capital models are emphasized. Generic framework for working capital models was proposed.
Main contribution for the thesis	Financial value chain analysis method was introduced.	Companies have different strategies for working capital management. All companies do not benefit from the shortening of the CCC.	Companies have different working capital models which are not necessarily determined by the company's location in the supply chain.	Different working capital models should be better acknowledged in value chain wide working capital management.	WCM matrix for analyzing working capital models was introduced.	Generic framework for working capital models was constructed on the basis of findings from empirical data. The framework introduces six generic working capital models and one sub-model.
Research questions	RQ1	RQ1	RQ1, RQ2	RQ2	RQ1, RQ2, RQ3	RQ2, RQ3

4.2 Cycle times of working capital in the value chains

This chapter is related to the first research question of the thesis, and concentrates on how working capital and its components have been managed in the value chains. In other words, the cycle times of working capital and its components are reviewed from the value chain perspective in the context of the automotive and ICT industry, and in relation to relative profitability in the context of the automotive industry. In addition, the results are compared to the cycle times of working capital in the value chain of the pulp and paper industry, which have been analyzed outside this thesis. The results of the cycle times in the value chain of the pulp and paper industry are shown in Appendix B.

The analysis of the cycle times of working capital in different value chains was the starting point of the research in this thesis. The purpose of this research question is to provide background information about the working capital management in the studied value chains. Publications I, II, III and V contribute to the first research question, which is answered in this chapter.

Publication I

The objective of the paper was to study working capital management by cycle times in the value chain of the automotive industry, consisting of 65 companies operating on six consecutive value chain stages from raw material suppliers to car dealers. Secondary data from financial statements and annual reports was collected for each year of the observation period 2006–2008. The cycle times for working capital and its components were calculated and analyzed at the value chain and value chain stage level. Figure 12 shows the results of the cycle time analysis.

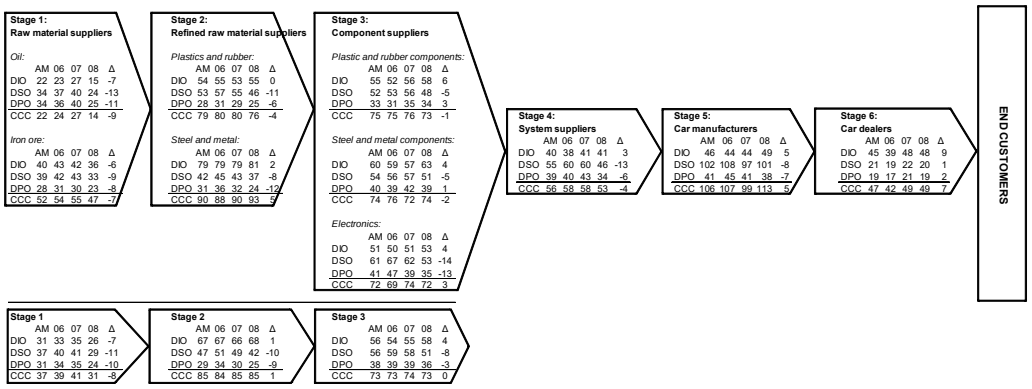


Figure 12. Cycle times of working capital and its components in Publication I.

The results showed that the CCC was positive in each stage of the chain. This means that the value chain of the automotive industry ties up working capital. The average CCC of

the value chain stages was 67 days. During the observation period, only slight changes in the average CCC of the value chain were detected. As the cycle times were calculated in relation to sales (see formulas in chapter 3.4), the finding indicates that the relation between sales and working capital is constant, and the amount of working capital can be determined from the sales forecast. The study did not find significant changes in the position of the value chain stages during the observation period measured by the CCC. The only exception was observed between system suppliers and car manufacturers: the CCC of system suppliers reduced by 4 days, whereas the CCC of car manufacturers lengthened by 5 days. This could indicate that system suppliers reduced their working capital with the help of their customer stage. In comparison to the cycle times of working capital in the value chain of the pulp and paper industry (see Appendix B) in years 2006–2010, the average CCC of the stages was 8 days longer in the value chain of the automotive industry. Moreover, the results in the pulp and paper industry support the conclusion of the constant relation between the sales and working capital.

However, while the CCC remained roughly the same during the observation period in the value chain of the automotive industry, there were variations in the cycle times of inventories and trade credit. These variations did not affect the CCC as usually the variations in trade credit components accounts receivable and accounts payable offset each other. This was seen for example among electronics suppliers, whose DSO reduced by 14 days, but at the same time the DPO shortened by 13 days. If a stage was able to reduce its working capital, the change in the CCC mainly followed the change in the DIO. The findings also suggested that the payment terms had tightened during the observation period as, in most stages, the changes of DSO and DPO were negative. The results indicated that the tightening of payment terms runs through the value chain: if suppliers require faster payments, companies are not willing to invest more in working capital, and they require faster payments from the customers as well. Overall, the results indicated that companies in the automotive industry had paid attention to the management of accounts receivable as the DSO was shortened in each stage of the value chain except for car dealers. At the value chain level, none of the value chain stages actually gained benefits from the shortening of the DSO as the trend was dominating the whole value chain, but at the value chain level, the need for invested working capital reduced. The reduction of DSO may be a consequence of the increased use of factoring services, i.e. an arrangement in which a firm sells its accounts receivable for a financial institution for immediate cash.

An interesting finding in this study was the long CCC of car manufacturers (106 days), which was remarkably higher than in the other stages of the value chain. This was caused by a long DSO, as the accounts receivables of car manufacturers were high due to their financing and leasing business. These items (i.e. accounts receivable related to the financing and leasing businesses) were reported separately in the balance sheets of car manufacturers, but in this study, they were seen as a part of the total accounts receivable of these companies. Therefore, car manufacturers are also working as banks in the value chain by financing their customers with trade credit. From this perspective, the value

chain of the automotive industry differs from the one in the pulp and paper industry, where cycle time of working capital got shorter close to end customers.

The study highlighted that the terms of trade credit are an issue to be negotiated with the suppliers and customers, and its cycle times cannot be completely affected by the firm itself. If a firm is willing to reduce its working capital, the component that can best be controlled alone is the cycle time of inventories by developing the internal value chain within the company. However, collaborative actions in the value chain to ensure accurate information flow between the value chain partners could support in achieving lower inventory levels.

In addition to the analysis of the cycle times of working capital in the value chain of the automotive industry, the paper introduced the method of financial value chain analysis, which has been used in all publications of this thesis. The method offers a holistic view of the value chain with financial figures during the selected observation period, and shows the position and performance of the value chain stages. The method was introduced in more detail in chapter 3.3.

Publication II

The objective of the paper was to study the effects of the management of working capital and its components on relative profitability in the context of the value chain of the automotive industry. After studying the relation between the cycle times of working capital with correlation and regression analyses, simulations based on the regression models were conducted in order to study how the value chain could improve its profitability through working capital management. The sample consisted of 48 companies operating in a four-tier value chain consisting of raw material suppliers, component suppliers, system suppliers and car manufacturers. The data was collected from publicly available financial statements for each year of the 2006–2009 period. For each company, the cycle times of working capital and its components, as well as the ROC% to measure the relative profitability of companies, were calculated.

First, the relation between working capital management and profitability was studied at the value chain level. The results showed that there was no statistically significant correlation between the CCC and ROC%, and the initial conclusion was that the reduction of working capital does not have a remarkable effect on profitability. The finding deviates from several previous studies (e.g. Shin and Soenen, 1998; Deloof, 2003) which have studied the relationship between working capital management and profitability, and provided opposite evidence. The result of this study was caused by the DIO, which did not have a statistically significant connection with the ROC%, whereas the DSO and DPO had statistically significant negative correlations with the ROC%. This indicates that the reduction of inventories does not improve profitability in this value chain, but in turn, it could be done by shortening the DSO and DPO by adjusting payment terms. In addition, strong and positive correlation was found between the DSO and DPO. This supports the

finding that the cycle times of accounts receivable and accounts payable follow each other in the value chain context (Publication I).

Second, the same analysis was conducted for each stage of the value chain separately. The results showed that depending on the value chain stage, correlation between working capital management and relative profitability differed. The results showed that the first stage of the value chain, suppliers of refined raw material, had a strong positive correlation between the CCC and ROC%. This indicates that a longer cycle time of working capital increases the profitability of the stage. The relation is caused by the DIO, which has a positive relation to profitability while the connection between the ROC% and the DSO and DPO is negative. In other words, in this stage the companies with better profitability have larger inventories. In the following value chain stages, i.e. component and system suppliers, a similar connection between inventories and profitability was not found. In turn, in these stages the correlation between the DIO and ROC% was negative, which indicates that smaller inventories lead to better profitability within these stages. The car manufacturers benefit from different kind of working capital management than other stages. In this stage, the results were consistent with the previous studies that have found more profitable companies operating with shorter cycle times of working capital.

On the basis of the regression models of the previous analyses, five different simulations were conducted in order to examine the most efficient working capital management actions to improve the profitability of the value chain. The simulations considered 1) shorter payment periods, 2) longer payment periods, 3) inventory adjustments, 4) inventory and payment term adjustments, and 5) radical payment term adjustments. The results showed that the value chain could improve its profitability by managing all three working capital components simultaneously. This supports the view of Farris and Hutchison (2003), who emphasized the comprehensive approach to operational working capital instead of managing each component individually. Additionally, the findings indicated that all value chain stages would benefit from a radical reduction of payment terms.

The results of the above-mentioned analyses indicated that companies have – and should have – different working capital management strategies depending on their position, and all companies should not even try to aim at minimum working capital. This is in line with the findings by Baños-Caballero et al. (2012, 2014), Aktas et al. (2015) and Pais and Gama (2015), who have provided evidence for the existence of an optimal level of working capital in their studies concerning the connection between firm performance and working capital management. They found that an increase or decrease of the optimal working capital level deteriorates profitability. The results of Publication II indicate that stage-specific characteristics could be taken into account when optimizing working capital management in the value chain.

Publication III

The aim of the paper was twofold: first, financial value chain analysis was used to study the cycle times of working capital in the ICT industry. Second, working capital models were identified with cluster analysis. In this chapter, we concentrate on the first objective. The second objective is covered in chapter 4.3.

The ICT industry was chosen as a research subject as it was predicted that with strong service-orientation and small inventories it could provide a good benchmark and new insight in regard to working capital management. The sample included 61 companies operating on 9 different branches in the ICT industry, and the financial data from years 2006–2010 was collected to analyze the cycle time of working capital and its components. The results showed that the average CCC in the ICT industry, 40 days, was remarkably shorter than in the automotive industry (Publication I). Of course, the structures of the value chains are different, but even the longest CCC of the ICT stages, network hardware (60 days), is shorter than the average CCC of the automotive value chain. This shows the efficiency of working capital management in the ICT industry. Figure 13 shows the results of the study.

Network hardware

	CCC	DIO	DSO	DPO	ROC%
Alcatel-Lucent	41	50	91	101	-10%
Huawei	86	59	132	106	41%
Juniper networks	20	0	47	27	4%
Tellabs	87	33	74	20	-3%
ZTE	65	59	85	79	7%
AVERAGE	***60***	***40***	***86***	***66***	***8%***

Component manufacturers

	CCC	DIO	DSO	DPO	ROC%
AMD	38	43	47	53	-6%
Broadcom	34	27	38	31	7%
Infineon	56	57	55	56	0%
Intel	37	35	23	22	19%
NVIDIA	54	41	46	33	12%
STM	71	57	52	38	-1%
Texas Instruments	65	39	40	15	28%
TSMC	50	24	37	10	23%
UMC	67	36	36	36	3%
AVERAGE	***52***	***40***	***42***	***33***	***10%***

Contract manufacturers

	CCC	DIO	DSO	DPO	ROC%
Benchmark	72	51	64	43	4%
Celestica	36	42	47	54	-3%
Elcoteq	12	28	37	52	-14%
Flextronics	18	46	36	63	-9%
Foxconn	39	33	61	55	14%
Jabil	20	46	41	67	1%
Sanmina	44	45	50	51	-7%
AVERAGE	***34***	***42***	***48***	***55***	***-2%***

Computers and computer peripherals

	CCC	DIO	DSO	DPO	ROC%
Apple	-32	5	28	65	31%
Dell	-11	6	49	66	30%
HP	38	24	58	44	17%
IBM	80	10	99	29	24%
Lenovo	-19	13	20	51	9%
Lexmark	28	34	40	46	18%
Logitech	44	40	45	41	17%
SanDisk	46	54	35	43	2%
AVERAGE	***22***	***23***	***47***	***48***	***19%***

Mobile phones

	CCC	DIO	DSO	DPO	ROC%
Cisco systems	44	13	39	8	20%
HTC	22	22	69	69	60%
LM Ericsson	124	46	116	38	14%
Motorola	41	27	56	42	1%
Nokia	42	18	67	44	27%
RIM	74	21	69	15	49%
AVERAGE	***58***	***25***	***70***	***36***	***28%***

Network operators

	CCC	DIO	DSO	DPO	ROC%
AT&T	33	3	55	25	9%
BT Group	-34	2	32	69	12%
Deutsche Telekom	9	7	42	40	5%
France Telecom	-14	6	45	65	12%
Freenet	19	6	47	34	11%
TeliaSonera	17	5	45	32	14%
Verizon	34	6	44	16	9%
Vodafone	8	4	34	29	5%
AVERAGE	***9***	***5***	***43***	***39***	***10%***

IT Services

	CCC	DIO	DSO	DPO	ROC%
Accenture	27	0	43	16	55%
AtosOrigin	41	0	77	36	3%
Capgemini	27	0	64	37	8%
ComputaCenter	50	14	69	33	13%
Logica	52	0	74	21	6%
S&T	53	13	87	47	-10%
Tieto	58	0	73	16	10%
AVERAGE	***44***	***4***	***70***	***29***	***12%***

Software

	CCC	DIO	DSO	DPO	ROC%
Adobe	42	0	48	6	16%
Autodesk	46	0	59	13	20%
Microsoft	61	7	77	23	43%
Oracle	70	1	76	7	23%
RedHat	68	0	77	9	7%
Sage	40	2	64	26	16%
SAP	72	0	95	23	33%
AVERAGE	***57***	***1***	***71***	***15***	***23%***

Internet software

	CCC	DIO	DSO	DPO	ROC%
eBay	13	0	20	7	12%
Google	43	0	48	5	25%
United Internet	-15	4	26	45	40%
Yahoo	48	0	56	8	5%
AVERAGE	***22***	***1***	***37***	***16***	***20%***

Figure 13. Cycle times of working capital and its components in Publication III.

The study proved that some branches in the ICT industry do not require inventories at all, or have a DIO of 1–5 days. Overall, inventories were relatively effectively managed in the ICT industry. Some indications of carrying inventories on behalf of customers were

observed between contract manufacturers and mobile phone and computer firms: the average DIO of contract manufacturers was nearly 20 days longer than the one in their customer stages. However, even if many companies were able to operate with negligible inventory levels, a short DIO did not guarantee a short CCC, as many of these companies tied up working capital by offering trade credit. In some branches, relatively generous credit terms were offered to customers, and at the longest, DSOs were between two and three months, 70–86 days.

A special feature of working capital management in the ICT industry was the negative CCC. During the observation period, six companies had a negative average CCC. These companies included both service providers as well as providers of physical goods. The key to negative CCC was a low level of inventories (i.e. short DIO), which in a service company is not an issue, but somewhat more challenging to achieve in a manufacturing company, as production processes usually require tying up working capital into the inventories of raw material, work-in-progress and finished goods. In the ICT industry, a short DIO of a manufacturing company can partially be explained by outsourced production. Another common factor for the companies with negative working capital is long payment terms towards suppliers: their DPOs were longer than the average of their branches. The results of the study also showed that companies within the stages operated with very different working capital levels. This indicates that companies of a similar type may have different kinds of working capital strategies.

Publication V

Publication V studied working capital models in the automotive industry in 2006–2015. In this chapter, the focus is on the cycle times of working capital. The paper also observes the working capital models and positions of the companies in a working capital management matrix, which will be addressed in chapters 4.3 and 4.4, respectively.

The research sample of the study consisted of 41 companies operating in five value chain stages in the automotive industry: raw material suppliers, refined raw material suppliers, components suppliers, system suppliers, and car manufacturers. The sample was formed by following the research setting in Publication I, but due to incomplete information in the financials and restrictions in the availability of public data, the sample size in this paper was smaller than in Publication I. The cycle times for working capital and its components were calculated, and the results were presented as the averages for two five-year periods, 2006–2010 and 2011–2015. This enabled the analysis of the changes during the whole observation period as it balances the impact of one-year exceptions, and provides more realistic an outlook on the company's working capital level. Table 5 shows the results of the study.

Table 6. Cycle times of working capital and its components in Publication V.

		CCC				DIO				DSO				DPO			
		2006-10	2011-15	Δ	p-value	2006-10	2011-15	Δ	p-value	2006-10	2011-15	Δ	p-value	2006-10	2011-15	Δ	p-value
Stage averages	Automotive industry	74	66	-8	(0.003*)	50	48	-2	(0.216)	61	61	0	(0.761)	38	43	6	(0.002*)
	Raw material suppliers	36	18	-18	(0.046*)	31	29	-2	(0.116)	35	37	1	(0.753)	30	48	18	(0.046*)
	Refined raw material suppliers	80	76	-4	(0.310)	65	67	1	(0.735)	50	47	-3	(0.398)	35	38	2	(0.612)
	Component suppliers	76	69	-6	(0.301)	56	52	-4	(0.642)	60	60	0	(0.756)	40	42	2	(0.196)
	System suppliers	57	46	-11	(0.069)	41	37	-4	(0.123)	57	58	0	(0.575)	41	49	8	(0.036*)
	Car manufacturers	147	144	-3	(0.465)	51	49	-2	(0.465)	134	134	0	(0.715)	37	39	1	(0.715)

*Note: p-values indicate the statistical difference between the observation periods measured with the Wilcoxon signed-rank test. Asymptotic significances are displayed. * = significant at the 0.05 level.*

		CCC			DIO			DSO			DPO		
		2006-10	2011-15	Δ	2006-10	2011-15	Δ	2006-10	2011-15	Δ	2006-10	2011-15	Δ
Raw material suppliers	BHP Billiton	38	1	-37	33	33	0	34	26	-9	29	57	28
	BP	24	14	-10	29	24	-4	37	37	0	41	47	6
	ExxonMobil	8	9	1	11	15	3	25	27	2	29	32	4
	LKAB	62	57	-5	44	43	-1	46	42	-4	28	28	0
	Rio Tinto	52	8	-44	40	37	-3	32	32	0	20	61	41
	Royal Dutch Shell	32	16	-15	28	22	-6	36	56	20	32	61	29
Refined raw material suppliers	ArcelorMittal	71	48	-23	91	81	-10	35	20	-15	54	53	-2
	Dupont	86	92	6	69	80	11	53	61	9	36	50	14
	EMS	90	89	-1	62	61	0	55	50	-5	26	22	-4
	Evonik	71	63	-8	46	46	0	58	46	-12	33	30	-4
	Lanxess	72	73	1	56	60	4	47	46	-1	31	33	2
	Salzgitter	95	99	5	71	77	5	50	59	9	27	37	10
	ThyssenKrupp	76	70	-7	63	62	-1	52	46	-6	39	39	0
Component suppliers	Alps	64	72	8	37	44	7	60	64	4	33	35	2
	Austria Microsystems	135	76	-58	97	53	-45	81	54	-28	44	30	-14
	Bekaert	98	99	0	62	64	2	74	74	-1	38	39	1
	Daetwyler	85	78	-7	60	50	-10	44	48	4	19	20	1
	ElringKlinger AG	104	123	19	65	78	12	59	66	6	21	21	0
	Federal Mogul	76	85	9	52	59	6	59	70	11	35	43	8
	Georg Fischer	84	81	-3	64	63	-1	55	57	3	34	39	5
	GKN	45	31	-14	51	51	0	47	62	15	53	82	29
	Hella	53	51	-2	43	39	-4	49	50	2	39	38	-1
	Leoni	52	31	-21	51	47	-4	51	48	-3	50	63	14
	Miba	88	70	-18	53	50	-3	64	55	-10	30	35	5
	Nidec	62	72	10	41	53	13	82	84	2	61	65	4
	Polytec	47	43	-4	42	33	-10	45	39	-6	40	28	-12
	Rheinmetall	84	97	14	65	69	3	69	82	13	51	54	3
	Saint-Gobain	51	45	-6	51	54	3	50	44	-6	49	52	3
	Tyco	85	53	-32	53	24	-30	70	59	-11	38	30	-8
System suppliers	Schaeffler Group	97	73	-24	64	51	-14	53	55	2	20	33	13
	Continental	59	43	-16	42	33	-9	64	60	-4	47	50	3
	Bosch	84	88	4	50	52	2	62	65	3	28	29	1
	Mahle	73	70	-3	50	44	-5	56	60	3	33	34	1
	ZF Sachs	59	43	-16	40	38	-3	50	51	1	32	46	14
	Valeo	11	0	-11	23	26	3	59	50	-10	72	76	4
	BorgWarner	45	18	-27	31	25	-6	58	64	6	44	70	26
	Magna	29	33	4	27	28	1	55	57	2	53	52	-1
Car manufacturers	BMW	146	133	-13	49	47	-1	121	118	-3	23	32	9
	Daimler	137	127	-10	59	57	-2	109	99	-10	31	29	-2
	VW	123	119	-4	49	57	8	106	96	-9	32	35	2
	Renault	183	196	13	47	33	-14	199	223	24	63	59	-4

The results indicated that the CCC of the companies had fluctuated over the years, but the cycle time of working capital shortened during the latter part of the observation period. Two thirds of the sample companies had shortened their CCC in 2011–2015 compared to 2006–2010. This finding suggests that companies have started to focus on working capital management in recent years. On the other hand, the financial crisis that started in 2008 may have had an effect on the results during the first part of the observation period, and it also might explain why the cycle times had been longer back then. The Wilcoxon signed-rank test revealed that the two observation periods were statistically significantly different in regard to the CCC and DPO at the value chain level and at the stage of raw material suppliers. In addition, the difference in the DPO of system suppliers was statistically significant. The changes in the DIO and DSO, in turn, were not statistically significant for the total sample nor for individual stages.

In inventory management, only minor changes were found during the observation period. Most companies reduced their DIO, but the changes between the first and latter parts of the observation period were mainly just a few days. The results indicated that no collective change in the payment terms within the industry was applied during the observation period, as there were both reductions and increases in the DSO. However, the

changes in the DPO were mainly positive. Therefore, the finding of Publication I that in the value chain context, the changes in the DSO and DPO offset each other, is not supported by the results of this study. Prolongations of the DPO were quite remarkable in some stages of the value chain, but the results of the DSO do not show a similar trend in any of the stages. This may have resulted from the growth in the use of supply chain finance solutions, which increases the DPO of a buying company, but does not affect the DSO of the supplier in a similar way. On the other hand, this contradictory finding may indicate that the research sample is too limited for an analysis at the value chain level, and leaves out many buyer-supplier relations that affect the DSO and DPO of the sample companies.

Interestingly, some companies in the automotive industry operated with a negative CCC during some years of the latter part of the observation period. The results of previous studies on working capital management in the automotive industry have not reported this phenomenon. The finding supports the conclusion that companies have started to pay more attention to working capital management. Especially the results of the company Valeo indicate a systematic reduction of working capital that started already in 2008.

Summary

The first research question concerned the management of working capital in the value chains. Publications I, II, III and V provided information about the cycle times of working capital and its components in two different industries. In addition, the connection between working capital management and profitability was studied. It was found that the cycle times of working capital were remarkably longer in the automotive industry (average CCC 67 days) than in the ICT industry (average CCC 40 days). This was partially due to the natures of the value chains: the value chain of the automotive industry represented a traditional manufacturing chain from raw material suppliers to end customers, whereas the ICT industry is more service-oriented and characterized by outsourced production. This resulted in the differences in the efficiency of inventory management.

All four papers related to the first research question had different observation periods. The results of Publication V indicated that the cycle time of working capital has shortened in recent years in the automotive industry. The increase in the DPO in particular had led to the reductions in the CCC. At the level of individual companies, reductions in the CCC were remarkable. The results of Publication III showed that some companies in the ICT industry operated with a negative CCC: in other words, they receive payments from their customers before paying to their raw material suppliers. The results of Publication V revealed that, in recent years, companies in the automotive value chain have also been able to operate with a negative working capital during some years. Most of them were raw material suppliers, but the system supplier Valeo has also systematically reduced its working capital.

The analysis of the management of the material and financial flows of working capital in the value chains of the automotive and ICT industries showed that the cycle times of

working capital differ in different industries, but also within the industries. The study concerning the relation between working capital management and profitability in the automotive industry (Publication II) showed that different stages of the value chain benefit from different kind of working capital management practices. This indicates that all companies should not even try to reach zero – or even negative – level of working capital, but to find the most suitable working capital model which best supports the performance of the company and the value chain. The logic of working capital management seems to be different in the automotive and ICT industries: the results indicate that traditionally, working capital management in the automotive industry has been based on storing raw material and collective payment terms within the industry, while in the ICT industry, a more innovative – and possibly collaborative – approach to working capital management has been used. However, this seems to be changing in the automotive industry as well. In addition, the results indicate that not all companies within the same value chain stage operate similarly in regard to working capital management. This addresses the relevance of studying the different working capital models of companies. The finding that the profitability of the value chain can be improved by paying attention to all working capital components instead of managing them individually supports the relevance of the working capital models as well.

4.3 Identifying working capital models in the value chains

In this chapter, different working capital models in the value chains are identified and thus, the chapter provides answers to the second research question of the thesis. The analysis of different working capital models was motivated by the findings from the analysis of the cycle times in Publications I and IV, which showed that companies have managed their working capital differently, and according to Publications II and III, they also benefit from different working capital strategies in terms of profitability – contrary to traditional view according to which shorter cycle times of working capital lead to better profitability. Additionally, the findings of the Publication II showed that simultaneous management of all working capital components would improve the profitability of the value chain, which indicates that attention should be paid to working capital models. Therefore, the next step of the research process of this thesis was to identify working capital models in the value chains. First, the identification of the working capital models was conducted by cluster analysis in the value chains of the ICT and automotive industries (Publications III and IV, respectively), and then, Publication VI concludes and compares the findings in all three value chains studied in the thesis. Publication V introduces and applies the WCM matrix to evaluate the working capital models, and it is also used in Publication VI.

Publication III

In this paper, working capital management in the ICT industry was analyzed in two parts. First, the financial value chain analysis was used to study the cycle times of working capital. These results were reviewed in chapter 4.2. This chapter concentrates on the

results of the cluster analysis, where four different working capital models were identified. The sample consisted of 61 companies operating on different branches of the ICT value chain. Cluster analysis was conducted by using the average values of companies for the DIO, DSO and DPO from 2006–2010 as variables. This way, a company has only one working capital model, i.e. it belongs in one cluster. Figure 14 illustrates the final cluster centers of four working capital models in Publication III. Values on the X-axis indicate the number of days.

	Final cluster centers				*ANOVA*
	Cluster 1	*Cluster 2*	*Cluster 3*	*Cluster 4*	*F/Sig.*
DIO	53.6037	40.3665	10.6781	6.1535	52.736/0.000
DSO	106.2305	48.6606	36.7656	70.3427	49.806/0.000
DPO	80.8356	49.3074	34.0839	22.1033	18.391/0.000
n	4	18	19	20	

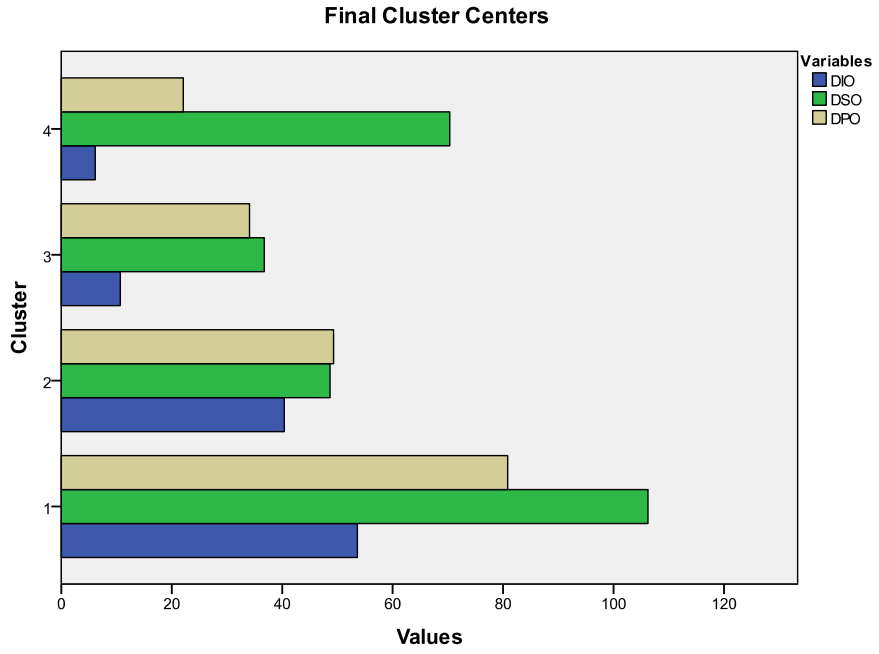


Figure 14. Final cluster centers in the ICT industry in Publication III.

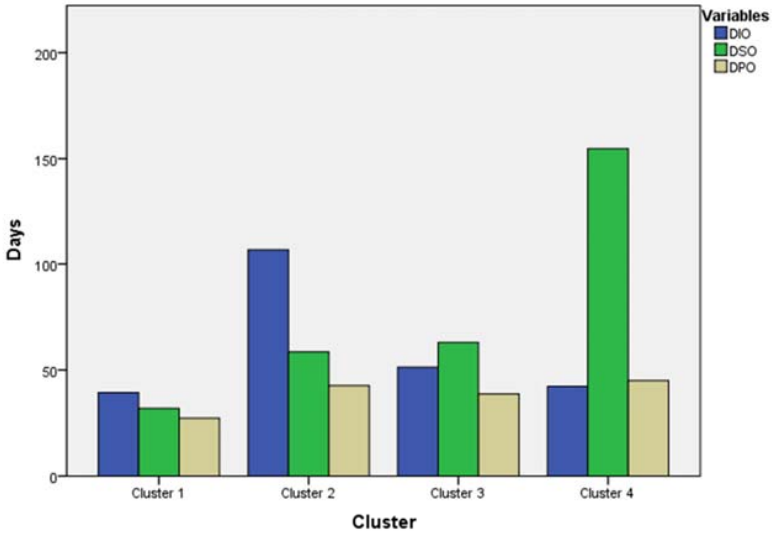
Clusters 1–4 were named as follows (respectively): *Long cycle companies, Inventory holders, Optimizers, and Credit granters.* Long cycle companies had the longest DIO, DSO and DPO. This was the smallest cluster: only four companies applied this working capital model, whereas the other three clusters were nearly equal in size. Long cycle

companies may not have been able to manage their working capital as efficiently as desired, or high inventory levels may be a part of their strategy. Credit terms offered to customers were generous, but on the other hand, the payment terms towards suppliers were long as well. Inventory holders had fairly balanced DIOs, DSOs and DPOs. The inventories were relatively high, but DPO was longer than DSO, which indicated that this cluster benefited from trade credit. It could be possible that customers in this cluster compensated inventory holding with fast payments. Optimizers had the shortest cycle time of working capital. Their inventory management was efficient, and credit terms to upstream and downstream quite balanced. It was pondered whether these companies were the strongest players in the value chain and gained their good position in the value chain in terms of working capital management through negotiation power. This cluster included the companies with negative CCCs. Credit granters, the fourth cluster, were typically service-oriented firms with negligible inventories. Credit terms given were generous, which may be a part of a planned strategy or a sign of working capital considered as a trivial matter.

When looking at the working capital models in the different value chain branches, the results showed that there is a typical, dominating working capital model for each branch. However, it was noted that all companies within the branch do not belong in the same cluster. This indicates that companies use different working capital strategies or models. Also, the profitability of the clusters was observed as it has been found to be connected to the efficiency of working capital management. The results showed that Optimizers and Credit granters, which had the shortest cycle times, were also the most profitable clusters measured by ROC%. However, as relative profitability is highly dependent on the amount of total assets, the clusters are not fully comparable due to different amounts of investments in fixed assets and management of inventories.

Publication IV

The aim of Publication IV was to detect different working capital models used in the value chain of the automotive industry, and to connect the working capital models to the profitability of the companies. First, the existence of different working capital models was studied using statistical cluster analysis, and second, it was examined using statistical methods (i.e. Kruskal-Wallis and Mann-Whitney tests) whether the profitability of companies using different working capital models differ. The empirical data was collected from the financial statements of 57 automotive companies. The observation period was 2006–2009, and the final research sample consisted of 222 firm-year observations. Using firm-year observations in the analysis means that the cluster of the company may vary during the observation period, but the results showed that changing the cluster was not common. The variables used in the cluster analysis were DIO, DSO and DPO. Figure 15 shows the final cluster centers in Publication IV.



	Final cluster centers				*Kruskal-Wallis*
	Cluster 1	*Cluster 2*	*Cluster 3*	*Cluster 4*	*Chi-Square/Sig.*
DIO	39.4	106.7	51.3	42.2	42.094/0.000
DSO	32.0	58.5	63.0	154.7	63.364/0.000
DPO	27.3	42.7	38.7	45.0	2.338/0.311
Number of cases in each cluster	73	15	122	12	
Average CCC	44	123	76	152	

Figure 15. Final cluster centers in the automotive industry in Publication IV.

The results of the cluster analysis showed that four different working capital models were detected, and the models differ from each other in the management of inventories and accounts receivable. The cycle times of accounts payable, in turn, were on a fairly similar level in all working capital models. The clusters were named as follows: *Successful minimizing model, Inventory holding model, Aiming-at-minimum model, and Credit granting model*. The successful minimizing model is based on the efficient management of all working capital components. In addition to short DIO, the cycle times of financial flows (i.e. DSO and DPO) were short and nearly balanced. The inventory holding model is based on large inventories. Aiming-at-minimum is the most typical model in this sample. These companies have not been able to manage their inventories in the most efficient way, and the benefits of trade credit cannot be used either, as the gap between the DSO and DPO is quite wide. It was interpreted that companies applying this model have tried to minimize their working capital but failed in the attempt. The credit granting model is based on generous credit terms given to the customers. The CCC in this model

is the longest of all the clusters even if the inventories are relatively small, as an extremely large amount of accounts receivable increases working capital. The analysis showed that the different levels of the value chain have typical working capital models. The working capital model may also vary yearly, and the variance happened typically between successful minimizing and aiming-at-minimum models, which indicates that most companies in the value chain of the automotive industry try to achieve short cycle times of working capital. This working capital model also seems to be the most profitable in the value chain of the automotive industry. The results of the Kruskal-Wallis test showed that the ROC% of the clusters differed to a statistically significant amount. Pairwise comparisons of the Mann-Whitney test revealed that cluster 1, Successful optimizers, is statistically significantly more profitable than the other clusters.

Publication V

The objective of the paper was to study the different patterns of managing working capital in the automotive industry. The observation period was 2006–2015, which was further divided into two five-year periods (2006–2010 and 2011–2015) to enable the observation of longer-term developments of working capital management in the sample. In this section, the focus is on the different working capital models identified in the automotive industry. The paper also studied the cycle times of working capital and its components, which were reviewed in chapter 4.2, as well as introduced the WCM matrix, which was briefly introduced in the methodology section (see chapter 3.3) and will also be addressed in chapter 4.4.

In this paper, the working capital models were studied in the WCM matrix. The WCM matrix divided companies into four categories on the basis of their DIO and DSO-DPO performance (short/long cycle time). The working capital models were first analyzed at the stage level. For this purpose, the average working capital models for the stages in the years 2006–2010 and 2011–2015 were defined on the basis of the average DIO and DSO–DPO of the companies. This is illustrated in Figure 16.

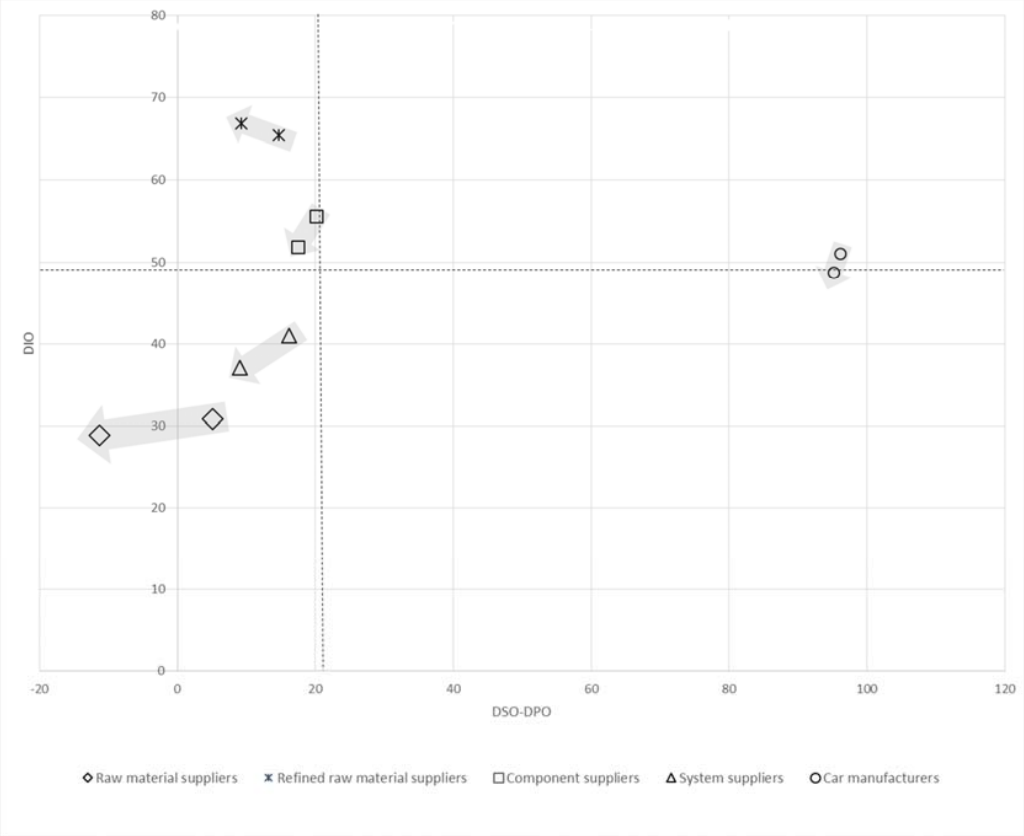


Figure 16. Average working capital models of stages in the automotive industry in 2006–2010 and 2011–2015 according to Publication V.

The analysis of the average working capital models of the stages showed that the smallest inventories and the most favorable payment terms were maintained by raw material and system suppliers. Both of the stages developed their working capital management during the observation period in both elements: in addition to minor reductions in inventories, their net trade credit (DSO–DPO) was reduced remarkably. Raw material suppliers even gained negative net trade credit, and system suppliers were approaching the limit as well. Refined raw material suppliers and component suppliers acted as the inventory holders of the value chain. Both of these stages had a moderate balance between the payment terms towards upstream and downstream, with a small reduction from the first part of the observation period to the latter. They differed in the development of the DIO: refined raw material suppliers increased their inventory levels during the observation period, whereas component suppliers were able to reduce them. Car manufacturers was the only stage that changed their working capital model. Due to small improvements in its DIO, it moved from the most unfavorable working capital model (long cycle times) to the working

capital model of a shorter DIO and a long DSO–DPO. The analysis revealed that the positions of the stages against each other had not changed during the observation period.

The analysis of the results at a company level was conducted next. Figure 17 shows all firm-year observations, i.e. the working capital models of the sample companies in 2006–2015 (410 observations). The findings indicated that moving from one working capital model to another may be a long-term process, as only a few companies had changed their average working capital model from 2006–2010 to 2011–2015. It seems that a sustainable reduction of working capital is conducted in small steps.

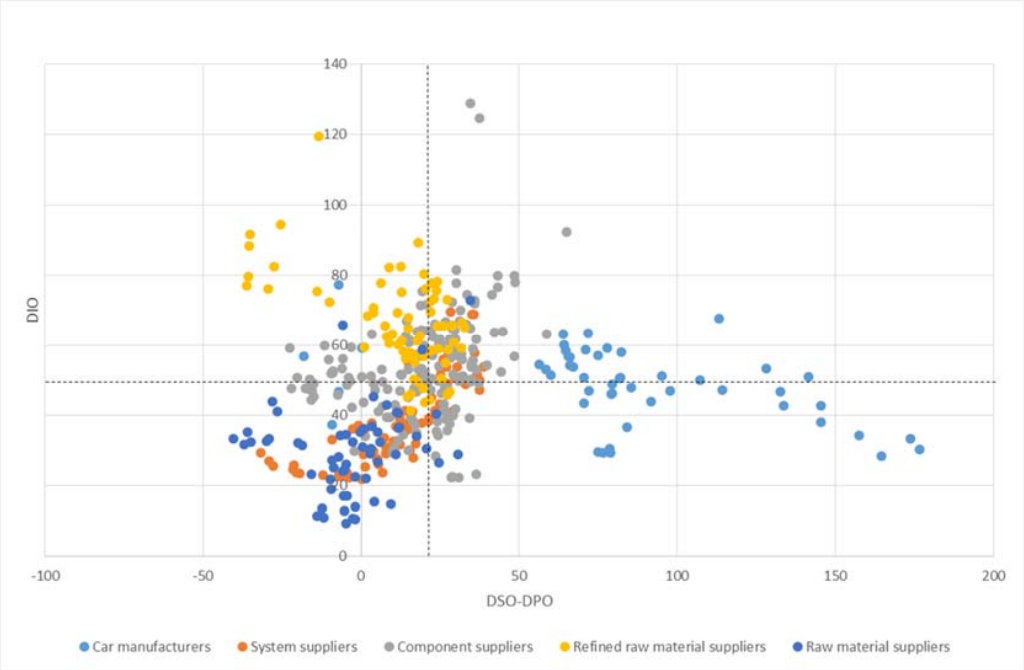


Figure 17. Working capital models of sample companies in Publication V.

The results showed that most firm-year observations (141 observations) from the whole observation period were positioned in the working capital model with the shortest cycle times. The second most observations (124 observations) were in the opposite working capital model of long cycle times. The working capital model concentrating on inventory holding had 87 firm-year observations, whereas the working capital model focusing on credit granting had 58 observations. All working capital models had companies from all value chain stages, but for most of the stages, a typical working capital model could be determined. Component suppliers had the most variation in the application of working capital models, and a typical model for the stage could not be found. System suppliers applied mainly two opposite working capital models: the working capital model of short cycle times and the one with long cycle times. A closer look at these stages revealed that

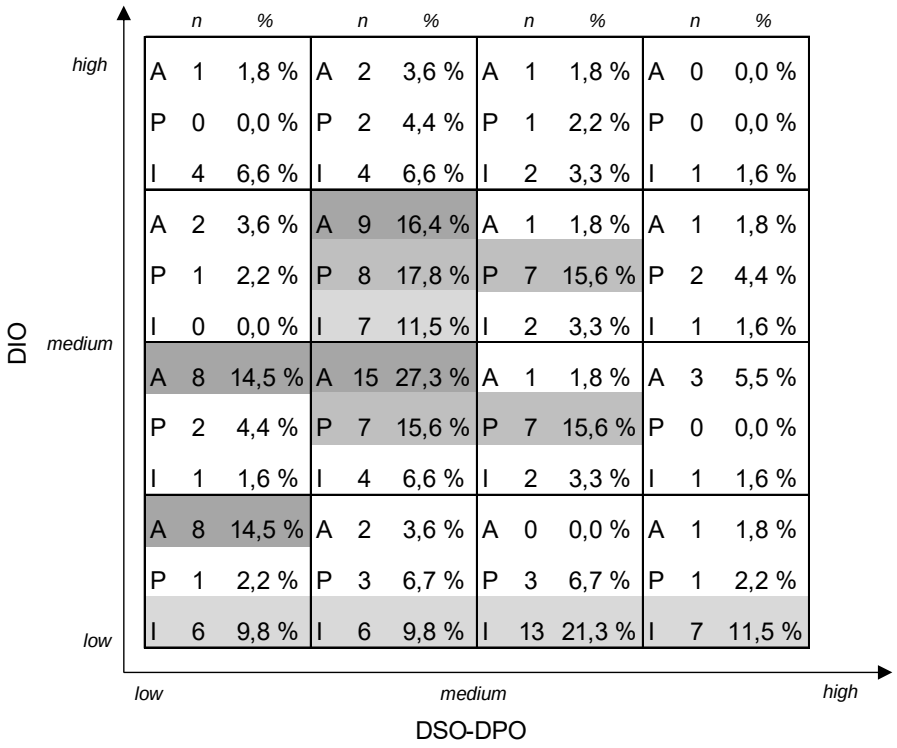
most of the companies keep the same working capital model from year to year with some annual exceptions. It also seems that the working capital management of the company changes in relation to one element: they emphasize either inventory management or trade credit management. This may indicate that a holistic perspective on working capital management, considering all working capital components, is not applied by the automotive companies.

Publication VI

The objective of the sixth publication was to explore different patterns of managing working capital in the value chains of the automotive, ICT, and pulp and paper industries. The observation period was 2006–2010. The analysis was two-fold: First, the financial value chain analysis and cluster analysis were used to observe working capital models in the value chains. Second, on the basis of empirical findings, a generic framework for working capital models is proposed. In this chapter, the results regarding the financial value chain analysis and cluster analysis are reported. Chapter 4.3 focuses on the generic framework.

An analysis similar to the one in the WCM matrix in Publication V was conducted for each value chain separately. However, the analysis in Publication VI differed in the way that both axes were divided into four equal parts between the minimum and maximum values of the samples. Thus, the WCM matrix consisted of 16 working capital models. This enabled a more accurate analysis of the applied working capital models. In the study, average values of the companies for 2006–2010 were used in the analysis.

In the value chain of the automotive and pulp and paper industries, the analysis of the stages indicated that companies within the stages were often located close to each other in the WCM matrix. In other words, many companies applied working capital models similar to their competitors. This was noticed in some service-focused stages in the ICT industry as well. However, this was not the norm, but it was found that in some stages companies applied several very different working capital models. These stages include e.g. component suppliers in the automotive industry, chemical and machinery suppliers in the pulp and paper industry, and the ICT industry in general. The results of all value chains showed that companies do have different working capital models, and similarities between the different industries can be found: e.g. inventory holders, working capital optimizers and value chain financiers can be identified in all value chains. The most popular working capital models clearly come up in the analysis. However, there are different emphases in the value chains: while the automotive value chain strongly aims at minimum working capital, in the pulp and paper industry the companies are focused around the medium values. The ICT industry places emphasis on minimum working capital and inventories and, on the other hand, on providing trade credit. Figure 18 shows the division of the sample companies in the WCM matrix. The grey shading in the figure highlights the most used working capital models in each value chain.



A = automotive industry, P = pulp and paper industry, I = ICT industry

n indicates the number of companies applying the working capital model

% describes the share of the sample

Figure 18. Working capital models in different value chains in Publication VI.

The K-Means cluster analysis was conducted in order to detect distinctive working capital models through statistical analysis. Differing from the cluster analyses in Publications III and IV, the variables used in this study were DIO and DSO-DPO. The variables were chosen according to the variables of the WCM matrix. Also the cluster analysis was conducted separately for each value chain. The main finding of the cluster analysis was that it pointed out a cluster with a negative DSO-DPO in each value chain. This indicates that differing from the other companies in the value chain, some actors gain benefits from a negative trade credit balance. These companies have more beneficial payment terms towards suppliers than they have granted for the customers.

The results of Publication VI found similar working capital models in different value chains. Inventory holders, financiers, trade credit users and minimizers were identified in all industries. Moderate working capital models as well as companies having long cycle times of working capital were identified as well, but not in all value chains. The paper

also detected the different orientations of the industries in regard to working capital models.

Summary

The second research question of this thesis concerned the identification of different working capital models. In this thesis, the working capital models were identified in the context of different value chains. The results of the cluster analyses in Publications III and IV indicated that similar working capital models could be detected in the ICT and automotive industries. Both studies detected clusters that could be named as inventory holders, minimizers/optimizers, and credit granters. The results of these publications also suggested to take into account the two sides of working capital – the material and financial flow – as the results pointed out the different approaches to inventories and trade credit.

Publications V and VI introduced and tested the WCM matrix approach in the analysis of working capital models. It enabled the observation of how the companies of the samples were spread into the matrix and thus, among different working capital models. The analysis revealed that even though similar working capital models were identified in all value chains, they are emphasized differently.

All publications related to the second research question found that even if the value chain stages had a typical working capital model, not all companies within the stage manage their working capital similarly. This finding shows that in addition to the value chain level, different working capital models can be identified in the value chain stages as well. The finding indicates that a certain position in a value chain does not necessarily direct to a certain working capital model, and an innovative approach to working capital management can create competitive advantage for a company.

4.4 A generic framework for working capital models in the value chain

The third research question of the thesis was related to the categorization of different working capital models, and it was studied in Publications V and VI. The papers concentrate on developing a way to analyze working capital models in the value chains, and finally, on a framework of generic working capital models. This research question was motivated by the finding of similar working capital models in different industries, which indicated of a possibility to develop a generic approach to working capital models. Additionally, it was found that there is a need for a tool which would enable the analysis of working capital positions between the companies in the value chains and value chain stages, as well as provide the possibility to have a holistic view on the working capital models consisting of both, the material and financial flow of working capital. Publication V takes an initial step towards working capital model definition by introducing a working capital management (WCM) matrix. Publication VI uses this matrix to define a framework for working capital models.

Publication V

Publication V studied working capital models in the automotive industry in 2006–2015. In this chapter, the focus is on the WCM matrix introduced in the paper. The positions of the 41 automotive companies in the WCM matrix were analyzed. The paper also studied and compared the cycle times of working capital in the years 2006–2010 and 2011–2015. The results of this analysis were presented in chapter 4.1, and the identified working capital models were presented in chapter 4.2.

The construction of the WCM matrix started with the idea of combining the observation on the material and financial flows of working capital in the same picture. In earlier literature of working capital, these two flows have been separated under two research streams, finance and operations management. In the matrix, the Y-axis presents the material flow of working capital, measured by the cycle time of inventories (DIO). The X-axis illustrates the financial flows of working capital by net trade credit, i.e. the difference between the cycle times of trade credit components accounts receivable and accounts payable (DSO-DPO). The aim of the WCM matrix is to enable a holistic view on working capital as a whole. The WCM matrix was illustrated in Figure 7 in the research methodology section of this thesis.

In Publication V, different categories in the WCM matrix were outlined by the average figures of DIO and DSO-DPO of the sample, as the average is a commonly accepted classification method in statistical analysis. The limitations of this approach were recognized, and it was pointed out that border values may be quite different in different samples and in different industries. However, previous research on working capital management has not defined specific limits for “good” or “bad” DIO and DSO-DPO which could have been set as benchmark values in the WCM matrix.

In this paper, the WCM matrix was tested with the data from 41 automotive companies. The matrix was used in three different contexts. First, the positions of the average value chain stages were analyzed. Second, all observations were placed in the matrix in order to analyze the emphasis of different working capital models in the value chain. Third, the working capital models were analyzed within the stages. The WCM matrix provides an opportunity to categorize companies on the basis of their working capital management performance. It enables the observation of how companies in the value chain are positioned against each other, and, for example, which companies hold inventories or finance others with trade credit. In this paper, companies were placed in four different categories. According to previous literature, the most beneficial option for the company is to have both cycle times as short as possible. On the contrary, the least desired option for the company is the category where both cycle times are long. This means that they hold more inventories than average companies, as well as finance customers with trade credit.

Publication VI

Publication VI studied working capital models in the context of three different industries: automotive, pulp and paper, and ICT. The working capital models were analyzed with the WCM matrix and by cluster analysis. These results were reviewed in chapter 4.2. In this chapter, a generic framework for the working capital models proposed in the paper is introduced.

The construction of the framework was motivated by the finding that, regardless of the industry, all value chains seemed to have similar working capital models in use. The structure of the framework followed the structure of the WCM matrix introduced in Publication V: The Y-axis presents the effectiveness of the material flow with the cycle time of inventories (DIO), and the X-axis is formed by trade credit balance, i.e. net trade credit (DSO-DPO). The relevance of the choice of axes is also supported by the fact that inventories and trade credit are usually managed by separate functions in the companies. The generic working capital models were based on the empirical findings from the analysis of the results in the matrix as well as the results of the complementary cluster analysis. The framework illustrated in Figure 19 concludes the findings and introduces six generic working capital models and one sub-model.

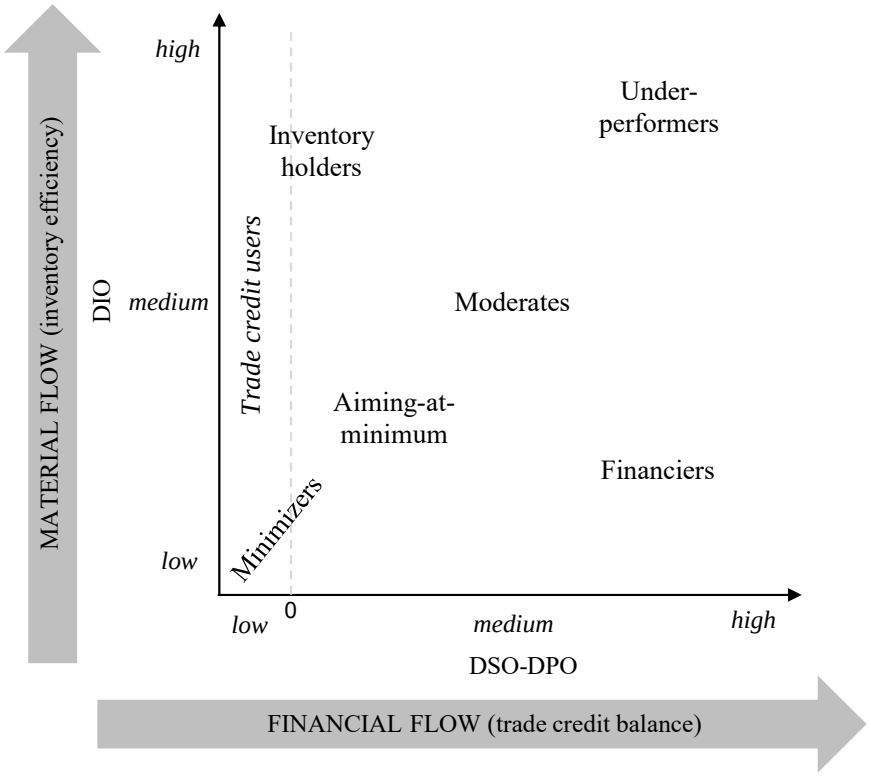


Figure 19. Generic framework for working capital models in Publication VI.

Minimizers were found especially in the automotive and ICT industries, but some companies in the pulp and paper industry also operated with minimum working capital. This working capital model is based on short cycle times, and negotiation power is required in order to have a low DSO-DPO. In other words, the payment terms with the customers need to be relatively short in comparison to the payment terms with the suppliers. This variable can even be negative. In this case, the company also applies the sub-model *Trade credit users*.

The *Aiming-at-minimum* working capital model was identified in the automotive industry in particular. The results indicated that several companies may have aimed at minimizing their working capital, but had not succeeded in achieving the lowest working capital levels in the value chain for one reason or another.

Moderates focused on operating with medium levels of DIO and DSO-DPO. The companies may not be willing to take risks and, therefore, they keep a certain level of inventories. The companies also do not take advantage of the value chain partners in terms of trade credit nor finance the value chain with exceptionally generous payment terms. Moderates were identified especially in the pulp and paper industry, where the working capital models around the center of the WCM matrix were used the most.

Inventory holders were identified in all studied value chains. These companies carry large inventories or have a long production lead time that ties up working capital into work-in-progress inventories. The results showed that especially in the automotive and ICT industries, several inventory holders applied the sub-model *Trade credit users*. In the value chain context, it could mean that the suppliers holding the inventories are compensated with fast payments by customers.

Underperformers have large investments in working capital. They carry large inventories and finance the value chain or end customers with generous credit terms. Therefore, their CCCs are the longest in the value chain. The results showed, however, that this undesired working capital model was only applied occasionally.

Financiers were also found in all value chains. These companies have notable differences in their payment terms towards upstream and downstream, and therefore, an inefficient financial flow of working capital. By operating this way, they finance the other value chain partners or end customers.

Trade credit users, as an opposite to Financiers, take advantage of trade credit by having long payment terms towards suppliers in comparison to the payment terms towards customers. As discussed above, this can be used as a sub-model by Minimizers and Inventory holders. With efficient inventory management, Trade credit users may achieve a negative working capital.

Summary

The third research question dealt with the issue of how to analyze working capital models. Publications V and VI contributed to this question. The development of the analysis method was two-fold. First, the WCM matrix was developed in order to be able to analyze both the material and financial flows of working capital, as well as all three working capital components, in one matrix. The matrix has two dimensions: inventory management and trade credit management. The WCM matrix combines all variables of the working capital model, and it was tested in different contexts and with different samples.

Publication VI finally concluded the findings of all publications of this thesis by providing a generic framework for working capital models. The framework is based on the WCM matrix, but the main contribution of the framework is the definition of six generic working capital models and one sub-model, which were identified on the basis of systematically analyzed empirical financial data: Minimizers, Aiming-at-minimum, Moderates, Inventory holders, Underperformers, Financiers, and Trade credit users. The generic working capital models were identified by analyzing the value chains in the automotive, ICT, and pulp and paper industries.

5 CONCLUSIONS

This chapter concludes the findings of the research. Theoretical contributions describe how the research presented in this thesis extends and advances current academic knowledge. Managerial implications discuss the practical relevance of the thesis. Finally, directions for future research in the area of working capital models and financial supply chain management are suggested.

5.1 Theoretical contribution

This thesis studied different working capital models in the value chain context. The scope of the research was in the interface of finance and operations management. In addition, working capital model was defined as a part of business model (Mullins and Komisar, 2009), which connects this research to the literature of strategic management. However, this thesis focused only on working capital models, and the role of the working capital model in the overall business model of the firm was left out of scope at this point. Next, the theoretical contributions of the thesis are discussed.

First, the thesis contributes to the literature of working capital management by bringing the working capital models into discussion. As suggested by Farris and Hutchison (2003), instead of focusing on each working capital component individually, companies should take a holistic view on working capital and define their own unique combinations considering all three variables of operational working capital. The findings of the research support this view. This thesis has taken an initial step towards this non-researched area, and complements the previous research on working capital management practices (e.g. Belt and Smith, 1991; Howorth and Westhead, 2003) by looking at the topic from another perspective. While previous research studied different working capital management practices by collecting data from companies with survey questionnaires, this thesis used numerical data from financial statements which show the realization of the working capital management of the company.

Second, the fragmented academic literature on the management of working capital and its components from two separate research streams is joined together in this thesis in the concept of working capital model. Despite the increased academic interest in working capital, research on working capital management still often takes the perspective of either finance or supply chain management (Gelsomino et al., 2016). Shifting the focus to working capital models forces researchers to take into account both sides of working capital, the material as well as financial flows.

Third, the thesis introduces a generic framework for working capital models. The framework is founded on the empirical findings from three large industry value chains and provides a novel way for looking at working capital in the value chain. The results of the study showed that companies have different strategies for managing working capital. Six generic working capital models (Minimizers, Aiming-at-minimum, Moderates,

Inventory holders, Underperformers and Financiers) and one sub-model (Trade credit users) describe the roles related to working capital management that companies had in the value chain context. The structure of the framework enables the holistic observation of working capital management, as it combines all three variables of operational working capital into the same graph. The framework serves as a theoretical foundation for future research on working capital models. Additionally, it can be used as a managerial tool in several ways which will be described in the following chapter. The framework differs from the cash-to-cash map by Farris and Hutchison (2003) by providing a categorization of working capital models in two dimensions, and by showing the distances between the companies. This simplifies the analysis and makes it more visual. This study also advances the categorization of working capital strategies by Meszek and Polewski (2006) through a more diverse selection of working capital models/strategies, and by taking into account the components of operational working capital in the categorization of working capital models.

Fourth, the framework reveals the working capital positions of the value chain partners and describes the current conditions in the value chain. This identification of the working capital positions and different working capital models in the value chains is important (e.g. Grosse-Ruyken et al., 2011), and can be considered as a pre-requisite for the optimization of inter-organizational working capital management. Thus, the study takes an initial step towards tightening collaborative actions in the value chains, and encourages academics and practitioners to consider how genuine collaboration and win-win situations in inter-organizational working capital management could be possible. Current research on financial supply chain management largely emphasizes the services provided by financial institutions as an option to solve the financing issues of the value chains (e.g. Grüter and Wuttke, 2017; Liebl et al., 2016). However, standardized tools do not take into account the specific needs and characteristics of unique business relationships. In the long run, factoring or reverse factoring may not be the solutions for improving the financial flows in the value chain as they only shift the problem somewhere else. Instead, genuine collaboration between the value chain partners aiming at the optimization of working capital at the value chain level could be a source of competitive advantage. Of course, this requires trust, mutual understanding and certain attitude towards collaboration, but on the other hand, may lead to remarkable benefits. The underlying theoretical foundation of this thesis was the importance of ensuring the allocational efficiency of the capital markets in order to be able to use the limited available resources in the most productive way (Arnold, 1998). The introduced framework provides an opportunity for value chain wide collaboration. It can be used to identify potential objects from the value chain to release financial resources in terms of working capital for more productive use, which is significant in terms of the attractiveness and competitiveness of the entire industry.

Fifth, the research of this thesis contributes to the emerging theory of financial supply chain management. This is a new research area and, thus, still lacking an established theoretical foundation. As noted by Singh and Kumar (2014), previous literature on working capital management lacks systematic theory development studies. This thesis

has systematically built a theoretical framework for working capital models and opened up a new direction of research on working capital models by applying the grounded theory methodology. The emerged theoretical framework was constructed on the basis of empirical observations from archival data.

5.2 Managerial implications

This thesis also provides practical implications for working capital management in the value chains as well as companies. The practical relevance of the study mainly focuses on the application of the introduced generic framework as a managerial tool to identify working capital models and to improve working capital management. Managerial implications of the research are as follows.

First, the introduced framework can be used as a managerial tool for working capital management in the companies. The management of working capital is a complex issue: different functions and managers are responsible for the management of the individual components of working capital, and even if working capital were followed actively in the top management, the reality can be that no one in the company is in charge of the total working capital. Thus, the introduced framework, which considers all aspects of operational working capital, can be used to form a general view of working capital in a company. When aiming at the improvements in working capital management, a holistic perspective should be taken: it should be understood how working capital is constituted from different variables.

Second, companies can evaluate their working capital management against their competitors, suppliers and customers. In addition, different value chains as well as industries can be compared. In this respect, it complements the financial value chain analysis introduced in Publication I. The framework provides a visual analysis method for observing working capital positions in the chosen context, and encourages managers to consider working capital management at the value chain level.

Third, the framework supports companies and value chains in setting targets for working capital management as well as in the follow-up of the development of working capital levels. As discussed earlier, the most efficient strategy for working capital management from a single company perspective is reasonable minimization. This has a positive impact on profitability (e.g. Deloof, 2003), and it decreases the financing costs of capital (e.g. de Almeida and Eid Jr., 2014). When all companies in the value chain follow this strategy and reduce their working capital, the boundaries in the matrix change as well. Therefore, the framework enables the continuous improvement and follow-up of working capital management in order to release capital from the value chain for other objectives, such as investments in growth. However, in the value chain context it is not possible for every company to approach minimum working capital. Companies have different premises, for example regarding production processes, bargaining power and financial conditions. These affect the working capital management of the companies as well. As shown in Publication II, not all companies benefit from similar actions related to working capital

management. Thus, as a continuum for target setting, the framework can be used to define the different roles of value chain actors in order to find the optimal working capital management for the value chain. This would mean for example avoiding the working capital model of Underperformers. In addition, it should also be ensured that the companies operating as Financiers have the lowest cost of capital (Hofmann and Kotzab, 2010).

5.3 Future research

The findings, as well as the limitations of this study, offer several avenues for future research in the area of working capital models and financial supply chain management. Next, possible directions for further research are pointed out.

First, this thesis raised the working capital model into discussion and introduced a novel framework for working capital models based on the empirical findings from three industry value chains. The robustness of the introduced framework could be further tested with different samples. At the same time, more knowledge on the emphasis of working capital models in different value chains could be gained. Additionally, it could be studied what kind of companies apply the same working capital models. It would be interesting to know if for example the size of the firm directs to certain working capital model in the value chain. This could be studied for example by conducting statistical analyses.

Second, the financial wealth of the companies is based on several aspects: growth, profitability, liquidity, and solvency. This thesis focused on working capital models, and thus, took a stand on the liquidity positions of the companies. However, this examination did not take into account the well-being of the company in terms of growth, profitability and solvency. It is possible that a company that looks efficient in the light of working capital management is suffering from financial difficulties in other areas. Future studies could find ways to implement these dimensions in the framework as well in order to evaluate the holistic financial positions in the value chain. This information could be elaborated further to determine the most optimal strategy for working capital management of the value chain.

Third, this thesis used archival data to study the working capital models. The data of the research consisted of real-life financial figures from public sources. However, the quantitative data alone does not reveal what is behind the numbers. It would be interesting to study whether the working capital model of a company is a consequence of the defined working capital strategy, or whether it has resulted from passive drifting towards a certain working capital model. Case studies and interviews could be used to complement the knowledge gained via this quantitative study. Additionally, it would be interesting to use internal, company-specific financial data to analyze the impact of seasonal fluctuation and the changes in working capital during different business cycles with the created framework.

Fourth, in this thesis, the working capital model was seen as a part of a business model. However, previous literature and issues related to strategic management and business models were left out of the scope of this study. Therefore, it opens several directions for future research. The business model of a company is a complex construct where the working capital model may only have a minor role. On the other hand, companies such as Valeo and KONE have highlighted working capital management as part of their corporate strategy. It would be interesting to study the role of working capital management in the strategic management of companies. How is working capital connected to the other elements of a business model? How is working capital strategy supported by corporate strategy?

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APPENDIX A: Research samples in the automotive studies

Stage	Company name	Publication 1	Publication 2	Publication 4	Publication 5	Publication 6
Raw material suppliers	BHP Billiton	x		x	x	x
	BP	x		x	x	x
	Exxon Mobil	x		x	x	x
	LKAB	x		x	x	x
	Rio Tinto	x		x	x	x
	Royal Dutch Shell	x		x	x	x
	Total	x		x		x
	Vale	x		x		x
Refined raw material suppliers	Arcelor Mittal	x	x	x	x	x
	BASF	x	x	x		x
	Dupont	x	x	x	x	x
	EMS	x	x	x	x	x
	Evonik	x	x	x	x	x
	Lanxess	x	x	x	x	x
	Salzgitter	x	x	x	x	x
	Stahl-Metall-Service	x	x			
	Thyssen Krupp	x	x	x	x	x
	Voestalpine	x	x	x		x
	ZAPP	x	x	x		
Component suppliers	Alps	x	x	x	x	x
	Austria Microsystems	x	x	x	x	x
	Bekaert	x	x	x	x	x
	Daetwyler	x	x	x	x	x
	Draexlmaier	x	x	x		x
	Elring Klinger	x	x	x	x	x
	Federal Mogul	x	x	x	x	x
	Georg Fischer	x	x	x	x	x
	GKN	x	x	x	x	x
	Hella	x	x	x	x	x
	Leoni	x	x	x	x	x
	Miba	x	x	x	x	x
	Neumayer Tekfor	x	x			
	Nidec	x	x	x	x	x
	Polytec	x	x	x	x	x
	Rheinmetall	x	x	x	x	x
	RUAG	x	x	x		x
	Saint Gobain	x	x	x	x	x
	Seissenschmidt	x	x			
	Trimet	x	x	x		x
	Tyco	x	x	x	x	x

Stage	Company name	Publication 1	Publication 2	Publication 4	Publication 5	Publication 6
System suppliers	Borg Warner	x	x	x	x	x
	Bosch	x	x	x	x	x
	Continental	x	x	x	x	x
	Denso	x	x	x		x
	Magna	x	x	x	x	x
	Mahle	x	x	x	x	x
	Schaeffler	x			x	
	Valeo	x	x	x	x	x
	ZF Sachs	x	x	x	x	x
Car manufacturers	BMW	x	x	x	x	x
	Daimler	x	x	x	x	x
	Geely	x				
	Honda	x	x	x		x
	Hyundai	x	x	x		x
	Nissan	x	x	x		x
	Renault	x	x	x	x	
	Toyota	x	x	x		x
	Volkswagen	x	x	x	x	x
Car dealers	AVAG	x		x		x
	Autohaus Wolfsburg	x		x		x
	Feser Graf	x				
	Lueg	x				
	Löhr & Becker	x		x		x
	MAG Metz	x				
	Wellergruppe	x		x		x

APPENDIX B: Cycle times in the pulp and paper industry

		DIO						DSO						DPO						CCC					
	n	06	07	08	09	10	avg	06	07	08	09	10	avg	06	07	08	09	10	avg	06	07	08	09	10	avg
Pulp and paper industry	**42**	**40**	**40**	**43**	**41**	**40**	**41**	**55**	**54**	**52**	**56**	**53**	**54**	**36**	**35**	**34**	**36**	**38**	**36**	**59**	**59**	**62**	**60**	**55**	**59**
Chemicals	*4*	*47*	*46*	*46*	*49*	*48*	*47*	*56*	*54*	*44*	*50*	*47*	*50*	*34*	*30*	*26*	*28*	*29*	*29*	*70*	*70*	*64*	*72*	*66*	*68*
BASF		46	41	39	48	49	45	57	54	45	56	58	54	33	24	16	20	27	24	70	71	69	84	80	75
Dow		45	47	38	56	48	47	37	41	24	46	31	36	28	31	21	34	30	29	54	56	41	68	50	54
Imerys		54	54	65	58	59	58	68	67	55	48	49	57	33	34	36	34	35	34	90	86	84	72	74	81
Kemira		42	40	41	36	34	39	63	54	51	50	50	54	40	30	31	23	24	30	65	64	61	63	60	63
Machinery	*3*	*57*	*57*	*65*	*61*	*58*	*60*	*66*	*61*	*60*	*58*	*65*	*62*	*45*	*39*	*38*	*36*	*53*	*42*	*78*	*80*	*88*	*83*	*70*	*80*
Andritz		29	28	36	37	34	33	47	44	43	52	52	48	46	35	31	30	31	35	30	37	48	59	55	46
Metso		82	82	92	85	86	85	71	58	53	54	62	60	59	50	42	44	91	57	94	91	103	95	58	88
Voith		60	62	68	60	55	61	80	80	84	69	80	79	29	31	40	33	37	34	111	111	113	96	98	106
Market pulp	*5*	*50*	*49*	*63*	*56*	*50*	*54*	*43*	*41*	*37*	*60*	*42*	*45*	*28*	*24*	*25*	*35*	*24*	*27*	*65*	*66*	*76*	*81*	*68*	*71*
Arauco		52	46	58	73	70	60	71	60	53	59	58	60	26	23	32	38	35	31	97	84	79	94	93	90
Canfor		60	53	57	54	49	54	21	22	15	24	22	21	30	16	16	17	21	20	52	59	56	60	50	55
Fibria		49	47	56	67	59	55	57	57	46	131	66	71	25	29	24	71	25	35	80	74	78	127	100	92
Metsä-Botnia		34	45	69	40	25	43	39	38	29	38	25	34	31	31	17	17	7	20	43	52	81	61	44	56
Södra Skogsägarna		54	52	77	49	46	56	27	28	45	45	41	37	31	21	34	34	32	30	51	59	88	60	54	62
Paper and board	*##*	*43*	*45*	*47*	*44*	*46*	*45*	*56*	*55*	*52*	*54*	*53*	*54*	*37*	*39*	*36*	*41*	*45*	*40*	*62*	*61*	*62*	*56*	*53*	*59*
Holmen		51	58	65	58	69	60	55	57	59	55	52	56	41	45	43	39	51	44	66	71	81	74	71	72
Industrial Paper		32	35	37	34	34	34	45	53	48	39	41	45	32	36	31	32	37	34	45	51	54	41	38	46
Kimberly-Clark		44	49	47	39	44	44	51	51	47	49	46	49	26	29	27	37	41	32	68	71	67	51	49	61
MeadWestvaco		40	42	38	36	41	39	53	50	41	56	53	51	26	30	28	31	35	30	67	61	51	61	59	60
M-Real		42	49	55	47	54	49	64	55	50	45	52	53	24	26	21	23	28	24	82	78	84	69	78	78
Myllykoski		42	39	38	31	31	36	55	58	64	61	66	61	25	33	35	42	44	36	72	64	68	50	52	61
Nippon		46	50	51	51	47	49	69	70	58	69	64	66	39	38	32	34	34	35	75	83	77	86	77	80
Norske Skog		34	37	37	36	39	37	49	48	51	41	43	46	49	50	59	56	56	54	35	35	29	21	26	29
Oji		44	44	45	43	45	44	99	82	78	79	79	83	68	62	51	56	61	60	75	64	71	66	62	68
Sappi		52	49	45	54	46	49	35	38	36	45	41	39	56	63	59	76	71	65	31	24	22	23	17	23
SCA		39	44	46	38	42	42	55	58	58	53	52	55	44	47	47	40	45	45	49	55	57	50	49	52
Stora Enso		51	48	53	52	52	51	44	41	41	49	49	45	23	19	18	33	60	31	72	69	77	69	41	66
UPM		44	46	50	51	51	49	49	49	48	53	51	50	26	26	23	31	29	27	67	69	75	74	73	72
Merchants	*2*	*46*	*48*	*42*	*38*	*41*	*43*	*72*	*77*	*62*	*60*	*61*	*66*	*56*	*56*	*50*	*51*	*50*	*52*	*62*	*68*	*54*	*48*	*52*	*57*
Paper Linx		43	40	40	35	37	39	69	67	66	62	71	67	46	46	45	49	49	47	66	62	61	48	59	59
Sequana		49	55	44	41	44	47	74	87	57	59	51	66	66	67	54	52	51	58	58	75	47	48	45	54
Printers	*3*	*20*	*22*	*22*	*22*	*24*	*22*	*81*	*80*	*69*	*76*	*76*	*76*	*43*	*40*	*36*	*45*	*44*	*42*	*57*	*61*	*56*	*53*	*56*	*57*
Consolidated Graphics		17	20	17	18	18	18	67	70	55	63	59	63	21	19	15	31	31	24	63	71	57	50	46	57
DNP		22	22	28	27	32	26	111	102	92	103	91	100	79	72	67	71	63	70	54	52	53	59	60	55
RR Donnelley		20	22	22	21	23	22	64	69	60	62	78	67	29	30	24	33	38	31	55	61	58	50	63	57
Brand owners	*6*	*42*	*42*	*45*	*41*	*42*	*42*	*44*	*46*	*46*	*44*	*44*	*45*	*30*	*32*	*32*	*30*	*35*	*32*	*56*	*56*	*59*	*55*	*50*	*55*
BAT		77	72	96	84	88	83	40	46	54	44	45	46	23	23	24	17	17	21	95	96	125	112	116	109
Beiersdorf		39	39	38	36	37	38	52	55	55	58	59	56	35	35	42	44	51	41	56	59	51	49	45	52
Danone		16	25	19	19	21	20	38	42	35	41	42	40	47	63	51	47	51	52	7	3	3	12	12	8
Procter & Gamble		34	33	37	32	30	33	31	32	30	27	25	29	26	27	30	28	34	29	38	37	37	31	21	33
Roche		49	48	47	42	38	45	76	76	77	76	70	75	12	9	8	10	9	10	113	115	115	108	100	110
Unilever		35	35	35	33	36	35	28	27	25	21	21	24	35	34	35	36	50	38	28	29	25	18	7	21
Publishers	*6*	*17*	*14*	*16*	*17*	*14*	*16*	*50*	*50*	*60*	*60*	*56*	*55*	*33*	*32*	*34*	*30*	*30*	*32*	*34*	*31*	*42*	*46*	*40*	*39*
Axel Springer		6	5	6	4	3	5	31	38	35	42	49	39	29	33	25	29	31	29	9	10	17	18	21	15
EMAP		1	0	4	29	22	11	54	30	57	91	60	58	23	4	5	9	6	9	32	26	56	111	76	60
New York Times Company		4	3	3	2	2	3	45	50	50	51	46	48	27	23	22	18	17	21	22	30	31	36	31	30
Pearson		29	31	38	29	28	31	63	63	78	64	66	67	28	29	34	30	29	30	64	65	82	63	65	68
Reed-Elsevier		43	22	24	17	14	24	71	80	103	77	78	82	65	80	95	75	77	78	49	22	31	19	14	27
SanomaWSOY		20	21	21	19	16	19	35	36	36	33	37	35	27	25	23	22	23	24	27	33	33	30	31	31

Publication I

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Working capital management in the automotive industry: Financial value chain analysis

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ABSTRACT

Financial value chain analysis is used to examine working capital management by cycle times in the value chain of the automotive industry during 2006–2008. The applied method offers a holistic view of the value chain from raw materials to the end customers. The average cash conversion cycle of the value chain of the automotive industry was 67 days. According to the study, the change of cycle times of working capital followed mainly the change of cycle time of inventories. The position of the stages of the value chain measured by the cash conversion cycle did not change substantially from 2006 to 2008.

1. Introduction

1.1. Background

Working capital management is an essential part of the short-term finance of a firm. With an efficient working capital management, a company can release capital for more strategic objectives, reduce the financial costs, and improve profitability. Supply chain management has typically concentrated on the physical flow of goods and services. Working capital management represents, however, the management of financial flows, which was highlighted by the recent financial downturn.

The recent financial crisis had major effects on the automotive industry, but in fact the industry faced profitability problems even before the crisis, and suffered from raised pressure on costs and competition. The situation has aroused interest in improving working capital management. At present companies see it as an important part of the management. This was also stated by the BMW Group (2010) in their annual report of 2009: "Stringent working capital management is a further key parameter for managing the business".

1.2. Objectives and research methods

The objective of this study is to examine working capital management in the value chain of the automotive industry in the years 2006–2008 by using financial value chain analysis. The purpose is to analyze working capital management through the value chain from the raw material suppliers to the end customers. The research design is similar to the one applied by Pirttilä et al. (2010) in their study of working capital management, where the cycle times of working capital in the value chain of the pulp and paper industry in the years 2004–2008 were analyzed.

The main research question of this paper is as follows: How was working capital managed in the value chain of the automotive industry during the observation period? The main question is divided to the following sub-questions: What were the cycle times of working capital in the stages of the value chain? How did the cycle times of working capital and its components change during the observation period? The results of the study are also compared to previous studies on the working capital management.

In this study, we introduce a method of financial value chain analysis that shows the position of the value chain and its stages and compares the stages of the value chain during the selected observation period. The method reveals the performance of the stages and its effects for the rest of the value chain. This is a systematic method to analyze value chains. The financial value chain analysis consists of seven steps that follow each other. The phases are presented in Fig. 1: (1) choose the industry under study; (2) define the value chain, including the stages and companies; (3) define the key figures, (4) collect data for the period under analysis; (5) calculate the values of the defined key figures; (6) analyze the calculated key figures and (7) draw conclusions. Analyzing the value chain this way gives a holistic picture of the value chain with financial figures.

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After the industry to be studied has been defined, the first phase in forming the value chain is to define its structure. The number of stages may vary, but in general the value chain should include more than three stages for the financial value chain analysis, as the purpose of the method is to give a broad view of the value chain from the raw material suppliers to the end customers. To ensure that the value chain is reasonable and describes the situation in the real world, a discussion with professionals working in the industry could be useful during phase two. The key figures should be selected so that the data can be collected from public sources. The data used in the method is commonly figures of financial statements, as they are published regularly and follow accepted accounting principles. The financial value chain analysis summarizes the calculated values of the key figures for the stages of the value chain. The results are analyzed similarly at the stage level. The method of financial value chain analysis is designed for analyzing industry-level phenomena, even though it is based on the key figures of companies.

The paper is structured as follows: Section 2 presents the key figures of the study, introduces the findings of previous literature of working capital management, and expresses the relevance of studying working capital management in the value chain context. The research process, data and limitations are described in Section 3. The results are presented in Section 4, and the conclusions in Section 5.

2. Literature review

In this study, working capital is studied from the operational perspective. Working capital can be defined from the operational perspective (inventories plus accounts receivable less accounts payable) or from the financial point of view (current assets less current liabilities). The latter one is actually net working capital, but commonly referred to as working capital. Working capital should be considered as an investment for a firm. Inventories and accounts receivable represent tied-up capital that could be earning interest if invested for example in financial instruments. Accounts payable decrease the tied-up capital. Firms that allow customers to make purchases on credit usually acquire goods and services on credit as well. In the value chain context, the accounts receivable of the supplier are equivalent to the accounts payable of its customer.

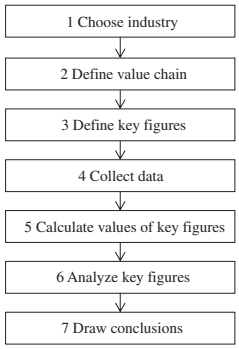

Fig. 1. Method of financial value chain analysis.

One measure of working capital management is the Cash Conversion Cycle (CCC), developed by Richards and Laughlin (1980). It is also known as the cash-to-cash (C2C) cycle (Farris and Hutchison, 2002). The CCC presents the length (days) of the time a firm has funds tied up in working capital, starting from the payment of purchases to the supplier and ending when remittance of sales is received from the customers. The CCC consists of the cycle times of inventories, accounts receivable and accounts payable, and is defined as days inventory outstanding (DIO)+days accounts receivable outstanding (DSO)−days accounts payable outstanding (DPO). The DIO is calculated as [inventory × 365]/sales. The DSO is calculated as [accounts receivable × 365]/sales. The DPO is calculated as [accounts payable × 365]/sales. The CCC is illustrated in Fig. 2, and a numerical example is provided in Table 1.

Fig. 2 visualizes a positive CCC. In this case the company has to finance accounts receivable and partially inventories. There is evidence that a company can operate with a negative CCC (for example Apple Inc.), or the CCC can be null. The CCC is commonly calculated at a company level, but there is no obstacle to lowering the calculation level to a business unit, a customer, or even an order. The CCC is a valid measure for the managers of a company. The importance of the CCC from the perspective of value chain management is that it bridges through purchasing activities with

Table 1
Selected financial data of BMW and Cash Conversion Cycle and its components.

	2008	2007	2006
Million EUR			
Sales	53,197	56,018	48,999
Inventories	7290	7349	6794
Accounts receivable	18,176	16,668	14,761
Accounts payable	2562	3551	3737
Number of days			
DIO	50	48	51
DSO	125	109	110
DPO	18	23	28
CCC	157	133	133

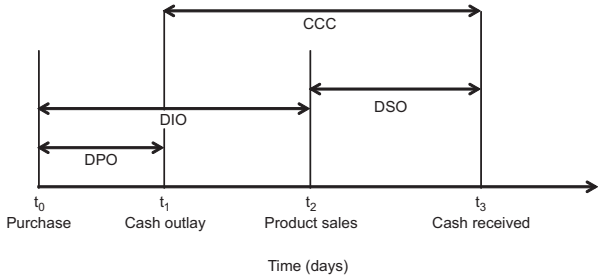

Fig. 2. Cash Conversion Cycle (adapted from Richards and Laughlin, 1980).

suppliers, internal supply chain activities and sales activities with the customer (Farris and Hutchison, 2002). Table 1 illustrates the primary point of the CCC with a numerical example. The shortening of the cycle time of inventories (DIO) from 2006 to 2007 did not improve the CCC, because at the same period the cycle time of accounts payable (DPO) shortened and offset the impact of the improved DIO. From the value chain point of view, a shortened DPO poses a lower risk to the suppliers. The DIO reflects mainly the efficiency of the internal supply chain, and therefore its changes do not affect the other actors of the value chain directly. The increase of the CCC from 2007 to 2008 indicates that the management of working capital was not as efficient in 2008 as it was in the previous years.

Traditionally, the cost of goods sold (COGS) has been used as a denominator when calculating the cycle times for inventories and accounts payable. In this paper, the CCC actually indicates "the number of 'days sales' the company has to finance its working capital under ceteris paribus conditions" (Shin and Soenen, 1998, p. 38). When the value of sales is used instead of the COGS as the denominator, the turnover time of inventories and accounts payable is shorter for most companies, because the value of sales is normally more than the value of the COGS. Some companies provide the value of the COGS in their financial statements, but it is not discussed how it has been defined. Therefore it is not unambiguous to define the value of the COGS on the basis of public sources for those who do not report it. To fulfill the objectives of this study, the use of sales as a denominator was reasonable, because the different cost structures of the companies would have blurred the information of the analysis.

The previous literature of working capital management has concluded that companies can increase their profitability by shortening the CCC (e.g. Shin and Soenen, 1998; Deloof, 2003; Lazaridis and Tryfonidis, 2006; Grosse-Ruyken et al., 2011), but there are also arguments against a short CCC. A long cycle time of inventories reduces the risk of delivery interruptions, price fluctuations and business losses due to scarcity of products (Blinder and Maccini, 1991; Wang, 2002), and a company can sometimes achieve higher sales and strengthen its customer relationships with a generous trade credit policy (Long et al., 1993; Deloof and Jegers, 1996; Shah, 2009). However, in previous academic literature, working capital has been mostly considered from the perspective of an individual company. The literature lacks the perspective of the value chain. It is even more difficult to adjust the proper cycle time of working capital and its components, if we take the perspective of the whole value chain. Attempts to tighten the payment periods of the big actor create liquidity pressures to the other companies of the value chain (Blackman and Holland, 2006). On the other hand, in the value chain a strong dominant player could finance weak subcontractors and customers by adjusting the payment periods and credit terms (Saranga, 2009).

Losbichler et al. (2008) studied a dataset of 6925 European companies for the period 1995–2004. Their results show that companies were on average able to decrease the CCC only by 2 days between 1995 and 2004. To study whether there are industries or companies which reduce their CCC at the expense of other companies in the value chain, Losbichler et al. linked industries which typically supply to each other. They found out that the leading industry of a value chain was able to shorten its CCC more significantly than its supplying industries. Pirttilä et al. (2010) researched the cycle times of working capital in the pulp and paper industry and found also that working capital management is more efficient in the downstream, nearer to the end customer. Moss and Stine (1993) investigated retail firms and showed that the length of the CCC was inversely related to average sales, as the smallest 20% of the companies had a significantly longer CCC than the largest 20% of the companies of their dataset. Saranga (2009) found empirical evidence that efficient working capital management resulted in higher operational efficiency in the value chain of the auto-component industry. Ulbrich et al. (2008) studied working capital management in the automotive industry by comparing the cash conversion cycle and its components between car manufacturers and their suppliers, but the perspective of a broader value chain was not considered. In this study, we examine the state of working capital management from the value chain perspective in the automotive industry.

According to Porter (1985), a sustainable competitive advantage can be achieved either by reducing the costs of the value chain or by reconfiguring the value chain the company operates at. Shank and Govindarajan (1989), who introduced value chain analysis, argue that the decisions should be analyzed in the wider context of the value chain, not just from the perspective of one company and its closest suppliers and customers. The performer of the analysis should look beyond the organizational boundaries of the value chain from upstream to downstream. Hofmann and Kotzab (2010) emphasize that working capital management should be analyzed in the value chain context. The method of analysis used in this study, referred to as financial value chain analysis, extends the analysis to the industry level.

3. Research process, data and limitations

The research process started with defining the structure of the value chain of the automotive industry. The value chain was formed by discussions with managers working in the automotive industry, and value chains presented in previous literature (Wheelen and Hunger, 2002; Blackman and Holland, 2006; Heneric et al., 2005) offered a basis for the construction of the value chain of the study. Fig. 3 presents the value chain references from previous literature. The bottom value chain in Fig. 3 describes the value chain structure of this study, six stages before the end customers. The stages raw material suppliers, refined raw material suppliers, component suppliers, system suppliers, car manufacturers and car dealers (see Fig. 4) represent the main elements needed for producing and delivering a car for the end customer. The first three stages have been divided further to branches. It should be noted that the upstream of the value chain, especially the raw material suppliers, are suppliers to other industries as well. As our target was to observe the value chain from raw materials to the end customer, the stage of raw material suppliers (branches oil and iron ore) were included in the analysis.

Secondary data was used in this study, because it was obtained from financial statements and annual reports. A research implemented like this study is time-consuming compared to the use of databases, but it ensures that the data is gathered in a similar manner from each company included in the sample. There were two main requirements for the companies included in the sample: the financial statements had to be publicly provided, and the annual sales of the company had to be more than 100 million euros, in order to ensure a higher degree of homogeneity of the stages. The companies of this study are named in Fig. 4 and listed also in Appendix A1. The financial statements were collected from public sources: mainly the firms' web sites, and some were found in the German Company Register database, which is free of charge and provided by the Bundesanzeiger (official publication of the Federal Republic of Germany published by the German Department of Justice). The research sample presents the value chain of the automotive industry, and it has been constructed from the financial statements of 65 firms for each year of the 2006–2008 periods.

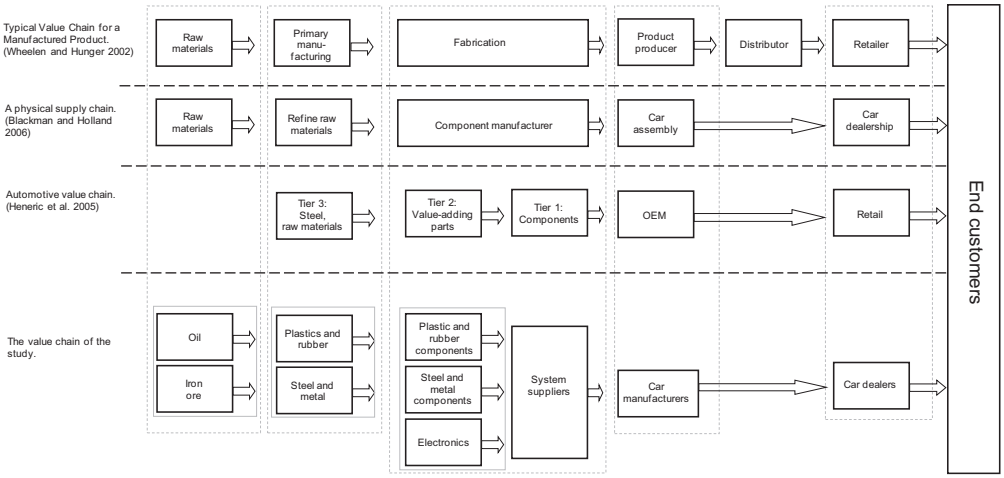

Fig. 3. Structure of the value chain in the present and previous studies.

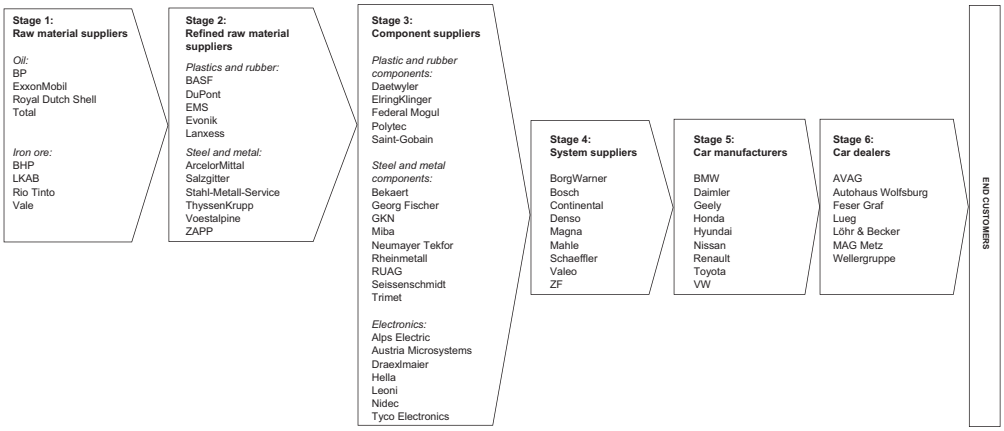

Fig. 4. Value chain of the automotive industry with the companies of the sample.

Table 2 contains descriptive statistics on the sample: the number of firms, the range of assets and sales in 2008, the change percentage of sales from 2006 to 2008, and the proportion of working capital of total assets of each stage.

Principally, the values a company has reported have been used. To ensure the homogeneity of the sample, some modifications to the figures presented by a company have been made. Advance payments to suppliers have been removed from the inventories. The inventories include raw material, work-in-process, finished goods or similar. The accounts receivable and payable reflect the receivable and payable that are overdue within a year and are related to trade, for example note payable is not included in the accounts payable.

The biggest restriction for the method presented here is the unavailability of data: the figures of annual reports are not detailed enough to calculate the key figures or the annual report is missing. In this study both problems occurred. The car manufacturers Ford and Fiat, for example, had to be left out of the study because their long- and short-term liabilities were not presented separately in the balance sheets. The system supplier Delphi and the chemical company Rhodia were excluded from the sample because annual reports for each year of the observation period could not be found.

The sample of this study has some limitations as well. Firstly, it has a strong regional focus because the research was done in Europe. It was difficult to find financial statements of American and Asian companies from public sources. The sample does not cover all the components of an automobile, as for example textiles, software and glass are missing. In the downstream side, independent garages and spare part shops, as well as car rentals

Table 2
Descriptive statistics on the sample.

	Number of firms	Total assets 2008 (M€) max	Total assets 008 M€) min	Sales 2008 (M€) max	Sales 2008 (M€) min	Change of sales 2006–08 (%)	Working capital % of total assets[a]
Car dealers	7	327	86	1 217	278	5	41
Car manufacturers	9	190 628	993	134 661	420	−8	20
System suppliers	9	46 761	3 173	45 127	3 579	3	18
Component suppliers	–	–	–	–	–	–	22
Plastic and rubber components	5	43 395	765	43 800	658	5	24
Steel and metal components	9	5 107	115	5 496	175	14	21
Electronics	7	14 686	307	10 086	185	−3	21
Refined raw material suppliers	–	–	–	–	–	–	30
Plastics and rubber	5	50 860	1 058	62 304	947	10	37
Steel and metal	6	90 742	34	84 947	143	48	21
Raw material suppliers	–	–	–	–	–	–	8
Oil	4	192 011	118 310	312 478	179 976	15	8
Iron ore	4	60 932	3 778	40 437	2 405	70	8

[a] Average of the years 2006–2008.

and leasing companies were left out of the analysis because of a lack of public data detailed enough. However, it can be considered that including these branches in the chain would not have had a significant impact on the main findings of the study. To test the validity of our results, we compared them to the results of Ulbrich et al. (2008) and the annual studies of working capital performance of the REL consultancy.

The inventories, accounts receivable and accounts payable demonstrate a day's value. During the fiscal year, the need for working capital fluctuates depending on the company's business cycle. In the automotive industry, seasonal fluctuation is slightly modest, and so the working capital levels of the end of the fiscal year represent the need of working capital well. Public financial statements present the fiscal year of a group of companies, and a group with a broad product program may be seen for instance as a system supplier with one of their products, while another product would locate them in the stage of component suppliers. Similarly, a group may operate with other industries as well.

4. Results and analysis

To analyze working capital management in the value chain of the automotive industry in the years 2006–2008, the CCC and its components were calculated for each year of the observation period. Fig. 5 shows the average values of the CCC and its components in days in every stage of the value chain. Difference Δ has been calculated between the years 2008 and 2006. Appendix A1 shows the CCC and its components for each company of this study.

4.1. Cycle times of working capital

The results of the analysis showed that the value chain of the automotive industry ties up working capital: the CCC was positive in each stage of the value chain. The average CCC of the average of the value chain stages was 67 days, while the average of the sample was 70 days. There were only slight differences in the averages of the CCC between the years 2006 and 2008, which indicates that the relation between sales and working capital could be considered constant (the CCC was defined as working capital/sales). This was seen also when studying the CCC in the value chain of the pulp and paper industry (Pirttilä et al., 2010). The results indicate that working capital can be forecasted by the sales in both value chains. The equation of the CCC enables forecasting when the CCC is known and the sales forecast is available. How the working capital will be divided between inventories, accounts receivable and accounts payable is not important in the forecasting phase, because it is the increase of working capital that should be financed or decrease of working capital that should be reinvested.

Pirttilä et al. (2010) and Losbichler et al. (2008) found that the stages closer to the end customer had shorter turnover times than the stages in the upstream. In the value chain of the automotive industry, the situation was different—the phenomenon did not exist. The reason for this was a high CCC of the car manufacturers in the downstream. The car manufacturers' long CCCs were due to a long cycle time of accounts receivable. This is because the financing business of car manufacturers requires long credit periods. If the DSO of the car manufacturers did not include the receivables of their financing business, their CCC would be significantly lower, only 32 days, and the same conclusion of a shorter CCC in the stages closer to the end customers could be drawn. The car manufacturers can be seen to work as a bank towards the end customers by paying their own bills relatively fast compared to the cycle times of their accounts receivable.

The position of the stages measured by the CCC did not change substantially from 2006 to 2008. The single change in the position of the stages was that the stage of the system suppliers managed to reduce its CCC by 4 days, while the CCC of their customer stage, the car manufacturers lengthened by 5 days. Comparing the stages of the automotive value chain to each other revealed that there was a notable difference between the maximum and minimum CCC: 69 days. The car manufacturers had the longest CCC, 106 days, which was due to their accounts receivable that consisted mainly of receivables from their financing business, which seemed to be profitable for the car manufacturers. For example the EBIT margin of Volkswagen Financial Services was 8.7%, while the margin of the Group was 5.6% in the year 2008. The raw material suppliers had the shortest CCC, 37 days, which reflected the cycle time of accounts receivable, as the accounts payable offset the need of financing inventories. The first stage of the value chain differed from the other stages by having the biggest changes in each component of the CCC: its components shortened by 7–11 days from the years 2006 to 2008. The raw material suppliers operate also in many other industries, and therefore the development of the automotive industry is not the only one that affects its cycle times.

4.2. Cycle times of the components of working capital

Even though the CCC remained roughly the same during the observation period in each stage of the value chain of the automotive

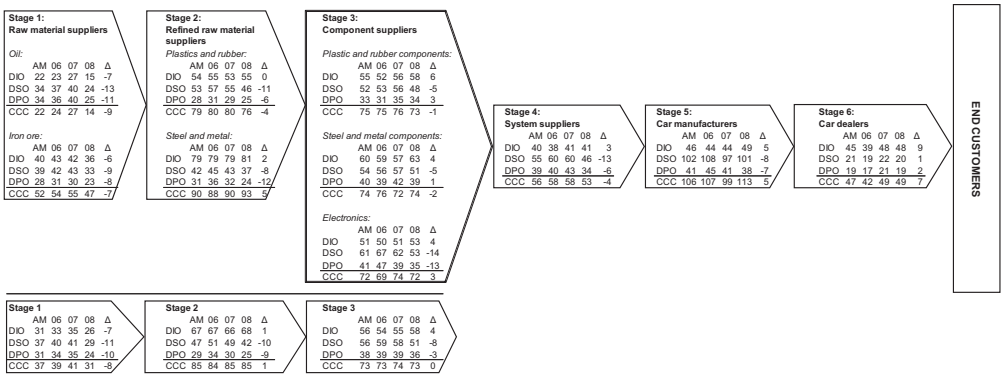

Fig. 5. Cash conversion cycles of the automotive value chain in 2006–2008.

industry, the components of the CCC varied a lot. This was not shown in the CCC, because usually the variations of the DSO and DPO offset each other. The change that occurred resulted from a change in inventories. For example in the stage of component suppliers branch of electronics, the DSO shortened by 14 days, but at the same time also the DPO shortened by 13 days. Therefore the change of the CCC, 3 days, was mainly affected by the lengthened cycle time of the inventories. In the supplying industry (stages 2–4), the differences in the CCC were caused by the cycle times of inventories. The difference in the CCC between the system suppliers and component suppliers was 17 days, whereas the difference in the DIO was 16 days. Between the stages component suppliers and refined raw material suppliers, the difference of the CCC was 12 days, which is the same as the difference in the DIO. The average figures of the DSO and DPO were almost the same on stage 3 as on stage 4. It seems that the payment terms are relatively well established on these supplier levels.

In most stages the changes of both the DSO and DPO were negative, which means that in these stages the cycle times of accounts receivable and accounts payable shortened during the observation period. The changes of the DSO and DPO in the stage of the car dealers were positive. Only in the branches of plastic and rubber components and steel and metal components in the stage of component suppliers the development of the DSO and DPO led to different directions: both branches were able to reduce their DSO by 5 days while the DPO prolonged by 1–3 days. The finding of a reduction of the DSO and DPO in most stages of the chain indicates that the tightened payment terms required by a supplier affect the credit terms given to a customer: in other words, when a company is required to pay its suppliers faster, it also wants to get faster payments from its customers because they are not willing to invest more capital. Especially if there are difficulties in getting external financing, collecting payments from customers faster is reasonable from the supplier's point of view. The negative direction of the change may have also been a consequence of profitability problems that the automotive industry has been facing in recent years: in all stages, except for the car dealers, the DSO was shortened by 5–14 days. The system suppliers, for example, were able to reduce their DSO by 22%. This indicates that in the value chain of the automotive industry, the companies have paid attention to the management of accounts receivable as they have not been willing to carry credit risk. This has been done partially by using more factoring services. When selling accounts receivable to a third party, the DSO of a firm looks shorter even if the payment terms given to a customer are generous. It seems that none of the stages really got benefits from the shortening of the DSO, as the trend was dominating in the whole value chain, but overall this reduced the need for invested working capital in the value chain of the automotive industry.

The traditional view on working capital management has been that inventories can be financed with accounts payable. When comparing the components of the CCC to each other, it could be seen that only the system suppliers (excluding the last year of the observation period) had been able to finance their inventories with accounts payable. The cycle times of inventories were lengthened by 2–9 days or remained almost the same in the observation period, except for the raw material suppliers that were able to shorten their DIO by 7 days from the years 2006 to 2008. This indicates that making sales forecasts became more difficult during the period, and therefore the inventories tied up more working capital in 2008 than in 2006.

The DSO and DPO depend on the payment terms negotiated with the customers and suppliers. If the firm is willing to shorten the CCC, the component it can best affect by itself is the DIO by developing the internal value chain. Of course, depending on the contracts between the companies, the DIO can also be affected by a customer, if for example a certain level of inventories is required by them. The system suppliers had a relatively short DIO, 40 days. Their suppliers in turn kept their inventories 16 (stage 3) or even 27 (stage 2) days longer. This might reflect the information flow in the chain: the system suppliers get sales forecasts from their customers, which makes it possible for the system suppliers to manage their inventories on the basis of that information, but the information is not transferred to the earlier levels in the chain. The relationship between the car manufacturers and the system suppliers is based more on partnership, while there is more traditional purchasing between the system suppliers and their suppliers.

The products of the refined raw material suppliers and component suppliers are more standard than the products of the following levels, which enables mass production and leads to bigger inventories that also explain the longer cycle times of inventories. In stage 3, which operates as suppliers for the system suppliers, the reliability of delivery may create a competitive advantage for the companies that are able to supply goods for their customers when needed. The weakened demand in the automotive industry could also be seen in the value chain, as the inventories in the stage of system suppliers and component suppliers had increased. The raw material suppliers and refined

raw material suppliers operate in other industries as well, and their manufacturing process (processing industry) differs from the other stages (batch production).

The best and worst practices in the value chain of the automotive industry were analyzed by creating two different chains from the sample. In each stage of the value chain, the company with the shortest CCC was picked to the best chain and the company with the longest CCC to the worst chain. In the stages that included branches, the CCC was picked from each branch. The average CCC of the best chain was 37 days, which was 30 days shorter than the average of the stages. The average CCC of the worst chain was 101 days, 34 days longer than the average of the stages. In most stages, the difference between the best and worst company came from the inventories. For example, in the stage of refined raw material suppliers' branch of steel and metal, the difference in the DIO between the companies with the best and worst CCC was 55 days.

4.3. Comparisons

The results of this study, compared to the study of the pulp and paper industry (Pirttilä et al., 2010) indicate that the average CCC of the pulp and paper industry in the years 2004–2008 was 63 days (62 days in the years 2006–2008), while the average CCC of the automotive value chain in the years 2006–2008 was 4 days longer. The difference is surprisingly small, even though the end commodities of the automotive industry are products bought by end customers, whereas the end commodities of the pulp and paper industry are used to complement other products as well. It can be considered that the difference would be very small if the structures of the value chains were more uniform. In the value chain of the pulp and paper industry, two or three of the four downstream stages have a relationship to the end customers, while in the value chain of the automotive industry only one stage has a direct relationship to the end customers. Both studies indicate that companies acting in the downstream have shorter cycle times of working capital than upstream companies.

The results of our financial value chain analysis were also compared to the figures of working capital studies by the REL consultancy (2010, 2009, 2008a, 2008b, 2007a and 2007b). The comparison was made by collecting industry level figures for the same period from the yearly working capital scorecard publications of Europe and the United States. Exactly similar stages as defined in this study were not available in the studies of REL, where iron ore and steel and metal were combined to metals and mining, and the figures of component suppliers and system suppliers were mainly shown in the auto components industries. The stage of car dealers was not defined in the REL studies. The number of firms included in the structured sample varied from 259 to 270. The average CCC of the REL studies calculated for the period of 2006–2008 was 58 days, while the average cash conversion cycles of this study was 67. The difference of the results is mainly a consequence of a different way of dealing with the accounts receivable of the car manufacturers. In our study, short-term accounts receivable of financial services were included in the analysis. The study of REL did not include accounts receivable of car manufacturers' financial services in the figures of the year 2008, while in the figures of the years 2006 and 2007 both long-term and short-term accounts receivable of financial services were considered. On the other hand, it can be noticed that more firms of the steel and metal branch were included in REL study, which increased the CCC because of the longer inventory cycle time than in iron ore. A similar effect can be seen in the auto-components industries. More component suppliers than system suppliers were included in the industry. The oil and chemical companies' cash conversion cycles were similar in both studies. The similarities of the results confirm that our study reflects the real world value chain of the automotive industry.

In a study of Ulbrich et al. (2008), the CCC of five car manufacturers and 12 first-tier automotive suppliers, referred to as system suppliers in this study, was examined in the periods of 2001–2004. The results of their study showed that in this period, the car manufacturers managed their working capital more efficiently in each component of the CCC than the suppliers. When comparing the results of the study of Ulbrich et al. to the results of our study, it seems that the suppliers had been able to improve their working capital management from the year 2004. In our study, the DIO of the system suppliers was even shorter than the DIO of the car manufacturers. On the other hand, the results of the suppliers may not be comparable with the stage of the system suppliers, as many of the companies Ulbrich et al. (2008) considered as first-tier suppliers were in this study of the automotive value chain placed on the stage of component suppliers.

5. Conclusions

In this study, financial value chain analysis was used to examine working capital management in the value chain of the automotive industry during 2006–2008. The companies operating in the value chain are dependent on their relations with other companies. A company that seeks to reduce its working capital at the expense of its value chain partners does not become more competitive, because competition is rather a value chain against a value chain than a company against a company. The financial value chain analysis applied in this study reveals the present state of value chain that can be used as a starting point for managing working capital through the value chain.

The measure of working capital management used in this study was the cash conversion cycle (CCC). The average CCC of the automotive industry was 67 days for the period 2006–2008. The position of the value chain had not changed, as the difference of the CCC between the years 2006 and 2008 was small. This indicates that the relation between working capital and sales is nearly constant. Pirttilä et al. (2010) made the same conclusion of the CCC in their study of the pulp and paper industry, and the findings of a study by Losbichler et al. (2008) were similar. On the other hand, even though the CCC remained constant in the value chain of the automotive industry, its components, the days accounts receivable outstanding (DSO) and days accounts payable outstanding (DPO), changed remarkably, while the change in the days inventory outstanding (DIO) was low. Because the changes of the DSO and DPO usually offset each other, the CCC follows the changes of the DIO. An interesting finding was that in each stage of the automotive industry, the turnover time of accounts receivable had shortened. This indicates that the companies had paid attention to the management of accounts receivable and focused on collecting remittance from the customers.

The cycle time of inventories depends more on the policy of production and inventory management than the terms of purchase and sales, which define the turnover time of accounts receivable and payable. Evidence of the benefits of just-in-time (JIT) and similar policies to managing the physical supply chain has been given, but the terms of purchase and sales still follow the traditions adopted after an era of cash payments. The terms of payment are bargaining issues that could be redefined without jeopardizing the production of the physical product. The authors would like to emphasize the meaning of relatively long payment periods for working capital. Long credit terms could be a part of sales promotion or required by the customer, but have the companies considered that the credit periods also tie up capital into the value chain. The amount of working capital tied into the

value chain affects the return on investment (ROI) directly by increasing the invested capital and decreasing the ROI.

By analyzing working capital management with the method of financial value chain analysis, a company receives a holistic view of the value chain it operates at. On the other hand, the company can benchmark its position against competitors in its own stage and its position in the value chain, but the company can also see the most efficient partners and the chain which it wants to belong to. Besides this, it is worthwhile to benchmark other industries as well in order to adopt suitable practices for working capital management. Therefore more research is needed in this area to increase the understanding of working capital management in the holistic value chain context.

Appendix A

The dataset of study is presented in Table A1.

Table A1
Dataset of study.

	CCC					DIO					DSO					DPO				
	06	07	08	Δ	AM	06	07	08	Δ	AM	06	07	08	Δ	AM	06	07	08	Δ	AM
Stage 1: Raw material suppliers																				
Oil (average)	24	27	14	−9	22	23	27	15	−7	22	37	40	24	−13	34	36	40	25	−11	34
BP p.l.c.	21	27	13	−9	20	26	34	17	−9	26	46	44	25	−21	38	51	51	29	−22	44
Exxon Mobil Corporation	8	8	4	−4	7	11	10	9	−1	10	25	29	15	−10	23	28	31	20	−8	26
Royal Dutch Shell p.l.c.	32	38	19	−12	30	27	32	15	−11	25	35	43	25	−11	34	30	37	20	−10	29
Total S.A.	33	34	20	−13	29	28	32	20	−8	26	41	44	31	−10	39	36	42	30	−6	36
Iron ore (average)	54	55	47	−7	52	43	42	36	−6	40	42	43	33	−9	39	31	30	23	−8	28
BHP Billiton	31	33	51	20	39	31	30	31	−1	31	32	31	49	18	37	31	28	28	−3	29
LKAB	52	48	51	−1	50	41	36	43	2	40	42	43	31	−12	39	31	31	23	−8	28
Rio Tinto	49	78	41	−8	56	36	59	35	−1	43	31	54	23	−7	36	19	34	18	0	24
Vale S.A.	85	59	46	−39	63	63	43	37	−26	47	65	44	30	−34	46	43	27	21	−21	30
STAGE AVERAGE	39	41	31	−8	37	33	35	26	−7	31	40	41	29	−11	37	34	35	24	−10	31
Stage 2: Refined raw material suppliers																				
Plastics and rubber (average)	80	80	76	−4	79	55	53	55	0	54	57	55	46	−11	53	31	29	25	−6	28
BASF	70	71	69	−1	70	46	41	39	−7	42	57	54	45	−12	52	33	24	16	−17	24
DuPont	95	91	83	−12	89	66	66	68	2	66	58	58	46	−12	54	29	32	31	2	31
EMS Group	91	98	83	−8	91	59	65	59	0	61	61	60	41	−20	54	29	27	17	−12	25
Evonik Industries	75	73	76	1	75	47	46	50	4	48	61	60	59	−2	60	33	33	34	1	33
Lanxess	72	67	72	0	70	55	49	58	3	54	49	45	40	−8	44	32	27	27	15	28
Steel and metal (average)	88	90	93	5	90	79	79	81	2	79	45	43	37	−8	42	36	32	24	−12	31
ArcelorMittal	106	61	62	−44	77	119	75	72	−47	89	57	35	21	−36	37	70	49	31	−40	50
Salzgitter	91	100	96	5	96	70	73	73	4	72	48	54	48	0	50	26	27	25	−1	26
Stahl-Metall-Service Holding AG	57	60	65	9	61	53	61	50	−3	55	25	22	22	−3	23	22	23	7	−15	17
ThyssenKrupp	77	81	80	3	79	57	63	65	8	61	55	53	54	−1	54	35	35	39	4	36
Voestalpine	79	120	106	27	102	73	104	91	18	89	50	61	41	−9	51	45	45	26	−19	39
ZAPP	118	120	148	31	128	100	98	132	32	110	36	32	34	−2	34	18	10	17	−1	15
STAGE AVERAGE	84	85	85	1	85	67	66	68	1	67	51	49	42	−10	47	34	30	25	−9	29
Stage 3: Component suppliers																				
Plastic and rubber components (average)	75	76	73	−1	75	52	56	58	6	55	53	56	48	−5	52	31	35	34	3	33
Datwyler	94	86	86	−7	89	67	59	62	−5	62	49	48	42	−7	46	22	21	17	−5	20
Elring Klinger	98	99	108	9	102	62	66	72	10	67	56	56	54	−2	56	19	23	18	−1	20
Federal Mogul	81	76	64	−16	74	51	57	48	−4	52	57	58	50	−7	55	28	38	33	5	33
Polytec	45	68	56	12	56	33	48	59	27	47	47	65	49	2	54	36	45	53	17	44
Saint−Gobain	56	53	51	−5	53	49	49	51	2	50	55	52	47	−8	52	48	48	47	−2	48
Steel and metal components (average)	76	76	73	−3	74	59	57	63	4	60	56	56	48	−7	53	39	35	34	−5	36
Bekaert	98	99	101	3	100	67	65	70	3	67	72	74	66	−6	71	41	39	35	−7	38
Georg Fischer	87	80	81	16	83	58	57	67	9	61	65	59	46	−20	57	36	36	31	−5	35
GKN	52	43	48	−3	48	47	52	60	13	53	46	48	46	0	47	41	57	57	16	52
Miba	84	85	89	5	86	49	50	57	8	52	66	64	54	−11	61	31	29	23	−9	28
Neumayer Tekfor	43	33	25	−17	34	54	47	43	−10	48	36	42	37	0	38	47	56	54	7	52
Rheinmetall	66	84	90	24	80	63	64	71	8	66	50	71	67	17	63	47	50	48	1	48
RUAG	103	96	102	−2	100	97	97	94	−3	96	68	74	84	17	75	61	74	76	15	71
Seissenschmidt	84	81	90	6	85	48	54	70	23	57	53	48	33	−20	45	17	21	13	−3	17
Trimet	67	44	41	−26	51	51	30	34	−17	38	44	30	24	−21	33	27	16	16	−11	20
Electronics (average)	69	74	72	3	72	50	51	53	4	51	67	62	53	−14	61	47	39	35	−13	41
Alps Electric	69	62	59	−10	63	40	38	35	−5	38	67	58	46	−21	57	38	34	22	−16	31
Austria Microsystems	80	157	162	82	133	60	92	125	65	92	98	105	73	−25	92	78	40	36	−43	51
Draexlmaier	61	50	46	−15	52	50	45	39	−11	45	42	30	32	−10	35	31	25	25	16	27
Hella	56	49	47	−9	50	47	39	41	−6	43	51	50	41	−10	47	43	40	36	−7	40
Leoni	74	60	44	−30	59	57	53	44	−14	51	54	45	47	−7	49	37	39	47	9	41
Nidec	54	48	59	4	54	37	34	34	−3	35	85	73	66	−19	75	68	60	42	−26	57
Tyco Electronics	90	91	88	−2	90	55	56	57	2	56	72	73	67	−5	71	37	37	36	−1	37
STAGE AVERAGE	73	74	73	0	73	54	55	58	4	56	59	58	51	−8	56	39	39	36	−3	38
Stage 4: System suppliers																				
BorgWarner	49	44	43	−6	45	32	32	32	1	32	60	55	42	−17	53	43	43	32	−10	39
Bosch	85	82	84	−1	83	47	49	54	6	50	65	62	56	−8	61	27	29	26	−1	27
Continental	61	82	51	−9	65	39	56	39	0	45	57	87	50	−8	65	36	61	37	1	45
Denso	49	39	40	−9	42	32	28	30	−2	30	67	59	43	−24	56	50	48	33	−17	44

Table A1 (*continued*)

	CCC					DIO					DSO					DPO				
	06	07	08	Δ	AM	06	07	08	Δ	AM	06	07	08	Δ	AM	06	07	08	Δ	AM
Magna	22	30	27	5	26	22	24	25	4	24	55	56	43	−11	51	54	49	42	−12	49
Mahle	70	67	70	0	69	41	48	55	14	48	62	56	47	−14	55	33	36	32	0	34
Schaeffler Group	104	104	98	−6	102	69	69	69	1	69	55	54	43	−13	51	20	19	14	−5	18
Valeo	19	19	11	−8	16	24	24	23	−1	23	67	65	49	−18	60	72	70	61	−10	68
ZF Group	59	57	55	−4	57	38	38	41	3	39	50	49	42	−8	47	29	30	28	0	29
STAGE AVERAGE	58	58	53	−4	56	38	41	41	3	40	60	60	46	−13	55	40	43	34	−6	39
Stage 5: Car manufacturers																				
Bayerische Motoren Werke	133	133	157	24	141	51	48	50	−1	50	110	109	125	15	114	28	23	18	−10	23
Daimler	181	111	135	−46	143	68	51	63	−4	61	164	86	96	−67	115	50	25	25	−26	34
Geely	31	5	−3	−34	11	28	39	41	13	36	59	49	56	−3	55	56	83	100	44	79
Honda Motor Company	83	77	95	11	85	39	36	45	6	40	82	72	74	−8	76	37	31	25	−13	31
Hyundai	39	59	70	31	56	57	59	77	20	64	29	33	31	2	31	47	33	38	−9	39
Nissan Motor Company	120	126	138	17	128	35	34	33	−2	34	144	130	132	−13	135	59	38	27	−32	41
Renault	179	181	192	13	184	47	53	51	4	50	197	202	194	−4	198	65	74	52	−13	64
Toyota Motor Corporation	86	83	97	11	89	27	25	26	−2	26	92	88	94	2	91	34	31	23	−11	29
Volkswagen	114	119	132	18	122	43	47	57	14	49	99	103	106	7	103	29	30	31	3	30
STAGE AVERAGE	107	99	113	5	106	44	44	49	5	46	108	97	101	−8	102	45	41	38	−7	41
Stage 6: Car dealers																				
Autohaus Wolfsburg	42	46	48	6	46	37	47	49	13	44	22	27	23	1	24	17	28	24	8	23
AVAG	38	39	42	4	39	30	31	36	6	32	14	14	12	−2	13	6	6	7	1	6
Feser Graf	22	26	24	2	24	27	34	32	5	31	21	31	26	4	26	26	40	33	7	33
Löhr & Becker	38	48	56	18	47	35	47	44	9	42	16	18	20	4	18	13	17	9	−5	13
Lueg	43	52	45	2	47	38	44	40	2	41	28	28	21	−6	26	22	20	16	−6	19
MAG Metz	60	76	86	26	74	50	63	76	26	63	20	25	22	2	22	10	13	12	2	12
Wellergruppe	51	60	44	−7	52	58	69	58	0	62	14	14	16	2	15	21	23	30	8	25
STAGE AVERAGE	42	49	49	7	47	44	44	49	5	46	19	22	20	1	21	17	21	19	2	19

Δ change from 2006 to 2008 in days (CCC, DIO, DSO, DPO), AM average of the years 2006–2008.

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Publication II

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Using working capital management to improve profitability in the value chain of automotive industry

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Using working capital management to improve profitability in the value chain of automotive industry

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Abstract: The impact of operational working capital management (including inventories, accounts receivable and accounts payable) on relative profitability in the value chain context is studied. The empirical study offers numerical analysis with real world numbers concentrating on improving profitability through working capital management. The prior finding of a negative relation between the cycle time of working capital and profitability is too blinkered, as companies in the value chain have and should have different working capital management strategies. By analysing the cycle times of working capital components, the value chain partners can work together to increase the profitability of the value chain. The findings of the study suggest that the most efficient way to increase the profitability of the value chain is to manage all the components of working capital simultaneously. In addition, a radical reduction of payment terms would increase profitability.

Keywords: working capital management; cycle time; profitability; automotive industry; value chain; financial supply chain.

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1 Introduction

Cycle times are important measures in the current competitive and global world. The efficiency of operations and the physical flow of products have been highlighted by researchers and practitioners for a long time (e.g., Cigolini et al., 2004; Koskinen et al., 2009; Olson and Xie, 2010). Only recently, the discussion on operation and supply chain management has addressed the financial flows and the cycle time of working capital as important elements of value chain management and profitability (Gupta and Dutta, 2011; Protopappa-Sieke and Seifert, 2010, 2011; Randall and Farris, 2009). Besides profitability, the cycle time of working capital has an impact on the liquidity and productivity of a company as well (Johnson and Templar, 2011). Tsai (2011) also points out that a long cycle time increases the collection risk contributed by late collection and default. At the same time, management accounting researchers have recognised the need of inter-organisational accounting practices (Ramos, 2004) and accounting systems for networks and chains (Håkansson and Lind, 2004). Companies should take a comprehensive approach to managing operational and financial flows together, and a holistic view to take the profitability of the whole value chain into account.

In this paper, we examine the impact of operational working capital management on relative profitability in the value chain of the automotive industry. In our definition, operational working capital consists of three components: inventories, accounts receivable and accounts payable. The management of these components is measured by cycle times. Together, the cycle times of the working capital components form a measure called the cash conversion cycle (CCC) (Richards and Laughlin, 1980), also called the cash-to-cash (C2C) cycle (Farris and Hutchison, 2002).

The impact of the CCC on profitability has been discussed widely in the financial literature. Prior research findings show that a company can improve its profitability by shortening the CCC (e.g., Deloof, 2003; Shin and Soenen, 1998). The short cycle time of orders is also emphasised in supply chain management as a technique to reduce costs, to shorten the response time, and to increase efficiency (Gunasekaran et al., 2001). Some recent studies have taken the supply chain view in working capital management. These studies show that the minimisation of the CCC from the perspective of an individual company does not add value to the whole supply chain (Hofmann and Kotzab, 2010), and

the optimum level of the CCC depends on the business model, supply chain design configurations, and risk aspects within the supply chain (Grosse-Ruyken et al., 2011).

Randall and Farris (2009) have utilised the cycle times of working capital components as tools to improve profitability in the supply chain. They have studied net savings and present scenarios with partly self-created figures of how supply chain partners in a dyad relationship can share the benefits gained by adjusting the cycle times of working capital components. In this paper, we study the possibilities of improving profitability through working capital management in a four-tier value chain. Our approach to profitability also differs from the one applied by Randall and Farris, as we use a relative measure, return on capital employed (ROC%) as the measure of profitability. The research questions of the paper are:

1 How do the cycle times of working capital components affect profitability in the value chain of the automotive industry?

2 How can the value chain of the automotive industry increase its profitability through working capital management?

Working capital management in the value chain is observed in the automotive industry, which suffered from a recent financial crisis. In fact, it was facing profitability problems already before the crisis because of raised cost and competition pressures. Companies in the automotive industry see working capital as an important part of management at the present moment. This was stated also in the annual report of year 2009 by the BMW Group (2010, p.72): "stringent working capital management is a further key parameter for managing the business".

The paper is structured as follows. In the next section, a literature review is presented, giving a background to the study from the point of view of financial supply chain management and management accounting. It also reviews previous findings of working capital management research. After that we introduce our research design consisting of the research variables, methodology, sample and data. The results answering the first research question are presented in Section 4. In Section 5, we examine how the changes in the cycle times of working capital components affect the profitability of the value chain and of the individual levels of the chain. This section gives an answer to the second research question. Finally, Section 6 concludes the paper.

2 Literature review

Supply chain management has recently started to discuss financial supply chain management, including working capital management, instead of just concentrating on operations. At the same time, some management accounting researchers have emphasised new approaches to facilitating the management of inter-organisational relationships, and new tools for accounting in networks (Chiadamrong et al., 2007; Laine et al., 2006). Inter-organisational cost management (IOCM) has been seen as a way to reduce costs in a network of companies. The key enabler of IOCM is the practice of disclosing cost information in the network (open-book accounting) (Kajueter and Kulmala, 2005). Möller et al. (2011) have studied the effect of relational factors on IOCM among automotive suppliers. Their results show that the suppliers' commitment is a key success factor for open-book accounting in the automotive industry. The value chain analysis

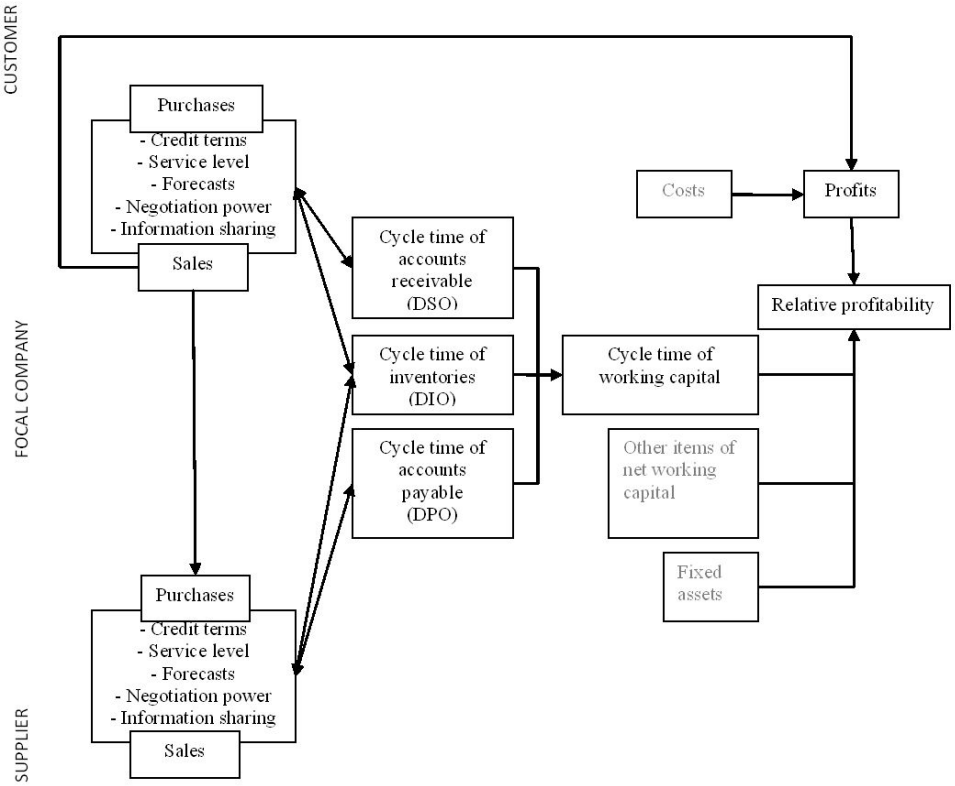
applied in this paper is one approach of IOCM, enabling cost management in collaboration (Dekker, 2003; Shank and Govindarajan, 1992) and the analysis of value creation in the supply chain (Håkansson and Lind, 2007). Both research streams, financial supply chain management and management accounting in the network context, aim at the same target: improving the performance of value chains or value networks, not just individual firms.

Time has long been recognised to be important in business, but after manufacturing innovations, such as just-in-time (JIT), and the development of time-based management (TBM), time has become a source of competitive advantage (Gehani, 1995; Ng et al., 1997). At first, the research of cycle times concerned only manufacturing and new product development. Ng et al. (1997) added all business operations to the discussion by introducing the total cycle time concept including inbound logistics (purchase), manufacturing, and outbound logistics (transportation). However, even the total cycle time does not include all aspects of the business cycle, as it neglects the financial flows. Recent research on financial supply chain management suggests that also financial costs and working capital have an impact on profitability in a supply chain (Randall and Farris, 2009; Protopappa-Sieke and Seifert, 2010, 2011). Gupta and Dutta (2011, p.47) argue that "for an effective supply chain system, the management of upstream flow of money is as important as the management of downstream flow of goods".

The body of research that has modelled inventory policies under trade credit has been active since the Goyal model in 1985 (Chang and Teng, 2008), but in recent years, models taking account of trade credits in the supply chain context have emerged. Darwish and Goyal (2010) present a mathematical model for a single-vendor single-buyer supply chain under conditions of permissible delay in payments. Protopappa-Sieke and Seifert (2010, 2011) have developed models for a single product inventory and a multiple inventory system that take payment delays and working capital into account.

The flow of goods and the flow of money can be combined with the C2C measure, which is an important measure for both accounting and supply chain management (Farris and Hutchison, 2002). In accounting and finance, the C2C is known as the CCC. Several studies have found a negative relation between the CCC and the relative profitability of a company, which means that companies can improve their profitability by more efficient working capital management, i.e., by shortening the cycle time of working capital (e.g., Deloof, 2003; García-Teruel and Martínez-Solano, 2007; Lazaridis and Tryfonidis, 2006; Shin and Soenen, 1998; Talha et al., 2010). The adjustment of the cycle times is not unambiguous, however. A company has to take into account the effect of the shorter CCC on the service levels and on customer relations (Deloof and Jegers, 1996; Long et al., 1993), as well as consider the trade-off between low inventory levels and the risk of delivery interruptions, price fluctuations, and business losses due to scarcity of products (Blinder and Maccini, 1991; Wang, 2002). The management of operational working capital means balancing between the reduction of capital tied up in the processes and current assets, and the minimising of adverse effects caused by a too small amount of operational working capital. In the value chain context, companies should not sub-optimise their own cycle times at the expense of their counterparts, but think about the whole value chain (Hofmann and Kotzab, 2011; Viskari et al., 2011). Figure 1 illustrates working capital management in the value chain context, as well as the relation between working capital management and relative profitability.

Figure 1 Impact of working capital management on profitability in the value chain context



Only a few studies on working capital management in the automotive industry have been published so far. Since the fiscal year 1997, the CFO Magazine has published working capital performance studies of the REL consultancy (Karaian, 2008). The annual studies include the 1,000 largest European and 1,000 largest US companies representing different industries. During the period of 2006–2008, the annual studies included approximately 20 companies from the automotive industry and 30 companies from the auto components industry. The studies show that the cycle times of accounts payable and accounts receivable decreased while the cycle times of inventories increased during 2006–2008. Ulbrich et al. (2008) studied the working capital management of five car manufacturers and 12 first-tier automotive suppliers during the period of 2001–2004. The results of their study showed that in the research period, the car manufacturers operated with shorter CCCs than the suppliers. The relation between working capital management and profitability has not been discussed in the automotive value chain before our study.

3 Research design

3.1 Variables and methodology

In this study, profitability is measured by the ROC%, which describes the relative profitability of companies. The ROC% has also been used to measure relative

profitability in previous studies on working capital management, and it enables the comparison of companies of different sizes. The ROC% of each year (t) is calculated as follows:

$$\mathrm{ROC\%} = \frac{\mathrm{EBIT}}{\frac{\left(\mathrm{Equity_t} + \mathrm{Equity_{t-1}}\right)\left|\left(\mathrm{Long\ term\ liabilities_t} + \mathrm{Long\ term\ liabilities_{t-1}}\right)\right.}{2}} \quad (1)$$

The cash conversion cycle is used to measure working capital management. The CCC was developed by Richards and Laughlin (1980), and it has been argued to be a good proxy for working capital management (e.g., Shin and Soenen, 1998; Deloof, 2003; Hutchison et al., 2007; Ulbrich et al., 2008). The CCC presents the length (days) of the time a firm has funds tied up in working capital, starting from the payment of purchases to the supplier and ending in the receiving of a remittance of sales from the customer. The CCC consists of three components (presented in Table 1), and it is calculated as CCC = cycle time of inventories (DIO) + cycle time of accounts receivable (DSO) – cycle time of accounts payable (DPO).

Table 1 Working capital components

Working capital component	*Definition*
Cycle time of inventories (DIO)	DIO = (inventories / sales) * 365
Cycle time of accounts receivable (DSO)	DSO = (accounts receivable / sales) * 365
Cycle time of accounts payable (DPO)	DPO = (accounts payable / sales) * 365

Traditionally the cost of goods sold (COGS) is used as a denominator when calculating the DIO and the DPO, but in this study, the components of the CCC are expressed as a proportion of sales, which according to Shin and Soenen (1998) measures the efficiency of working capital management better. Using sales instead of the COGS makes the estimation of the need of working capital simpler and the data gathering unambiguous. A profit measure, the EBIT% (defined as earnings before interest and taxes per sales) is included in the analysis, as profits have a significant impact on the ROC% (see Figure 1). In previous studies, also other control variables related to finance, such as the ratio of fixed financial assets to total assets, the financial debt ratio, and the current ratio (Deloof, 2003; Lazaridis and Tryfonidis, 2006; Shin and Soenen, 1998) have been used. As our perspective is operational, variables related to debt are not included in the analysis. We tested the results by controlling the cycle time of fixed assets, as fixed assets are a significant part of the total assets, but the new variable did not change the results remarkably. Thus, we left the additional variable out and kept our study simple by focusing only on the relationship between the operational working capital components and profitability.

This study can be defined as empirical archival research. We have applied correlation and regression analyses to analyse archival data (Moers, 2007) collected from the financial statements of selected companies. Pearson correlation analysis has been used to observe the mutual relationship between the variables, and a multiple linear regression model [equation (2)] has been constructed for studying the effects of the cycle times of the working capital components on the ROC%:

$$\mathrm{ROC\%} = b_0 + b_1\mathrm{EBIT\%} + b_2\mathrm{DIO} + b_3\mathrm{DSO} + b_4\mathrm{DPO} \quad (2)$$

It should be noted that the ROC% and the EBIT% are converted to percentages: for example if the ROC% is 5.0%, it is 5.0 in the data, not 0.05.

3.2 Sample and data

The sample of the study represents the value chain of the automotive industry, and it has been constructed from the financial statements of 48 international and Central European firms during 2006–2009. The value chain used in this study consists of four different levels that represent the main elements needed for producing a car for an end customer (see Figure 2). The chain begins with the level of raw material suppliers: producers of plastics, rubber, steel and metal. These companies supply material to the next level, component suppliers. The component suppliers supply small parts, like bearings and gaskets, to the system suppliers, who make complete systems and parts that are then delivered to the car manufacturers. The car manufacturers take care of the assembly of the final vehicle. The structure and the companies of the chain have been defined on the basis of previous literature (e.g., Blackman and Holland, 2006; Heneric et al., 2005; Wheelen and Hunger, 2002), discussions with professionals working in the automotive industry, and the Top 100 Automotive Suppliers' Global Ranking publication (Automobilproduktion, 2010). Figure 2 shows the structure and companies of the value chain utilised in this study. It should be noted that some levels of the value chain have been left out of the study as we have focused on the real relationships between the levels of the core automotive industry. For example, car dealers, which could be located between the end customers and the car manufacturers were not included in the core value chain, as the car manufacturers already have a strong relation with the end customers. For example, a major part of the accounts receivable of car manufacturers comes directly from the end customers.

Moers (2007) has criticised the archival research approach for an uncritical use of databases that scholars have easy access to. In this study, the problem has been circumvented by using only official financial statements and annual reports instead of databases and by collecting all the needed information manually, which has ensured the correctness of data and a similar manner of data collection. The careful data collection restricted the sample mainly to European companies. All financial statements were found in public sources: the firms' websites and the German Company Register (Unternehmensregister), which is a free and publicly available internet database provided by the Bundesanzeiger (official publication of the Federal Republic of Germany published by the German Department of Justice). The observation period was 2006-2009, including 176 firm-year observations. Due to unavailability of data, the sample included only 40 observations in the years 2006 and 2009.

Figure 2 The value chain of the automotive industry and sample companies

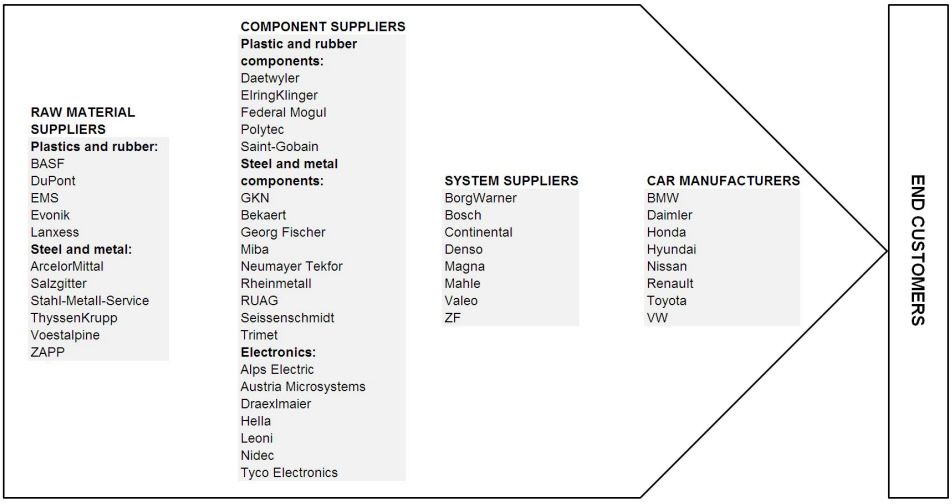


Table 2 presents the descriptive statistics of the value chain and its different levels: the average, minimum and maximum values of the CCC, DIO, DSO, DPO, ROC%, EBIT%, and annual sales. The sales have been converted to Euros by the yearly average rate course released by the European Central Bank.

The car manufacturers have the longest cash conversion cycles in the value chain, due to the long cycle times of their accounts receivable: the financing and leasing businesses of car manufacturers require long credit periods and tie up a remarkable amount of working capital. The DIO varies a lot between the value chain levels. The system suppliers have been able to keep relatively low inventory levels. For example, the raw material suppliers keep their inventories on average one month longer than the system suppliers. In the value chain, the difference between the maximum and minimum DIO is approximately four months. The system suppliers are also the slowest payers to the suppliers. The raw material suppliers have the shortest average cycle times of accounts receivable (48 days) and accounts payable (30 days). The difference between the minimum and maximum CCC in the value chain is big as well, approximately six months.

The average ROC% of the value chain during the observation period was 8%, which is rather low. According to the annual working capital surveys by the REL consultancy, the average return on capital employed among the 1,000 largest US and 1,000 largest European companies is approximately 12% (REL, 2010a, 2010b). According to our study, the most profitable companies are on the first level of the chain: raw material suppliers have a ROC% of 14% and EBIT% of 9%. These companies operate in other industries as well, and the past and current problems in the automotive industry do not seem to have impacted them. The differences between the companies in the EBIT% and ROC% are biggest on the level of component suppliers, where also the number of companies is highest.

Table 2 Descriptive statistics

	Value chain			*Raw material suppliers*			*Component suppliers*			*System suppliers*			*Car manufacturers*		
Number of companies	48			11			21			8			8		
Sample size	176			39			76			31			30		
	Ave	*Min*	*Max*	*Ave*	*Min*	*Max*	*Ave*	*Min*	*Max*	*Ave*	*Min*	*Max*	*Ave*	*Min*	*Max*
DIO (days)	54	22	132	68	39	132	57	30	129	38	22	68	46	25	77
DSO (days)	64	21	209	48	21	62	57	22	105	57	30	87	109	26	209
DPO (days)	38	7	80	30	7	60	40	13	78	44	26	80	36	18	74
CCC (days)	80	4	192	85	60	148	74	25	163	51	4	87	118	39	192
ROC%	8%	–35%	39%	14%	–7%	39%	8%	–35%	39%	6%	–7%	24%	5%	–3%	13%
EBIT%	5%	–34%	23%	9%	–6%	23%	5%	–34%	20%	3%	–5%	11%	4%	–3%	9%
Sales (M€)	22,706	108	164,011	21,990	108	84,947	4,550	137	43,800	16,738	2,840	46,320	75,799	33,712	164,011

4 Results

4.1 Value chain

First, the impact of the cycle times of the working capital components on the ROC% was studied on the value chain level. Table 3 shows the results of the linear regression analysis (upper part of the table) and the correlation coefficients of the variables (lower part, on the right), as well as the scatter chart of the observations in the CCC-ROC% coordination (lower part, on the left). Both the results of the statistical analyses and the chart indicate that the CCC and the ROC% do not have a strong relation in the value chain of the automotive industry. There is no statistically significant correlation between the CCC and ROC%, and the regression curve in the chart does not follow a linear pattern. The initial conclusion is that the reduction of the cycle time of working capital does not have a remarkable effect on the relative profitability.

The result above is due to the DIO, which seems to have no statistically significant connection to the ROC%. The DSO and the DPO, on the other hand, have a statistically significant and negative correlation with the ROC%, which is consistent with the findings of previous studies. The regression model shows similar results. Due to the dominant effect of the EBIT%, the adjusted R^2 of the regression model is strong (0.715). The initial conclusion would be that the reduction of the cycle time of inventories does not lead to better profitability in this value chain, but the shorter cycle times of accounts receivable and accounts payable increase profitability.

The DSO and the DPO have a strong and positive correlation (0.306) with each other. This may indicate that the cycle time of accounts receivable and accounts payable follow each other in the value chain context. If a company needs to pay the suppliers faster, it also requires quicker payments from the customers and vice versa. According to the results, the management of trade credit is important in the value chain of the automotive industry. Companies should aim at shorter credit terms to improve their profitability. On the other hand, more profitable companies also attempt to pay their bills to the supplier faster.

Because we did not find a strong connection between the CCC and profitability on the value chain level, as was expected according to prior research, the value chain was divided into smaller units, levels, to study whether the relation was not found because of the differences of levels or whether there is no strong relation between working capital management and profitability in any part of the automotive value chain.

4.2 Levels of the value chain

Second, multi-group analysis was conducted, and four levels of the automotive value chain – raw material suppliers, component suppliers, system suppliers and car manufacturers, were analysed separately. We used similar analysing methods as with the value chain. Tables 4–7 show the results of each level of the value chain.

On the level of the raw material suppliers, a positive and statistically significant correlation between the CCC and the ROC% (0.359) was found, which can also be seen in the scatter chart (Table 4). This indicates that the longer the cycle time of working capital is, the higher is the profitability of a raw material supplier. This result is contrary to the findings of previous studies. The regression and correlation analyses show that the DIO causes a positive connection between the CCC and the ROC%, as the relation of the

DIO to profitability is positive, while the DSO and DPO have a negative relation with the ROC%. In addition, the correlation between the DIO and CCC is statistically strong. According to the results, the more profitable raw material suppliers keep bigger inventories. Large inventories can be part of the companies' strategy and give competitive advantage to them. For example the customers of the raw material suppliers may prefer suppliers with a high reliability of delivery, and higher inventory levels are kept to ensure the availability of products for customers, or the customers value a situation where they need to keep only small inventories themselves.

On the level of the component suppliers, a statistically significant relation between the ROC% and the CCC was not found (Table 5). The scatter chart shows that even if outlier observations with overlong CCCs were removed, the results would not change. Opposite to the prior level, the regression model shows that now the DIO has a negative relation with the ROC%, which indicates that keeping inventories no longer advance profitability. According to the regression model, the DSO has no impact on the ROC%, and also the impact of the DPO is trivial.

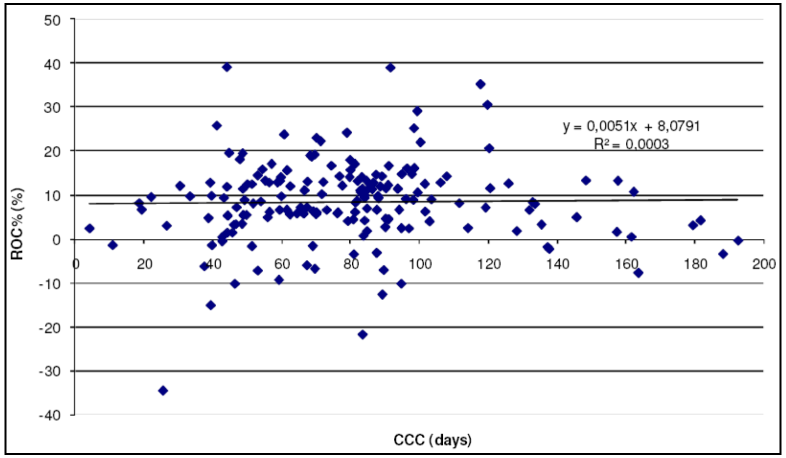
The results of the system suppliers resemble the results of the prior level of component suppliers (Table 6). As on all levels, the EBIT% is the variable affecting profitability most, but on this level, the impact of the EBIT% is even stronger than on the previous levels. The correlation coefficient between the EBIT% and the ROC% is 0.945, and the adjusted R^2 in the regression analysis is 0.902. For the system suppliers, the DIO is again the statistically most significant component of the CCC affecting profitability negatively, as on the level of the component suppliers.

The results of the car manufacturers are out of line when compared to the other levels of the automotive value chain (Table 7). The CCC correlates significantly and negatively with the ROC% (–0.541). The scatter chart also shows a negative relation. All three components of the CCC have a negative correlation with profitability, suggesting that the shorter the cycle times, the better the profitability. While inventories were the most significant component of working capital on the other levels of the value chain, it seems that accounts receivable and accounts payable are more important to the car manufacturers. The DSO has the greatest impact on the CCC, as the car manufacturers have long cycle times of accounts receivable because of their financing and leasing businesses. The regression model shows that besides the EBIT%, which has a dominant impact on the ROC%, the DSO and the DPO also have a statistically significant impact on the ROC%. The results of the car manufacturers are consistent with previous studies, which have concluded that more profitable companies operate with shorter cycle times of working capital. An interesting detail in the results is that the DPO has a positive impact on the ROC% in the regression analysis. This means that profitability can be improved by releasing capital with longer payment periods to the suppliers.

Financing and leasing are an important, and also profitable, part of the car manufacturers' business. That is why it is reasonable to include the receivables of financing and leasing in the analysis. As mentioned above, this increases the average DSO of the car manufacturers. It is worth noting, however, that if the receivables of financing and leasing were left out, the DSO and the ROC% would have a positive correlation, and the statistically significant correlation between the CCC and the ROC% would now vanish. On the value chain level, this would mean that the CCC and the ROC% would have a statistically significant and positive relation. In this case, none of the levels would support the findings of previous research, and the results would be rather reversed.

Table 3 Results of the value chain (see online version for colours)

Value chain	b_0 *(constant)*	b_1 *(EBIT%)*	b_2 *(DIO)*	b_3 *(DSO)*	b_4 *(DPO)*	*Adj.* R^2	*n*
ROC%	6.098 ***	1.230***	–.005	–.028**	–.050*	.715	176
p-values	(.000)	(.000)	(.816)	(.031)	(.072)		

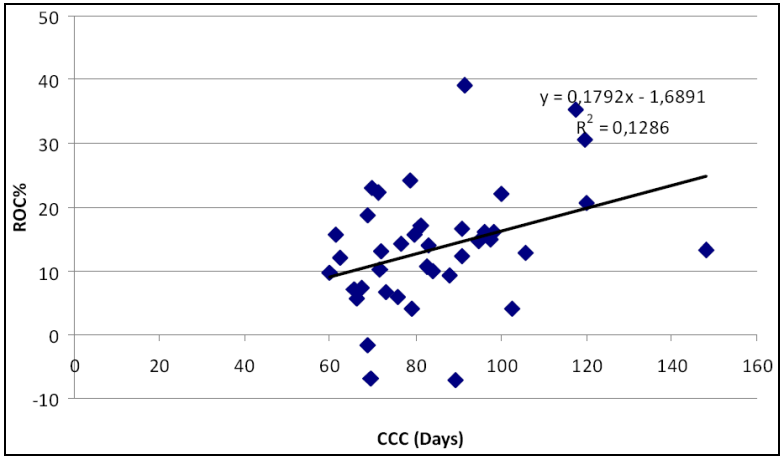


	DIO	*DSO*	*DPO*	*CCC*	*ROC%*
DIO					
DSO	–.126*				
DPO	–.072	.306***			
CCC	.481***	.708***	–.192**		
ROC%	.103	–.152**	–.229***	.018	
EBIT%	.115	–.044	–.151**	.090	.838***

Notes: Regression analysis is presented in the upper part of the table. n is the number of observations. In the lower part, there is a scatter chart on the left, and the correlation coefficients between the variables on the right. *, ** and *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

Table 4 Results of the raw material suppliers (see online version for colours)

Raw material suppliers	*b_0 (constant)*	*b_1 (EBIT%)*	*b_2 (DIO)*	*b_3 (DSO)*	*b_4 (DPO)*	*Adj. R^2*	*n*
ROC%	8.280	1.206***	.091*	–.114	–.188*	.623	39
p-values	(.200)	(.000)	(.097)	(.279)	(.072)		

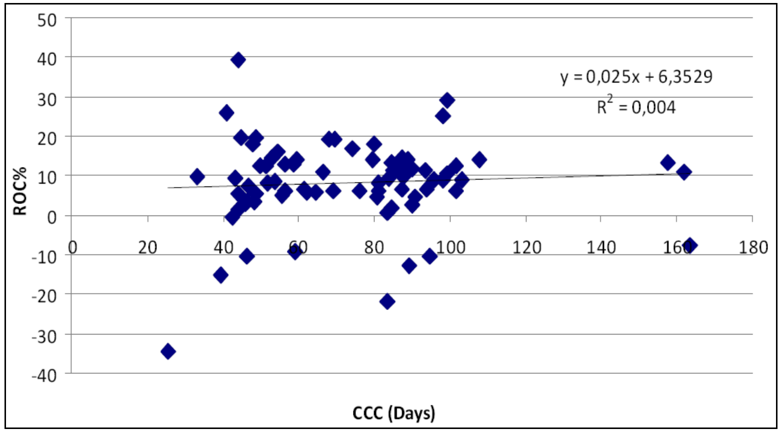


	DIO	*DSO*	*DPO*	*CCC*	*ROC%*
DIO					
DSO	–.313*				
DPO	.105	.308*			
CCC	.781***	.107	–.253		
ROC%	.194	.017	–.277*	.359**	
EBIT%	–.017	.353**	–.064	.228	.738***

Notes: Regression analysis is presented in the upper part of the table. n is the number of observations. In the lower part, there is a scatter chart on the left, and the correlation coefficients between the variables on the right. *, ** and *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

Table 5 Results of the component suppliers (see online version for colours)

Component suppliers	b_0 *(constant)*	b_1 *(EBIT%)*	b_2 *(DIO)*	b_3 *(DSO)*	b_4 *(DPO)*	*Adj.* R^2	*n*
ROC%	9.143***	1.176***	–.067*	.012	–.081	.704	76
p-values	(.002)	(.000)	(.099)	(.826)	(.124)		

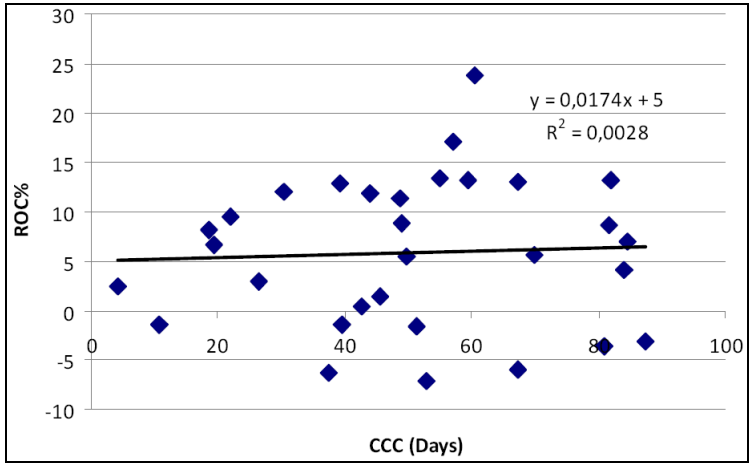


	DIO	*DSO*	*DPO*	*CCC*	*ROC%*
DIO					
DSO	.426***				
DPO	.191*	.529***			
CCC	.834***	.590***	–.125		
ROC%	–.133	.081	–.185	.063	
EBIT%	–.002	.214*	–.067	.165	.831***

Notes: Regression analysis is presented in the upper part of the table. n is the number of observations. In the lower part, there is a scatter chart on the left, and the correlation coefficients between the variables on the right. *, ** and *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

Table 6 Results of the system suppliers (see online version for colours)

Component suppliers	*b_0 (constant)*	*b_1 (EBIT%)*	*b_2 (DIO)*	*b_3 (DSO)*	*b_4 (DPO)*	*Adj. R^2*	*n*
ROC%	8.351**	1.676***	–.077*	–.064	–.028	.902	31
p-values	(.012)	(.000)	(.075)	(.166)	(.454)		

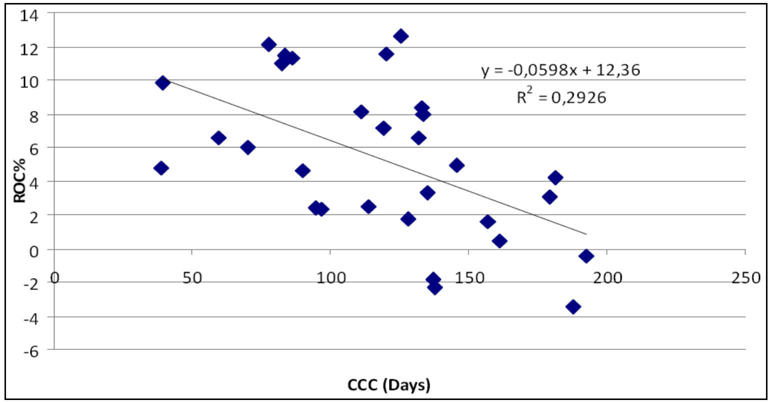


	DIO	*DSO*	*DPO*	*CCC*	*ROC%*
DIO					
DSO	–.054				
DPO	–.484***	.362**			
CCC	.813***	.207	–.734***		
ROC%	–.097	.083	–.099	.053	
EBIT%	–.006	.195	–.074	.137	.945***

Notes: Regression analysis is presented in the upper part of the table. n is the number of observations. In the lower part, there is a scatter chart on the left, and the correlation coefficients between the variables on the right. *, ** and *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

Table 7 Results of the car manufacturers (see online version for colours)

Component suppliers	*b_0 (constant)*	*b_1 (EBIT%)*	*b_2 (DIO)*	*b_3 (DSO)*	*b_4 (DPO)*	*Adj. R^2*	*n*
ROC%	1.621	1.190***	–.032	–.019***	.065***	.937	30
p-values	(.256)	(.000)	(.139)	(.006)	(.002)		



	DIO	*DSO*	*DPO*	*CCC*	*ROC%*
DIO					
DSO	–.204				
DPO	.010	.586***			
CCC	.034	.934***	.359*		
ROC%	–.263	–.407**	–.052	–.541***	
EBIT%	–.253	–.382**	–.150	–.474***	.958***

Notes: Regression analysis is presented in the upper part of the table. n is the number of observations. In the lower part, there is a scatter chart on the left, and the correlation coefficients between the variables on the right. *, ** and *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

The correlation coefficients between the CCC and the ROC% vary a lot between the different value chain levels (from 0.359 to –0.541). Also, the cycle times of working capital components have different impacts on the ROC%, depending on the level. The DIO is the most significant component affecting the ROC% on the first three levels. Both positive and negative relations can be found. On the level of car manufacturers, the DSO has the most remarkable effect on the ROC%.

The results are somewhat opposite to the previous findings that companies should aim for aggressive working capital management. The previous studies have not considered the different impacts of working capital management actions on profitability in different company groups. According to our results, some levels of the value chain gain benefits from longer cycle times of inventories. It seems that in the beginning of the value chain, profitable companies keep larger inventories, and in the end of the value chain the most profitable strategy is to reduce the inventory levels and the CCC overall. The component suppliers and the system suppliers in the middle do not have so clear strategies. Could this indicate that they try to be flexible and invest on working capital if needed?

The impact of the cycle time of accounts payable on the ROC% is interesting, as the relation between the DPO and the ROC% is negative on the other levels of the value chain, except for the car manufacturers. This indicates that it is more profitable for companies to pay their bills fast and utilise possible discounts than to release working capital by stretching out the payments to the suppliers. This may also be an issue of reputation and collaboration. Profitable companies do not have to stretch their payment periods. On the other hand, the more profitable car manufacturers get longer payment periods from their suppliers than the not so profitable ones. This might indicate the negotiation power of car manufacturers.

Studying the relationship between the CCC and profitability in the smaller value chain units showed that a strong connection between these two variables could not be found on the value chain level due to differences between the levels/level-specific attributes.

5 Simulations: improving value chain profitability through working capital management actions

The constructed regression models explained the dependent variable, the ROC% very well, mainly because of the strong connection between the EBIT% and the ROC%. Thus, we conducted five simulations with the regression models on each of the levels described in the previous section to answer the second research question. We examined which working capital management actions are the most efficient in improving the value chain profitability. The average value chain profitability calculated with the regression models, as well as the results of the simulations are presented in Appendix.

In the first simulation, the companies want to release working capital by tightening their terms of payment. The cycle time of accounts receivable decreases by ten days on every level. When all companies in the chain act similarly, it leads to a decrease of the DPO as well. It should be noted that the CCC remains on the same level, as the changes of the DSO and the DPO offset each other. The results show that the shorter payment terms would increase the value chain profitability from 8.2% to 9.3%. The value chain profitability is calculated as an average of the profitability of the levels. The profitability of all other levels except that of the car manufacturers would increase as well.

In the second simulation, the car manufacturers decide to negotiate longer payment terms for their purchases to release working capital. If the system suppliers agree to this, it increases their cycle time of accounts receivable. In turn, the system suppliers decide to pressure their suppliers to give more generous payment terms to them. The same pattern recurs on all levels of the value chain. As a result, the DSO and the DPO increase by ten days throughout the value chain. This would lead to lower value chain profitability (7.2%).

In the third simulation, the partners of the value chain try to increase the value chain profitability by adjusting the inventory levels. The customers and the suppliers negotiate about the inventory transfers and collaboration, aiming at more efficient cycle times of inventories. The component suppliers shift their inventories upstream to the raw material suppliers, which means a ten-day reduction in the DIO of the component suppliers and a ten-day increase in the DIO of the raw material suppliers. The system suppliers and the car manufacturers decide to reduce the cycle time of the inventories of the system supplier by ten days with more efficient information sharing and collaboration, as the regression analysis showed a negative impact of the DIO on the ROC% on the level of the system suppliers. At the same time, the inventories of the car manufacturers remain at the initial level. These adjustments would raise the value chain profitability to 8.8%.

The fourth simulation combines the working capital management actions of the second and third simulations. The companies tighten the payment terms and adjust the inventory levels to improve profitability. These combined actions would raise the value chain profitability to almost 10%. In reality, inventory adjustment may be difficult to implement. The payment terms are widely negotiation questions, however. In the fifth simulation, we demonstrate a situation where all payment terms through the value chain are decreased radically to ten days. This would increase the profitability by 3.5 percentage units to 11.7%. In addition to improved value chain profitability, this simulation is the only one where the profitability of all value chain levels would increase.

The results of the simulations suggest that changes in working capital components affect the car manufacturers differently from the other levels. The shorter DSO and DPO (simulation 1) on each level of the value chain improves the profitability of the whole value chain and all other levels, except for the car manufacturers. Lengthening the DSO and DPO (simulation 2), in turn, has a positive effect on the car manufacturers' profitability, but the profitability of the whole value chain and the other levels decreases. This might be a problem for the management of the whole value chain, as the car manufacturers usually have a dominating position in the chain. This conflict should be turned to a situation which all the value chain partners could benefit from. For example the system suppliers could reward the car manufacturers for information sharing or other collaboration actions that would reduce the inventories of the system suppliers, by granting more generous credit terms to the car manufacturers.

According to the simulations, the most efficient way to increase profitability in the value chain by working capital management is to manage all three working capital components simultaneously. This supports the argument that besides collaboration of the companies in the value chain, working capital management should be collaboration of the different departments in a company: sales, supply, production and finance.

Long credit terms are traditionally used as a part of sales promotion or they are required by the customer, but have the companies considered the profitability improvements that could be gained by reducing the credit periods radically? The current technology with electronic invoicing and payment would enable faster cycle times of

accounts receivable and payable, as well as an increase in the competitiveness of the value chain.

6 Conclusions

In this paper, we have analysed the impact of the cycle times of working capital and its components on relative profitability, and studied how working capital management could affect profitability in the value chain of the automotive industry. On the value chain level, we did not find a statistically significant negative relation between the cash conversion cycle and profitability, as found in earlier studies. The result of a multi-group analysis showed that there are differences in this basic negative relation when the different levels of the value chain are considered. The results indicate that companies should have different working capital management strategies, depending on their position. It is not beneficial for everyone to aim at shorter cycle times. In the value chain context, this is not even possible, as the actions of the value chain partners affect the other companies in the chain, and improvements cannot be made by passing the negative effects up to the suppliers or down to the customers. The level-specific attributes can be taken into account when optimising the profitability of the value chain. In the value chain of the automotive industry, this could mean for example shifting the inventories to the raw material suppliers and compensating that with fast payments to them.

According to our study, the most efficient way to increase profitability by managing the cycle times of working capital components is to manage all the components of working capital, inventories, accounts receivable and accounts payable, simultaneously. We also showed that a radical reduction of payment terms would increase profitability radically on the value chain level. Currently, companies grant generous credit terms, even if technology would enable much shorter payment periods.

This paper contributes to the area of financial supply chain management by observing working capital management in a four-level value chain. The study has two main results. First, companies in the value chain have different strategies for working capital management. Not all companies benefit from the shortening of the CCC. Second, a radical reduction of payment terms would be the most efficient working capital management action to increase profitability in the value chain. By analysing real data from financial statements, the study offers a realistic and broad view of working capital management in the automotive industry. The data for this paper was collected manually to ensure the reality of the research design. This limited the sample size, which affected the statistical significance of the results. Therefore the simulation results are only suggestive. On the other hand, we received a more detailed view through the levels of the value chain. In the future, it would be interesting to do even more detailed observations and study real individual supply chains to find collaborative solutions in working capital management that would benefit all members of the supply chain. According to our study, companies cannot manage their working capital similarly just by decreasing the amount of working capital. More research is needed in other value chain contexts to examine the most suitable strategies to manage working capital in companies with different capital structures, positions in the value chain, end products, and relationships with the other value chain partners.

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Appendix

Results of the simulations

	EBIT%	*DIO*	*DSO*	*DPO*	*ROC%*
Average 2005–2009					
Raw material suppliers	8.55	68	48	30	13.6
Component suppliers	4.62	57	57	40	8.2
System suppliers	3.16	38	57	44	5.9
Car manufacturers	4.03	46	109	36	5.2
Value chain					*8.2*
Simulation 1: shorter payment periods					
Raw material suppliers	8.55	68	*38*	*20*	16.6
Component suppliers	4.62	57	*47*	*30*	8.9
System suppliers	3.16	38	*47*	*34*	6.8
Car manufacturers	4.03	46	*99*	*26*	4.8
Value chain					*9.3*
Simulation 2: longer payment periods					
Raw material suppliers	8.55	68	*58*	*40*	10.6
Component suppliers	4.62	57	*67*	*50*	7.5
System suppliers	3.16	38	*67*	*54*	5.0
Car manufacturers	4.03	46	*119*	*46*	5.7
Value chain					*7.2*
Simulation 3: inventory adjustments					
Raw material suppliers	8.55	78	48	30	14.5
Component suppliers	4.62	*47*	57	40	8.9
System suppliers	3.16	*28*	57	44	6.7
Car manufacturers	4.03	46	109	36	5.2
Value chain					*8.8*
Simulation 4: inventory and payment terms adjustments					
Raw material suppliers	8.55	*78*	*38*	*20*	17.5
Component suppliers	4.62	*47*	*47*	*30*	9.6
System suppliers	3.16	*28*	*47*	*34*	7.6
Car manufacturers	4.03	46	*99*	*26*	4.8
Value chain					*9.9*
Simulation 5: radical payment terms adjustments					
Raw material suppliers	8.55	68	*10*	*10*	21.7
Component suppliers	4.62	57	*10*	*10*	10.1
System suppliers	3.16	38	*10*	*10*	9.8
Car manufacturers	4.03	46	*10*	*10*	5.4
Value chain					*11.7*

Publication III

Lind, L., Monto, S., Kärri, T., and Schupp, F.
Detecting working capital models in the ICT supply chains

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Detecting working capital models in the ICT supply chains

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Abstract: A working capital model, consisting of the management of inventory, accounts receivable and accounts payable, is a part of the business model and can be a source of competitive advantage. This paper studies working capital models in the ICT industry from the supply chain perspective. The financial value chain analysis showed that companies within the same branch had remarkable differences in their working capital management. Some companies were even able to operate with a negative cycle time of working capital (CCC). The key to a negative CCC was a short cycle time of inventories, but the efficient management of payables was critical as well. With cluster analysis, four different working capital models (clusters) were indicated: long cycle companies, inventory holders, optimisers, and credit granters. Identifying different working capital models helps supply chain actors in optimising the working capital management of the chain to improve its competitiveness.

Keywords: working capital management; cash conversion cycle; CCC; working capital models; cluster analysis; financial value chain analysis; financial supply chain; inventory management; accounts receivable management; accounts payable management; ICT industry.

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1 Introduction

This paper concerns operational working capital management, including the management of inventories, accounts receivable and accounts payable, as part of a business model, and studies working capital models in the information and communications technology (ICT) industry from the perspective of a supply chain. The study continues the research on different strategies and business models in value chains (Samuel et al., 2012) and adds knowledge to the research stream of financial supply chain management discussed in the supply chain literature lately (e.g., Protopappa-Sieke and Seifert, 2010; Wuttke at al., 2013).

Efficient management of working capital, which is usually associated with a short cycle time of working capital, is found to have a positive impact on profitability (e.g., Deloof, 2003; Enqvist et al., 2014; García-Teruel and Martínez-Solano, 2007; Lazaridis and Tryfonidis, 2006; Shin and Soenen, 1998). It also improves the liquidity of a company (Johnson and Templar, 2011) and decreases the financing cost of capital (Viskari et al., 2012a). Working capital can be an essential part of the business model

when the company manages it efficiently (Mullins, 2009). A company can achieve a negative cycle time of working capital if it operates with a working capital model which allows short cycle times of inventories and accounts receivable and a long cycle time of accounts payable. In case of a negative cycle time of working capital, the cycle time of accounts payable should cover the sum of the cycle times of inventories and accounts receivable. In other words, powerful companies can use their position to dominate suppliers and customers, or other operators in a network, and use them as financiers, and then benefit from the situation where working capital is not tied up in the company itself.

The purpose of the paper is to identify different working capital models companies in the different parts of ICT supply chain operate with. The working capital management of a firm is affected by the actions of customers and suppliers, which makes it reasonable to view the situation also from a wider supply chain perspective and not only from the point of view of a single company. In this study, the sample companies form a tight value network consisting of real-life supply chains and companies operating on different branches in the ICT industry. Lind et al. (2012) have observed the cycle times of working capital in a broad value chain by using the financial value chain analysis. In this paper, in addition to financial value chain analysis, cluster analysis is used to classify companies on the basis of the cycle times, and to find different working capital models. The following research questions are addressed:

1 What are the cycle times of working capital in the value network of the ICT industry?

2 What kind of working capital models do the companies in the value network of the ICT industry operate with?

Previous studies of working capital management in the network context have highlighted the importance of effective inventory management. Lind et al. (2012) found that the change in the cycle time of working capital follows the change in the cycle time of inventories, whereas the changes in the cycle times of accounts receivable and payable offset each other. This finding was supported by Viskari et al. (2012b). Their study also indicated that the same behaviour is visible regardless of the economic trend. However, Viskari et al. (2012c) highlight that all working capital components should be managed simultaneously to increase the profitability of the value chain. They also found evidence that all companies in the value chain do not benefit from similar working capital management strategies.

The ICT industry is characterised by an integrated business environment and fast technology development. A working capital model is seen as a part of a business model (Mullins and Komisar, 2009). The business models in the ICT industry are different from the ones applied in the previously studied pulp and paper (Viskari et al., 2011) and automotive industries (Lind et al., 2012), which are more capital-intensive and represent a traditional process industry and batch production. The ICT industry is service-oriented, and it has a large variety of tangible and intangible end products, as well as customers. Because of the nature of the industry, the research sample includes many companies which provide only services and therefore operate with negligible inventory levels. The ICT industry is known also for the use of contract manufacturers. On the basis of these characteristics, it could be anticipated that studying working capital management in the context of the ICT industry would bring up new aspects and interesting findings, and provide an opportunity to identify different working capital models.

The paper is structured as follows. The next section is a literature review providing the theoretical background for the study. It is followed by a section describing the research methods. Section 4 focuses on research question 1, and a short overview of the cycle times of working capital in the ICT industry is given. After this, the analysis of working capital models is conducted with cluster analysis, answering the second research question. A short discussion is provided in Section 6. In the last section, the conclusions and limitations of the study are presented, and topics for future research are suggested.

2 Literature review

The working capital model is an important part of a company's business model. Mullins and Komisar (2009) divide a business model into five elements: the revenue model, gross margin model, operating model, working capital model, and investment model. Mullins and Komisar argue that companies need to consider every element included in their business model, but an innovative approach in one or two elements can offer a company substantial advantages in business. In this paper, we concentrate on working capital models. Previous literature on working capital management in finance and supply chain management, which has discussed working capital practices and determinants, has been reviewed for our study. In addition, working capital management in the inter-organisational context is discussed, as the context of our study is an inter-organisational value network.

The relation of financial performance and supply chain management has not been explicitly established in the academic literature (Ellinger et al., 2011), but working capital management has an opportunity to do that. Working capital performance has been traditionally observed through cycle times. The number of days from the payment of raw materials to suppliers to the money received from customers for a product or services sold is the key measure of working capital performance (e.g., Schilling, 1996; Soenen, 1993). This metrics is called the cash conversion cycle (CCC) and it is calculated from three cycle times: the cycle time of inventories + the cycle time of accounts receivable – the cycle time of accounts payable (e.g., Richards and Laughlin, 1980). From the point of view of supply chain management, the CCC integrates activities from inbound logistics and supplier relationships to outbound logistics and customer relations. It is an important measure of the performance of the business process. On the other hand, the CCC is also an important metric from the financial perspective, as it studies value creation and liquidity (Farris and Hutchison, 2002). Innovative and successful working capital models are based on a short CCC, which frees cash, decreases costs, and enhances growth (Mullins, 2009). Several studies have concluded that a shorter cycle time of working capital increases the profitability of a company (e.g., Deloof, 2003; Enqvist et al., 2014; García-Teruel and Martínez-Solano, 2007; Lazaridis and Tryfonidis, 2006; Shin and Soenen, 1998). In some cases, a company can even operate with a negative CCC (Mullins, 2009).

Early studies of working capital in the literature of finance have examined the practices of working capital management. It has been found in these studies that most companies manage working capital informally, and different components of working capital are managed separately (Khoury et al., 1999; Sartoris et al., 1983). Hill et al. (2010), who have examined the determinants of working capital, suggest that the optimal level of working capital depends on internal factors inside a company rather than on

external ones. For example, the ability to receive finance has been found to be an important determinant of whether a company wants or needs to use accounts payable as a source of finance (e.g., Niskanen and Niskanen, 2006). Howorth and Westhead (2003) have conducted a study of working capital management practices in SMEs, in which they identify four working capital models:

1 concentration on cash management

2 concentration on inventory management

3 concentration on revenue management

4 no working capital management routines.

They also used cluster analysis to identify the four models, but they gathered the data by a survey, whereas our study is based on financial data collected from the official publications of the sample companies.

Lately, the research stream of financial supply chain management has been interested in linking the supply chains of physical goods with financial aspects. Protopappa-Sieke and Seifert (2010) have built a model to combine financial and operational measures by treating financial flows as constraints on inventory decisions. Their findings suggest that collaboration in the management of operational and financial costs is required for a more holistic view. The study of Wuttke et al. (2013) adds empirical knowledge about financial supply chain management by analysing eight interview-based case studies and creating a framework for financial supply chain management. Working capital management practices and the CCC have also been topics for several studies. Farris and Hutchison (2003) have compared the CCC performance of different industries. They divided the industries into silos according to high/low level of inventories, accounts receivable and accounts payable. They found three industries which operated on average with a negative CCC in 2001: eating and drinking places, amusement and recreation, and communications. Farris and Hutchison conclude that the negative CCC was achieved through low inventories and extended accounts payable rather than through a low level of accounts receivable. Lind et al. (2012) have performed a study of CCCs in an extended value chain of the automotive industry from an oil and iron ore supplier to car dealers. Lind et al. (2012) conclude that the changes of the CCC in the value chain follow the changes of the cycle time of inventories, as the changes of the cycle times of accounts receivable and accounts payable offset each other in the value chain context. Pirttilä et al. (2014) compared the CCC performance in three industries: ICT, pulp and paper, and automotive. They found that the CCC varies between the industries mainly because of the differences in the cycle time of inventories. Brandenburg (2016) used the CCC and the efficiency of cost of goods sold (COGS) as measures in his study of supply chain efficiency and value creation in the European automotive industry. He found that both costs and working capital should be managed continuously and simultaneously in order to create value, whereas focusing in the optimisation of only one factor can result in value loss.

Hofmann and Kotzab (2010) argue that working capital should be managed in collaboration with the other value chain actors, and not from the perspective of a single company. Sub-optimisation of working capital may harm the value chain partners, which can have a negative effect on the company itself in the end. Viskari et al. (2012c) have examined the relation between working capital management and profitability in the value

chain context. They conclude that the relation between short cycle times and increased profitability is not straightforward. Companies can also benefit from longer cycle times. In this paper, the value chain context is combined with the research on working capital models. We apply the cluster analysis utilised by Howorth and Westhead (2003) and the financial value chain analysis developed by Lind et al. (2012) to increase the understanding of working capital models. It is important for a company to have a holistic view of the value chain in order to find the optimal CCC (Grosse-Ruyken et al., 2011).

3 Research design

This study applies two research methods. First, an analysis of the cycle times of working capital has been conducted with financial value chain analysis, based on archival data (Moers, 2007; Rabinovich and Cheon, 2011). The method was also used by Lind et al. (2012) and Pirttilä et al. (2014) in their analyses of working capital management. Second, working capital models are detected with cluster analysis, which Howorth and Westhead (2004) also used when they identified different types of SMEs regarding working capital management.

The sample consists of the financial statements of 61 companies operating in different branches of the ICT supply chain. The observation period was 2006–2010. All data for the study was collected from public sources, and only official financial statements and annual reports found on the company websites were used. The data was collected manually from the companies' balance sheets and income statements by one person during the fall of 2011, which ensures that all the data of the companies was gathered and handled in a similar manner. In addition to the cycle times of working capital and its components, the profitability levels of the companies were calculated. The focus of the study is on the working capital performance of different groups of companies in order to get a picture of the dynamics of the industry, and only a little attention is paid to the performance of individual companies.

Working capital management is studied through the CCC developed by Richards and Laughlin (1980). The CCC consists of three components: cycle times of inventories (days inventory outstanding, DIO), accounts receivable (days sales outstanding, DSO) and accounts payable (days accounts payable outstanding, DPO). Relative profitability is measured by the return on capital employed (ROC%). The definitions and calculations for each measure are shown in Table 1.

Table 1 Measures of working capital management and profitability

Variable	*Description*	*Definition*
DIO	Cycle time of inventories	DIO = (Inventories / Sales) * 365
DSO	Cycle time of accounts receivable	DSO = (Accounts receivable / Sales) * 365
DPO	Cycle time of accounts payable	DPO = (Accounts payable / Sales) * 365
CCC	Cash conversion cycle	CCC = DIO + DSO – DPO
ROC%	Return on capital employed	ROC% = EBIT / (($Equity_t$ + $Equity_{t-1}$) + (LT $liabilities_t$ + LT $liabilities_{t-1}$)) / 2

The ICT industry has been divided into nine different branches in the study:

1 component manufacturers

2 contract manufacturers

3 mobile phones

4 computers and computer peripherals

5 network hardware

6 network operators

7 IT services

8 software

9 Internet services and software.

Some of the sample companies were familiar to the authors beforehand, and the list of companies was extended with the help of different sources, such as yahoo finance's industry centre (Yahoo!, 2011), REL/CFO working capital studies, which list the 1,000 largest US and 1,000 largest European public companies (REL, 2010a, 2010b), ICT companies' annual reports, and ICT related news in the media. The sample companies are listed in Figure 1. Placing companies into branches was not always unambiguous, because many companies offer a large variety of different products and services. Apple, for example, offers personal computing products and media devices, and develops its own software products (Apple, 2011), and it could be placed in several branches. In this study, Apple is located in the branch of computers and computer peripherals, as until the end of the year 2009, computers made the biggest portion of Apple's sales before mobile phones.

Table 2 Descriptive statistics

	Number of companies	*Total assets 2010 (M€) max*	*Total assets 2010 (M€) min*	*Sales 2010 (M€) max*	*Sales 2010 (M€) min*	*Change of sales 2006–2010*	*ROC% 2010 (max)*	*ROC% 2010 (min)*
Component manufacturers	9	47,662	3,391	32,906	2,673	7%	41%	4%
Contract manufacturers	7	11,633	475	28,680	1,070	–2%	15%	–14%
Mobile phones	6	61,198	4,559	42,446	6,675	7%	63%	5%
Computers and computer peripherals	8	93,915	1,862	95,069	2,363	28%	41%	11%
Network hardware	5	24,876	1,963	20,641	1,239	97%	45%	-2%
Network operators	8	202,390	2,542	93,747	3,340	16%	15%	4%
IT services	7	9,968	181	16,256	351	11%	47%	-81%
Software	7	64,957	1,659	47,133	686	45%	43%	10%
Internet software and services	4	43,638	1,271	22,117	1,907	82%	37%	6%
Sample	61	202,390	181	95,069	351		63%	-81%

Table 2 presents descriptive statistics on the sample by different branches: the number of firms, maximum and minimum values of total assets, sales and ROC% in the year 2010, and the change of the average sales of the branch from 2006 to 2010. During the observation period, the sales of each branch, excluding the contract manufacturers, increased. In the network hardware branch the growth was enormous, 97%, from 2006 to 2010. Especially the sales of Taiwanese companies developed rapidly. Also the sales volume of internet software and services grew significantly, by 82%. The branches had very different ROC%s. The variation was also wide within the branches when observing the minimum and maximum values.

4 Cycle times related to working capital management

As stated above, the ICT industry has some special characteristics affecting the management of working capital in the industry. The service-orientation and small inventories give grounds for expecting shorter cycle times of working capital in the ICT industry than found in previous studies of working capital management. This expectation came true: the average CCC of the study was 40 days in the observation period of 2006–2010, whereas the average in the value chain of the pulp and paper industry was 60 days during the observation period of 2004–2008 (Viskari et al., 2011), and in the value chain of the automotive industry 67 days in 2006–2008 (Lind et al., 2012). Interestingly, the short cycle time of inventories does not seem to be a guarantee for a short CCC: the companies operating with only negligible inventories or completely without them are not in most cases the ones having the shortest, or even negative, CCC. The branch with the longest CCC, 60 days, is a network hardware one, whereas its customer branch, network operators, has the shortest CCC, 9 days. Hence, even the longest CCC of the ICT study is shorter than the value chain averages found in the pulp and paper and automotive studies. Seven of the nine branches had managed to shorten their CCC from 2006 to 2010 by 2–7 days. Figure 1 shows the results of the financial value chain analysis as unweighted averages: the average CCC, DIO, DSO, DPO and ROC% of each company in the sample in the observation period, and the average of each branch.

Some branches in the ICT industry do not require inventories at all. Overall, the results indicate that the inventories are relatively well managed in the ICT industry. The DIOs were 42 days at the longest, whereas in the automotive industry (Lind et al., 2012) only two out of nine branches were able to operate with a DIO shorter than 42 days. The branches network operators, IT services, software, and internet software and services do not need to maintain inventories. These branches had a DIO of 1–5 days. The results suggest that contract manufacturers carry inventories on behalf of the branches of mobile phones and computers and computer peripherals by having a DIO which is about 20 days longer than the DIO of their customer branches. Some of the branches in the study offer quite generous payment terms to their customers. Network hardware, mobile phones, IT services and software companies had a DSO of 70–86 days, while the rest of the branches required payment in 42–48 days. The network operators, who were able to shorten their CCC by seven days during the observation period, made it by collecting the payments from the customers seven days faster in 2010 than in 2006. The network operators were able to halve the cycle time of working capital during the observation period. The branches contract manufacturers and computers and computer peripherals had more

generous credit terms from their suppliers than the terms they gave to their customers. However, the DSO and DPO of the branch computers and computer peripherals were quite balanced, as the difference was only one day. The contract manufacturers' DPO was one week longer than the DSO: they received payments from the customers in a shorter time than they used for paying their suppliers.

Figure 1 Results of the financial value chain analysis: average figures of 2006–2010

Network hardware

	CCC	DIO	DSO	DPO	ROC%
Alcatel-Lucent	41	50	91	101	-10%
Huawei	86	59	132	106	41%
Juniper networks	20	0	47	27	4%
Tellabs	87	33	74	20	-3%
ZTE	65	59	85	79	7%
AVERAGE	***60***	***40***	***86***	***66***	***8%***

Component manufacturers

	CCC	DIO	DSO	DPO	ROC%
AMD	38	43	47	53	-6%
Broadcom	34	27	38	31	7%
Infineon	56	57	55	56	0%
Intel	37	35	23	22	19%
NVIDIA	54	41	46	33	12%
STM	71	57	52	38	-1%
Texas Instruments	65	39	40	15	28%
TSMC	50	24	37	10	23%
UMC	67	36	36	36	3%
AVERAGE	***52***	***40***	***42***	***33***	***10%***

Contract manufacturers

	CCC	DIO	DSO	DPO	ROC%
Benchmark	72	51	64	43	4%
Celestica	36	42	47	54	-3%
Elcoteq	12	28	37	52	-14%
Flextronics	18	46	36	63	-9%
Foxconn	39	33	61	55	14%
Jabil	20	46	41	67	1%
Sanmina	44	45	50	51	-7%
AVERAGE	***34***	***42***	***48***	***55***	***-2%***

Computers and computer peripherals

	CCC	DIO	DSO	DPO	ROC%
Apple	-32	5	28	65	31%
Dell	-11	6	49	66	30%
HP	38	24	58	44	17%
IBM	80	10	99	29	24%
Lenovo	-19	13	20	51	9%
Lexmark	28	34	40	46	18%
Logitech	44	40	45	41	17%
SanDisk	46	54	35	43	2%
AVERAGE	***22***	***23***	***47***	***48***	***19%***

Mobile phones

	CCC	DIO	DSO	DPO	ROC%
Cisco systems	44	13	39	8	20%
HTC	22	22	69	69	60%
LM Ericsson	124	46	116	38	14%
Motorola	41	27	56	42	1%
Nokia	42	18	67	44	27%
RIM	74	21	69	15	49%
AVERAGE	***58***	***25***	***70***	***36***	***28%***

Network operators

	CCC	DIO	DSO	DPO	ROC%
AT&T	33	3	55	25	9%
BT Group	-34	2	32	69	12%
Deutsche Telekom	9	7	42	40	5%
France Telecom	-14	6	45	65	12%
Freenet	19	6	47	34	11%
TeliaSonera	17	5	45	32	14%
Verizon	34	6	44	16	9%
Vodafone	8	4	34	29	5%
AVERAGE	***9***	***5***	***43***	***39***	***10%***

IT Services

	CCC	DIO	DSO	DPO	ROC%
Accenture	27	0	43	16	55%
AtosOrigin	41	0	77	36	3%
Capgemini	27	0	64	37	8%
ComputaCenter	50	14	69	33	13%
Logica	52	0	74	21	6%
S&T	53	13	87	47	-10%
Tieto	58	0	73	16	10%
AVERAGE	***44***	***4***	***70***	***29***	***12%***

Software

	CCC	DIO	DSO	DPO	ROC%
Adobe	42	0	48	6	16%
Autodesk	46	0	59	13	20%
Microsoft	61	7	77	23	43%
Oracle	70	1	76	7	23%
RedHat	68	0	77	9	7%
Sage	40	2	64	26	16%
SAP	72	0	95	23	33%
AVERAGE	***57***	***1***	***71***	***15***	***23%***

Internet software

	CCC	DIO	DSO	DPO	ROC%
eBay	13	0	20	7	12%
Google	43	0	48	5	25%
United Internet	-15	4	26	45	40%
Yahoo	48	0	56	8	5%
AVERAGE	***22***	***1***	***37***	***16***	***20%***

The results show that some companies were able to achieve negative CCCs during the observation period: Dell (CCC = –11 days), Apple (–32 days) and Lenovo (–19 days), the network operators France Telecom (–14 days) and BT Group (–34 days), as well as the internet software and service company United Internet (–15 days). These companies deliver both services and physical goods. The results suggest that these companies are also profitable: these companies, excluding Lenovo, are the most profitable companies in their branches. A negative CCC, however, is not a requirement for good profitability. The negative CCC is rarely achieved and exceptional. According to this analysis, it could be seen as a working capital model.

5 Working capital models in the ICT industry

The results of the financial value chain analysis suggest that there are different working capital models existing in the ICT industry. In order to identify the working capital models applied by ICT companies, cluster analysis was used to divide companies into groups on the basis of the length of the DIO, DSO and DPO. Four clearly different groups, i.e., four different working capital models, were detected by applying K-means cluster analysis (non-hierarchical). The method requires determining the number of clusters beforehand, so the suitable number of clusters was tested iteratively by adding

and removing clusters, and the number of clusters was tested by measuring the difference between the clusters with ANOVA. As a result, four proved to be the most functional solution for the number of clusters. In addition, the clusters were tested with individual firm-year observations (305 observations) and with the averages of the companies (61 observations). No remarkable differences were found between the samples. The results of the analysis of the averages of the companies are reported in this paper. Figure 2 shows the final cluster centres. Table 3 presents the clusters, cluster names and characteristics for each cluster.

Figure 2 Cluster centres of four working capital management models (see online version for colours)

	Final cluster centres				*ANOVA*	
	Cluster					
	1	*2*	*3*	*4*	*F*	*Sig.*
DIO	53.6037	40.3665	10.6781	6.1535	52.736	0.000
DSO	106.2305	48.6606	36.7656	70.3427	49.806	0.000
DPO	80.8356	49.3074	34.0839	22.1033	18.391	0.000
n	4	18	19	20		

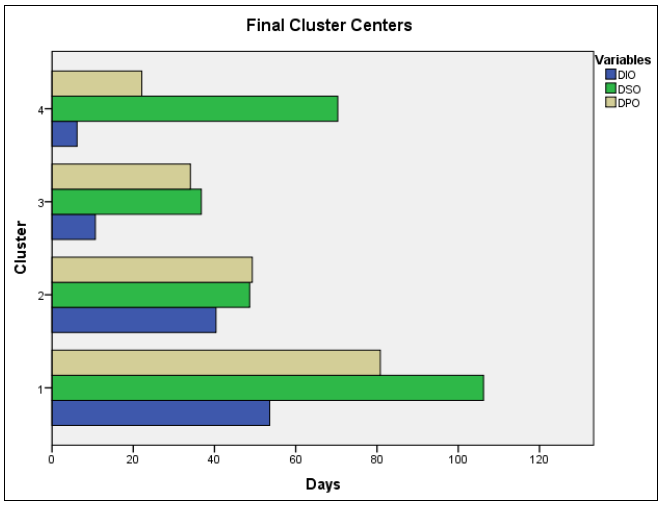


Table 3 Working capital models in the ICT industry

Cluster	*Name*	*Characteristics*
Cluster 1	Long cycle companies	Long DIO, DSO and DPO
Cluster 2	Inventory holders	DIO, DSO and DPO in balance DIO longer than in cluster 3 DSO longer than DPO
Cluster 3	Optimisers	Short CCC Short DIO DSO and DPO in balance
Cluster 4	Credit granters	DIO close to zero Long DSO

The first cluster is named 'long cycle companies', and it consists of only four companies with the longest DIO, DSO and DPO. The relatively long DIOs indicate that the companies carry large inventories. The companies may not have been able to manage their inventories efficiently, or perhaps their working capital models include gaining value by holding inventories. Long cycle companies grant generous credit terms, but also receive long payment terms from their suppliers. From the point of view of working capital management, there is potential to improve the efficiency of both the cycle time of inventory and the flow of money.

The second cluster consists of 'inventory holders'. The DIO, DSO and DPO are quite balanced in this cluster. The DIO is relatively long and clearly longer than in cluster 3. On the other hand, the DPO is longer than the DSO, meaning that these companies are in a position where the credit terms towards the customers are shorter than the credit terms given by the suppliers. This is quite unusual. This may indicate that the customers of this cluster compensate the holding of their inventories with fast payments.

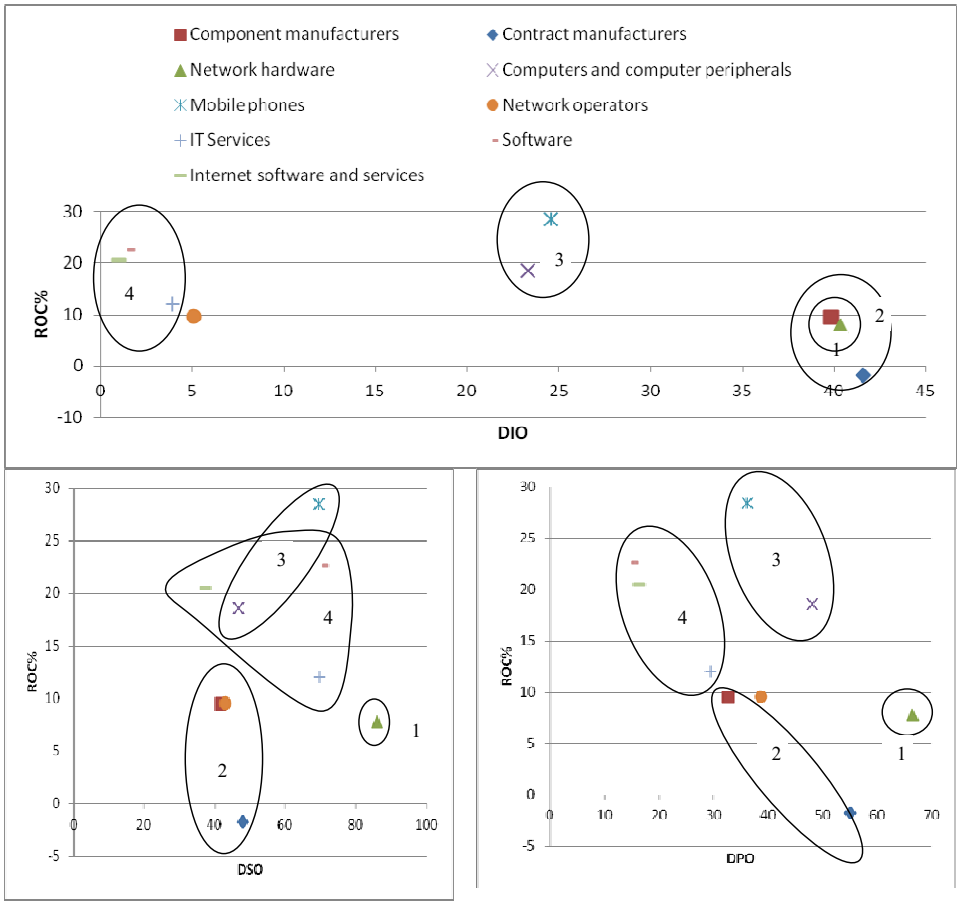
The third cluster is called 'optimisers'. The CCCs of the companies in this cluster are the shortest. This indicates that these companies manage their working capital efficiently. They have short DIOs, and the DSOs and DPOs are quite balanced. These companies may be the strongest players in the value network or they may possess negotiation power with which they have gained a good position in a value network. In this cluster, some companies are able to operate with a negative cycle time of working capital.

The companies in the fourth cluster are called 'credit granters'. These companies are typically service-oriented firms where the business does not require inventories and the DIO is zero (or close to zero). These companies have long DSOs, however. Again, this may be part of a planned strategy to give generous credit terms, or these companies may have forgotten the management of working capital as capital is not tied up in inventories, and probably also the investments on fixed assets are relatively small, giving the companies light balance sheets.

Appendix 1 shows to which cluster the companies of the study belong. Next, the clusters are connected to the branches by observing the average DIOs, DSOs and DPOs of the branches. In Figure 3, the average cycle times of the branches are presented in a scatter chart with profitability (ROC%). In addition, the clusters are outlined and numbered in the same charts. This offers an opportunity to observe the typical working capital models of the branches and to indicate the profitability of each model. It can be seen that each branch has a typical working capital model which dominates within the branch, but it should be noted that not all companies in the same branch belong to the same cluster. Appendix 2 shows the average cycle times of the sample companies in a chart similar to Figure 3.

In Figure 3, the averages of network hardware represent the working capital model 1 (cluster 1) with long cycle times quite well. Especially in the DSO and DPO charts, the network hardware stands out clearly by having the longest DSO and DPO on average. Inventory holders (cluster 2) can be found among contract manufacturers and component manufacturers. The difference between the first two working capital models can be seen in the chart of DIO, where the inventory holders and long cycle companies stand out with a relatively long DIO in comparison to the optimisers and credit granters. These branches produce physical products and operate as suppliers mainly in the business-to-business markets, and are dependent on the performance of their customer branches.

Figure 3 Four clusters and the average cycle times of branches (see online version for colours)



Notes: 1 = long cycle companies, 2 = inventory holders,
3 = optimisers, 4 = credit granters.

The branches mobile phones and computers and computer peripherals can be seen as representatives of optimisers (cluster 3). The branches are manufactures of the core products of the industry. They operate on the customer interface and also have the best profitability. It seems that the original equipment manufacturers (OEMs), which belong to the branches of mobile phones and computer and computer peripherals, are able to operate with shorter cycle times than for example their suppliers. On the other hand, short cycle times may be more essential in the OEMs businesses, and contract manufacturers and component suppliers rely on models where they keep inventories for their customers. On average, however, the OEMs are more profitable measured by the return on capital employed. The lighter balance sheets of the OEMs may be one explanation for this.

The service branches, IT services, internet software and services, and software, clearly belong to the fourth cluster credit granters. These companies have no inventories, but they do have working capital, as the average DSO is quite long, although there is great variation in this. These companies operate mainly in B-to-B markets, where the payment terms are more of a negotiation issue.

An outlier in the branch analysis is network operators, which have on average relatively short DSOs, average DPOs and short DIOs. This way they have adopted working capital model 3 with very short inventories and working capital model 2 with a favourable DSO and DPO, and thus the network operators can achieve even negative CCCs. The network operators have the shortest CCC on average (Figure 1), and some companies have achieved a negative CCC (BT Group and France Telecom). The network operators, which clearly have most B-to-C business in the value network and apply established payment practices with consumers, have the shortest DSO. The cash flow is stable because of monthly payments from consumers.

In addition to the BT Group and France Telecom, some other companies which have gained a negative CCC (Apple, Dell, Lenovo, United Internet) operate differently from the branch they belong to. It can be seen that these companies are able to operate differently, i.e., more efficiently in some sectors of working capital than their branch on average. On the other hand, the management of each working capital component must be efficient in order to achieve a negative CCC. The explaining factors for the negative CCC are partially common for all the six companies. The key to the negative CCC is the short DIO: the companies have a low level of inventories. In service companies this is not an issue, but manufacturing companies need to be able to operate with a short cycle time of inventories. In the case of Apple, Dell and Lenovo, the short DIO can be partially explained by outsourced production: the inventory of these companies is carried by their outsourcing partners. According to Apple (2011), outsourcing partners produce practically all its assembled products. Beside a short DIO, the common factor of the negative working capital companies is a long cycle time of accounts payable. For these companies, the DPO is longer than the average DPO of the branch they operate in.

Figure 3 shows that cluster 3, optimisers, and cluster 4, credit granters, have the best profitability and have been able to operate with shorter cycle times in comparison to clusters 1 and 2. On the other hand, relative profitability is highly dependent on the amount of total assets, which is often due to short DIO. It is only natural that companies with fixed assets investments have also lower return on capital employed. The analysis also reveals that companies at the beginning of the value chain, upstream and in B-to-B business, operate with longer cycle times of working capital.

6 Discussions

The companies in the ICT industry have a variety of end products and customers, and their targets and business models differ remarkably. According to this study, the results of the financial value chain analysis indicated that different working capital models inside the business model can be detected. The results of the cluster analysis show that business branches have a typical working capital model which is used by most of the companies in the same branch. This was also observed by Farris and Hutchison (2002) in their study of the CCC in different industries. However, our study shows that even though there is a dominant working capital model within each branch, not all companies of the branch operate with the same working capital model. The companies may have made a conscious choice to use different strategies to manage working capital, or the desired working capital strategy cannot be used because of a weaker negotiation position in the network. It may also differ based on how much attention is paid to working capital management in different companies. As shown by previous studies (Lind et al., 2012; Viskari et al.,

2011), management of inventories plays a key part when aiming at a lower CCC. In the ICT industry, many companies operate with negligible inventories, but overall in the whole ICT supply chain, the cycle times of inventories remain relatively short in comparison to the pulp and paper (Viskari et al., 2011) and automotive (Lind et al., 2012) industries. This indicates that even in the branches, where raw materials are stored and physical goods are produced, inventories are managed in an effective manner. Also cluster 2, despite the name inventory holders, does not stand out by having a very long DIO when compared to the pulp and paper, automotive and ICT industries. Therefore the ICT industry could provide a good benchmark for the value chains in other industries in terms of inventory management. However, the study showed that a short DIO is not a guarantee for a short CCC in the ICT industry. It should be noted that managing all three working capital components is essential to achieving the best results.

The analysis of clusters and companies with negative working capital suggests that negative working capital can be achieved by operating differently from competitors. In other words, competitive advantage can be based on an innovative working capital model. According to this analysis, efficient inventory management is necessary for manufacturing companies when aiming at a negative CCC. Service-oriented companies with consumer customers can achieve a negative cycle time of working capital if they pay attention to their flows of accounts receivable and payable. In addition, large, powerful companies can achieve a short or even negative cycle time of working capital, but the question is whether they operate at the expense of their suppliers by offloading their inventories to the suppliers and by requiring longer payment times.

A short, even negative CCC improves the performance of the company itself. The company benefits from the situation where no working capital is tied up in its operations, but how does this affect the other companies in the supply chain? A company's achievement of a negative cycle time of working capital cannot unambiguously be seen as a positive thing when viewing the situation from a wider perspective. A negative CCC of one company may improve the performance of other actors as well, for example when managing inventories effectively (Hofmann and Kotzab, 2010). Payment term adjustments at the expense of suppliers and customers, in turn, harm the partners.

This study is the first attempt towards identifying different working capital models on the supply chain level. The working capital model of a company depends on several actors, such as its position in the supply chain, and bargaining power and relationships with suppliers and customers. Companies also have different needs for inventories depending on their end products and production technologies. All companies in the chain cannot act with similar working capital model and, according to the findings by Viskari et al. (2012c), it is not even beneficial for all companies to aim at shorter cycle times of working capital. Identifying different working capital models is essential when aiming at optimising the working capital management of the supply chain in order to add competitive advantage in the tightening competition, which no longer only exists between the companies but also between the supply chains.

7 Conclusions

This study has concerned working capital models in the ICT industry. First, the cycle times of working capital were examined during the observation period of 2006–2010. The results of the financial value chain analysis showed that the average CCC of the ICT

industry was 40 days, which is clearly shorter than the averages in the previously studied pulp and paper (Viskari et al., 2011) and automotive (Lind et al., 2012) industries. In many branches of the ICT industry, the inventories were very small, but this did not necessarily lead to a short cycle time of working capital. The companies within the same branch had remarkable differences in their cycle times of working capital management, which indicated that the companies use different strategies or models for working capital management.

Cluster analysis was used to detect different working capital models in the ICT industry, and four clusters were identified. Long cycle companies (cluster 1) operate with long DIOs, DSOs and DPOs. This cluster contained only four companies, however. Inventory holders (cluster 2) have a long DIO, but they manage their financial flows efficiently and have a DPO longer than the DSO. Optimisers (cluster 3) operate with the shortest cycle times. They are leaders of the value chain with efficient working capital management. Credit granters (cluster 4) are service-oriented companies with near zero inventories. Even if the DIO is near zero, the CCC is not the shortest due to a relatively long DSO.

Six companies were able to operate with a negative cycle time of working capital. They did it with a short DIO and long DPO. The negative working capital companies were either service-oriented companies which also had relatively short DSOs or companies with efficient inventory management enabling a fast cycle time. The common factor for all the companies with negative working capital was a long cycle time of accounts payable.

The data used in the study was collected from public sources, which limited the amount of available information. At the time of data collection, there were many joint ventures in the ICT industry, such as Nokia Siemens Networks or Sony-Ericsson, which could not be analysed as their financial figures are not published separately. To conduct a deeper analysis of the companies in the ICT industry, more detailed information should be gathered for example by interviews, in addition to collecting material from financial statements.

This paper is the first initiative toward detecting the working capital models of companies. There is still very little knowledge on how explicative the different models are. Can we find similar models in different industries? It is known that, in general, operating with an efficient working capital model with a short CCC is the most favourable strategy, but is it always so? Can benefits be found in other models as well? The results of the study suggest that certain companies manage their working capital and benefit from the advantages of a negative CCC at the expense of the other value chain partners. In the future, it would be interesting to examine the relationships between companies from the perspective of working capital management. How much collaboration is there between companies in working capital management and can a win-win situation be found? The impact of the overall business model on working capital management is also a non-researched area.

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Publication IV

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Working Capital Models: Avenues for Financial Innovations

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Abstract: Business models consist of different pillars or sub-models. Business models have been mostly discussed in the context of new technology development and innovations management, but in this study we take the perspective of operations efficiency as a key pillar of a business model. The study concentrates on operational working capital models as one sub-model inside the whole business model. We have detected four different working capital models used in the value chain of the automotive industry: successful optimizing, inventory holding, aim at minimum, and credit granting. Our statistical analyses show that companies which use a successful optimization model are also the most profitable. However, different models could be better acknowledged when managing working capital value chain -wide or when developing new financial innovations for working capital finance.

Keywords: business model, working capital model, financial innovation, value chain

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1 Introduction

Mullins and Komisar (2009) define a business model as the economic underpinning of the business of a company that can be divided into smaller entities: revenue model, gross margin model, operating model, working capital model and investment model. This paper concentrates on working capital models. The competitive advantage of a new business model is based on managing processes that support flexibility and unique relationships with value chain partners and stakeholders (Walters, 2004). Business models have been mostly discussed in the context of new technology development and innovations management (e.g. Chesbrough, 2010; Järvi et al., 2010). In this paper, we take the perspective of operations efficiency as a source of innovative business models and observe working capital models in the value chain context. The aim of the paper is to detect different working capital models used in the value chain of the automotive industry and to connect working capital models to the profitability of companies.

Working capital is an investment. It appears in the balance sheet of a company as inventories, accounts receivables and accounts payable. The first two components need to be financed, as capital is tied up into the operating cycle before money is received from the customer, and the latter one reduces the need of (external) finance, as the supplier gives trade credit and purchases do not have to be paid in advance or immediately after the material/service has been received. Efficient working capital management has been highlighted with the conclusion that companies should aim for the lowest level of working capital (inventories and accounts receivable) possible to free capital (e.g. Deloof, 2003; Farris and Hutschison, 2002; Mullins, 2009), use trade credit as a source of finance (e.g. Kestens et al., 2012; Niskanen and Niskanen, 2006), and be able to respond to market changes flexibly (Walters, 2004). Mullins and Komisar (2009) argue that operating with a negative working capital is a holy grail of business and enables fast market entry as well as rapid growth, and can thus be the cornerstone of an innovative business model.

On the other hand, all working capital cannot just be reduced. Inventories are needed because of demand uncertainties, trade credit granted is business as usual, and its abandonment may decrease sales. In the value chain context, a company aiming at reducing its working capital may harm the partners in the supply chain, and in the end of the day it may harm the company itself. Some scholars have argued that working capital should be managed in collaboration with the value chain partners (e.g. Hofmann and Kotzab, 2010). It has been also shown that in the value chain context, companies can have different successful working capital management strategies (Viskari et al., 2012). The different working capital models in a value chain should be taken into account more explicitly to increase the value of the value chain partners. On the other hand, inter-organizational working capital management offers new opportunities for financial service providers (e.g. banks) to create innovative financial solutions and financial instruments for working capital finance to supply chains.

However, little is still known about successful working capital management models, especially in the inter-organizational value chain context. In this paper, the issue of working capital models and their success is discussed as a part of a business model. As efficient working capital management can create competitive advantage for a company, it can constitute a core in the company's business model, and it should also be discussed in the

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context of the business model. In this paper, we use the data of financial statements of companies belonging to the value chain of the automotive industry, and answer the following research questions with statistical methods:

1. *Do companies have different working capital models in the value chain of the automotive industry?*

2. *Is there a difference in profitability between companies using different working capital models?*

This study contributes to the research of business models and financial supply chain management. The research of business models has been versatile. This paper extends the knowledge of different aspects of business models further and directs its focus on one part of the business model – the working capital model, which is a more operational element of the business model entity and has not been studied widely. In addition, the literature of working capital management in the inter-organizational supply chain context is scarce. By analyzing the data of a value chain, the study contributes to the literature of financial supply chain management. This paper offers a practical contribution to financial innovations. Even though the paper takes the view of working capital as an asset, it should be remembered that the other side of the coin is the view of working capital as an investment that needs to be financed. This paper offers ideas for financial service providers to create innovative solutions for working capital financing.

The paper is structured as follows. After the introduction, section 2 reviews the literature on business models and working capital management and connects business model innovations and working capital models. Section 3 introduces the design of our statistical study and section 4 the results. Section 5 discusses the results from the perspective of financial service providers. Section 6 concludes the paper.

2 Literature review

Business model research is versatile, and there are various definitions for business models. Nenonen and Storbacka (2010) have studied the definitions of business models and found five dimensions that are usually included in a business model in the academic literate by using different expressions: customer value creation, earning logic, value network, resources and capabilities, and strategic decisions. Nenonen and Storbacka (2010) conceptualized the business model into four dimensions: market, offering, operations, and management. Mullins and Komisar (2009) divide the business model into five sub-models: revenue model, gross margin model, operating model, working capital model and investment model. This definition of the business model is adopted in this paper, as the working capital model is under consideration.

Business model innovations are the fundamentally different models to configure business (Markides, 2006; Eppler et al., 2011). A business model innovation does not necessarily contain a new product or service. However, the research of business models has concentrated on new product and service development. Although the previous research has been conducted

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partly from the perspective of processes, for example by highlighting open innovation as an innovative business model to utilize firms' resources in new product development (Chesbrough, 2010), taking account of the network partners in value creation (Järvi et al., 2010; Pynnönen et al. 2012), investments and operations, i.e. working capital management or asset management as part of business models have been studied very little.

Efficient working capital management can be the basis of an innovative business model and competitive advantage (Mullins, 2009). Koen et al. (2011) argue that companies are successful in business model innovation when it comes to new technology, but innovations based on a value network and financial hurtle are more challenging. According to Koen et al., low-cost business models based on lower hurdle rates than those of competitors are challenging. An efficient working capital model may offer an opportunity to low costs and lower than industry-average hurdle rates.

In recent years, operational working capital management consisting of inventories, accounts receivable and accounts payable have been raised up in supply chain management, as it has been argued that the efficiency of financial flows should also be taken into account, not just the physical flow of goods (Gupta and Dutta, 2011; Protopappa-Sieke and Seifert, 2011). Some studies have examined working capital in the inter-organizational value chain context (e.g. Grosse-Ruyken et al., 2011; Hofmann and Kotzab, 2010; Randall and Farris, 2009; Viskari et al., 2012), and emphasized the value creation opportunities in collaborative working capital management. The basic argument of these studies has been that a value chain and the partners within it would benefit if working capital was not sub-optimized by an individual company, but the working capital management actions were planned through the value chain.

Nenonen and Storbacka (2010) argue that no business model is superior per se, but the financially superior model depends on the firm and its customers. The same can be concluded regarding working capital models. Not all companies in the value chain can operate with a negative working capital, even though it has been argued that efficient working capital management with short cycle times of inventories and accounts receivable and extended cycle time of accounts payable is the best working capital model (Mullins, 2009). Even though the superiority of operating with negative working capital has been acknowledged, working capital models in a value chain have not been examined or defined explicitly. In addition, negative working capital is hard or even impossible to achieve in manufacturing industries, which the automotive industry belongs to.

3 Research design

The approach of this study can be defined as archival and empirical. We have used statistical analysis in this quantitative study. Statistical K-Means cluster analysis has been conducted to detect different working capital models. In addition, statistical tests have been performed to test the statistical differences of profitability between clusters.

The financial statement data of the value chain of the automotive industry during 2006-2009 forms the empirical data for this study. The final research sample consists of 57 companies

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and 222 firm-year observations. The data has been gathered from the annual reports of international companies belonging to the value chain of the automotive industry. Nonprobability sampling has been used. The sample has been formed with the best knowledge available and according to the availability of data, in collaboration with practitioners working in the value chain.

Figure 1 shows the structure of the value chain of the automotive industry consisting of six levels, and the number of firms at each level. The raw material suppliers include companies in the oil and iron ore industries. The refined raw material suppliers are plastic, rubber, steel and metal producers. After the raw material levels, there are component suppliers which supply plastic, rubber, steel and metal components to the system suppliers that assemble larger blocs for the car manufacturers that assemble the final product. The last level is the car dealers that operate between the car manufacturers and the end customer. The companies belonging to the sample represent typical companies operating on these levels. Figure 3 shows the companies included in the research sample.

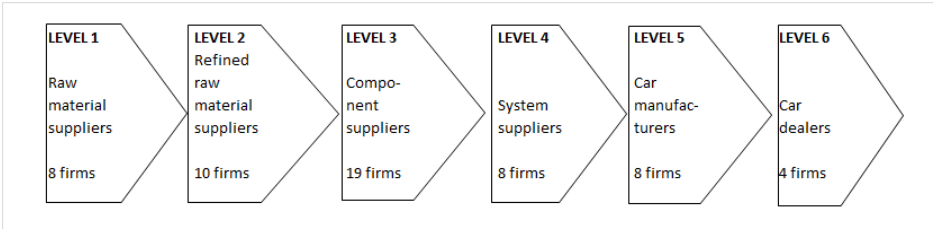

Figure 1. Structure of the value chain of the automotive industry in this paper

Working capital models are defined with three determinants representing the components of working capital management. Working capital management is typically observed through cycle times, i.e. how many days the capital is tied up into the company (e.g. Deloof, 2003; Farris and Hutschison, 2002;Hofmann and Kotzab, 2010). The cycle time approach is also adopted in this paper, and working capital models have been determined by the cycle time of inventories (DIO), the cycle time of accounts receivable (DSO) and the cycle time of accounts payable (DPO). Together the components constitute the cycle time of working capital management (cash conversion cycle, CCC), which can be defined as DIO + DSO – DPO. Table 1 shows the determinants of the working capital model, as well as the definition of relative profitably also observed in this study.

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Table 1. Determinants of the working capital model

Variable	*Component*	*Definition*
DIO	Cycle time of inventories	DIO = (Inventories/Sales)*365
DSO	Cycle time of accounts receivable	DSO = (Accounts receivable/Sales)*365
DPO	Cycle time of accounts payable	DPO = (Accounts payable/Sales)*365
ROC%	Return on capital employed	ROC% = EBIT/((Equity$_t$+Equity$_{t-1}$)+ (Long term liabilities$_t$+Long term liabilities$_{t-1}$))/2

4 Working capital models in the value chain of the automotive industry

Cluster analysis was used to find the different working capital models in the value chain of the automotive industry. Four different clusters were detected. The results of the cluster analysis are shown in figure 2. The average CCC of clusters is also calculated. The correct number of clusters was tested iteratively by adding and removing clusters and testing the statistical differences of the variables (DIO, DSO and DPO) between the clusters. The statistical difference was tested with the Kruskal-Wallis test (the results are shown in figure 2). Nonparametric Kruskal-Wallis was used, as the research variables were not normally distributed. The tests showed that there was a statistically significant (at level of 0.01) difference between the clusters in the DIO and DSO, but the DPO did not differ statistically significantly between the clusters. This indicates that different working capital models do exists in the value chain of the automotive industry, but the models differ in the management of inventories and accounts receivable, while the cycle time of accounts payable is quite similar in all the working capital models.

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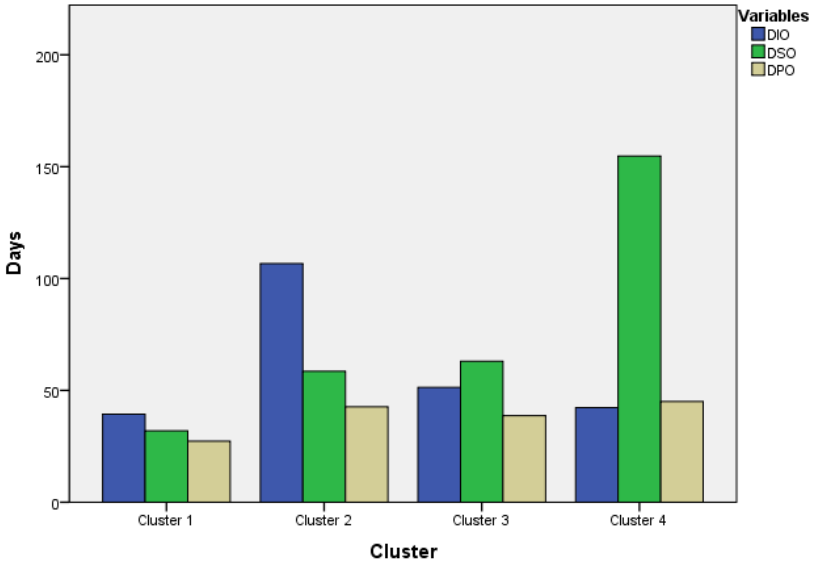

	Final cluster centers				*Kruskal-Wallis*
	Cluster 1	*Cluster 2*	*Cluster 3*	*Cluster 4*	*Chi-Square/Sig.*
DIO	39.4	106.7	51.3	42.2	42.094/0.000
DSO	32.0	58.5	63.0	154.7	63.364/0.000
DPO	27.3	42.7	38.7	45.0	2.338/0.311
Number of cases in each cluster	73	15	122	12	
Average CCC	44	123	76	152	

Figure 2. Final cluster centers and the result of the Kruskal-Wallis test

Cluster 1 is called the "*Successful minimizing model*". The working capital model of this cluster is based on the efficient management of all the components of working capital. The cycle time of each component is relatively short. Especially the financial trade flows (DSO and DPO) are optimized when they are shorter than the DIO and almost in balance. The second cluster is called the "*Inventory holding model*". The model is based on owning large inventories, but the DSO is tolerable and the shortest after the successful minimizers. The third model is typical for the studied value chain. It has been interpreted to be the model of companies that aim at short cycle times, but have not succeeded like the companies in cluster 1. The model is called the "*Aiming-at-minimum model*". The DSO of the companies in this cluster is longer than the DIO and there is a relatively long gap between the DSO and the DPO. The fourth cluster is called the "*Credit granting model*". Like the inventory holders, also this group has an unusual working capital model, in this case because of the long DSO.

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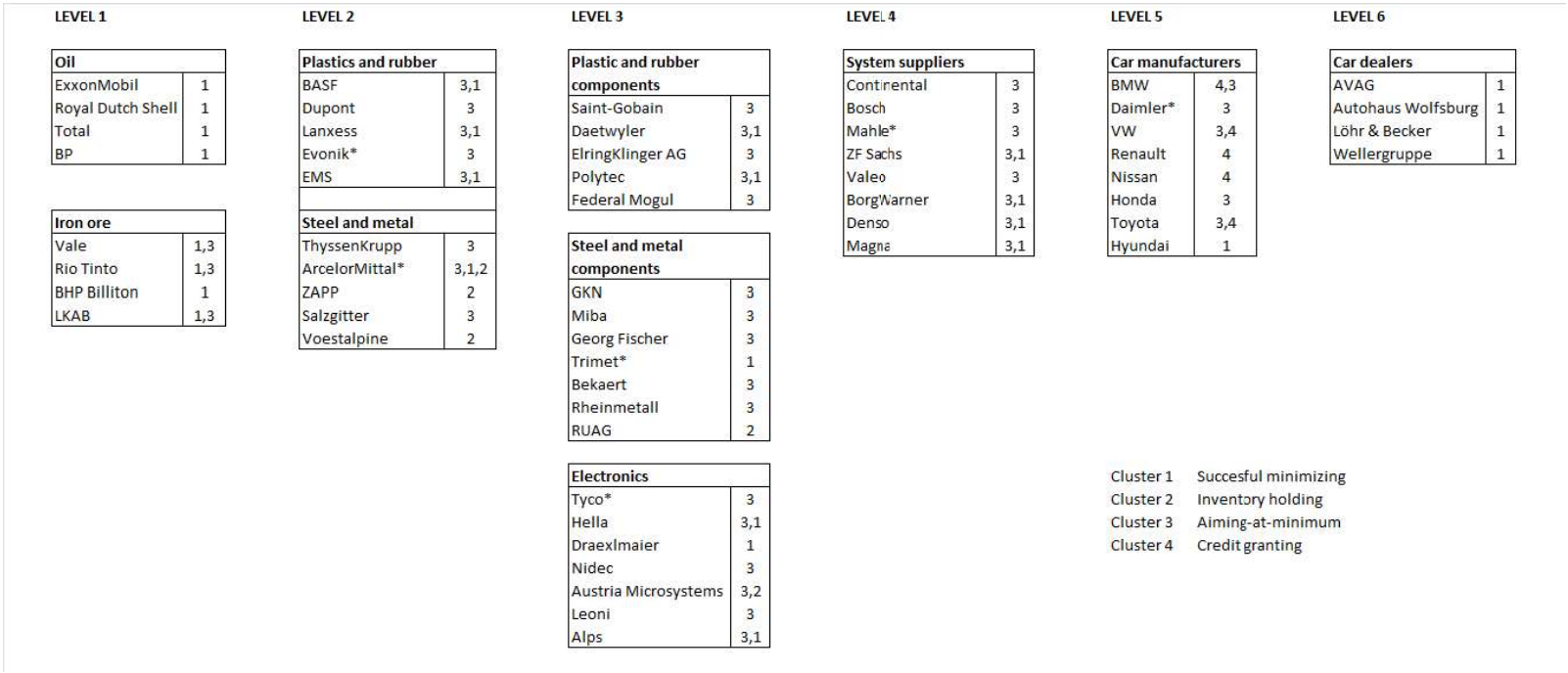
The model is based on generous credit terms granted to the customers. Even though the inventories are at a relatively low level, the long trade credit period increases the average CCC, which is clearly the longest in this model.

Figure 3 shows how the working capital models are used in the value chain of the automotive industry. It should be noted that some companies belonged to more than one cluster during the observation period, but the changing of cluster was not common. About one third of the companies belonged to more than one cluster, and typically the change occurred between clusters 1 and 3, which supports the interpretation that model 3 and 1 can be achieved by similar companies. The aim of all the companies in clusters 1 and 3 is to minimize their working capital, but only some companies have accomplished that. There is a certain typical working capital model on every level of the value chain. According to this study, the working capital model depends on the position of the company in the value chain.

In the value chain of the automotive industry, the companies in the very beginning and the end of the chain are successful optimizers. The oil and iron ore companies are suppliers for several industries, not just the automotive industry. It can also be argued that the oil companies do not necessarily belong to the upstream of the value chain, but as suppliers of fuel are as near to the end customer as the car dealers, which base their business on a fast operating cycle. There are not many inventory holders in the value chain. More typical is the aim at low inventory levels. However, some refined raw material suppliers hold large inventories. This may be due to the fact that it is cheaper to have stocks in the upstream where the production costs are not committed to the product yet.

The aiming-at-minimum model is the most popular working capital model in the middle of the value chain. More accurate demand forecasts may fasten the cycle time of inventories, but the relatively long DSO indicates that the companies do not have very strong negotiation power as they give relative long trade credit to their customers compared to the payment time they receive from their suppliers. This means that the flow of money is still inefficient and the companies have to invest in working capital. Many car manufacturers have leasing business and they are credit granters. This affects the level of working capital but is profitable, since many car manufacturers are willing to operate with this unusual working capital model.



Note: * indicates that the figures for 2006 are missing

Figure 3. The clusters of the sample companies

The Kruskal-Wallis test was conducted again to test whether the relative profitability differed between the clusters. The result of the test showed that the ROC% differed statistically significantly. Pairwise comparisons between the individual clusters were conducted next, to study which clusters differed in profitability. The results of Mann-Whitney tests (p-values) are shown in table 2 together with the average ROC%s of the clusters. The results indicate that the profitability of the successful optimizers is statistically significantly better than the profitability of the other clusters. The average ROC% of the cluster 1 is 22 %, whereas the average profitability of the other clusters is under 10 %.

Table 2. Average ROC% in the clusters and the results of Mann-Whitney tests (pairwise comparisons)

ROC%	*Cluster 1*	*Cluster 2*	*Cluster 3*	*Cluster 4*
Means	21.8 %	8.75 %	9.2 %	2.9 %
Pairwise comparisons of difference (Mann-Whitney)				
Cluster 1		0.012*	0.000*	0.000*
Cluster 2			0.831	0.118
Cluster 3				0.02*

The argument rising from this analysis is that companies have different working capital models, which also means that they have different needs of working capital financing. Working capital can be reduced by collaborating on a certain level, for example by sharing more detailed demand information. However, innovative finance solutions are still needed as all working capital cannot be reduced in the value chains.

5 Discussion: opportunities of working capital financing innovations

This discussion adopts the perspective of financial service providers and reviews the results in the light of financial innovation opportunities. Our results suggest that there are business opportunities in inventory and accounts receivable financing, which would decrease the cycle times and shift companies towards the successful optimizing model.
Optimizing is the most desired working capital model. This study shows that successful optimizers have the best profitability, differing statistically significantly from the other clusters operating with different working capital models. This study also indicates that most of the companies aim at the successful minimizing model, which means operating with as short a cycle time of working capital (as short DIO and DSO) as possible. Financial service providers with solutions such as inventory financing, factoring and risk management methods could have a key role when companies aim at lightening their working capital burden.

When working capital is still needed, and some companies even benefit of having it, instead of radical reductions of working capital, the other solution is to find innovative financing solutions which could be value chain -wide. There has been discussion on working capital finance for a single company in the academic literature (Badachi et al., 2012). Relatively little attention has been paid to the financing solutions in the value chain context, and value chain -wide financing solutions are rare, even though it has been stated that the optimization of working capital should be planned in collaboration in the value chain (Hofmann and Kotzab, 2010; Grosse-Ruyken et al, 2012). Hofmann and Belin (2011) introduce the huge market potential which supply chain finance solutions

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may have. They also list some large corporations offering financing services to their value network partners (e.g. IBM Global Financing and Siemens Financial Services) and financial service providers offering supply chain finance (e.g. Bolero and Prime Revenue).

Working capital can be financed either by long-term or short-term debt. According to the accepted theory, only the permanent portion of working should be financed by long-term financing (Gitman, 2000). The size of the permanent portion depends on the working capital model and the position of the company in the value chain. Financial service providers can take this into account when developing new financial solutions. Especially for SMEs, acquiring finance from formal sources is problematic, and informal procedures, such as payment delays, are used to finance working capital (Padachi et al, 2012). Different working capital models can be also taken into account within the value chain, and a strong player can act as the financier of working capital for the whole value chain. This could benefit the other partners in that they would not have to acquire expensive finance, but also the financier could benefit from the additional business. In the value chain of the automotive industry, the car manufacturers already offer financial services to their customers. They may be willing to offer finance also to their suppliers. In the other extreme are the refined raw material suppliers, who possess large inventories. They may be willing to acquire finance from their value chain partner instead of using external service providers. Randall and Farris (2009) show in their article a numerical example of how the partners of a dyad supply chain can benefit from this kind of arrangements.

6 Conclusions

This paper has studied working capital models in the value chain of the automotive industry. We have adopted the view of the working capital model as a part of the business model of Mullins and Komisar (2009), and argue that a working capital model can be a source of competitive advantage similarly to any other parts of the business model.

Four statistically significantly working capital models were found with cluster analysis: the Successful minimizing model in which all the cycle times of working capital management (DIO, DSO and DPO) were relatively short, the Inventory holding model in which the cycle time of inventories was a long, but compensated with a relatively short cycle time of accounts receivable, the Aiming-at-minimum model in which the cycle times were somewhat longer than in the Successful minimizing model, and the Credit granting model in which the cycle time of accounts receivable was significantly longer that the cycle time of inventories. The companies operating with the successful minimizing model were the most profitable ones. Our analyses showed that the different levels of the value chain have a typical working capital model. In addition, the working capital model may vary yearly. However, the typical variance was between successful minimizing and aiming at the minimum, which indicates that most of the companies prefer shorter cycle times of working capital, but the success of achieving them varies.

Even though this paper has taken the perspective of working capital as an asset, it should be remembered that working capital can also be seen as an investment that needs to be financed. The practical implications of this study are directed towards financial service providers. The main finding of this paper is that companies utilize different working capital models, which also means that they have different needs of working capital

financing. The most desired model in the light of the profitability analysis is successful minimizing. New financing solutions for working capital are needed, as working capital cannot be reduced totally in the value chain. Innovative finance solutions can be found inside a value chain when the partners of the value chain take the role of a financier, but also financial service providers outside the value chain have business opportunities in working capital finance.

It should be noted that only operational working capital has been considered in this paper. Although the financing need concerns all current assets, including cash and other financial items of the current assets. In addition, the study has been restricted to the value chain of the automotive industry. In the future, it would be interesting to consider larger and different contexts. Studies of the innovative financial solutions for working capital from the perspective of a financial service provider are one interesting avenue for future research as well.

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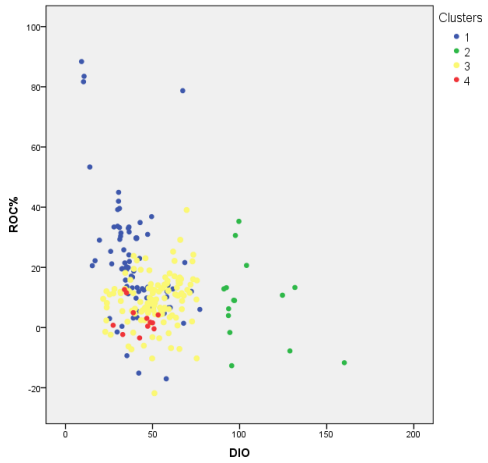
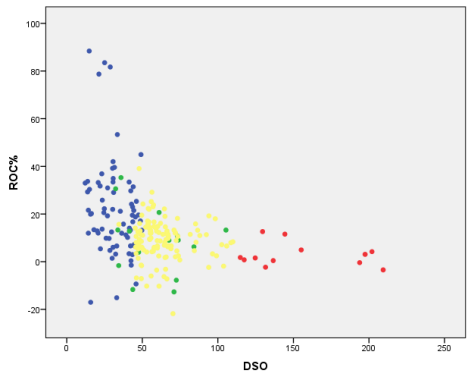
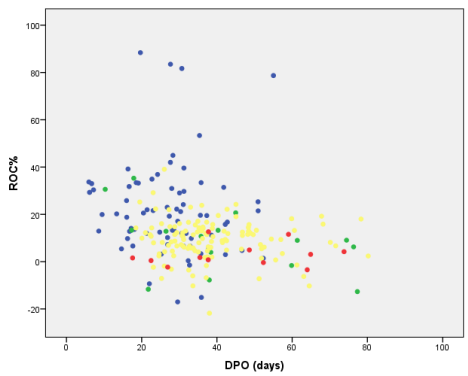
Appendix. Scatters of observations according to the research variables







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Mapping working capital models in the automotive industry

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Mapping working capital models in the automotive industry

Abstract

Purpose: The purpose of this study is to analyze the working capital models applied by companies in the automotive industry. The paper contributes to the emerging research stream of financial supply chain management and provides support for improving inter-organizational working capital management.

Design/Methodology/Approach: Financial value chain analysis is used as a research method. The data for the observation period 2006–2015 has been collected by analyzing the financial statements of 41 companies operating in the value chain of the automotive industry.

Findings: The paper introduces a WCM matrix which combines the two sides of working capital: inventory management and trade credit. The matrix can be used for identifying working capital models in the value chains. The results showed that different working capital models are applied within the value chain stages. The analysis of the cycle times revealed that two thirds of the companies reduced their working capital during the observation period.

Research limitations: The availability of the data affected the size of the sample: some companies were excluded from the study due to missing or incomplete public data.

Practical implications: The WCM matrix complements the financial value chain analysis in positioning the companies in the preferred context by their working capital management and shows how the working capital of companies is formed.

Originality/value: The paper is based on an extensive set of real-life financial figures and offers new insights for studying working capital models in the value chains.

Keywords: working capital management, financial supply chain management, automotive industry, cash conversion cycle

Introduction

Research on working capital management (WCM) has been segmented in the different traditions of management literature: finance literature focused on trade credit, whereas supply chain management literature focused on inventory management. In recent years, the research stream of financial supply chain management has gained increasing interest. The aim of financial supply chain management is to optimize the planning, management and control of cash flows in a supply chain so that efficient material flows in a supply chain are supported (Wuttke et al., 2013). Lately, a more holistic perspective of a supply chain instead of a single company has also been applied by many researchers in their studies on working capital management (e.g. Hofmann and Kotzab, 2010; Brandenburg, 2016). Researchers have highlighted that companies should understand the structures of and positions in the value chains related to working capital management (Grosse-Ruyken et al., 2011; Wuttke et al., 2013). Mullins and Komisar (2009) raise the working capital model of a company as an important element of the business model. However, even if the importance of understanding working capital management from the broader perspective of the value chain has been recognized, previous research on working capital management and financial supply chain management lacks the studies related to

the classification of different working capital models in the value chain context. In this paper, we aim to fill this gap by introducing a matrix for analyzing the structure and positions in the value chain in terms of working capital management and for studying the working capital management models holistically as a combination of inventory and trade credit management. The paper provides a new approach for observing working capital management in the value chains.

The importance of working capital management, consisting of the management of inventories, accounts receivable, and accounts payable, has been recognized in companies operating in the automotive industry. For example, Magna (2015) lists the improvement of working capital via inventory levels, lead times and material flow as one element of its operational principles, whereas Schaeffler Group (2012) thanked its sustainable working capital management for being able to control the increase in inventories while production was growing. In the upstream part of the value chain, ArcelorMittal (2012) highlights that its wide market reach helps in the optimization of working capital through efficient management of supply chain inventories. BMW (2011), in turn, emphasized stringent working capital management as a key element for managing the business, and Valeo's business is based on a financial model that enables operating on a negative working capital. This has become possible by closely integrating suppliers into the value chain. (Valeo, 2014) The past financial crisis and fewer opportunities for external financing made companies more interested in avoiding excessive working capital and releasing financial resources to more productive objectives.

Previous academic research has studied working capital management in the context of different industries. Filbeck and Kruger (2005) found that different industries have significant differences in working capital management. Lind et al. (2012) and Brandenburg (2016) focused on the automotive industry, and found evidence for the accelerated collection of receivables as well as the deteriorated working capital performance of car manufacturers. Pirttilä et al. (2014) did a comparison between the cycle times of working capital in three industries: automotive, ICT, and pulp and paper. They found that the cycle time of working capital differed mainly because of the differences in inventory management. The study of Viskari et al. (2012) showed that not all companies benefit from similar working capital management strategies, and the study of Lind et al. (2016) indicated that companies within the same value chain stages in the ICT industry had remarkable differences in their working capital management. Thus, more research on working capital management on a company level in the value chains is needed to add knowledge of different working capital management practices or working capital models applied by companies, and to make it easier to optimize the working capital of the value chain. This was the motivation for the paper: our aim is to study the different patterns of managing working capital applied by companies in the automotive industry.

In this paper, we study operational working capital management from two perspectives. First, we use financial value chain analysis, a systematic process for analyzing financial figures, for observing the cycle times of working capital in the value chain and its stages (Lind et al., 2012). Second, we introduce a WCM matrix which we constructed on the basis of the traditional dichotomy in working capital literature. The WCM matrix considers both sides of working capital management: the management of material flows (inventories) and financial flows (trade credit). The paper examines how companies in the value chain of the automotive industry are positioned in the matrix. The value chain of the automotive industry has been studied previously from the perspective of working capital and its components (Lind et al., 2012; Viskari et al., 2012), but in this paper the perspective is shifted towards working capital management strategies or models, examining the combinations of the management of financial and material flows. We apply the value chain perspective, but differing from the study by Lind et al. (2012), we also look inside the value chain stages, as it has been detected that all companies in the same value chain stage do not act similarly in regard to working capital management. The observation period covers the years 2006–2015, which gives an opportunity to

study the kind of changes companies have had in their working capital management during a 10-year time frame. The research questions of this paper are:

1) *How can the working capital models of companies be analyzed in the value chain?*
2) *How was working capital managed by the companies in the value chain of the automotive industry in 2006–2015?*

The rest of the paper is structured as follows. The literature review consists of previous literature on inventory management, trade credit and financial supply chain management. Then, we focus on the first research question and introduce our framework for analyzing the working capital models, the WCM matrix. This is followed by a research setting section. The results and analysis section introduces the findings of the research and answers the second research question. In the final section, the results of the study are discussed and concluded, and some future research suggestions and managerial implications are given.

Literature review

Earlier studies on working capital management took mainly the perspective of a single firm and looked for possibilities to improve working capital performance by either reducing inventories and accounts receivable or by increasing accounts payable. During the last decade, the concept of financial supply chain management has emerged, and it acknowledges the inventory financing costs together with the financial flows towards upstream and downstream (Protopappa-Sieke and Seifert, 2010; Wuttke et al., 2013). Research in the field of financial supply chain management has gained more interest, and many researchers have taken a holistic view on working capital management as well (e.g. Brandenburg, 2016; Grosse-Ruyken et al., 2011; Hofmann and Kotzab, 2010; Pirttilä et al., 2014; Viskari and Kärri, 2012). Studies have shown that collaborative inventory management or trade credit adjustments can improve the performance of the supply chain and, in fact, are already used in practice (Randall and Farris, 2009; Hofmann and Kotzab, 2010). Even if research in this area has increased, the literature has still been strongly divided into the finance-oriented perspective, focusing on short-term financial solutions provided by financial institutions, and the supply-chain-oriented perspective, focusing on working capital optimization, which has led to conflicting definitions, and general frameworks considering both aspects are still lacking (Gelsomino et al., 2016).

Research on working capital management has been divided into two different research streams in the past. Traditionally, literature on finance has concentrated on trade credit issues, liquidity and profitability (e.g. Charitou et al., 2010; Deloof, 2003;; Jose et al., 1996; Shin and Soenen, 1998), while supply chain management discussed efficient operations, including inventory management with management philosophies such as lean and just-in-time (Chen et al., 2005; Claycomb et al., 1999; Gunasekaran et al., 2001; Hofer et al., 2012; Johnson and Templar, 2011). In this paper, we take a holistic view on working capital consisting of inventory and trade credit. According to the definition by Lee and Rhee (2010), trade credit is a short-term business loan from supplier to buyer allowing payment time for the customer after the purchase. It is used for several reasons such as competitive and industry pressures, substituting or complementing bank credits, and reduction of transaction costs (Seifert and Seifert, 2008; Seifert et al., 2013).

Efficient working capital management has found to impact positively on profitability (e.g. Deloof, 2003), but also on the firm value by increasing free cash flow (Wasiuzzaman, 2015). Balakrishnan et al. (1996) studied the relation between different inventory types and profitability in manufacturing companies. They found that efficient inventory management was not associated with a superior return

on assets. Chen et al. (2005) found that abnormally high inventories lead to abnormally poor stock performance. The study of Capkun et al. (2009) considered different inventory types (raw material, work-in-progress and finished goods), and found significant positive correlation between inventory management and financial performance for firms in the manufacturing industries. Cannon (2008) presented opposite findings in his study of 244 firms over a 10-year observation period: he found that only little or no relationship exists between the improvements in inventory performance and overall financial performance. The findings by Eroglu and Hofer (2010) suggest that reducing inventories to a minimum may not be a suitable strategy for all companies depending on the products, production technologies and characteristics in the demand. The longitudinal study by Huff and Rogers (2015) showed that payment term adjustments only give short-term benefits, but improvements in inventory management offer longer-lasting advantages for a company. Similarly, Grosse-Ruyken et al. (2011) stated that by forcing supply chain partners to accept longer payment terms a firm can only achieve short-term success. In the value chain context, Lind et al. (2012) found that payment term adjustments offset each other, and sustainable reduction of working capital should be done via effective inventory management. Simulations by Viskari et al. (2012) showed that managing all working capital components simultaneously would be the most efficient way to improve profitability in the value chain of the automotive industry.

Companies seem to apply and also benefit from different working capital management models. Size and bargaining power may have an impact on the working capital model of the company. The study by Moss and Stine (1993) showed that smaller firms have significantly longer cycle times of working capital than larger ones. In the value chain of the automotive industry, the amount of tied-up working capital varied in the different parts of the chain: while refined raw material suppliers and component suppliers had long cycle times of working capital due to bigger inventories, raw material suppliers and system suppliers had managed their working capital more effectively (Lind et al., 2012). Car manufacturers, in turn, had the longest cycle times of working capital due to remarkably long cycle times of accounts receivable caused by their financing and leasing businesses. Even if several studies have found a negative relation between the cycle time of working capital and profitability (e.g. Shin and Soenen, 1998; Deloof 2003; García-Teruel and Martínez-Solano, 2007), the results by Viskari et al. (2012) showed that when studying this relation in the context of a value chain, it was not as straightforward: they found that all companies do not necessarily benefit from the shortening of the cycle time of working capital. In this respect, different working capital models have been studied surprisingly little. Previous research has recognized the need to optimize the working capital on the value chain level, but only a little attention has been paid to identifying different working capital models even if they would be a pre-requisite for successful working capital optimization of the value chain. Howorth and Westhead (2003) identified four types of working capital management routines in their study of UK small firms: companies focused either on 1) cash management, 2) inventory management, or 3) credit management, or 4) had no working capital management routines. This classification could be applied to larger firms as well, but it lacks the holistic view to working capital models which was also emphasized by Farris and Hutchison (2003). They argued that instead of managers directing the efforts at individually decreasing inventories, extending payables, or reducing receivables, a more preferable approach would be to find the unique combination of all three working capital variables. Belt and Smith (1991) categorized working capital management policies into four descriptive groups: Risk-avoiding, risk-accepting, situational, and changing over time. Meszek and Polewski (2006) divided working capital management strategies into three categories on the basis of the management of short-term liabilities and short-term assets: 1) aggressive (high level of short-term liabilities and low level of short-term assets) 2) conservative (low level of short-term liabilities and high level of short-term assets), and 3) moderate (between aggressive and conservative). Using the similar categorization, Baker et al. (2017) found that the majority (54.5%) of the studied Indian firms

used the moderate policy for working capital management, whereas the conservative (30.9%) and aggressive (14.5%) approaches were less popular.

Introducing the WCM matrix for analyzing working capital models

In order to classify the companies on the basis of their working capital management, we constructed the WCM matrix shown in Figure 1. Farris and Hutchison (2003) as well as Meszek and Polewski (2006) applied matrixes for categorizing working capital management strategies or models. The 2x2x2 matrix by Farris and Hutchison (2003) used all three working capital components as variables, and divided them into high/low categories by industry medians. Meszek and Polewski (2006), in turn, used shares of short-term liabilities and short-term assets to total assets as variables. In order to keep the matrix simple, we chose two variables: The Y-axis presents the cycle time of inventories (DIO), and the X-axis illustrates the net trade credit, i.e. the difference between the cycle times of accounts receivable and accounts payable (DSO-DPO), which has also been used by Nadiri (1969) and Lorentz et al. (2016) in their studies of trade credit. This variable combines the components of the financial flows. In case the DSO-DPO remainder is positive, i.e. the cycle time of accounts receivable is longer than the cycle time of accounts payable, the company's payment terms towards its customer are more generous than the payment terms towards the supplier. In case the DSO-DPO remainder is zero, the payment terms are the same towards both directions, and the company's working capital consists only of the inventory. In case the DSO-DPO remainder is negative, i.e. the cycle time of accounts payable is longer than the cycle time of accounts receivable, the company has negotiated longer payment terms towards the supplier than to its customer. The smaller the value of the remainder is, the less working capital is tied up in the company's financial flows and the shorter the time for which external financing is needed.

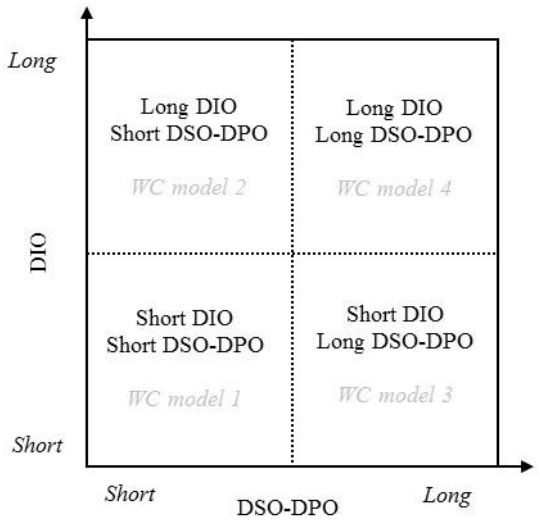


Figure 1. WCM matrix.

To highlight the importance of a holistic perspective to working capital management and to avoid the traditional separation of inventories and trade credit in working capital research, our aim was to show both the material (inventories) and financial flows (trade credit) of working capital in the same picture. In the results section, companies are located in the matrix on the basis of their working capital management. The WCM matrix shows, for example, which companies in the value chain hold inventories and which companies finance other value chain actors with trade credit. The matrix enables the observation of the working capital management performance of the companies in the value chain and shows their positions against each other.

The different categories of the matrix are numbered as WC models 1–4 to simplify the use of the matrix. Companies applying WC model 1 have managed their working capital most efficiently in the value chain: they have a short DIO, and beneficial payment terms. The DSO-DPO may even be negative. According to previous literature, WC model 1 is the most beneficial option for a single company. WC model 2 is similar in terms of financial flows, but in this category inventories are bigger. This may be due to the company's position in the value chain: usually, suppliers in the upstream part of the manufacturing chain hold more inventories than companies in the downstream, as it is cheaper to store raw material than finished goods. Also the length of the production process may cause the long DIO, as the inventories consist of three types of inventories: raw materials, work-in-progress, and finished goods. In WC models 3 and 4, payment terms towards customers are substantially more generous than payment terms towards suppliers. These companies can be seen financing customers with trade credit in the value chain. This may be due to weaker negotiation power in the value chain, but it can also be caused by a conscious choice due to the company's business model. WC models 3 and 4 differ from each other in terms of inventory management: in WC model 3, the inventories are smaller. Thus, companies applying WC model 4 are in the most difficult position in the value chain. They tie up more working capital than others by holding inventories and financing customers.

When using the WCM matrix, border values for working capital models can be set according to one's own preferences. In this study, different working capital models are outlined by the average figures of DIO and DSO-DPO of the sample. Averages were chosen as border values as it is a commonly accepted classification method in statistical analysis. Previous research has not defined certain values as "good" or "bad" DIO or DSO-DPO which could have been used as benchmark measures. Naturally, due to the use of average values in defining the categories, we can only evaluate the companies' working capital performance and positioning within this sample. It should be kept in mind that the shortness or length of the cycle times depends on the context, and a short DIO, for example, can mean a totally different number of days in different industries. Other alternatives for the border values could be e.g. medians or modes of the sample or industry statistics. Also target values could be defined and used to separate different working capital models.

Research setting

Method and measures

The research method used in this study follows the financial value chain analysis developed by Lind et al. (2012). In this study, working capital management is measured through cycle times. Cash Conversion Cycle (CCC) presents the number of days a firm has funds tied up in working capital (Richards and Laughlin, 1980). The advantage of the CCC is its suitability to measure both internal and external working capital management as it bridges the in- and outbound activities within and between the companies, and provides information that benefits finance as well as supply chain management (Farris and Hutchison, 2003). Table 1 shows the definitions of the working capital components used in this study. We follow the approach used by Shin and Soenen (1998) and Lind et

al. (2012) to use sales as a denominator to ensure the uniformity of the data of different companies when using public sources. Cost of goods sold (COGS) has been used instead of sales by Deloof (2003), Farris and Hutchison (2003) and Viskari and Kärri (2013), for example.

Table 1. Measures of working capital management

Variable	Description	Definition
DIO	Cycle time of inventories (days)	DIO = (Inventories/Sales)*365
DSO	Cycle time of accounts receivable (days)	DSO = (Accounts receivable/Sales)*365
DPO	Cycle time of accounts payable (days)	DPO = (Accounts payable/Sales)*365
DSO-DPO	Net trade credit	Net trade credit = DSO – DPO
CCC	Cycle time of working capital (days)	CCC = DIO + DSO – DPO

Data and limitations

The value chain of the study (Figure 2) illustrates the material supply in the automotive industry from raw material suppliers to end customers. The financial flow, in turn, goes upstream in the value chain. The structure and the companies of the value chain were formed by closely following the study of Lind et al. (2012), where working capital management in the value chain of the automotive industry was observed in the years 2006–2008. Our study extends this timeline to ten years by covering the period of 2006–2015, and offers a novel perspective to working capital by looking at the information in the introduced WCM matrix. Deviating from the study by Lind et al. (2012), the stage car dealers is not included in the sample. Unavailability of the data for the whole observation period and the regional nature of car dealers, in addition to the finding by Lind et al. (2012) that car manufacturers carry large amounts of accounts receivable caused by their leasing and financing businesses, supported the decision to exclude the stage of car dealers from the study. The scale of the accounts receivable of car manufacturers indicates that end customers have a remarkable, direct relationship with them.

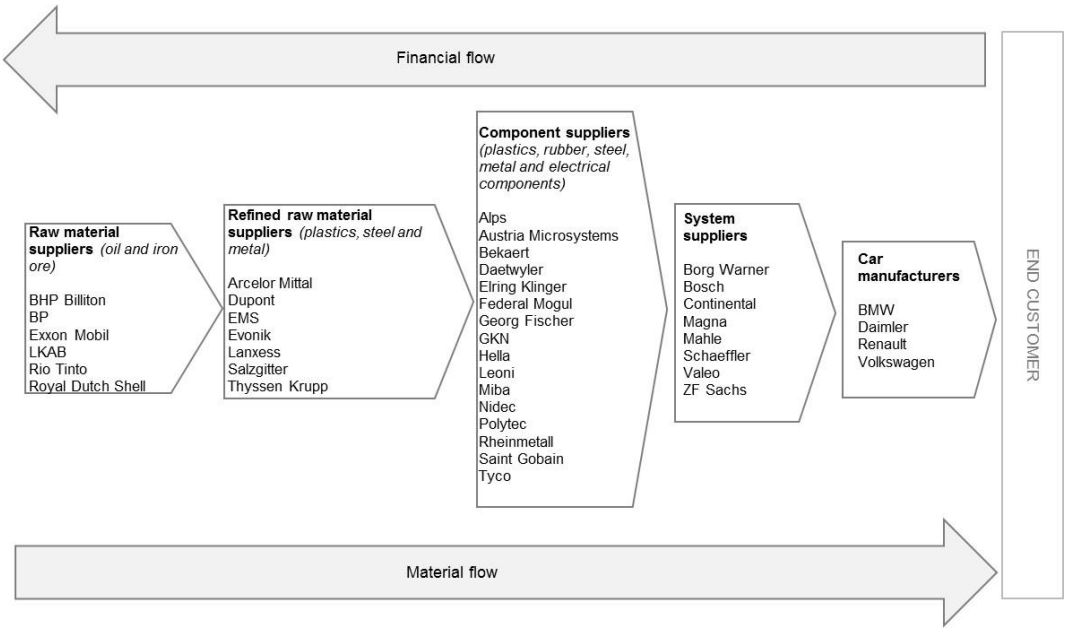


Figure 2. The sample of the study.

Secondary data from the official consolidated financial statements and annual reports has been collected to study the cycle times and different models of working capital management. The sample consists of 41 companies operating in the value chain of the automotive industry. The sample focuses on the European automotive industry. The observation period is 2006–2015. All data used in the study is collected from publicly available sources: from the company websites or the German company register (Bundesanzeiger). The necessary financial figures were collected manually by one person. We chose this approach instead of picking figures and key ratios directly from the databases to ensure that all data was gathered in a similar manner. The figures were collected mainly as reported. However, if reported in inventories, advance payments were excluded from the value. Additionally, trade credit components include only short-term trade related accounts receivable and accounts payable. Table 2 represents the descriptive statistics for the sample: it shows the average, minimum and maximum values of selected key figures in 2006 and 2015 for each value chain stage.

Table 2. Descriptive statistics on the sample.

		Raw material suppliers (n = 6)			Refined raw material suppliers (n = 7)			Component suppliers (n = 16)			System suppliers (n = 8)			Car manufacturers (n = 4)		
		2006	2015	Δ (%)	2006	2015	Δ (%)	2006	2015	Δ (%)	2006	2015	Δ (%)	2006	2015	Δ (%)
Sales (millions of Euros)	Min	1579	1732	10 %	888	1784	101 %	196	623	218 %	3652	7231	98 %	41528	45327	9 %
	Max	291070	242345	-17 %	47125	57303	22 %	41596	39623	-5 %	43684	70607	62 %	104875	213292	103 %
	Mean	134039	125901	-6 %	20893	22061	6 %	5458	6714	23 %	14466	26805	85 %	73656	125065	70 %
Working capital (millions of Euros)	Min	225	-616	-374 %	221	420	90 %	43	60	41 %	491	-99	-120 %	17818	25700	44 %
	Max	22039	15645	-29 %	13615	7078	-48 %	6411	4750	-26 %	10128	16707	65 %	49164	72608	48 %
	Mean	7643	4541	-41 %	5111	3846	-25 %	975	1065	9 %	2484	3960	59 %	30028	47489	58 %
Working capital of sales (%)	Min	2 %	-2 %	-188 %	20 %	11 %	-43 %	12 %	8 %	-36 %	5 %	-1 %	-113 %	31 %	34 %	9 %
	Max	14 %	16 %	16 %	29 %	29 %	1 %	27 %	35 %	29 %	29 %	24 %	-17 %	50 %	57 %	14 %
	Mean	9 %	4 %	-51 %	24 %	21 %	-12 %	20 %	19 %	-8 %	16 %	12 %	-25 %	42 %	42 %	0 %
Inventories of sales (%)	Min	3 %	6 %	104 %	13 %	13 %	2 %	9 %	6 %	-29 %	6 %	8 %	34 %	12 %	9 %	-23 %
	Max	11 %	18 %	61 %	33 %	24 %	-25 %	18 %	21 %	16 %	19 %	14 %	-27 %	18 %	16 %	-11 %
	Mean	8 %	9 %	17 %	18 %	18 %	0 %	14 %	14 %	-1 %	11 %	10 %	-4 %	14 %	13 %	-6 %
Trade credit of sales (%)	Min	-1 %	-11 %	730 %	-4 %	-10 %	172 %	1 %	-6 %	-758 %	-1 %	-9 %	614 %	19 %	18 %	-9 %
	Max	3 %	0 %	-87 %	9 %	8 %	-13 %	10 %	13 %	34 %	10 %	10 %	-3 %	36 %	48 %	31 %
	Mean	1 %	-5 %	-599 %	5 %	2 %	-55 %	6 %	4 %	-25 %	5 %	2 %	-66 %	27 %	28 %	3 %

Our requirements for the sample companies were twofold: sales had to be more than 100 M€, and annual reports needed to be publicly available. The requirement for the public data restricted the sample, and some companies were left out of the study as all reports for the observation period were not available. A few companies were excluded due to changes in the reporting policies during the observation period, as the financial figures between different years were not comparable. Therefore, our study has fewer firms than the study by Lind et al. (2012). Although not fully comparable to the earlier study, the results provide an overview of the working capital management during the observation period 2006–2015 for companies operating in different parts of the value chain of the automotive industry, and thus meet the targets of this paper. The numerical figures presented in the financial statements naturally only demonstrate the value of working capital components on one, last day of the fiscal year, so it may not illustrate the actual amount of working capital companies have during the other days of the fiscal year. However, in the automotive industry, seasonal fluctuation is not as strong as for example in the pulp and paper industry.

Results and analysis

The analysis of the results is divided into two parts. First, we focus on the cycle times of working capital. After that, we use the WCM matrix to study working capital models, and test the matrix with three different approaches.

Cycle times of working capital management in 2006–2015

The cycle times of working capital and its components were calculated for each year of the 2006–2015 period. The results are reviewed as the average values of two 5-year periods, 2006–2010 and 2011–2015. We chose this approach as it balances the impact of one-year exceptions in the figures, gives a more realistic understanding of a company's working capital level, and enables the observation of longer-term changes in working capital management. The results of the averages for periods 2006–2010 and 2011–2015 are shown in Table 3. Additionally, we compared the observation periods (2006–2010 and 2011–2015) with the statistical Wilcoxon signed-rank test. The test was conducted for the total sample and for the individual stages. This nonparametric test was chosen due to its suitability for the comparison of dependent samples. The results show that our two datasets have statistically significant differences in relation to the CCC and DPO when looking at the overall sample and the raw material suppliers, and to DPO at the stage of systems suppliers. The changes in the DIO and DSO were not statistically significant. The p-values of the test are shown in Table 4.

Table 3. Average cycle times of the sample in 2006–2010 and 2011–2015.

		CCC				DIO				DSO				DPO			
		2006-10	2011-15	Δ	p-value	2006-10	2011-15	Δ	p-value	2006-10	2011-15	Δ	p-value	2006-10	2011-15	Δ	p-value
Stage averages	Automotive industry	74	66	-8	(0.003*)	50	48	-2	(0.216)	61	61	0	(0.761)	38	43	6	(0.002*)
	Raw material suppliers	36	18	-18	(0.046*)	31	29	-2	(0.116)	35	37	1	(0.753)	30	48	18	(0.046*)
	Refined raw material suppliers	80	76	-4	(0.310)	65	67	1	(0.735)	50	47	-3	(0.398)	35	38	2	(0.612)
	Component suppliers	76	69	-6	(0.301)	56	52	-4	(0.642)	60	60	0	(0.756)	40	42	2	(0.196)
	System suppliers	57	46	-11	(0.069)	41	37	-4	(0.123)	57	58	0	(0.575)	41	49	8	(0.036*)
	Car manufacturers	147	144	-3	(0.465)	51	49	-2	(0.465)	134	134	0	(0.715)	37	39	1	(0.715)

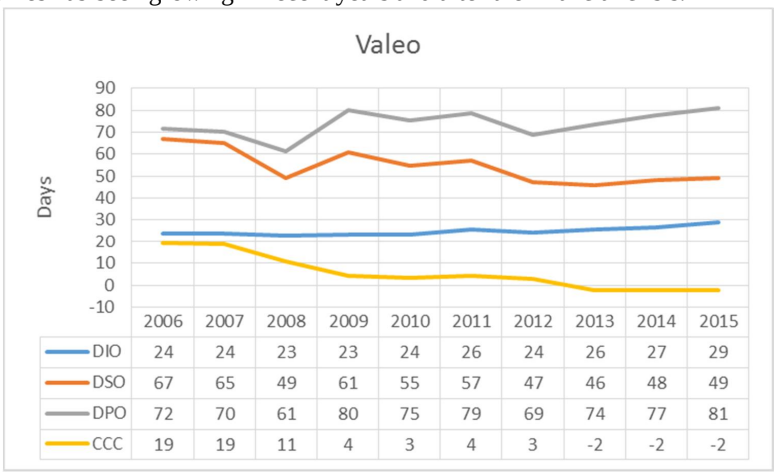
*Note: p-values indicate the statistical difference between the observation periods measured with the Wilcoxon signed-rank test. Asymptotic significances are displayed. * = significant at the 0.05 level.*

		CCC			DIO			DSO			DPO		
		2006-10	2011-15	Δ	2006-10	2011-15	Δ	2006-10	2011-15	Δ	2006-10	2011-15	Δ
Raw material suppliers	BHP Billiton	38	1	-37	33	33	0	34	26	-9	29	57	28
	BP	24	14	-10	29	24	-4	37	37	0	41	47	6
	ExxonMobil	8	9	1	11	15	3	25	27	2	29	32	4
	LKAB	62	57	-5	44	43	-1	46	42	-4	28	28	0
	Rio Tinto	52	8	-44	40	37	-3	32	32	0	20	61	41
	Royal Dutch Shell	32	16	-15	28	22	-6	36	56	20	32	61	29
Refined raw material suppliers	ArcelorMittal	71	48	-23	91	81	-10	35	20	-15	54	53	-2
	Dupont	86	92	6	69	80	11	53	61	9	36	50	14
	EMS	90	89	-1	62	61	0	55	50	-5	26	22	-4
	Evonik	71	63	-8	46	46	0	58	46	-12	33	30	-4
	Lanxess	72	73	1	56	60	4	47	46	-1	31	33	2
	Salzgitter	95	99	5	71	77	5	50	59	9	27	37	10
	ThyssenKrupp	76	70	-7	63	62	-1	52	46	-6	39	39	0
Component suppliers	Alps	64	72	8	37	44	7	60	64	4	33	35	2
	Austria Microsystems	135	76	-58	97	53	-45	81	54	-28	44	30	-14
	Bekaert	98	99	0	62	64	2	74	74	-1	38	39	1
	Daetwyler	85	78	-7	60	50	-10	44	48	4	19	20	1
	ElringKlinger AG	104	123	19	65	78	12	59	66	6	21	21	0
	Federal Mogul	76	85	9	52	59	6	59	70	11	35	43	8
	Georg Fischer	84	81	-3	64	63	-1	55	57	3	34	39	5
	GKN	45	31	-14	51	51	0	47	62	15	53	82	29
	Hella	53	51	-2	43	39	-4	49	50	2	39	38	-1
	Leoni	52	31	-21	51	47	-4	51	48	-3	50	63	14
	Miba	88	70	-18	53	50	-3	64	55	-10	30	35	5
	Nidec	62	72	10	41	53	13	82	84	2	61	65	4
	Polytec	47	43	-4	42	33	-10	45	39	-6	40	28	-12
	Rheinmetall	84	97	14	65	69	3	69	82	13	51	54	3
	Saint-Gobain	51	45	-6	51	54	3	50	44	-6	49	52	3
	Tyco	85	53	-32	53	24	-30	70	59	-11	38	30	-8
System suppliers	Schaeffler Group	97	73	-24	64	51	-14	53	55	2	20	33	13
	Continental	59	43	-16	42	33	-9	64	60	-4	47	50	3
	Bosch	84	88	4	50	52	2	62	65	3	28	29	1
	Mahle	73	70	-3	50	44	-5	56	60	3	33	34	1
	ZF Sachs	59	43	-16	40	38	-3	50	51	1	32	46	14
	Valeo	11	0	-11	23	26	3	59	50	-10	72	76	4
	BorgWarner	45	18	-27	31	25	-6	58	64	6	44	70	26
	Magna	29	33	4	27	28	1	55	57	2	53	52	-1
Car manufacturers	BMW	146	133	-13	49	47	-1	121	118	-3	23	32	9
	Daimler	137	127	-10	59	57	-2	109	99	-10	31	29	-2
	VW	123	119	-4	49	57	8	106	96	-9	32	35	2
	Renault	183	196	13	47	33	-14	199	223	24	63	59	-4

The average CCC of the sample was 74 days in 2006–2010, and 66 days in 2011–2015. The results are consistent with the finding, 70 days, by Lind et al. (2012). The results show that the companies' CCC has fluctuated over the years, but the overall trend in this sample shows a shortening in the cycle time of working capital. The finding of a reduced working capital is in line with the results by Brandenburg (2016) whose study indicated significant improvements in working capital in the automotive industry in 2002–2010. Our results show that all stages on average, as well as 28 out of the 41 companies in the sample, have shortened their CCC in the years 2011–2015 compared to their average figures from the years 2006–2010. The average reduction of these 28 companies was 16 days. The shortening of the CCC could indicate more attention by the firms to their working capital management in recent years. Companies also might have returned to more usual conditions after the financial crisis which has caused the improvement in the cycle times. However, this would require a more-detailed analysis of the cycle times before the financial crisis, as the results by Brandenburg (2016) suggested that the economic crisis only amplified the deteriorated working capital situation, but was not the major cause for that.

An interesting finding was that some companies have operated with a negative cycle time of working capital during some years in the latter part of the observation period. Three of them are located in the

stage of raw material: BHP Billiton in the years 2012–2013 and 2015, ExxonMobil (2011–2012) and Rio Tinto (2015). Another company operating with a negative CCC is the system supplier Valeo, whose results indicate a systematical reduction of working capital since the year 2008 (Figure 3). Its DIO has been quite stable over the years, but the shortening of the DSO and the prolongation of the DPO have made it possible to benefit from the situation where no working capital is tied up in the company. A negative working capital has been found previously in the ICT industry (Hutchison et al., 2009; Lind et al., 2016) and in retail firms (Moss and Stine, 1993), but no academic studies have been found reporting this phenomenon in the oil companies or automotive industry before. The results of this study also show that in this sample, none of the companies achieved negative working capital before the year 2011. This supports the view that interest and focus on working capital management in the companies has been growing in recent years and after the financial crisis.



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
DIO	24	24	23	23	24	26	24	26	27	29
DSO	67	65	49	61	55	57	47	46	48	49
DPO	72	70	61	80	75	79	69	74	77	81
CCC	19	19	11	4	3	4	3	-2	-2	-2

Figure 3. Cycle times of working capital by Valeo in 2006–2010.

Similarly to Lind et al. (2012), the results mainly show only minor changes in inventory management. However, the results of some companies, such as ArcelorMittal, Austria Microsystems, Schaeffler Group, and Renault indicate a systematic and remarkable reduction of the DIO. Twenty-two out of 41 companies have been able to shorten their DIO in 2011–2015 in comparison to 2006–2010, but the changes have mainly been only a few days. Within the stages, there are a lot of differences between the companies. For example, in the stages of component suppliers and system suppliers, companies have quite different levels of inventories. In the automotive industry, system suppliers seem to have more effective inventory management compared to car manufacturers. However, car manufacturers have been able to improve their DIO in 2011–2015. This does not seem to have harmed the system suppliers' DIO in this sample: it indicates that car manufacturers have not forced their suppliers to keep bigger inventories by shifting inventories upstream in the chain, but the overall inventory management within these two stages has been made more effective.

In the cycle time of accounts receivable, 16 out of 41 companies had a change of 7 days or more in their average DSO from 2006–2011 to 2011–2015. Both reduction and increase of the DSO were found in all stages in the sample. This could indicate that there has not been any collective change in the payment terms within the industry. However, in the cycle time of accounts payable 15 out of 41 companies have had a change of 7 days or more in their average DPO from 2006–2010 to 2011–2015. These changes were, apart from a few exceptions, mainly positive, which means that the payment terms towards suppliers have lengthened. In some cases this could also be a sign of liquidity issues. The results of this study do not support the previous finding of Lind et al. (2012) that, in the value

chain context, the changes in DSO and DPO offset each other. Even if the prolongations of the DPO are quite remarkable in some stages, the results of the DSO do not show a similar trend in any of the stages. This may reflect the growing use of supply chain finance, which lengthens the DPO of the customer, but does not have the same effect on the DSO of the supplier. This could indicate that the sample of this study is not large enough for an analysis at value chain level: there are many buyer-supplier relations that are not included in this sample, but which affect the sample companies' DSO and DPO.

The positions of the stages measured by the CCC did not change and remained the same as in the study by Lind et al. (2012). Raw material suppliers had the shortest and car manufacturers the longest CCC. Otherwise, the CCC shortened while moving towards end customer in the chain. The positions in terms of DIO and DSO did not change substantially, but the developments in the DPO led to the changes in the positions of raw material suppliers and car manufacturers in relation to other stages.

Working capital models in the automotive industry

To study working capital models in the automotive industry, we used the WCM matrix introduced earlier in this paper (see Figure 1). First, the positions of the value chain stages and their change from 2006–2010 to 2011–2015 were observed. Figure 3 illustrates the averages of the stages in 2006–2010 and 2011–2015, and the arrows describe the direction of the change from the first period to the latter. The dashed lines describe the average levels of DIO (49.07 days) and DSO-DPO (20.79 days) of the sample, and divide the observations into four categories.

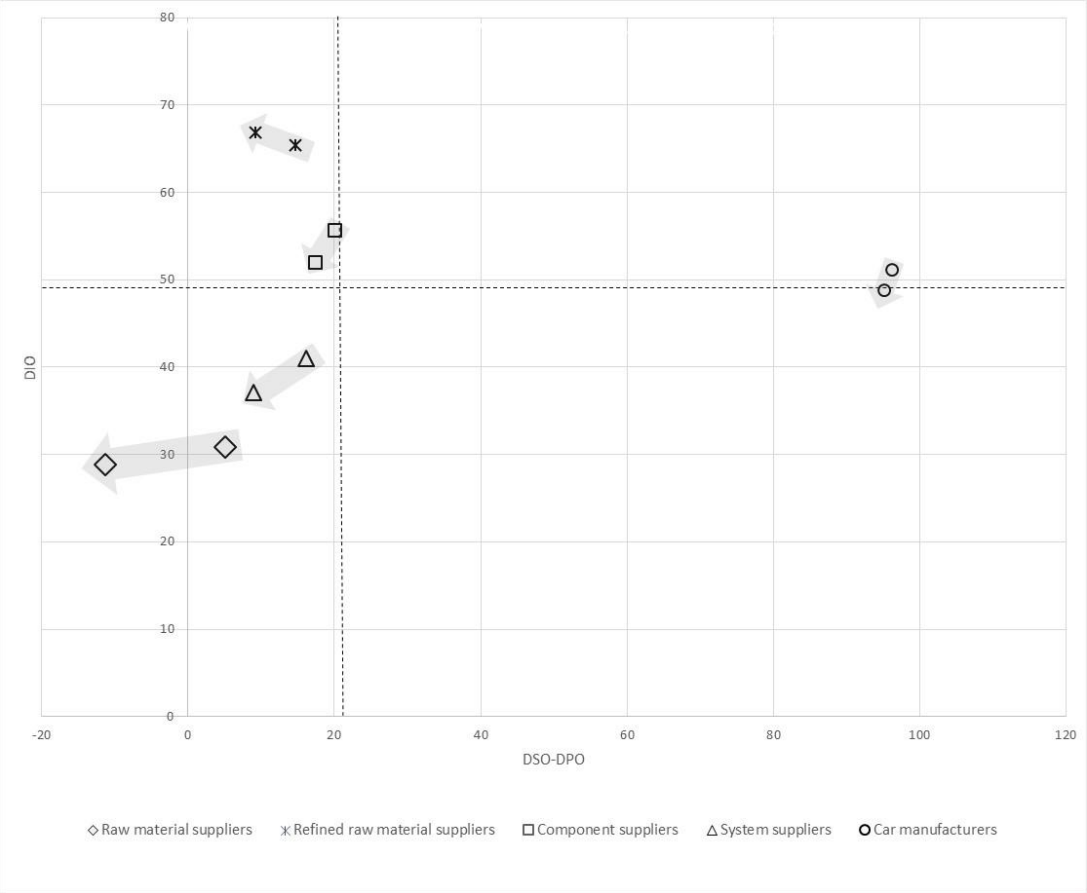


Figure 4. Average working capital models by stages in 2006–2010 and 2011–2015.

Figure 4 shows how the averages of the stages moved from the first observation period to the latter. According to this analysis, the least inventories and the most favorable payment terms are maintained by raw material and system suppliers. The DSO-DPO of raw material suppliers has become negative, and also the system suppliers are approaching the limit. Refined raw material and component suppliers are the inventory holders of the value chain. Component suppliers have reduced the level of inventories during the observation period, whereas the inventories of refined raw material suppliers have increased. However, these stages do not seem to suffer from unfavorable payment terms either. Car manufacturers was the only stage changing from one category to another: due to reduction in inventories, it has barely moved from the unfavorable WC model 4 to the WC model 3. Even if all of the stages had changes in their working capital management, the positions against each other have not changed. This supports the findings by Lind et al. (2012). When looking at individual companies, it was quite surprising to see that only 8 out of 41 companies had moved from one category to another when comparing the averages of 2006–2010 and 2011–2015. The findings indicate that changing the working capital model is a long-term process, and sustainable reduction of working capital is conducted in small steps.

Next, we plotted all firm-year observations into the WCM matrix. Figure 5 shows all firm-year observations, i.e. working capital models applied by all companies in the value chain during each

year of the observation period 2006–2015 (410 observations). The results of companies in the same stages are shown in the same color.

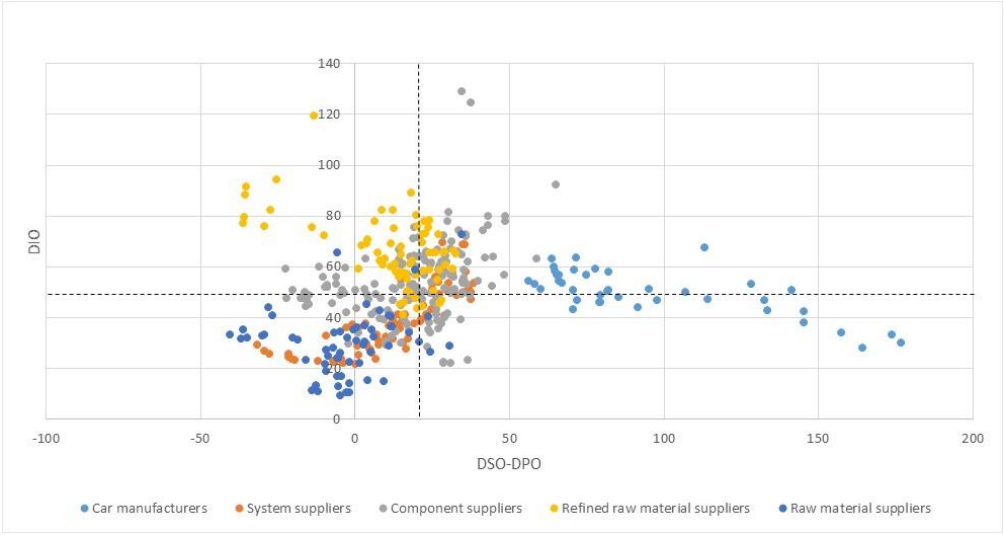


Figure 5. Average working capital models by sample companies in 2006–2015.

As shown by Figure 5, most of the firm-year observations (141 observations) were positioned in the category of short cycle times (WC model 1). WC model 2 had 87 firm-year observations, WC model 3 was applied in 58 observations, and WC model 4 in 124 observations. This indicates that most companies in the sample are aiming at minimal working capital. Surprisingly, the second most observations were found in the category of long cycle times (WC model 4), which is probably not the desired category for the companies. The results show that all categories include observations from all stages of the value chain. However, apart from a few exceptions, raw material suppliers are positioned mainly in the category where both the DIO and DSO-DPO are below the average values of the value chain (WC model 1). In addition, car manufacturers are located mainly in the two categories of long DSO-DPO (WC models 3 and 4). Refined raw material suppliers are strongly focused on the category of a long DIO and a short DSO-DPO (WC model 2). Component suppliers are the most wide-spread stage, whereas system suppliers mainly seem to apply two working capital practices quite different from each other: while most companies are minimizing their working capital components (WC model 1), others are located in the category where the cycle times are long (WC model 4). A closer look at these stages (see Figure 6) revealed that most system suppliers remained in the same working capital model during the observation period. Apart from the company Mahle, which has been located in all four categories and thus may not have a clear working capital strategy, all other companies have only had one or two exceptional years in comparison to their usual category. The situation is similar in the stage of component suppliers: most companies remain in the same category with some annual exceptions. The companies seem to move either in relation to the effectiveness of material flow (DIO) or financial flow (DSO-DPO). This supports the finding that automotive companies do not improve all working capital components simultaneously (Brandenburg, 2016).

Figure 6. Working capital models by system and component suppliers in 2006–2015.

The results of this sample suggest that most stages have a typical working capital model partially defined by their business model. An important part of car manufacturers' business is offering financing and leasing services which makes their DSO-DPO longer. On the other hand, refined raw material suppliers are holding bigger inventories as it is natural that more inventories are held in the upstream part of the chain. However, not all companies within the stage of refined raw material suppliers apply similar practices in their working capital management. When looking at the results of the stages of system and component suppliers, it is typical that the practices change in relation to one component, DIO or DSO-DPO.

In this analysis, we tested the WCM matrix in three different contexts. First, analyzing the position of the stages by their average values in 2006–2010 and 2011–2015 showed that the positions of the stages against each other did not change during the observation period. In this sample, the least working capital was tied up by raw material and system suppliers. The stages refined raw material suppliers and component suppliers were acting as inventory holders. Car manufacturers, who were the only stage moving from one working capital model to another, were identified as financing the customers with trade credit. Second, based on the categorization of 410 firm-year observations, most companies of the sample applied a working capital model based on minimizing the working capital. However, all four categories had observations from all value chain stages. Third, a more detailed analysis of two value chain stages showed that different practices of working capital management are applied within the stages. Companies have some fluctuation between different years, but they are mainly positioned in the same area in the matrix during the observation period.

Discussion and conclusions

In this section, we conclude and discuss the results of the study and point out directions for future research. The paper studied working capital models, i.e. unique combinations of working capital components, applied by companies in the automotive industry. Working capital models can be studied with the WCM matrix introduced in this paper. The WCM matrix combines two literature streams related to working capital management, namely finance and supply chain management, and thus offers a holistic perspective on the analysis of working capital in the value chain. From another perspective, the WCM matrix is an additional tool for analyzing the CCC. As a metric the CCC, which bridges purchasing activities with suppliers, production, and sales activities with customers, is a reasonable approach for studying working capital management through the value chain. The WCM matrix illustrates the working capital management in the value chain from two perspectives: it shows how working capital is combined by its two flows, inventories describing the material flow and trade credit the financial flows, as well as describes the position of companies against each other. It reveals the inventory holders and value chain financiers, and shows the targets for development in order to improve the inter-organizational working capital management.

Cycle times of working capital were calculated for 41 companies operating in the different stages of the value chain of the automotive industry. A comparison of the cycle times in 2006–2010 and 2011–2015 showed that two thirds of the sample companies reduced their CCC in the latter period. The average reduction of these companies was 16 days. Even negative working capital was achieved by a few companies. The results showed a clear trend of working capital reduction in the value chain. It can be predicted that the trend will continue, as the financial issues in the value chain context have received increasing interest, and the offering of services, e.g. factoring and reverse factoring, to support the management of financial supply chains has increased. The limitation of this study is that the data from the financial statements represent the value of working capital components only on one day of the fiscal year, and it does not reveal whether there is a defined working capital management strategy, an active and conscious choice of a working capital model, passive drifting towards the used

model or a failed attempt at the implemented strategy behind the result. For some companies, some hint of that can be found in their publications. For Valeo, a French system supplier, operating on a negative cycle time of working capital is a part of their strategy which is also mentioned in their annual reports. A study like this only offers one side of the story, but based on an extensive set of real-life financial figures, it is a good starting point for deeper investigations of the working capital management of the companies operating in the value chain of a specific industry.

The WCM matrix for categorizing different working capital models was introduced. With the data from 41 companies, we tested the matrix in the three different contexts. First, the positions of the value chain stages were analyzed. Second, all value chain actors were placed in the matrix. Third, we analyzed working capital models within the stages. The categorization of companies on the basis of the combination of their inventory and trade credit management showed that the sample seems quite divided. The category with the most observations was the one with a short DIO and DSO-DPO (WC model 1), but only a little less observations were positioned in the opposite category where both cycle times were long (WC model 4). Within the stages, different practices of working capital management are applied. A closer look at the stages of system and component suppliers showed that practices change in relation to one component, DIO or DSO-DPO. However, the position of most companies does not seem to change remarkably from one year to another.

Managerial implications

The financial value chain analysis method introduced a process through which a company can receive a holistic view of its value chain and benchmark its position against the competitors in its own stage (Lind et al. 2012). The categorization of working capital management by the companies' DIO and DSO-DPO performance with the WCM matrix introduced in this paper offers companies a further tool for visualizing the working capital management practices applied in the value chain or in the preferred value chain stage: companies can observe what kind of working capital management practices are applied within the value chain and see their position in the chain, or they can take a look at their own value chain stage and observe how they are positioned against their competitors, and detect possible targets for improvement. The categorization matrix positions the companies on the basis of the management of their inventories and financial flows. The matrix shows visually how the companies' CCCs are formed and how they are positioned against each other in terms of working capital management. When companies decide to reduce their CCC, they need to take a closer look at the working capital components. This categorization matrix offers a starting point for this.

Future research

This study was the first to apply the WCM matrix created by the authors. Therefore, its development would benefit from studies in different contexts: in other industries as well as between the players in certain value chain stages, for example. The variables and the boundaries of different working capital models are not locked to the approach used in this study. It could be useful to test the matrix for example by combining the inventories and accounts payable to observe which companies are able to finance their inventories with supplier credit, and therefore use DIO-DPO and DSO as variables. This could be a suitable approach for companies involved in businesses that require large inventories. Additionally, it could be considered how to best set the boundaries for different categories. Within this sample, the long DSO by car manufacturers had a remarkable effect on the average DSO-DPO of the sample. One option could be to set zero as the border value for DSO-DPO and DIO-DPO. This would point out more clearly the value chain actors which benefit from working capital management more than the others.

Interviews and case studies could support the numerical data and add to the understanding of what kind of strategies companies have set for working capital management, and what kind of combinations of working capital components they have planned: have they had a holistic view on working capital or did they focus on one of the working capital components? Or have they chosen to concentrate either on financial or material flows? It would be interesting to find what kinds of targets have been set for the cycle times of working capital and whether they were achieved. The results offer a slight indication of sustainable reduction of working capital happening in small steps year by year. It would be interesting to study the background for the changes and, overall, the stories behind the figures. Also studying the authentic value chains with inter-company data (e.g. monthly figures instead of annual financial statements) could bring up useful findings of the working capital models in the value chains.

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Publication VI

Lind, L., Kärri, T., Virolainen, V.M., and Monto, S.
Working capital models: A generic framework

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Revised and further submitted version.

Working Capital Models: A Generic Framework

Abstract

The importance of working capital management has been recognized in both, business and academia. Yet, research on working capital models has been scarce. This paper studies working capital models comprising the management of inventories, accounts receivable and accounts payable. Based on the systematical analysis of empirical data, consisting of the financial figures of 161 companies operating in the value chains of the automotive, pulp and paper, and ICT industries, the study introduces a theoretical framework for working capital models. The framework includes six generic working capital models and one sub-model, and offers a holistic view of working capital management. The study takes the initial step towards tightening collaborative actions between value chain partners regarding working capital. The introduced framework offers a managerial tool for analyzing the material and financial flows at the company level as well as in the inter-organizational context.

Key words: working capital management; financial supply chain management; financial collaboration; cash conversion cycle; working capital models

1. Introduction

Working capital is an asset which keeps the operations running. It combines material and financial flows in the value chain: it is an investment in inventories and balancing between financial flows towards upstream and downstream. Besides the rapid change in the business landscape, the challenging financial conditions have increased the interest towards efficient asset management (Mullins 2009). The efficient management of working capital can be the core of a company's successful business model, which nowadays are more based on the reduction of activities, focusing on core processes and managing assets within a company, but especially in the supply chain as well, rather than owning resources (Walters 2004). Mullins and Komisar (2009) divide business models into smaller sub-models: revenue model, gross margin model, operating model, working capital model and investment model. This paper concentrates on working capital models. Many companies have focused on decreasing their operational working capital by reducing inventories, tightening trade credit terms towards downstream, and stretching payments towards upstream. Often, this has been done by focusing on each component of working capital individually. According to Farris and Hutchison (2003), more advisable an approach would be to define the unique combination of all three variables (i.e. working capital model) to optimize the working capital of the company. This approach was recommended also by Viskari et al (2012), but the study by Brandenburg (2016) revealed that companies have not applied this kind of comprehensive view to working capital.

Working capital management has been studied under several research fields: the advantages of a small amount of working capital have been discussed mainly in academic literature on short-term finance (e.g. Shin and Soenen 1998; Deloof 2003; Wasiuzzaman 2015) and supply chain management (Farris and Hutchison 2002), but also on business

strategy (Mullins and Komisar 2009). The concept of a working capital model calls together the fragmented academic literature on working capital management from these streams. However, prior research on working capital models is scarce, and studies have mainly concentrated on different working capital management practices analyzed with the data gathered by surveys (e.g. Belt and Smith, 1991; Ricci and Morrison, 1996; Howorth and Westhead, 2003). The literature lacks studies based on numerical financial data, which reveal the realized working capital models applied in the companies.

The traditional view in previous literature as well as in business has focused strongly on the single company perspective and the superiority of the strategy aiming at minimizing working capital, and several studies using large datasets have shown that the profitability of a company could be improved by efficient working capital management (e.g. Jose, Lancaster and Stevens 1996; Shin and Soenen 1998; Deloof 2003; Lazaridis and Tryfonidis 2006; Talha, Christopher and Kamalavalli 2010; Pais and Gama 2015). However, in the networked environment and competition between inter-organizational value chains, the traditional view of working capital management is too narrow and the management of working capital quite complicated an issue. In the value chain context, actions aimed at minimizing working capital for one company may cause problems to their value chain partners. At the moment, small suppliers face problems due to the lengthening payment periods of their large customers. In addition, service level requirements increase inventory levels. Recently, the research stream of financial supply chain management (FSCM) has gained more interest and brought the value chain perspective and collaborative working capital management into discussion. Studies have shown that companies can achieve monetary benefits by planning working capital strategies together in a supplier-customer relationship (Randall and Farris 2009), and scholars have emphasized that the optimization of working capital should be done in collaboration between value chain partners (Hofmann and Kotzab 2010; Viskari et al. 2012; Lind et al. 2012; Protopappa-Sieke and Seifert 2017). In inter-organizational value chains, all companies cannot reduce their working capital close to zero due to their different premises, such as their position in the value chain, bargaining power and financial conditions. As decisions in the value chains affect a company's capital and cost structure, risk level, profitability, and market value, a more holistic and collaborative perspective to the financial flows in the value chains is required (Gomm 2010).

In this paper, our hypothesis is that companies in the value chain can benefit from different working capital management strategies: whereas one company minimizes its working capital, the other may benefit from large inventory levels or generous credit terms. Thus, it should be possible to identify different working capital models in the value chain context. The aim of this paper is to explore the working capital models applied by companies in three large industry value chains representing the automotive, ICT and pulp and paper (P&P) industries. The answers to the following research questions are sought after: *Which working capital models can be identified in the value chains? Can we find patterns in working capital management between the value chains in different industries?*

In the following section, we review previous literature forming a basis for the working capital models. The research design section introduces the research process, methodology

choices and empirical data. After that, empirical results from the financial value chain analysis (FVCA) and cluster analysis are provided. Based on our findings, we propose a generic framework for working capital models which builds theory for FSCM, but also provides a managerial tool to evaluate working capital management in companies and value chains. The paper ends with discussion and conclusions. As a relatively new area of research, FSCM still lacks general frameworks and systematic theory development studies (Gelsomino et al. 2016; Singh and Kumar 2014). This paper is an initiative towards the theory development of working capital models targeted at strengthening the basis of FSCM literature with a holistic view of working capital.

2. Literature review

In the recent years, the concept of FSCM has gained more attention among researchers and brought the flow of money and financial aspects into the discussion about supply chains (Lee and Rhee 2010; Protopappa-Sieke and Seifert 2010; Knight and Tate 2016). Wuttke, Blume and Henke (2013) defined the purpose of FSCM as "optimized planning, managing, and controlling supply chain cash flows to facilitate efficient supply chain material flows". On the other hand, finance literature reasons that due to a limited amount of resources, it is essential to take care of the allocational efficiency of capital markets and to ensure that the resources are allocated to where they are most productive (Arnold 1998). As a combination of these two perspectives, it can be concluded that financial resources should be allocated to more productive objectives in the supply chains. This calls for the reduction of working capital to a reasonable minimum in the supply chains, but also for the optimization of the working capital within the supply chains. This view serves as the theoretical foundation of this paper.

The management of operational working capital, consisting of the management of inventories, accounts receivable and accounts payable, has been an attractive topic for many scholars lately, but traditionally, the majority of the research on working capital management has been divided into two research streams: finance and operations management. Next, we review relevant literature from both fields.

In operations management, inventory management research has concentrated on efficient operations and the correct sizing of inventory in relation to economic order quantity (EOQ), management philosophies like just-in-time (JIT) and lean, and issues in demand characteristics and marketing environment (Koumanakos 2008). Logistic researchers have developed models for inventory control (e.g. Andreou, Louca, and Panayides 2016) and studied collaborative inventory management (Williams and Tokar 2008). The common overall target for the studies has been inventory reduction: one remarkable motivation for this being the possibility to improve cash flow with immediate and direct impact (Tersine and Tersine 1990). On the other hand, it provides a company the greatest financial return as the costs of holding inventories include more than simply the cost of capital (Farris and Hutchison 2003). Inventory management involves the control of the assets that are produced to be sold in the normal course of the firm's operations. The inventory includes the inventories of raw materials, work-in-process and finished-goods. The importance of inventory management to the firm depends on the extent of its inventory investment.

Inventories can be seen as tied up capital, as a more or less intended investment, which should be aimed at achieving solutions as economical as possible. Managing inventories involves the lack of funds and inventory holding costs. The maintenance of inventory is expensive, so why should firms hold inventories? Keynes (1936) differentiated three motives for holding money/cash: 1) the transaction motive, 2) the precautionary motive, and 3) the speculative motive. These can also be applied to inventory problems, and they are motives to be distinguished in the most used classification (e.g Arrow et al. 1958):

1. *The transaction motive* propels a business to maintain inventories in order to avoid bottlenecks in production and sales. It is natural for a business to plan inventory investment commensurate with the level of transactions in the business.
2. *The precautionary inventory management motive* necessitates the holding of inventories for unexpected changes in demand and supply factors.
3. *The speculative inventory management motive* compels to hold some inventories to take advantage of changes in prices and getting quantity discounts.

The purpose of carrying inventories is to uncouple the operations of the firm – that is, to make each function of the business independent of each other function – so that delays or shutdowns in one area do not affect the production and sale of the final product. Decision-making about inventory levels involves a basic trade-off between risk and return: if the level of inventory is too low, the various functions of a business do not operate independently, and it can result in delays in product and customer delivery. But a lower level of inventory can also save the firm money and increase returns. Moreover, as the size of inventory increases, storage and handling costs as well as the required return on capital invested in the inventory rise. In short, as the inventory a firm holds is increased, the risk of running out of inventory is lessened, but inventory expenses rise.

Several studies have also considered the financial aspects of inventory management and especially its influence on the financial performance or profitability of a company (e.g. Eroglu and Hofer 2011; Shin, Ennis, and Spurliu 2015). Chen, Murray and Wu (2005) found abnormally high inventories leading to abnormally poor stock performance, and the results by Capkun, Hameri, and Weiss (2009) indicated a significant positive correlation between inventory performance and financial performance. However, opposite findings on the relation have been presented as well: for example, Cannon (2008) found only a little or no link between the improvements in inventory management and overall financial performance. He points out that improved inventory performance should not be considered as an only indication of the improved overall performance.

It is also worthwhile to mention the cash (i.e. cash and cash equivalents consisting of excess cash and cash needed for daily operations) in the light of inventory management. This is because the stock of cash carried by a firm is simply a special type of inventory. In terms of uncoupling the various operations of the firm, the purpose of holding a stock of cash is to make the payment of bills independent of the collection of accounts due. When cash is kept on hand, bills can be paid without prior collection of accounts. Bianco and Gamba (2017) show that inventory and cash holdings are synergic tools: while the first is a valuable

operational hedge against the commodity price risk, the second enhances the hedge offered by inventory in the face of costly external finance.
The financial flows of working capital, accounts receivable and accounts payable (i.e. trade credit), have been studied in the literature of short-term finance. Studies have concerned e.g. credit risk models, trade credit motives and credit term decisions (Seifert, Seifert and Protopappa-Sieke 2013). Several studies have taken the perspective of trade credit as a tool for supply chain coordination (e.g. Lee and Rhee 2011; Luo and Zhang 2012). The connection of trade credit to firm performance has also been studied (Martinez-Sola, García-Teruel and Martínez-Solano 2014; Kestens, Van Cauwenberge and Vander Bauwhede 2012). Kroes and Manikas (2014) found that the reduction of accounts receivable was associated positively with firm performance, but the changes in accounts payable are not related to changes in performance. They argue that the increase of accounts payable only improves immediate liquidity, but in the long-term may have a negative impact on the firm. The longitudinal study by Huff and Rogers (2015) on the relationship of working capital components and the financial performance of a firm showed that payment term adjustments only give short-term benefits, but the advantages gained by improving inventory management are longer-lasting. Similarly, Grosse-Ruyken, Wagner and Jönke (2011) and Wandfluch, Hofmann and Schoensleben (2016) argue that by forcing suppliers to accept longer payment terms a firm can only achieve short-term success.

Efficient working capital management through the whole chain is a key element of FSCM, and companies are suggested to take a supply chain approach to working capital to ensure the supply chain to profit as a whole, instead of the traditional internal approach (Hutchison, Farris and Fleischman 2009). The study by Vázquez, Sartal and Lozano-Lozano (2016) showed that no collaboration regarding working capital management existed between the second- and first-tier suppliers in the automotive industry: the first tier moved all the harm in terms of inventories and trade credit backwards in the chain. The authors demand a more collaborative way of working capital management, as taking advantage of supply chain partners only leads to short-term benefits. Lorentz et al. (2016) also found evidence of passing extensions in the cycle time of accounts payable upstream along the value chain which affects the cycle time of accounts receivable in the value chain as well. They suggest collaborative cash management to be considered to improve value chains as a whole and emphasize the holistic view on working capital management because of its sustainability and economic sense, but they note that improvements might be difficult to achieve as real operational changes would be needed.

Simulations by Viskari et al. (2012) showed that managing all working capital components simultaneously would be the most efficient way to improve profitability in the value chain of the automotive industry, but according to Brandenburg (2016), companies have not had the comprehensive view to working capital management. In the value chain environment it should be considered how working capital should be managed in the different parts of the chain as all companies cannot reduce working capital radically without affecting other companies. Grosse-Ruyken, Wagner and Jönke (2011) suggest that each firm should ensure that the cycle time of working capital is in line with the structure of the value chain. Similarly, Wuttke, Blome and Henke (2013) state that the firms should understand their position in the supply chain before making decisions related to FSCM. Findings by Viskari

et al. (2012) revealed that the relation between working capital management and profitability differs in different parts of the value chain, which suggests that companies have and should have different strategies in working capital management depending on their position in the chain. Previous literature on working capital management lacks the research on these different patterns of managing working capital. The aim of this study is to narrow down this gap by exploring the working capital models existing in the value chains.

3. Research process and design

Figure 1 describes the threefold research process of the study. The research is based on the financial value chain analysis (FVCA), a systematic process consisting of seven consecutive steps through which the financial figures can be observed in the value chain and its different stages (Lind et al., 2012). The method has been used to analyze the cycle times of working capital at the value chain level (e.g. Lind et al. 2012, 2016; Pirttilä et al. 2014). However, the method is not limited to similar approaches in regard to the choice of key figures and analyzing methods, but leaves the decision open for the researcher. Thus, in this paper we elaborate the two final steps of the FVCA and divided the research process into three parts: 1) value chain definitions and data collection (FVCA steps 1–5), 2) analysis of the results (FVCA step 6) with a WCM matrix (Lind, Monto and Kärri 2017) and statistical cluster analysis, and 3) concluding the findings of the research process (FVCA step 7) by combining the results of two classifications and three value chains. As a final result, the paper introduces a generic framework for working capital models. In this section, the choices regarding data, sample, measures and methods are introduced. The limitations of the choices are discussed as well.

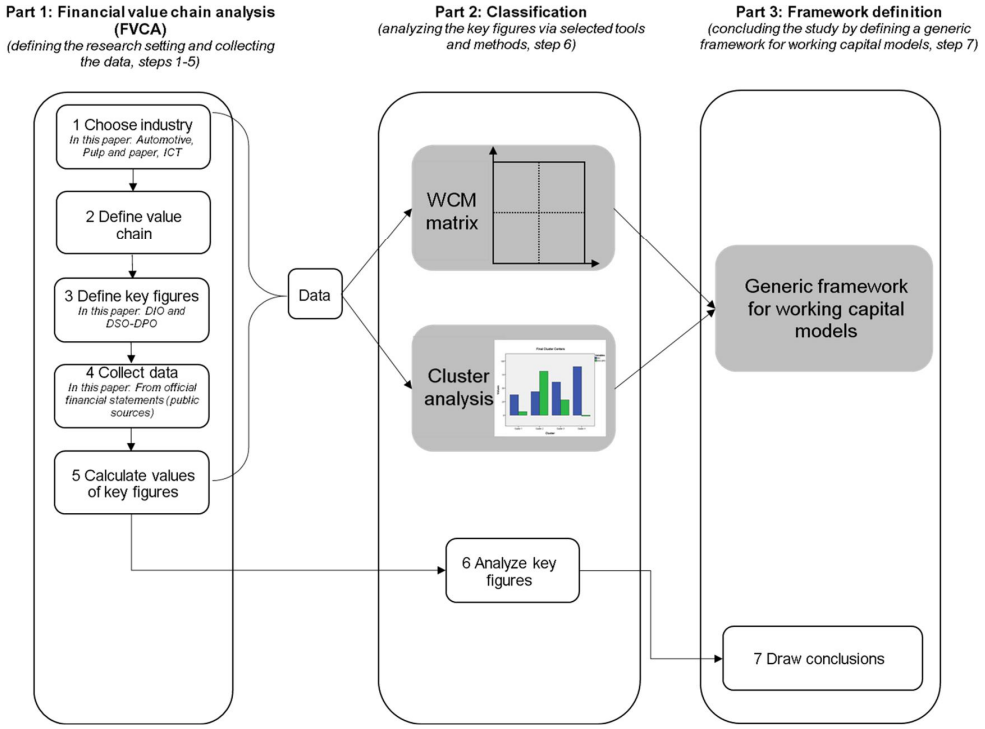


Figure 1. Research process.

3.1 Description of the Value Chains

Steps 1–2 of the FVCA are related to defining the sample. The empirical study concentrates on three large industry value chains: automotive, P&P and ICT. The choice of industries is based on the different use of capital in different fields. While the ICT industry is known for its fast technology development and effective management of working capital, it provides a good contrast for the more capital-intensive representatives of traditional manufacturing industries, where the business practices and production processes require certain amounts of working capital to be tied up in the companies. In this paper, the automotive industry represents batch and serial production, whereas the P&P industry represents the field of process industry. As a forerunner of lean management, the automotive industry has a strong orientation towards efficient working capital management – e.g. BMW (2010) and Valeo (2014) highlight the importance of working capital management as a key element of their businesses. In the P&P industry, the return on capital employed is very sensitive to the amount of capital tied in the inventories of raw materials and finished products. Therefore, companies have tended to focus more and more on reducing their working capital (Carlsson and Rönnqvist 2005). For example, UPM has a group-wide program targeted at the sustainable reduction of working capital (UPM 2017). The choice of industries provides an extensive view of different working capital models.

The value chains used in this study are similar to the ones used by Lind et al. (2012, 2016) and Pirttilä et al. (2014) (see Appendix A). Table 1 shows the number of companies and value chain stages, and the average, maximum and minimum values of the cycle times of working capital (CCC), inventories (DIO), accounts receivable (DSO), accounts payable (DPO), and DSO-DPO in each value chain during the observation period 2006–2010.

Industry	Number of companies	Average CCC (days)	Average DIO (days)	Average DSO (days)	Average DPO (days)	Average DSO-DPO (days)
Automotive	55	70	49	55	35	20
Pulp and paper	45	59	41	53	35	18
ICT	61	39	21	56	37	19

Table 1. The research sample

Researcher have noted that industry-specific factors should be considered when studying the relationship between inventory management and financial performance (Capkun, Hameri, and Weiss 2009; Eroglu and Hofer 2011). These findings suggest that also working capital management should be approached by one industry at a time instead of using large, multi-industry datasets. Thus, the value chains are analyzed separately in this paper.

3.2 Data and Measures

Steps 3–5 of the FVCA concern data collection and selecting the measures for the study. The empirical data of the study consists of the financial figures gathered from the official consolidated financial statements of the years 2006–2010. The archival data approach has been criticized due to the uncritical usage of databases (Moers 2007). To ensure the correctness and traceability of used figures, all data for this research has been collected manually from public sources (mainly company websites).

In this study, working capital management is studied by cycle times. Table 2 summarizes the determinants of the working capital model. The working capital models have been determined by the DIO and the balance between trade credit components (DSO-DPO). Together the components constitute the cycle time of working capital, i.e. cash conversion cycle (CCC). Variable DSO-DPO (also called net trade credit), used by Nadiri (1969), combines the components of financial flow and describes the balance between them. The opposite order of trade credit components (DPO-DSO) has been used in previous research as well (Lorentz et al., 2016), but we chose the first mentioned approach as it is consistent with the formula of the CCC. The balance sheet accounts used for the analysis of working capital management were inventories, accounts receivable and accounts payable. The value of sales was collected from the income statement. Inventories include raw material, work-in-progress and finished goods inventories. It should be noted that in this definition, the length of the production process of a company may affect the cycle time of inventories remarkably as the work-in-progress inventories depend on the production lead time.

Variable	*Component*	*Definition*
DIO	Cycle time of inventories	DIO = (Inventories/Sales)*365
DSO	Cycle time of accounts receivable	DSO = (Accounts receivable/Sales)*365
DPO	Cycle time of accounts payable	DPO = (Accounts payable/Sales)*365
DSO-DPO	Net trade credit	
CCC	Cycle time of working capital	CCC = DIO + DSO - DPO

Table 2. The definitions of used determinants and measures

Some studies (e.g. Deloof 2003; Farris and Hutchison 2003; Viskari and Kärri 2013) have used the cost of goods sold (COGS) as the denominator when calculating the cycle times of inventories and accounts payable. As calculating COGS from the public sources is not unambiguous, we followed the approach used by Shin and Soenen (1998), Lind et al. (2012) and Talonpoika et al. (2016), for example, and used sales as a denominator in this paper. It is essential that the cycle times have been calculated similarly for all companies in the study.

In this paper, the results are shown by using the companies' average figures from 2006–2010 in order to observe the company's long-term working capital performance and to eliminate the yearly fluctuation in performance. Due to the unavailability of data, some firm-year observations from the automotive and P&P value chains are missing, and the company averages were calculated with the figures of the available years.

3.3 Methods

The approach of this empirical study is archival (Moers 2007). We used financial value chain analysis (FVCA) by Lind et al. (2012) to study the working capital models in the value chains of the automotive, P&P and ICT industries. The second part of the research process focuses on the sixth step of the FVCA: analysis of the results. The results were analyzed by classifying the companies on the basis of their working capital models.

The results are analyzed in two parts. First, the analysis of the results is conducted in the WCM matrix (Figure 2), which combines the management of inventories and trade credit (Lind, Monto and Kärri 2017). The vertical axis describes the inventory efficiency (DIO), whereas the horizontal axis presents the net trade credit (DSO-DPO). Lind et al. (2017) used average values of the sample to divide companies into four working capital models. We tested the same approach first, but in order to deepen the analysis, we conducted the analysis with 16 different working capital models. The 16 categories in the 4x4 matrix were outlined by dividing the axes equally into four parts between the maximum and minimum values of the samples. The purpose of this analysis is to see the positions of value chain companies against each other in terms of working capital management. The WCM matrix enables observing the both sides of working capital (inventory and financial flow) in the same figure, and it emphasizes the comprehensive perspective on working capital.

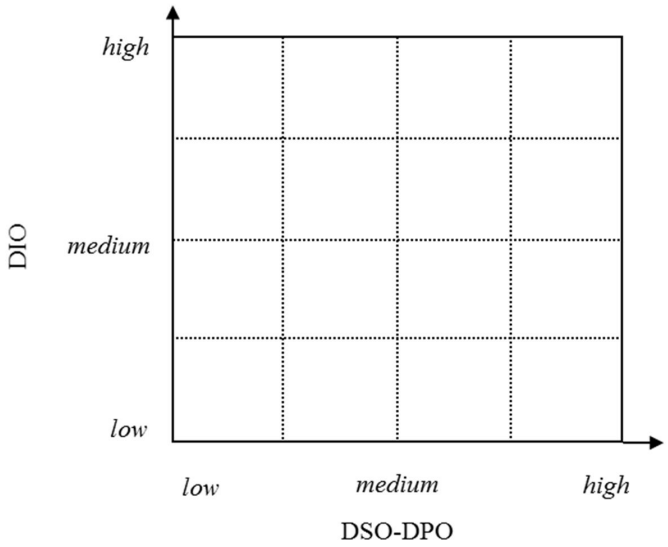


Figure 2. WCM matrix (adapted from Lind et al. 2017).

Second, we classify companies on the basis of their working capital models by applying statistical K-Means cluster analysis. The method was also used by Howorth and Westhead (2003) to categorize different working capital practices. K-Means cluster analysis requires defining the number of clusters before running the analysis. We divided the sample companies into four clusters in each value chain on the basis of their DIO and DSO-DPO performance. The suitable number of clusters was tested by conducting clustering with different numbers of clusters and by measuring the difference between the clusters with ANOVA. As a result, companies were divided into four clusters. Due to using average figures from 2006–2010 instead of firm-year observations, our sample size is smaller, but the number of observations in each industry is around 50, which is the requirement for cluster analysis (Nummenmaa 2009). By using average values a firm only belongs to one cluster.

3.4 Limitations

The data for this study was collected by analyzing financial statements. Characteristically, this kind of data only demonstrates the amount of working capital on one day of the fiscal year. During the year, the level of working capital may differ from the year-end figures, especially due to seasonal fluctuation. By using monthly data instead of annual figures, the differences in working capital during the year could be observed. However, obtaining monthly data reliably or from public sources at this scale is difficult. Therefore we rely on the annual figures from official sources. The year-end figures are suggestive enough for our analysis, but it is advised to keep this feature of the used data in mind.

The K-means cluster analysis used in the study sets some limitations as well. Being sensitive to the case order of the sample, results may change if the analysis is conducted with a different order of companies. The relatively small sample size of this study may also

have additional effects on this behavior. Therefore, it provides one, but not the only, possibility to formulate the clusters of the sample. In this paper, cluster analysis is used to describe the sample and support and compare the analysis of the results in the WCM matrix, and therefore the sensitivity of the method does not affect the final results of this study.

4. Empirical Results

4.1 Results of the Financial Value Chain Analysis in the WCM Matrix

The analysis of the results was started by positioning the companies on the basis of their DIO and DSO-DPO in a WCM matrix. The WCM matrix scatter charts (see Appendix B) show the average values of 2006–2010 for each company. Companies are grouped by the stages in order to see whether the stages are associated with certain working capital models. First, we followed the approach by Lind et al. (2017) and divided the sample into four working capital models by using the average values of the sample, but it was noticed that the categories in the 2x2 matrix were relatively wide, and several observations were located very close to border lines. Therefore, we organized the sample into sixteen working capital models (4x4 matrix) as described in the research design section in order to deepen the analysis. This approach enabled more accurate an analysis of the focus areas of applied working capital models.

The results show that in the automotive and P&P industry, companies within many stages are located close to each other in the WCM matrix. This indicates that many companies apply similar working capital models with their competitors. The situation was similar in the service-focused stages in the ICT industry (e.g. network operators, software and IT services). However, this was not the case in all stages, such as component suppliers in the automotive and chemical and machinery suppliers in the P&P industry, or in the ICT industry in general, where companies were applying several very different working capital models.

Figure 3 illustrates the division of the companies into different categories of the WCM matrix. In this figure, all three value chains are shown together. It should be noted, however, that the border values of the categories were different in the value chains due to different minimum and maximum values of the three separate samples. As shown by Figure 3, the most popular working capital models can explicitly be identified in all value chains (colored with grey in the figure). Other models contained only 1–4 companies. However, the value chains differ in the emphasis of working capital models. The automotive industry seems to strongly aim at the minimum working capital, whereas the most popular working capital models in the P&P industry are formed around the medium values. The ICT industry, in turn, has a strong focus on minimum inventories, and on the other hand, on providing trade credit.

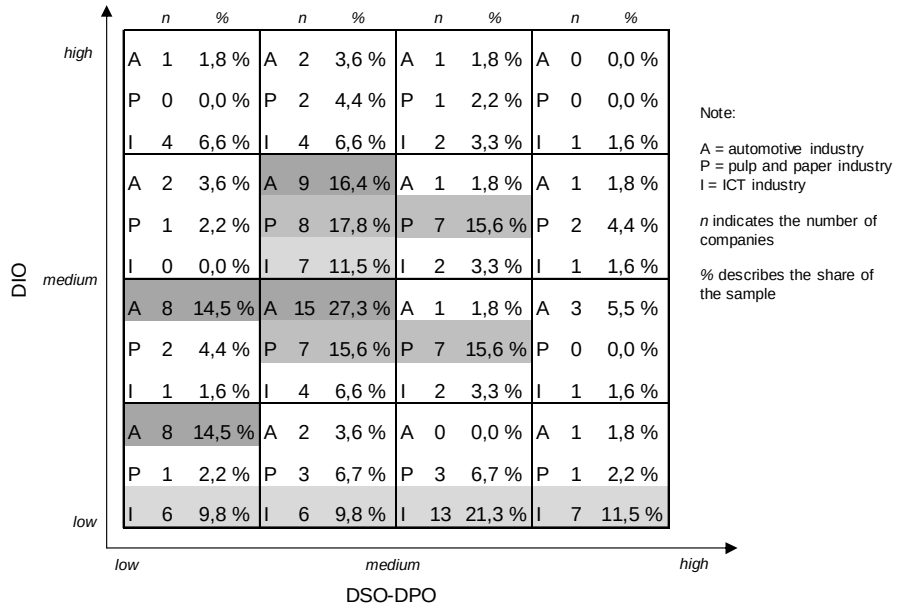


Figure 3. The division of working capital models in the value chains of the automotive, P&P and ICT industries.

In the value chain of the automotive industry, the most popular working capital model is the one directly below the medium borders of the matrix. This indicates that the companies may aim at minimum working capital, but for one reason or another, room for improvement in the management of material as well as financial flows still remain. Other three popular working capital models are applied by 8–9 companies. In the P&P industry, the working capital models in the middle of the matrix are the most popular. Companies are equally divided into these four models. The ICT industry had the most variation in the applied working capital models. The most applied working capital model has low inventory levels, but their trade credit balance is slightly over the medium level. The other four most popular working capital models focus on low inventories, except for one which is characterized by larger inventories and balanced trade credit.

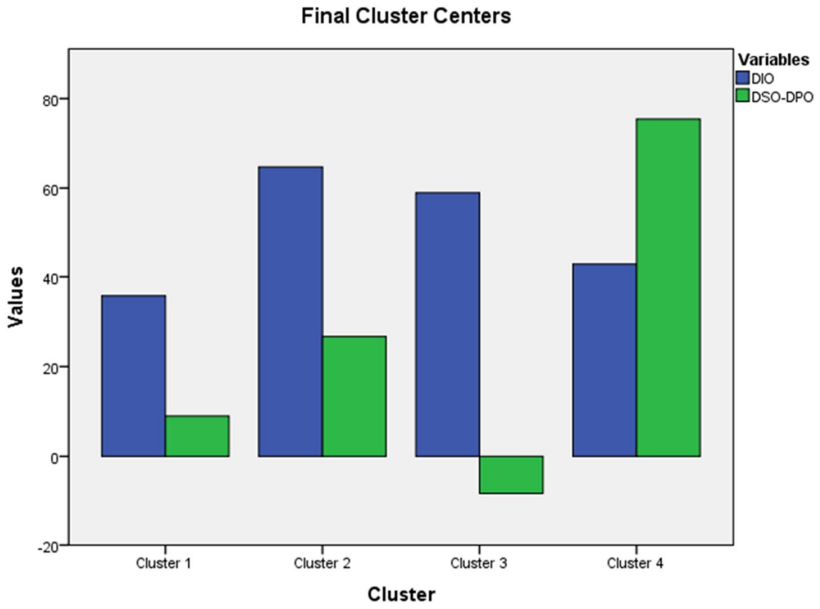
The analysis shows that companies within the value chains have different mixes of inventory and trade credit management, i.e. working capital models. Similar patterns are found in the studied value chains, but with different focuses: whereas most companies in the automotive industry seem to aim at minimizing the working capital, the ICT industry places emphasis on low inventories and financiers. The P&P industry, in turn, has focused on moderate working capital models.

4.2 Results of Cluster Analysis

K-Means cluster analysis was applied to discover whether distinctive working capital models can be detected in the value chains via statistical classification, and whether the results could bring up findings that were not discovered by analyzing the value chains in

the WCM matrix. The results of each value chain are presented with figures that show the details of final cluster centers in the chart illustration and results table. The clusters in the scatter chart are shown in Appendix C.

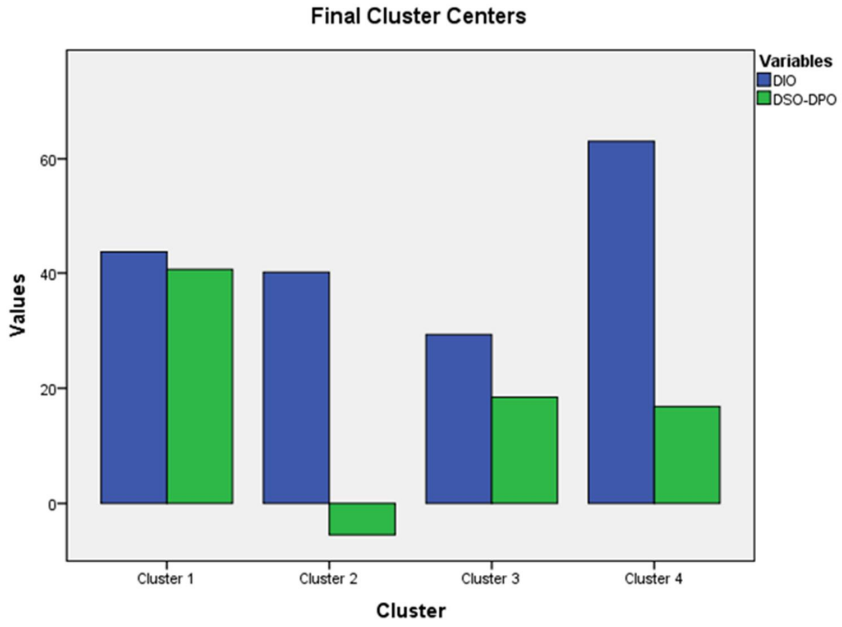
Figure 4 offers the details of the cluster analysis in the value chain of the automotive industry. Automotive cluster 1 has the shortest DIO and balanced trade credit. The CCC of the cluster is short, i.e. the companies of the cluster tie up the least working capital in the value chain. Automotive cluster 2 has the longest DIO, and they offer more generous credit terms to customers than they have from suppliers. The CCC of the cluster is long. Automotive cluster 3 also has a long DIO, but they have a negative DSO-DPO, which means that their payment terms towards suppliers are more generous than the ones they have given to customers. These companies have taken advantage of the trade credit. The fourth cluster of the automotive industry can be described as financiers. Their DSO-DPO is the longest, and thus, the companies finance their customers by offering trade credit. Automotive clusters 3 and 4 are quite small, consisting only of six companies, respectively. However, the observations belonging to these clusters are separated from the other companies by an exceptional use of trade credit which makes the division reasonable.



	Final cluster centers (automotive)				*ANOVA*
	Cluster 1	*Cluster 2*	*Cluster 3*	*Cluster 4*	*F/Sig.*
Number of cases in each cluster	24	19	6	6	
DIO	35.8	64.7	59.0	42.8	22.660/0.000
DSO-DPO	9.0	26.7	-8.2	75.4	75.665/0.000
Average CCC	44.8	91.4	50.8	118.2	

Figure 4. Final cluster centers in the value chain of the automotive industry.

Figure 5 shows the results of the cluster analysis in the value chain of the P&P industry. P&P clusters 1 and 2 are very similar in terms of DIO, whereas clusters 3 and 4 have fairly similar values in terms of DSO-DPO. However, there are remarkable differences in the other variable. P&P cluster 1 operates as financiers due to the long DSO-DPO. The DIO of the cluster center is moderate, but companies in the cluster differ remarkably in their inventory management. P&P cluster 2 also has a moderate DIO, and the companies take advantage of trade credit as the DSO-DPO of the cluster center is negative. The P&P cluster 3 has a short DIO and an average DSO-DPO. P&P cluster 4 is the inventory holding cluster of this value chain. Their DIO is long, and DSO-DPO is moderate.

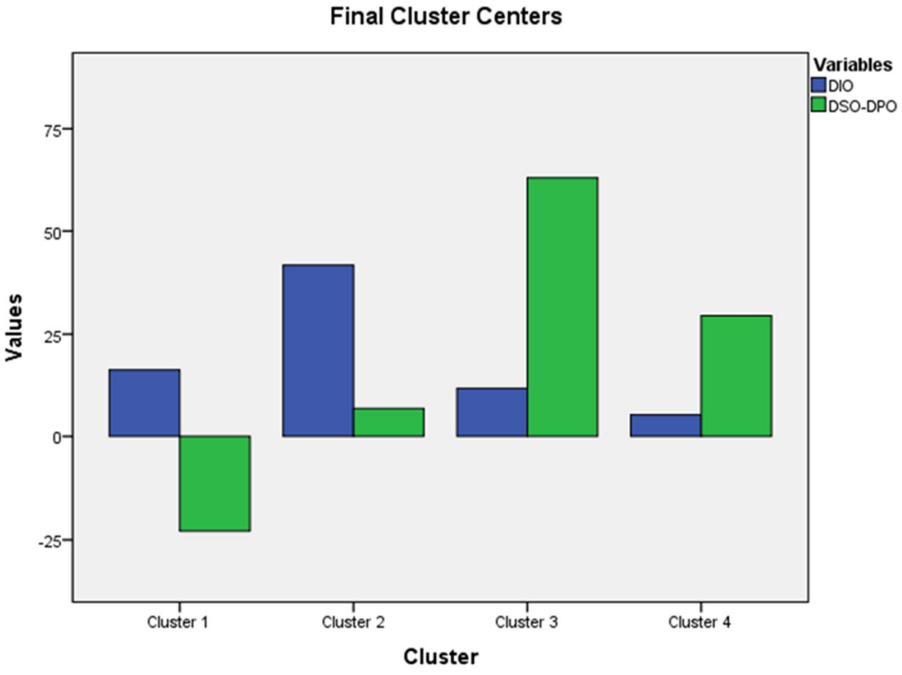


	Final cluster centers (pulp and paper)				*ANOVA*
	Cluster 1	*Cluster 2*	*Cluster 3*	*Cluster 4*	*F/Sig.*
Number of cases in each cluster	8	8	19	10	
DIO	43.8	40.2	29.3	63.1	13.729/0.000
DSO-DPO	40.6	-5.5	18.5	16.8	26.238/0.000
Average CCC	84.4	34.7	47.8	79.9	

Figure 5. Final cluster centers in the value chain of the pulp and paper industry.

The results of the cluster analysis in the value chain of the ICT industry are shown in Figure 6. ICT cluster 1 consists of companies which have minimized their working capital by having a short DIO and a negative DSO-DPO. ICT cluster 2 has a long DIO and an almost balanced DSO-DPO. ICT cluster 3 is the cluster of credit granters in this value chain, but their DIO is relatively short. ICT cluster 4, in turn, has a very short DIO, but a longer DSO-DPO. The cluster center of ICT cluster 4 is close to the average DSO-DPO. As in the

automotive and P&P industries, one cluster in the ICT industry is based on a negative trade credit balance. This has enabled a negative working capital for cluster 1. In addition, several companies in cluster 2 have a negative DSO-DPO. A negative DSO-DPO is not very common in the studied value chains, but offers remarkable advantage for the companies aiming at minimizing their working capital.



	Final cluster centers (ICT)				*ANOVA*
	Cluster 1	*Cluster 2*	*Cluster 3*	*Cluster 4*	*F/Sig.*
Number of cases in each cluster	10	21	10	20	
DIO	16.3	41.7	11.9	5.4	32.181/0.000
DSO-DPO	-22.9	7.0	62.9	29.5	101.428/0.000
Average CCC	-6.6	48.7	74.8	34.9	

Figure 6. Final cluster centers in the value chain of the ICT industry.

5. Generic framework for working capital models

In this section, a general framework of working capital models is formulated from the empirical results of the study. The framework is founded on the WCM matrix used in the results section of the paper. By dividing working capital components into the management of material (inventory) and financial flows (accounts receivable and accounts payable), they can be observed separately in one framework. These are also usually managed by

separate functions in the companies, which supports the relevance of the framework structure.

On the basis of the empirical findings, a theoretical framework presenting six generic working capital models and one sub-model (Figure 7) was created. The working capital models are named as *Minimizers*, *Aiming-at-minimum*, *Inventory holders*, *Financiers*, *Underperformers*, and *Moderates*. The sub-model of Minimizers and Inventory holders is called *Trade credit users*. The framework contains all working capital models identified in the studied value chains representing different kinds of industries. Next, we introduce each generic working capital model, and conclude the empirical results behind the models.

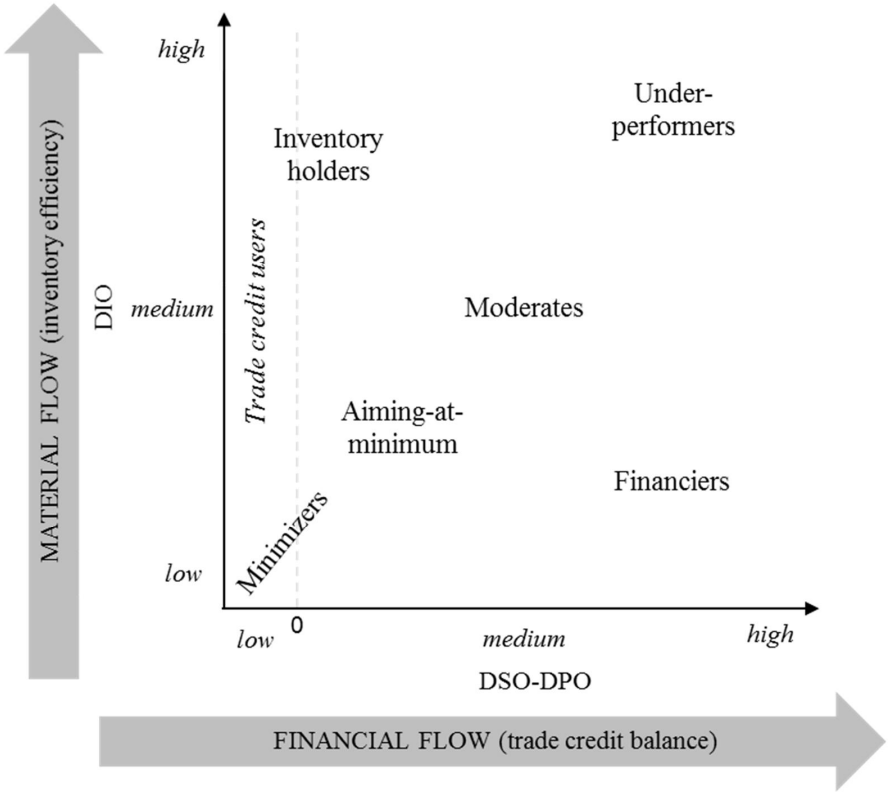


Figure 7. Framework for working capital models

Minimizers were found especially in the automotive and ICT industries (cluster 1 in both), but some companies in the P&P industry also operated with a short CCC. This working capital model is gained through a short DIO and DSO-DPO. The short financial cycle time requires the terms of payment agreed with customers to be relatively short compared to the payment terms with suppliers. Powerful companies with strong negotiation positions in a value chain are able to utilize this model. Additionally, the analysis in the WCM matrix indicated that several companies especially in the automotive industry may have *aimed at*

minimizing their working capital, but for one reason or another companies applying this working capital model did not achieve the lowest working capital levels in the value chain. Prior literature on working capital management suggests that the most efficient working capital model is to minimize working capital, as it results in better relative profitability for the company. Even negative working capital is possible, if the DSO-DPO is negative. In this case, company is applying the sub-model *Trade credit user*.

The analysis of working capital models in the WCM matrix revealed that many companies applied relatively moderate working capital models where both, the DIO and DSO-DPO were close to the averages of the samples. The working capital model used by these *Moderates* focuses on operating in the middle of the extreme levels of DIO and DSO-DPO. These companies are playing it safe and keep a certain level of inventories. They also do not take advantage of their value chain partners in terms of trade credit nor do they finance the value chain with exceptionally generous credit terms. Especially in the P&P industry, working capital models around the center of the matrix were emphasized.

All value chains had companies acting as *Inventory holders* (automotive cluster 2, P&P cluster 4, and ICT cluster 2). These companies have a long DIO due to large inventories, or a long production lead time that ties up working capital to work-in-progress inventories, but financial flows are in balance. In many value chains, inventories are essential for business and it is reasonable to concentrate on minimizing financial flows. Inventory holding can be a strategic choice but also a contextual factor due to a company's position and negotiation power in the value chain. The analysis revealed that especially in the automotive and ICT industries, several inventory holders applied the sub-model *Trade credit users*. In the value chain context, this could mean that suppliers holding inventories for others are compensated with fast payments by customers. The results suggest that this could be the case especially in the ICT industry.

Financiers were also identified with notable differences in their payment terms towards upstream and downstream (Automotive cluster 4, P&P cluster 1, and ICT cluster 3). Companies operating as financiers have a short DIO, but their DSO-DPO is relatively long, and companies tie up a lot of working capital due to the inefficient financial flow. Companies utilizing this model offer long credit terms to their customers, but do not receive equally long terms from their suppliers. By operating this way, they finance the other partners of the value chain or the end customer. In some cases, the large amount of accounts receivable is a strategic choice in a business model. For example, the leasing and financing business of car manufacturers lengthens their DSO. Also IT service providers and software companies provide trade credit for customers in the ICT value chain.

Trade credit users came up in the cluster analysis, which highlighted this extraordinary behavior in all studied value chains (P&P cluster 2, ICT cluster 1, and automotive cluster 3). The companies applying this sub-model are taking advantage of trade credit by having long payment times towards suppliers in comparison to the time payments are received from customers. However, the companies still may differ in the management of inventories. As discussed above, companies gaining benefit from a negative trade credit balance applying the sub-model Trade credit users were acting as Inventory holders or Minimizers.

With efficient inventory management, companies applying this sub-model may even achieve a negative cycle time of working capital.

The working capital model of *Underperformers* with a long DIO and DSO-DPO was applied only occasionally. This working capital model requires large investments in working capital. The companies having the longest CCCs in the value chain may have not been able to use, or they have not needed, systematic management of working capital. It is also possible that these companies have been constrained to function this way due to weak negotiation power. On the other hand, companies using this model may also have strong competitive advantages in other areas of the business model, and they do not need to pay attention to working capital management. In the manufacturing value chains (automotive and P&P industry), extreme working capital models in terms of one dimension of working capital model (DIO or DSO-DPO) were rare. In the ICT industry, more companies carried very large inventories or offered very generous credit terms.

6. Discussion and conclusions

The introduced theoretical framework combines the management of inventories and financial flows which have traditionally been separated into two different research streams: supply chain management and finance. The framework, with the concept of working capital model, puts together the elements of operational working capital, but also provides a framework for fragmented working capital research. The study complements the previous research on working capital practices (e.g. Belt and Smith, 1991; Howorth and Westhead, 2003) by providing insights on realized working capital models in companies on the basis of numerical data.

The results show that there are different strategies for managing working capital in the value chain context. The study continues the research by Lind et al. (2012) and Pirttilä et al. (2014) on working capital management in the value chains, and discusses collaborative working capital management (e.g. Hofmann and Kotzab 2010). The minimizing working capital model has traditionally been seen as the most beneficial for an individual company. It will decrease the amount of working capital and further the level of total assets. It also decreases interest costs caused by working capital. Previous studies have also shown that the profitability of a company increases with a shorter cycle time of working capital (e.g. Shin and Soenen 1998; Deloof 2003). However, in a value chain context, the minimizing working capital model is not possible for all companies, and its benefits in the long run can be questioned if the value chain is observed holistically. Therefore, the value chain approach to working capital management suggested by studies on FSCM (e.g. Hofmann and Kotzab 2010; Viskari and Kärri 2013; Lorentz et al. 2016; Vázquez, Sartal, and Lozano-Lozano 2016) should be taken into account, and decisions regarding working capital management should be done in collaboration with the value chain partners. The identification of different working capital models applied by companies in the value chain is a prerequisite for the optimization of inter-organizational working capital management.

But how should working capital management in the value chain be organized? Should the strongest partners in the value chain act as Financiers instead of Minimizers? At least the

working capital model of Underperformers should be avoided. To optimize the value chain, actors should work in collaboration to release working capital, and companies should not be forced to keep stock and finance other companies within the value chain. The companies with the strongest financial position in the value chain, i.e. companies with the easiest and cheapest external financing opportunities, could apply the working capital model of financiers and actively finance the other companies through trade credit finance (terms of payment), if the aim is to optimize working capital at the value chain level without external parties. Of course, another option is to use supply chain finance solutions, such as reverse factoring, which usually requires an arrangement with a bank as a factor in addition to customer and supplier (Lekkakos and Serrano 2016). The use of factoring releases working capital and thus lightens the balance sheets of companies. However, it should be taken into account that this – fairly standardized – service also has its cost, and its benefits in the long term should be analyzed carefully. Financial collaboration between value chain partners, taking into account the divergent individual needs of different actors, could be a source of sustainable competitive advantage.

6.1 Theoretical and Managerial Implications

This paper contributes to FSCM literature and inter-organizational working capital management research, which is a relatively new research area. Interest towards working capital management has been growing lately among companies as well as in academia. Previous studies have built conceptual and analytical models for inter-organizational working capital. This paper offers empirical analysis of working capital management in the value chain context and builds a theory of working capital models in the value chains.

In addition, through this study, we take the initial step towards tightening collaborative actions between value chain partners regarding working capital management. By being aware of one's own working capital models as well as the models of value chain partners, companies can start optimizing working capital by taking their value chain partners into account. Moving from one model to another requires collaborative actions within the value chain. The generic framework for working capital models can be applied by managers from three perspectives. *First*, companies can see how they are positioned in the value chain against their competitors, suppliers and customers in terms of working capital management. In addition, it enables the comparison of different value chains and industries. From this perspective, it complements the financial value chain analysis (Lind et al., 2012), provides a visual analysis method, and reveals the working capital positions in the value chains. *Second*, the framework offers the possibility to review how the companies' working capital is formed by material and financial flows. When aiming at improvements in working capital management, companies need to understand how working capital is combined from the working capital components, as stated by Farris and Hutchison (2003). The generic framework for working capital models offers a tool for this analysis. *Third*, the framework helps companies define the targets for their working capital management and shows the direction of movement. From the perspective of a single company, the reasonable minimization of working capital is the most efficient strategy. When companies in the value chain follow this strategy and reduce their working capital, new boundaries for the working capital models in the framework are set. Therefore, the framework can be used as

a management tool for improving the allocational efficiency of the whole value chain to release financial resources in terms of working capital for more productive uses. This is meaningful in regard to the attractiveness and competitiveness of the entire industry.

Another implication for managers is the different perspective on inventories. Firms should recognize their inventories as tied up capital, as an intended investment, which should be aimed at achieving economical solutions. Managing inventories involve the lack of funds and inventory holding costs but also provide some gains. Inventory and cash holdings are typically considered substitutes in operations and in generating liquidity. Earlier studies have suggested that inventory and cash holdings can be complementary assets, but the authors would like to highlight the importance of taking into account the broad definition of cash, including not only cash and cash equivalents, but the components of trade credit as well.

6.2 Limitations and Future Research

This study has some limitations, which offer avenues for future research. We point out four directions for future research in relation to working capital models and financial supply chain management.

First, the business model of a company is a complex construct, and the working capital model as part of it may only be a minor issue. This paper only observes working capital models. In the future, it would be interesting to connect working capital management to the other elements of business models and the strategies of companies.

Second, the archival nature of the empirical study also has its limitations. The data of this research consisted of real-life financial figures from public sources. However, the data does not reveal whether the applied model is the consequence of a successful implementation of the defined working capital strategy of the company. Companies may also passively drift towards a certain working capital model or fail in the chosen strategy. The results of this study show the working capital position of a company in the value chain context, against other companies involved in it. It would be interesting to study real value chains with internal data and interviews to gain understanding of working capital strategies in companies and to be able to create collaboration in working capital management in the value chains.

Third, the financial wealth of companies is based on several aspects: growth, profitability, liquidity, and solvency. The concept of a working capital model and the presented framework take a stand on the liquidity positions of the company, but do not reveal the well-being of the company in terms of growth, profitability and solvency. Future studies should find ways to implement these dimensions in the framework as well in order to evaluate the holistic financial positions in the value chain. This information could be further elaborated to determine the most optimal working capital management strategy for the value chain.

Fourth, this study offered a generic framework for working capital models based on empirical data from three industry value chains. Further research on working capital models could explore how companies in the value chain should be positioned in the framework in order to optimize the working capital of the value chain. Additionally, industry-specific factors cause differences in working capital management in different value chains, and sustainable changes in working capital models require actions related to the allocation of fixed-capital investments and the management of transactions in the value chains. Further research could investigate these relations from the perspective of collaborative working capital management.

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APPENDIX A. The value chains of the study with companies and cluster numbers.

Raw material suppliers

	Cluster
ExxonMobil	1
Royal Dutch	1
Total	1
BP	1
Vale	1
Rio Tinto	1
BHP Billiton	1
LKAB	1

Refined raw material suppliers

	Cluster
ThyssenKrupp	2
ArcelorMittal *	3
Salzgitter	2
Voestalpine	2
BASF	2
Dupont	2
Lanxess	2
Evonik *	1
EMS	2

Component suppliers

	Cluster
Saint-Gobain	3
Daetwyler	2
ElringKlinger AG	2
Polytec	1
Federal Mogul	2
GKN	3
Miba	2
Georg Fischer	2
Trimet *	1
Bekaert	2
Rheinmetall	2
RUAG	2
Tyco *	2
Hella **	1
Draexlmaier **	1
Nidec	1
Austria Microsystems	2
Leoni	3
Alps	1

System suppliers

	Cluster
Continental	1
Bosch	2
Mahle *	2
ZF Sachs	1
Valeo	1
BorgWarner	1
Denso	1
Magna	1

Car manufacturers

	Cluster
BMW	4
Daimler *	4
VW	4
Nissan	4
Honda	4
Toyota	4
Hyundai	3

Car dealers

	Cluster
AVAG	1
Autohaus Wolfsburg	1
Löhr & Becker	1
Wellergruppe **	3

Figures are average values for observation period 2006-2010
* Observation period 2007-2010
** Observation period 2006-2009

Figure A.1. The value chain of the automotive industry

Chemicals

	Cluster
Kemira	3
Dow	2
Imerys	4
Ciba *	4

Machinery

	Cluster
Metso	4
Andritz	3
Voith	1

Market pulp

	Cluster
Metsä-Botnia	3
Södra Skogsägarna	4
Aracruz *	1
Fibria	1
Votarantim *	4
Arauco	4
Canfor	2

Paper and board

	Cluster
IP	3
Stora Enso	4
SCA	3
UPM	4
Kimberly-Clark	3
M-Real	1
MeadWestvaco	3
Oji	3
Nippon	1
Sappi	2
Norske Skog	2
Myllykoski	3
Holmen	4

Merchants

	Cluster
Sequana	2
Paper Linx	3

Printers

	Cluster
DNP	3
Consolidated Graphics	3
RR Donnelley	3

Brand owners

	Cluster
Procter & Gamble	2
Danone	2
Unilever	2
BAT	4
Beiersdorf	3
Roche	1

Publishers

	Cluster
New York Times Company	3
Reed-Elsevier	3
EMAP	1
Axel Springer	3
Pearson	1
Aller *	3
SanomaWSOY	3

Figures are average values for observation period 2006-2
* Observation period 2006-2008

Figure A.2. The value chain of the pulp and paper industry

Component manufacturers

	Cluster
STMicroelectronics	2
Infineon Technologies	2
Intel Corporation	2
Texas Instruments	2
NVIDIA Corporation	2
ADM	2
Broadcom	2
TSMC	4
UMC	2

Contract manufacturers

	Cluster
Elcoteq	1
Foxconn	2
Jabil	1
Benchmark	2
Sanmina	2
Flextronics	1
Celestica	2

Network hardware

	Cluster
Juniper networks	4
ZTE	2
Huawei	2
Alcatel-Lucent	2
Tellabs	3

Computers

	Cluster
Logitech	2
HP	2
IBM	3
Dell	1
Apple	1
Lexmark	2
SanDisk	2
Lenovo	1

Mobile phones

	Cluster
Nokia	4
LM Ericsson	3
Cisco systems	4
RIM	3
HTC	2
Motorola	2

Network operators

	Cluster
Deutsche Telekom	1
France Telecom	1
BT Group	1
TeliaSonera	4
AT&T	4
Verizon	4
Vodafone	4
Freenet	4

IT services

	Cluster
Accenture	4
Capgemini	4
AtosOrigin	4
Logica	3
ComputaCenter	4
Tieto	3
S&T	4

Software

	Cluster
SAP	3
Sage	4
Adobe	4
Autodesk	4
Microsoft	3
Oracle	3
RedHat	3

Internet software and services

	Cluster
United Internet	1
Google	4
eBay	4
Yahoo	4

Figure A.3. The value chain of the ICT industry

APPENDIX B. Results in the WCM matrix.

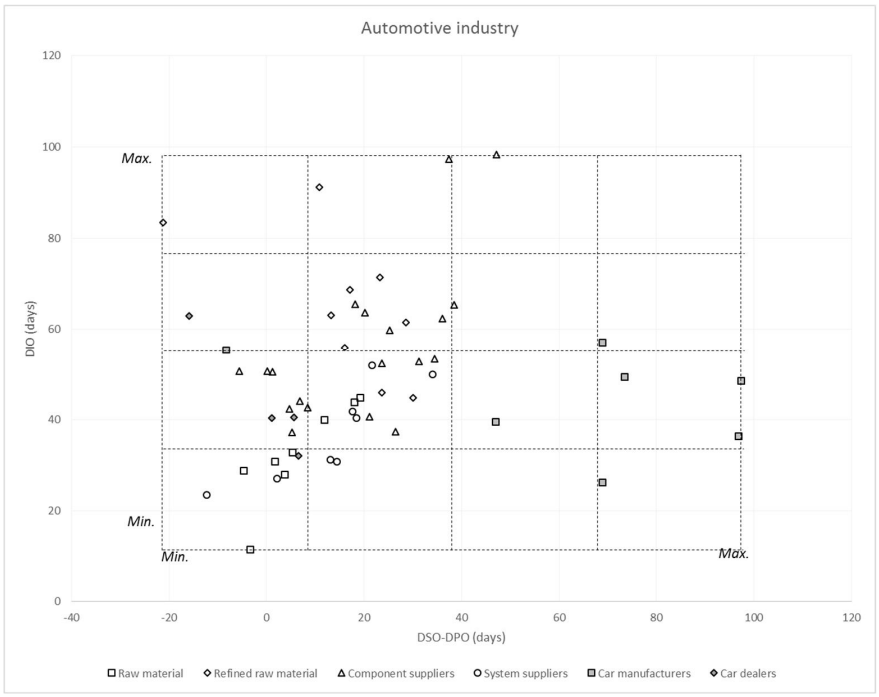

Figure B.1. Working capital models in the automotive industry.

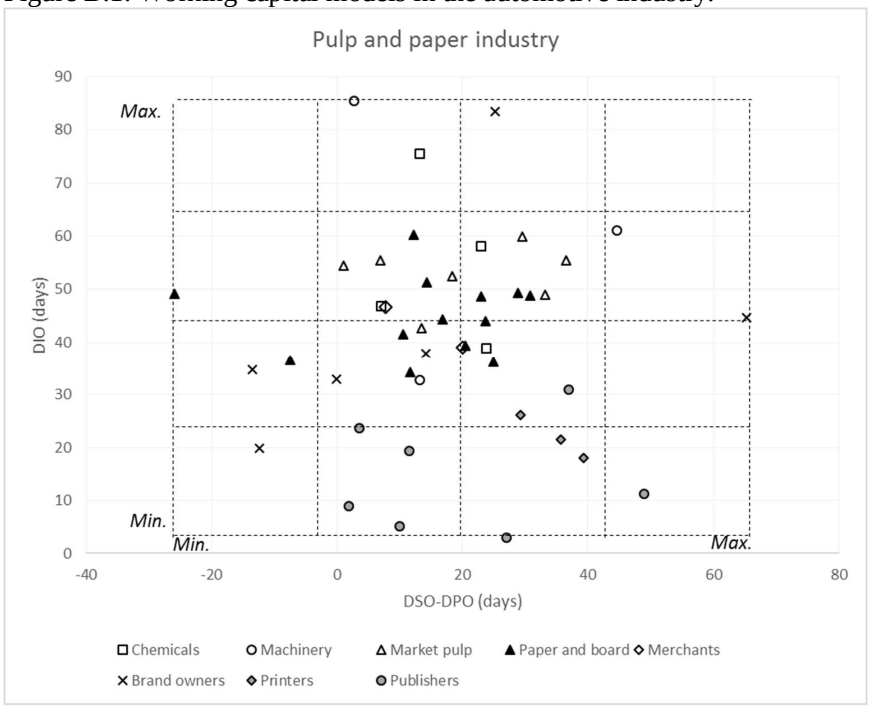

Figure B.2. Working capital models in the pulp and paper industry.

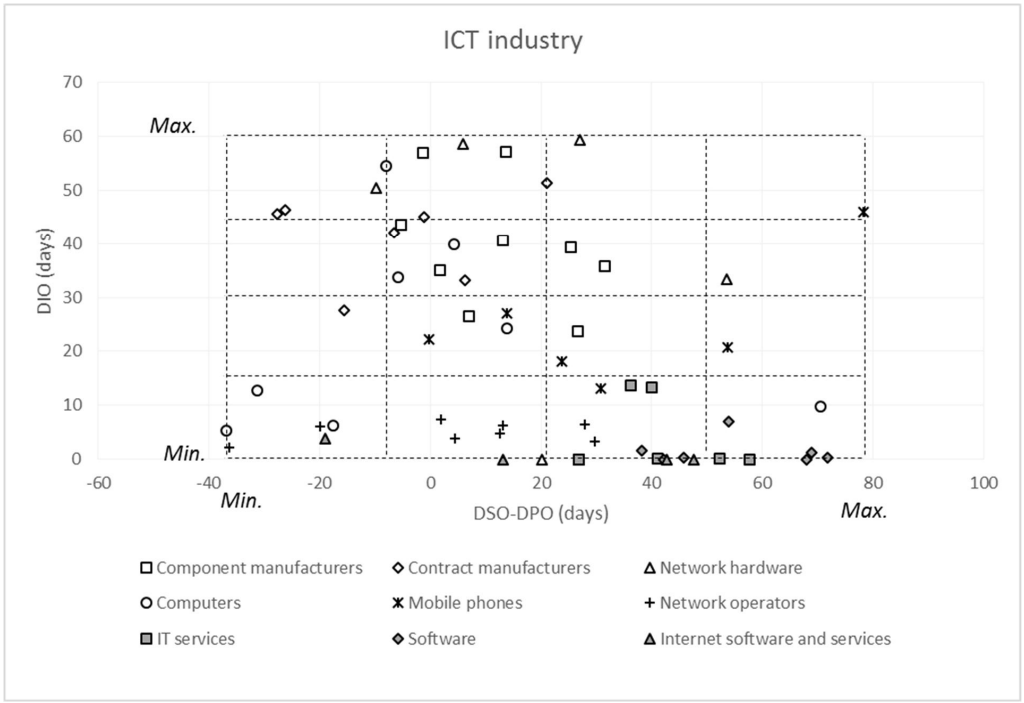

Figure B.3. Working capital models in the ICT industry.

APPENDIX C. Results of the cluster analysis.

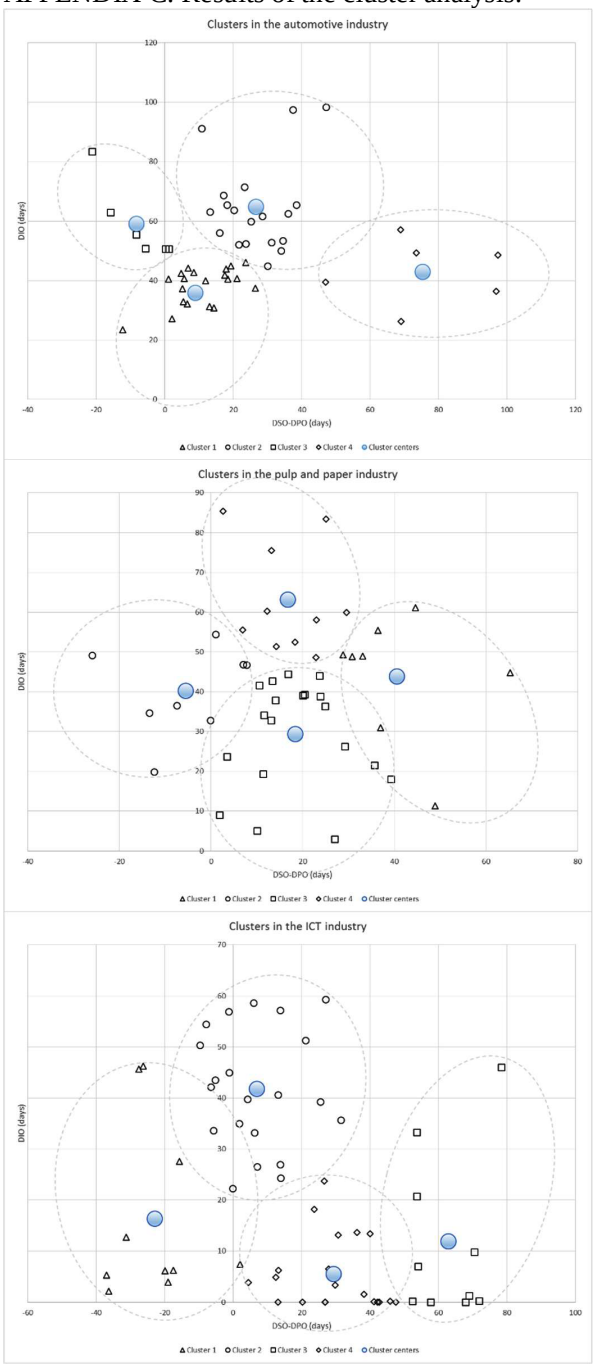

Figure C.1. Results of the cluster analysis.

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