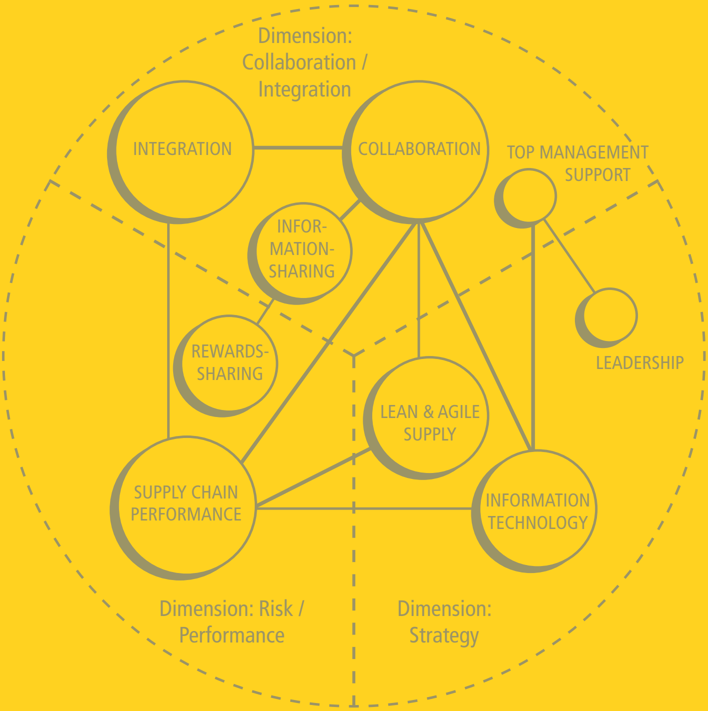
Florian Kache

Dealing with digital information richness in supply chain management – A review and a Big Data Analytics approach



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This work has been accepted by the Faculty of Economics and Management of the University of Kassel as a thesis for acquiring the academic degree of Doktor der Wirtschafts- und Sozialwissenschaften (Dr. rer. pol.).

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Acknowledgements

This doctoral dissertation provides a thorough overview of the current state of research in supply chain management, outlining a range of under-represented research areas as identified through a review of literature reviews. Taking the digital business transformation perspective, one exemplary area of research is assessed where a key focus is on Big Data Analytics and the value of information in supply chains.

The research project would not have been possible without the support and inspiration of a range of people. Thus, I would like to thank all the individuals that supported me during the research process.

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The doctoral seminars held by Prof. Dr. Seuring in cooperation with Prof. Dr. Martin Müller of the University of Ulm were a great arena to test hypotheses and discuss the overall research agenda. I would like to thank the many doctoral students who participated, provided thoughtful inputs and thus sparked off new ideas.

I am truly indebted and thankful to the participants of the Delphi study who dedicated their time and provided valuable input from which I was able to distil the main challenges and opportunities linked to the digital transformation of the business environment in general and Big Data Analytics in particular.

In addition, I would like to thank Prof. Dr. Werner Beile and Alice Beile-Bowes for the meticulous editorial and layout assistance.

Family is a source of energy. As the doctoral project required heaps of energy I would like to thank my family, especially my wife Wibke and my son Simon. They always encouraged and supported me during the dissertation process and were a vital source of inspiration.

Mainz, February 2015

Florian Kache

Preface

One consequence of the ever expanding availability of information is the challenge of handling this information appropriately. Information is one of the key enablers of modern business and a key constituent of supply chains and supply chain management. While related challenges now appear in our daily lives, this is even more the case along supply chains, where a multitude of actors is involved. Florian Kache takes this as the starting point for his PhD thesis in the field of supply chain management (SCM).

Taking up a challenging topic is one of the core decisions enabling a strong research contribution. Florian Kache has done so in two respects, tackling the challenge from two directions.

He analyses all relevant literature reviews published in 10 leading journals. Taken together, the 103 papers form in themselves a massive dataset. The research presented is the first attempt of a literature review of literature reviews in supply chain management, providing a thorough overview of the current state of research in supply chain management, which Florian Kache masters with a high degree of skill using established methodologies from content and contingency analysis. One apparent challenge is reaching ground in this broad analysis and moving beyond the obvious elements of supply chain management already evident. The relationship of supply chain collaboration and integration to performance and risk drives the comprehension of these central SCM constructs forward.

Based on this first step, he moves to the second step where he takes the digital business transformation perspective, focussing on Big Data Analytics and the value of (digital) information in supply chains. As research on the intersection of Big Data Analytics and supply chain management is still scarce, Florian Kache applies an exploratory approach based on a Delphi study. The conceptual work offers first insights into an emerging topic, both on the internal operations as well as on the supply chain level.

The PhD thesis is a uniquely deep and exciting contribution to the further comprehension of information richness in supply chain management. It opens up the field for future research so that I wish the thesis a good reception by the academic community.

Kassel, February 2015

Prof. Dr. Stefan Seuring

Contents

Glossary

B2B	Business-to-business
B2C	Business-to-consumer
BOM	Bill of material
CLSC	Closed Loop Supply Chain
CPS	Cyber physical system
CRM	Customer Relationship Management
CRS	Corporate Social Responsibility
DC	Dynamic Capabilities
ECR	Efficient Consumer Response
EDI	Electronic Data Interchange
ETO	Engineer-to-order
FMCG	Fast moving consumer goods
IJLM	International Journal of Logistics Management
IJOPM	International Journal of Operations & Production Management
IJPDLM	International Journal of Physical Distribution & Logistics Management
IJPE	International Journal of Production Economics
IJPR	International Journal of Production Research
IoT	Internet of Things
JBL	Journal of Business Logistics
JIT	Just-in-time
JOM	Journal of Operations Management
JSCM	Journal of Supply Chain Management
KBV	Knowledge-based view
M2M	Machine-to-machine
MRO	Maintenance, repair and operations
MTO	Make-to-order
OL	Organizational learning
PaaS	Platform as a service
POM	Production and Operations Management
POS	Point-of-sales
R&D	Research and development
RBV	Resource-based view of the firm
RFID	Radio Frequency Identification
SCM	Supply Chain Management
SCMIJ	Supply Chain Management: An International Journal
SCOR	Supply Chain Operations Reference-Model
SKU	Stock-keeping unit
SLR	Systematic literature review
SMAC	Social, mobile, analytics, cloud (digital key technologies/applications)
SSCM	Sustainable Supply Chain Management
Std. dev.	Standard deviation
TBL	Triple Bottom Line
TCE	Transaction Cost Economics
TCO	Theory of Constraints
TQM	Total Quality Management
VMI	Vendor Managed Inventory

Figures

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1 Introduction

1.1 Motivation

As a scientific research method, literature reviews play an important role in aggregating and disseminating knowledge in the management discipline (Tranfield *et al.*, 2003). However, in supply chain management (SCM), literature reviews have been utilized less often in the past compared to other research methods (Carter and Ellram, 2003). A reason may be that SCM is still in its infancy, compared to other disciplines of management (Chicksand *et al.*, 2012). Nevertheless, a higher utilization of literature reviews is required to foster theory development within the discipline (Gubi *et al.*, 2003). Accordingly, the recently growing number of SCM-focused journals publishing special issues on literature reviews, with a focus on *SCM Systematic Literature Reviews* (Supply Chain Management: An International Journal, Vol. 17 No. 4), *Building Theory in Supply Chain Management Through "Systematic Reviews" of the Literature* (Supply Chain Management: An International Journal, Vol. 19 No. 5/6), or *Literature Reviews in Supply Chain Management and Logistics* (International Journal of Physical Distribution & Logistics Management, Vol. 45 No. 1/2), already indicate an increase in the popularity of literature reviews among scholars in SCM.

Since the inception of SCM in the 1980s a plethora of researchers have developed models and frameworks to depict the essence of SCM (e.g. Burgess *et al.*, 2006; Chen and Paulraj, 2004; Mentzer *et al.*, 2001). However, to date no holistic analysis has been conducted which condenses major core SCM frameworks into one umbrella framework and applies this to the body of SCM knowledge represented in SCM literature reviews. Given the surge of academic SCM publications in the past 30 years, resulting in an increasingly fragmented field where disparate disciplines are claiming ownership, it may be required to understand how SCM research is developing (Zacharia *et al.*, 2014). This would enable identification of knowledge gaps, driving the development of SCM from a methodology as well as theory perspective (Tranfield *et al.*, 2003). Accordingly, a major motivation for this dissertation is to build a case for the enhanced application of systematic literature review research, in particular outlining the applicability of systematic literature review for developing and advancing SCM theory. In essence, the dissertation provides a thorough mapping and assessment of the academic SCM research landscape, obtained through a systematic review of literature reviews, pointing towards under-represented areas of SCM research.

Going further and following the thinking of Golicic *et al.* (2005), calling for a holistic, balanced approach in SCM research, the author of this dissertation combines exploratory desk research with exploratory field research in order to advance knowledge. This combined research approach is operationalized as a particularly under-represented research area, identified through the systematic literature review study, and is exemplarily researched in detail through use of a Delphi study methodology.

In particular, the research addresses the key role and value of information in supply chains. The selection of this topic for the exploratory field research is motivated from two directions: first, the topic was identified through the literature review process as being under-represented from a SCM point of view. Second, due to the incipient *digital transformation* process, expected to radically alter business ecosystems, change management practice and revolutionize supply chain dynamics (Waller and Fawcett, 2013), the management of data and information, being the raw materials of the digital age, is becoming increasingly important for businesses. The rationale is that the amount of data and information generated by, available to and collected through companies is growing at an unforeseen fast pace (McAfee and Brynjolfsson, 2012). The term *Big Data Analytics* has been coined in this respect, reflecting the volume, velocity, and variety surge of digital data which increasingly poses a challenge for companies, as it complicates the identification and extraction of the most relevant and valuable information required for managing the business and ultimately the supply chain (Beath *et al.*, 2012). However, having access to accurate and up-to-date information is paramount for informed decision-making at corporate as well as supply chain level. In turn, not having access to up-to-date, accurate and meaningful information represents a risk for companies and subsequently for the supply chain, as decisions need to be made on a reliable, evidence-driven basis (Ross *et al.*, 2013).

Although the need for businesses to develop their own *"digital agenda"* (Kim *et al.*, 2014, p. 83), is gaining increasing attention in the management sciences, empirical research on the topic is scarce. Due to the lack of comparable material on the role and value of information in supply chains, especially at the crossroad of SCM and the digital transformation agenda, the author approaches the topic in an exploratory fashion.

1.2 Research questions

The dissertation addresses five central research questions as presented in Table 1.1 (p. 3).

Reference	Research question
RQ 1	*How can key conceptual elements of SCM be interrelated and integrated into one umbrella framework?*
RQ 2	*What have been key research areas in SCM in the past?*
RQ 3	*Are there research areas in SCM which are relevant yet under-represented, and thus offer promising future research directions?*
RQ 4	*How can exploratory research help to address under-represented areas of SCM research?*
RQ 5	*What are the implications of Big Data Analytics on information usage at corporate and supply chain level, especially with regard to information identification required for decision-making?*

Table 1.1: Overview of research questions
(Source: Author)

Adding to the under-represented area of research in SCM, a conceptual framework is developed, which provides a structure for guided assessment of the information requirements on a business function level. This is the prerequisite for a focused application of analytics capabilities to Big Data, which subsequently could be leveraged to provide the information upon which business functions and supply chains can then build their evidence-based decisions.

Finally, enhancing the validity of the framework, a conceptual Delphi study employs industry experts' insights in order to outline potential chances and pitfalls of the digital transformation journey from a holistic perspective. By taking the Big Data Analytics example, the research provides fundamental insights for practitioners and academics alike in regard to the opportunities and challenges linked to the digital transformation process of businesses, considering the corporate and supply chain level.

Against the above presented background the dissertation aims at adding to knowledge generation in four ways:
First, the research aims at developing an integrated conceptual framework of SCM by condensing major elements of SCM into one “framework map”. Such a framework is beneficial for the research community as it maps the current state of SCM research. This approach yields a better understanding of the items of SCM and their interrelations as it enables a more aggregate view of SCM constituents, required to drive supply chain theory development.
Second, building on the conceptual framework map of SCM, the research aims to assess the landscape of SCM, as encapsulated in extant literature, and outline the key research areas.
Third, the research is designed to detect research gaps in the field of SCM as represented through under-represented areas of research. This procedure is expected to yield a rich knowledge base, suitable to allow future research initiatives to move into related topics.
Lastly, the research links the literature review findings into practice, executed through empirical field research, thereby showcasing how an under-represented research area could be addressed. The focus is on one exemplary under-represented area of research, concerning the role and value of information in supply chains in general, and the implications of Big Data Analytics on information usage at corporate and supply chain level in particular. Thus, the research builds a case for the increased use of literature reviews which, as being the foundation for knowledge creation, may provide a sound justification for subsequent empirical research endeavors.

The following section outlines the structure and flow of the dissertation, providing a brief summary of each chapter with a focus on highlighting individual objectives.

1.3 Structure of the dissertation and chapter overview

This dissertation is structured into twelve chapters as outlined in Figure 1.1 (p. 5). Allowing for a systematic assessment of the research questions, the chapters can be loosely separated into two consecutive parts: In the first part, comprising chapters 3-7, the current state of research in supply chain management is assessed and outlined. This is done through a large scale systematic literature review, supplemented by content analysis and contingency analysis. The application of this desk research approach leads to the identification of a range of relevant yet under-

represented research areas in the extant SCM literature, thereby providing answers to the research questions RQ 1 to RQ 3.
In the second part, which spans the chapters 8-11, a field research study, comprising a Delphi study, is conducted based on the previous literature review. Focussing on adding to knowledge generation in one exemplary under-represented area of research, this part is designed to answer the research questions RQ 4 and RQ 5.

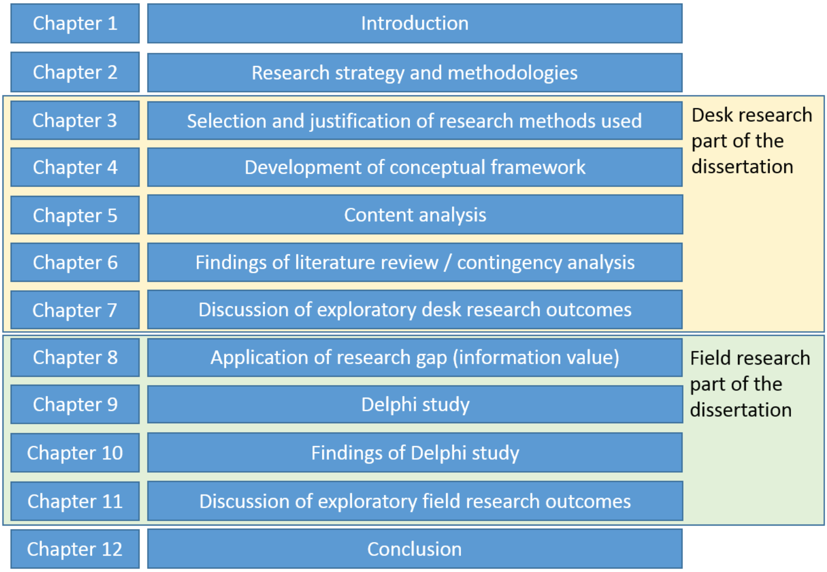


Figure 1.1: Schematic chapter overview
(Source: Author)

The following section provides a brief overview of the content of each chapter:

Chapter 1 (p. 1ff), the introductory section, motivates the overall research topic. It provides the rationale for the research, outlining why it is important to conduct research on the issues discussed in this thesis. Linking to the motivation and based on the aim of the research, five research questions are developed and presented. This is followed by a presentation of the research agenda, guiding the reader through the structure of this dissertation.

The theoretical foundations for the dissertation are developed in chapter 2 (p. 9ff). This chapter covers the definitions of SCM and takes a look at the development of

SCM over time. It also includes a discussion on the conceptualization of SCM in regard to other management disciplines. In addition, this chapter contains a broad section on research strategies and methodologies in SCM, considering ontological and epistemological perspectives, in order to prepare the grounds for the selection of the literature review methodology.

Chapter 3 (p. 21ff) builds on the research methodologies presented, serving as the methodological framing for the research methods applied in the empirical desk research part of the dissertation. The selected research methods, namely systematic literature review, content analysis, and contingency analysis, are presented and justified against the research aim. In addition, the chapter provides the rationale for the integration and systematic leverage of the three research methods in order to conduct transparent, replicable research. This chapter closes with an outlook towards research quality criteria as being applied throughout the thesis.

Taking the broad perspective on SCM, chapter 4 (p. 33ff) showcases vital frameworks outlining the essence of SCM. By condensing these key frameworks, a conceptual “framework map” of SCM is developed, comprising six distinctive dimensions and 26 categories. As content analysis requires the application of analytical categories in the coding process, this framework serves as the foundation which guides the subsequent content analysis approach applied to the literature reviews. In addition, this chapter contains a detailed presentation of each of the six dimensions and their respective 26 categories. Enhancing the validity of the 26 categories, a major focus of this section is on the thorough grounding of the categories in extant SCM theory.

Chapter 5 (p. 64ff) builds upon the conceptual framework map as developed in chapter 4. Applying the framework map, chapter 5 describes the thorough execution of the systematic literature review process through application of the four-step content analysis approach as proposed by Mayring (2010). Following the content analysis steps, namely material collection, descriptive analysis, category selection, and material evaluation, the role of each step of the content analysis is discussed. In addition, first results of the content analysis are presented as obtained through the descriptive analysis.

The findings from the review methodology, following the content analysis approach as utilized in this dissertation to execute the systematic literature review process, are presented in detail in chapter 6 (p. 85ff). The identification of current shortfalls in the literature provides the ground for a precise definition of the under-represented areas of research in SCM. To enhance the validity of the findings and as a means to assess possible interrelations between the dimensions and categories, a contingency analysis is applied to strengthen the content analysis results. Furthermore, the results from the previous chapters are disseminated into a holistic framework showing the interdependencies between the elements of SCM as a means to theory development.

The key insights from the dissertation's desk research part, comprising the literature review, the content as well as contingency analysis, are outlined and reflected upon in chapter 7 (p. 168ff). This includes a discussion of the contribution, the academic and managerial implications as well as the strength and limitations of the empirical desk research part. The chapter also bridges the deductive desk research part of the dissertation to the empirical field research part, thereby providing the transition link from the literature review part (chapters 3-7) to the exemplary assessment of an under-represented area of research in SCM (chapters 8-11).

Chapter 8 (p. 209ff) presents the rationale for the selection of the under-represented area. Thus, the relevance of the under-represented area, focussing on the role and value of information in supply chains, is outlined along the intersection of SCM and the implications of the digital transformation agenda, exemplified by Big Data Analytics. Enabling a focused application of Analytics capabilities to Big Data, a conceptual framework is developed in this chapter, which provides a structure for the guided assessment of business functions' information requirements on the corporate and supply chain level.

Enhancing the validity of the framework, a Delphi study is conducted in chapter 9 (p. 234ff). This chapter includes a critical review of methodological aspects of the Delphi study approach, including definitional aspects and characteristics, leading to a sound justification for the selected method. Next, the application of the Delphi study as employed in this dissertation is presented. Special consideration is given to the design of the study, the selection of the expert panel, as well as the overall data collection process covering three rounds (initial questions, aggregation of answers into group constructs, validation of group responses). Being the key contribution of chapter 9, the findings of the Delphi study utilizing experts' insights are outlined in order to identify opportunities and challenges linked to the adoption of Big Data Analytics in a corporate and supply chain environment.

Putting the findings of the previous chapter into perspective, chapter 10 (p. 298ff) provides a thorough discussion of the findings. Presenting the contribution of the empirical field research, the chapter outlines how the proposed conceptual information requirements framework (chapter 8.5.2, p. 226ff) can be enhanced by the results obtained through the Delphi study. This yields a better understanding of the relevance of the research. In a nutshell, this chapter gives guidance to academics and practitioners alike in regard to the opportunities and challenges linked to the digital transformation of business, exemplified through the application of Big Data Analytics. In addition, this chapter provides the transitory bridge between the field research and desk research part of this dissertation, looping the key Delphi study findings back into the literature review part of the dissertation.

Chapter 11 (p. 343ff) outlines the contribution of the dissertation's empirical field research part as well as the academic and managerial implications. In addition, this chapter also highlights the strengths as well as limitations of the study, uncovering future research opportunities. An additional aim of this chapter is to provide guidance on potential next research steps in order to further validate the proposed information requirements framework.

Concluding, chapter 12 (p. 360ff) summarizes the key aspects of the desk research as well as field research parts of this dissertation. Accordingly, this chapter briefly reflects on the research process by highlighting the essence of this dissertation.

This introductory chapter outlined in detail the rationale for the research, the five research questions as well as an overview of the chapters. In the next chapter, chapter 2, the theoretical foundations for the dissertation are developed.

2 Supply chain management: An overview, research strategies, and methodologies

This chapter develops the theoretical foundations for the dissertation. Accordingly, it covers the definitions of logistics and supply chain management, takes a look at the origins and the development of SCM over time, and also includes a discussion on the conceptualization of SCM in regard to other management disciplines (section 2.1). In addition, this chapter contains a broad section on research strategies and methodologies in supply chain management in order to prepare the grounds for the selection of the literature review methodology (section 2.2).

2.1 Definition of logistics and supply chain management

Early applications of the term logistics can be traced back to Roman and Byzantine times. Its first occurrence was tied to military functions of supply distribution, also marking the beginnings of organized trade (Harrison and van Hoek, 2008). Ever since, logistics activities were of significant importance to mankind's development, especially driven through military achievements (Christopher, 2010). The contribution of logistics in the Allied success in World War II allowed for a shift of focus, considering the possibilities of logistics in the modern business environment (Lambert *et al.*, 1998). However, it was not until the early 1960s that logistics gained popularity in business, most notably through Drucker's work (Drucker, 1962) proclaiming the value of business opportunities derived from the use of logistics as one of the last areas for real efficiency improvement.

However, logistics research has always been somewhat restricted to physical distribution and transportation theory (Mentzer *et al.*, 2004). A comprehensive well-cited definition of logistics in a business context is provided by Christopher (2010). He defines logistics as the *"process of strategically managing the procurement, movement and storage of materials, parts and finished inventory and the related information flows through the organization and its marketing channels in such a way that current and future profitability are maximised through the cost-effective fulfilment of orders."* (p. 2). Thus, logistics provides a strategic framework, an overall plan for materials and information flow through a single factory manufacturing environment.

Supply chain management has one of its origins in supply management, its predecessor, which can be traced back to the early 1980s. Kraljic (1983) suggested in an article published in the *Harvard Business Review* that the terms procurement and purchasing should be renamed “supply management,” as they focused too much on financial business aspects and did not embrace the logistics and manufacturing aspect of the business.

The modern term supply chain management was coined in 1982 by management consultants (Oliver and Webber, 1982), based on Forrester’s (1958) work and further refined by Houlihan (1984, 1988), closely linking it to the physical distribution and transportation theory of logistics. Despite their initiating character, these early practitioner-led theoretical conceptualizations were a major obstacle for the recognition of SCM as an emerging discipline of its own. The lack of strong theoretical grounding nurtured the misconception that the supply chain is *“simply the process of inventory and logistics management”* (Stewart, 1997, p. 64) despite Houlihan’s (1985) early proposition “*that the supply chain is a single entity, rather than a set of linked segments and fragmented responsibility”* (p. 22). This resulted in researchers repeatedly concluding that SCM and logistics cannot be differentiated (Harland *et al.*, 2006; Larson and Halldórsson, 2002). However, Cooper *et al.* (1997) outlined that a key difference between SCM and logistics concepts is the business-spanning strategic nature of SCM, most apparent in new product development, which ideally involves all business functions. This is not found in the logistics concept and thus marks the divide. Furthermore, SCM builds upon the logistics framework, but focuses more on linking processes and extending the single company view of the logistics framework to the overall alignment of the chain of companies (Fritz and Hausen, 2009; Harrison and van Hoek, 2002). The overarching and function-bridging character thus represents a key constituent of SCM. The relevance of this view is driven by the understanding that SCM was repeatedly labeled as not constituting a discipline of its own (compare Chicksand *et al.*, 2012; Cousins *et al.*, 2006; Harland *et al.*, 2006). However, as outlined by Chicksand *et al.* (2012), the adherence of SCM to criteria governing recognition as a discipline, in particular coherence and quality as well as breadth and depth, as requested by Fabian (2000), has made progress in recent years, especially in terms of more focused research with higher impact levels. Nevertheless, the recognition of SCM as constituting a full scientific discipline of its own is still hindered by the lack of a *“discipline-debate on the key issues”* (Chicksand *et al.*, 2012, p. 455), most notably the development of an individual “theory of SCM”.

Regardless of this ongoing discussion, SCM can well be described as being “interdisciplinary” in nature (Ellram and Cooper, 2014). The interdisciplinary character is linked to the role of SCM which orchestrates the business functions (Anderson *et al.*, 2007); it thus can be argued that SCM is required to understand how to create value between departmental flows. This is well in line with the findings by Harrison and van Hoek (2008), whereas a key benefit of supply chain management from a business perspective is to “*deliver superior value to the end customer at less cost to the supply chain as a whole*” (p. 6).

In general, it is common understanding in academia that the concept of SCM depicts an integrative philosophy, an orientation of the way companies conduct business (Ellram and Cooper, 2014); the key focus being on business function-spanning value-creation, driven by the seamless flow of goods, from raw material suppliers, to end customers (Towill, 1997). Taking into account this collaborative aspect of multiple suppliers, Christopher (2010) defines the supply chain as “*a network of connected and interdependent organisations mutually and co-operatively working together to control, manage, and improve the flow of materials and information from suppliers to end user*” (p. 19). The definition of SCM by Mentzer *et al.* (2001) adds to this systematic integrative nature of SCM, as the supply chain embraces *“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 source to the customer”* (p.4). However, the above definitions only represents a small portion of the multitude of supply chain management definitions; and researchers still struggle to agree on a common “received view” (Chicksand *et al.*, 2012; Mentzer *et al*, 2008). Croom *et al.* (2000) explain this abundance by taking into account the breadth of business areas in which supply chain management is rooted. Nevertheless, as stated by Stock and Boyer (2009) a *“consensus definition of SCM is of significant importance in the advancement of SCM theory and practice”* (p. 691). Accordingly, having identified 166 different definitions of SCM in the extant literature, Stock and Boyer (2009) distilled the following encompassing definition of SCM: *“The management of a network of relationships within a firm and between interdependent organizations and business units consisting of material suppliers, purchasing, production facilities, logistics, marketing, and related systems that facilitate the* *forward and reverse flow of materials, services, finances and information from the original producer to final customer with the benefits of adding value, maximizing profitability through efficiencies, and achieving customer satisfaction"* (p. 706). This dissertation will follow the definition by Stock and Boyer (2009) as it neatly condenses the core aspects of other authors' definitions in an encompassing, yet focused fashion.

From a managerial point of view, SCM gained popularity among practitioners especially in manufacturing management across industries, based on an article published by Fuller *et al.* (1993) in the *Harvard Business Review*, which outlined the emergence of SCM from the formerly undervalued logistics. SCM was declared to be a new business area and *"a key resource of competitive excellence"* (Frohlich and Westbrook, 2001, p. 197), as it offers high potential for savings identification and value creation for the customer.

Since its emergence, SCM has generated a plethora of synonyms, most notably "supply networks" (Lamming *et al.*, 2000), "demand pipelines" (Farmer *et al.*, 1991), "demand chain management" (Jüttner *et al.*, 2010), "seamless demand pipelines" (Bechtel and Jayaram, 1997), also embracing the "value stream" concept (Womack and Jones, 1996). New (1994), who proclaimed the supply chain hypothesis, i.e. that supply chain management offers competitive advantage by implementing efficiency related tools, has condemned the fruitless discussion about the most appropriate labelling, declaring it rather harmful. Of all the synonyms, especially the emergence of the term "value stream" seemed to be crucial in defining supply chain management. The "value stream" includes only value-adding supply chain activities, as opposed to all activities, such as waste. As such, it is to be seen as the core of the supply chain picture (Womack and Jones, 1996), underlining that value creation is essential for successful supply chain management (Porter, 1980).

2.2 Research strategies in SCM: Ontological, epistemological, and methodological perspectives

One of the main issues of empirical scientific research is concerned with the appropriate choice of research strategies as the key to further knowledge creation. As such, the use of research methodologies is controversially debated among scholars, also affecting the research in supply chain management (Creswell, 2013, Frankel *et al.*, 2005, Mentzer and Kahn, 1995, Meredith *et al.*, 1989). As ontological as well as epistemological considerations play a vital role in this discussion, the presentation of research strategies is outlined based on these grounds.

According to Frankel *et al.* (2005) the individuals' world view, the ontological position, sometimes referred to as *Weltanschauung* (Checkland, 1993), determines the starting point of every research endeavor. Two extreme ontological views can be differentiated from a philosophy perspective: The objectivist view portrays the understanding that *"social phenomena and their meaning have an existence that is independent of social actors"* (Bryman and Bell, 2011, p. 19). Following the antithetical constructionist position, the *"social phenomena and their meanings are continually being accomplished by social actors"* (Bryman and Bell, 2011, p. 20). This implies that social actors are the drivers behind social phenomena. Social reality can thus not be regarded as being definite as it is subject to constant change, triggered by individual's influence on the environment.

Following extant theory (Bryman and Bell, 2011) the ontological framework inevitably influences the cohesive selection of research strategies, ultimately governing the author's decisions in regard to the choice of the epistemological paradigm. Thus, from an epistemological perspective, the debate about research strategies is influenced by two distinctive scientific paradigms, namely positivism and interpretivism (Bryman and Bell, 2011, Burgess *et al.*, 2006). Scholars who adapt the positivist view aim to imitate the natural sciences (Bryman and Bell, 2011), driven by the point of view that reality can be understood (Bhaskar, 2013). Accordingly, as seen by Mentzer and Kahn (1995), positivist researchers pursue the "*goal to explain and predict reality, where reality is considered to be objective, tangible, and fragmentable*" (p. 232). The opposing interpretive view helps to "*understand a phenomenon but not to explain or predict*" as it depicts a "*collective of multiple socially constructed realities* [where] *people* [are] *proactive and voluntaristic"* (Mentzer and Kahn, 1995, p. 232).
In a logistics and SCM research context it has been found that the scholars' research focus gradually shifted from mainly following the positivist paradigm (Mentzer and Kahn, 1995) towards a more balanced use of the interpretivist and positivist paradigms (Golicic *et al.*, 2005).

In addition to the understanding that the ontological view poses an influence on the researcher's epistemological choice of research methods, the choice also depends on several other factors, such as the subject of research, and how the researcher designs the research (Eisenhardt, 1989; Yin, 2011).

A common understanding among academics builds on the idea that all research methods can be categorized into either objective and scientific, known as the “quantitative approach,” or subjective and cognitive, known as the “qualitative approach” (Bryman and Bell, 2011). Frankel *et al.* (2005), in their analysis of research articles published in the well-respected *Journal of Business Logistics*, identified eight commonly used methods in logistics and SCM research, namely surveys or questionnaires, interviews, observations, focus groups or Delphi panels, case studies, experiments, literature reviews, and content analyses.

Following this grouping approach, surveys or questionnaires, interviews, focus groups or Delphi panels, experiments, and literature reviews are primarily most suitable for static, economic use. As such they represent the quantitative methodology family (Bryman and Bell, 2011; Mentzer and Kahn, 1995). In contrast, case studies (Creswell, 2013), observations, and content analysis (Kassarjian, 1977; Mayring, 2010) are generally more concerned with research aspects of psychology and sociology (Mentzer and Kahn, 1995). As such, they are seen as part of the processual, qualitative methodology family (Bryman and Bell, 2011).

However, Frankel *et al.* (2005) point out that the divide between qualitative and quantitative is often not very definite, with research methodologies ranging somewhere in between the two extremes. This is further illustrated in Figure 2.1 (p. 15), which displays the use of logistics and SCM research methods as found by Frankel *et al.* (2005), based on earlier work by Easterby-Smith *et al.* (2002).

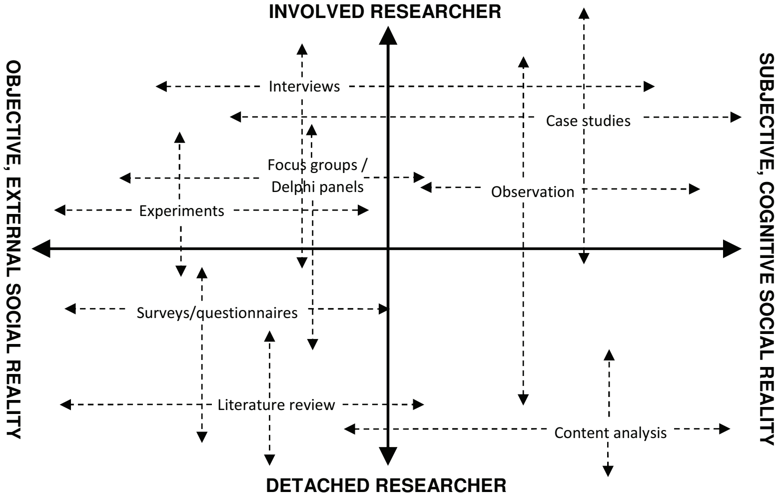


Figure 2.1: Use of methods in logistics and SCM research
(Source: adapted from Frankel *et al.*, 2005)

The majority of scholars in logistics and SCM research apply quantitative research methods such as surveys and usually not empirical modeling, whereas qualitative methods are not yet widely accepted (Burgess *et al.*, 2006; Frankel *et al.*, 2005; Mentzer and Kahn, 1995; Näslund, 2002; Seuring and Müller, 2008b, Solem, 2003). A major exception on the qualitative side is the case study method, which has a long history as the most utilized research method in management in general and is also a prime method for qualitative research in SCM in particular (Burgess *et al.*, 2006). Näslund (2002) sees the reason for the unbalanced usage of methodologies in a lack of training of scholars in interpretivist or qualitative methods for SCM, basing the imbalance on the history of positivism in logistics research. Golicic *et al.* (2005), in their study of research publications on SCM, link this into a geographical divide where North American scholars tend to use more quantitative research while European scholars seem to have a slight preference for qualitative research methods.

This adds to a problem long debated in the management science community: some researchers (Starkey *et al.*, 2009; Cousins *et al.*, 2006; Mentzer and Kahn, 1995) argue that most of the research in logistics and SCM is largely managerial in focus; as such it contributes little to theory development, testing or application. Focused theory development, however, supported by construct and concept development, is paramount for the advancement of SCM as stated by Chen and Paulraj (2004), based on earlier critiques (e.g. New, 1996), to prevent the research area from *"collapsing into a discredited management fad"* (Chen and Paulraj, 2004, p. 120). This discrepancy in research focus has been made responsible by a variety of scholars for the often cited relevance gap between theory and practice (Gulati, 2007; Ketchen and Hult, 2007; Merton, 1949; Storey *et al.*, 2006; Starkey and Madan, 2001; Weick, 2001). Prockl (2005) highlights this problem, demanding that modern SCM research needs to bridge the *"gap between theoretical rigor and practical relevance*" (p. 399). To bridge this gap, it has been suggested that theory and practice should be confronted in a straightforward and systematic manner that is of value for both academics and practitioners (Fawcett and Waller, 2011, Mentzer and Flint, 1997; Stock and Boyer, 2009; Weick, 2001). However, academics' theory is often based on fundamentals enhanced only by fragments of practice (Gummesson, 2000), while practitioners often lack general theory and therefore have to "*set aside their* [guru] *fads and begin working with fundamentals," w*hich provide the basis for getting "*the big picture*" (Weick, 2001, p. 72). Starkey and Madan (2001) propose that balancing distance and involvement between academics and practitioners is essential to foster the required levels of trans-disciplinary learning.

Nevertheless, the prevailing use of static quantitative approaches in SCM research theory offers little help for practitioners to improve the performance of the company or supply chain. They lack means for a thorough investigation of causality and do not cater for a careful consideration of case specific circumstances. This is in line with the findings of Giménez (2005), highlighting the fact that despite the amount of potential research objects "real" empirical research is still very rare. Apart from the researcher's quantitative orientation, this discrepancy is likely to be found in the rapidly and constantly evolving setting of the SCM research field. This overall dynamic nature of the SCM topology makes it difficult to generalize findings through a quantitative approach, using benchmarking for instance.

A *"significant need for more investigator-involved, qualitative research on supply chains"* (Childerhouse and Towill, 2011, p. 9) has thus been proclaimed to overcome the initial problems related to the quantitative-focused shortcomings (Mentzer and

Flint, 1997; Westbrook, 1995). In this light, Prockl (2005) highlights the benefits pursuing a cooperative research approach between industry and academia. Following Ellram's (1996) approach, Stuart *et al.* (2002) suggest the use of the processual case study methodology for logistics, operations management, and SCM theory building. The advantages of the collaborative case approach are that it aims to provide detailed explanations of best industry practices', leading to a better understanding and investigation of causality of data gathered, thus satisfying the above stated need for theory building ultimately allowing for value creation for both practitioners and academics (Stuart *et al.*, 2002). This has been underlined by various studies of methodology usage in logistics and SCM research (Ellram, 1996; Frankel *et al.*, 2005; Meredith *et al.*, 1989; Müller, 2005; Seuring, 2008) portraying a growing trend towards a more frequent use of the case study approach. This includes other previously neglected case-based methods, i.e. action research. Pannirselvam *et al.* (1999) forecasted this development as part of a general trend in logistics and SCM research, where the integrative nature of management research pushes the researchers for higher levels of innovation in terms of methodology usage. In general, it can be said that case-based methods present a very feasible approach to confront theory and practice due to the paralleling character of the methodology being able to allow for a situation-specific design in order to cover any case-specific circumstances.

Deshpande (1983) states that most research approaches are often regarded as mutually exclusive. However, both quantitative as well as qualitative approaches have certain advantages as well as disadvantages, and they cannot be substituted for one another. Accordingly, Bryman (2012) suggests that the qualitative methods may be slightly better suited to research a subject on the macro-level, whereas the quantitative approach is of great value for micro-level research. Nevertheless, as qualitative and subjective assumptions are the foundation for all quantitative assessment (Gummesson, 2006), both paradigms should be used in conjunction as one approach alone is often not sufficient to solve all research problems (Burgess *et al.*, 2006; Frankel *et al.*, 2005; Thomas, 2003). This is backed by Bryman and Bell (2011), who suggest that the applicability of the two approaches is dependent on the current phase the research is in. In terms of terminology, the supplementing approach is commonly referred to as multi-method research (Layder, 1993) or mixed model research (Creswell, 2013).

A viable reason for the multi-method research approach can be found in validity, as every research method lacks at least one aspect of it, i.e. surveys lack internal validity; models and case studies lack external validity (Mentzer and Flint, 1997). Thus, through triangulation (McGrath, 1982), applying a variety of methods helps to overcome a single method's shortcomings and maximize validity, as the validity of the research findings increases incrementally in proportion to the number of methods applied (Creswell, 2013). The findings by Boone *et al.* (2007), based on Jick (1979) add to this, highlighting the value of triangulation in SCM research *"as it leads to robust results and provides opportunities for cross-method synergies"* (p. 601), which provide more perspectives on the subject under investigation. Pursuing the complementing approach, Golicic *et al.* (2005) proclaim the use of a balanced approach to research in supply chain management, formalized in Figure 2.2 (p. 18).

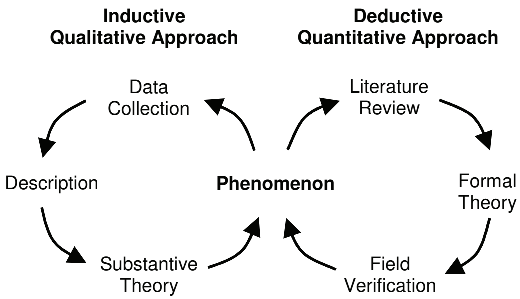


Figure 2.2: A balanced approach to research in supply chain management
(Source: Golicic *et al.*, 2005)

Reiteration of the Five Stage Research Process (Stuart *et al.*, 2002), linking research question development (stage 1), instrument development (stage two), data gathering (stage three), data analysis (stage four), and dissemination (stage five) through the two cycles helps to enrich the results gathered in the previous stages. The process depicts the common three-dimensional view, known as "*perceptual triangulation*" (Bonoma, 1985), thus cross-checking the results of the stages enables and enhances the validity, reliability, and generalizability of the findings (Bryman and Bell, 2011; Seaker *et al.*, 1993).

Based on the above outlined ontological as well as epistemological approaches and presentation of research strategies in SCM, the remainder of this section elaborates on the dissertation's positioning within these paradigms. The research strategies applied by the author in this dissertation can be clustered into two parts according to the applied research process: The desk research part (chapters 3-7) follows a positivist epistemological orientation which is based on the author's objectivist ontological assumptions. This part is quantitative in nature (literature review, content analysis, and contingency analysis), although being supplemented by qualitative aspects (content analysis). The second part, the field research (chapters 8-11), is of qualitative nature (Delphi study), portraying an interpretivist epistemological view based on a constructionist ontological understanding. Table 2.1 outlines the positioning of the desk as well as field research in an ontological and epistemological context.

	Desk research part	**Field research part**
Ontological orientation	Objectivism	Constructionism
Epistemological orientation	Positivism	Interpretivism
Principle research orientation	Quantitative research methods	Qualitative research methods
Research methods applied	Literature review, content analysis (partly qualitative), contingency analysis	Delphi study

Table 2.1: Ontological and epistemological positioning of the dissertation
(Source: Author)

The selected mixed methods approach (Creswell and Clark, 2007) follows recommendations as outlined above, advising a balanced research approach through methodological triangulation. Reduced to either the qualitative or the quantitative side of research, the dissertation shows a slight preference towards qualitative research methodologies (Delphi study as well as parts of the content analysis). Accordingly, in line with findings stated earlier, depicting a substantial lack of qualitative methodology usage in supply chain and logistics research, this dissertation aims to reduce and partly overcome the gap of unbalanced methodology application, adding to practical knowledge generation from a qualitative as well as quantitative perspective.

This chapter covered the definitions of SCM and outlined the development of SCM over time, which included a discussion of the conceptualization of SCM in regard to other management disciplines. Being the core of this chapter, a substantial part of this chapter deals with the presentation of qualitative and quantitative research strategies and methodologies in SCM, taking into account ontological and epistemological considerations. This prepares the grounds for the selection of the literature review methodology which will be further elaborated on in chapter 3.

3 Selection and justification of research methods used in empirical desk research part of the dissertation

A comprehensive overview of the plethora of quantitative and qualitative research methodologies, previously applied by various scholars in supply chain and logistics research, represents the foundation for the selection of an appropriate research methodology. The next sections focus on the research process, outlining the research methods applied in this thesis enabling identification of under-represented research areas. Accordingly, the key characteristics of literature review research (section 3.1), as well as content analysis (section 3.2), and contingency analysis (section 3.3) are presented. In addition, research quality considerations are outlined in order to provide structure along the lines of the applicable quality criteria, namely validity and reliability (section 3.4).

3.1 Literature review research

From the large range of qualitative and quantitative data collection methods that are suitable for supply chain management research outlined in the previous chapter, the literature review methodology represents the most feasible starting point to scope the area of research (Hart 1998; Mentzer and Kahn, 1995). The fact that the steadily growing popularity of supply chain management over the last decades has spawned a substantial amount of literature on this topic, covering a vast array of supply chain management aspects, builds a case for this approach of a comparative assessment of the literature available.

As a scientific research method, literature reviews play an important role in aggregating and disseminating knowledge in the management discipline (Tranfield *et al.*, 2003). However, in SCM, literature reviews have been utilized less often in the past compared to other research methods (Carter and Ellram, 2003). Gubi and co-authors (Gubi *et al.*, 2003) therefore called for a higher utilization of literature reviews which they see as a necessity to foster theory development. Accordingly, recent issues of SCM-focused journals publishing special issues on literature reviews (e.g. in Supply Chain Management: An International Journal, International Journal of Physical Distribution & Logistics Management) indicate a popularity increase of literature reviews in SCM.

As the *"backbone of almost every academic piece of writing"* (Seuring and Gold, 2012, p. 554) literature reviews play a vital part in the academic process of knowledge dissemination. However, as reported by Briner and Denyer (2012), few researchers are trained in the proper use of the literature review methodology; and the results are often driven by "*partial, haphazard and opinion driven synthesis of previous research findings*" (Briner and Denyer, 2012, p. 331). This neglects the strength of literature reviews as being an excellent tool to structure a research field (Mentzer and Kahn, 1995), reduce the area of research to a manageable size while providing the grounds for explaining and justifying research objectives, overall research design and methodology used (Hart, 1998). Tranfield *et al.* (2003) highlight the usefulness of literature reviews for mapping, disseminating, and evaluating the intellectual territory of a research area.

Frankel *et al.* (2005) argue that a literature review should comprise a detailed analysis and critical summary of previously collected data (often secondary data), allowing for research gap identification and aiding further knowledge development. In this light the literature review supports the researcher in mapping the various connections between different fields of literature, linking them to the corresponding research gaps identified. Thus, it has been recommended to include a literature review as an integral part of any research project (Mentzer and Kahn, 1995; Tranfield *et al.*, 2003). From a classification standpoint, the literature review methodology can be categorized as being part of the archival research method family (Searcy and Mentzer, 2003). According to Briner and Denyer (2012) five different types of literature reviews can be distinguished as outlined below:

- Literature reviews motivating empirical studies
- Formal full-length literature reviews by academics (argument/thematic review or expert review)
- Meta analyses
- Reviews in current textbooks
- Reviews in popular management books

Literature reviews motivating empirical studies represent the most commonly used type of literature review (Briner and Denyer, 2012, p. 333). This type of short, often descriptive-narrative review, also referred to as *"foundational literature"* (e.g. Hazen *et al.*, 2012), is often used at the beginning of published empirical research articles to build a case for the empirical research to follow. This type of review has been reported to be unbalanced in the selection of literature, including published academic articles in the review that follow the authors rationale, but omitting contradicting articles while rarely stating the specific reasons for the biased selection (Crowther and Cook, 2007).

Formal full-length literature reviews by academics can be further classified in two subtypes: *argument/thematic review* and *expert review*.

The *argument/thematic review* applies rigorous methods and usually follows a particular argument or theme (Briner and Denyer, 2012, p. 334). Often referred to as systematic literature review (SLR) (Denyer and Tranfield, 2006; Tranfield *et al.*, 2003) this evidence-based review approach (Rousseau *et al.*, 2008) is ground in psychology, psychotherapy, and evidence-based medicine (Briner and Denyer, 2012, p. 341). It follows a systematic and explicit design, engineered to maximize replicability while allowing for a high level of transparency (Crowther and Cook, 2007), and minimize researcher bias in every step of the research process (Carter and Easton, 2011). In addition, the careful mapping of the research process ensures that it is auditable (Wong *et al.*, 2012) as the analysis could be re-run by other researchers (Seuring and Gold, 2012), an aspect positivistic to scientific research.

Further advantages of the systematic literature review approach include that the literature can be analyzed through multiple perspectives (Ghadge *et al.*, 2012). It should be noted, however, that the explicit use of methods is not always stated or discussed. In addition, Tranfield *et al.* (2003) argue that researchers should apply quality assessment criteria on an article level instead of basing research on journal quality ratings only. Furthermore, as Crowther and Cook (2007) discussed, many literature reviews that state to be systematic are narrative, as it requires a skilled researcher to maintain the appropriate degree of rigor in a systematic review.

Despite the many advantages, researchers struggle with the proper application of systematic literature reviews as discussed by Briner and Denyer (2012). One major reason may be that the researchers are confronted with the task to manually review a large amount of text which to review has been reported to be time consuming and *"quite laborious"* (Ghadge *et al.*, 2012) while being prone to error and bias (Fink, 1998; Hart, 1998). To shorten the process of reviewing and analyzing the literature, qualitative data analysis software could be applied (Ghadge *et al.*, 2012). Still, some concerns prevail as the software does not "understand" the text (in the human sense of understanding) and thus may not decode the meaning of text often hidden in context of the words (Tausczik and Pennebaker, 2010, p. 30). As a result the analysis of the literature may be missing out important aspects, and findings may thus not be accurate.

An *expert review* is usually guided by the expertise of the individual researcher in the specific field of study (Briner and Denyer, 2012, p. 334). As opposed to the argument/thematic review this qualitative review does not follow any clear method and promotes a rather descriptive-narrative review style. Expert reviews have been found to be prone to systematic error (Crowther and Cook, 2007) and researcher bias issues (Fink, 1998; Hart, 1998), while lacking thoroughness and rigor (Tranfield *et al.*, 2003). This type of literature review is usually used in exploratory and conceptual studies (Frankel *et al.*, 2005). It can be described as unstructured, leaving the audience confronted with the researcher's intellectual outcome without disclosing the intellectual process (Seuring and Gold, 2012).

The *meta analysis* describes a quantitative research technique where "*data from comparable individual studies that address the same topic"* is quantitatively combined with the aim to derive higher-level conclusions (Briner and Denyer, 2012, p. 334). According to Kirca and Yaprac (2010), based on Cooper and Hedges (1994), the meta-analytical approach is not limited to combining findings across studies, but also includes a comparison of research findings aiming to distill the core methodological aspects of the research that lead to differentiated outcomes. The comparisons provide the ground for subsequent definition and testing of theoretical propositions, which may be conducted through statistical and path analyses. This is a key advantage of the meta analysis over other synthesis techniques (such as narrative reviews), as its application of statistical analysis facilitates the detection of effects and relationships, which is not supported by other techniques (Lipsey and Wilson, 2001; Rodriguez Cano *et al.*, 2004). In general, meta analyses of literature and traditional literature reviews do not oppose each other but rather complement one another (Kirca and Yaprac, 2010). While the literature review approach is suitable in case the research process requires to *"evaluate the presence or absence of something,"* the meta analysis is an excellent tool for *"measuring the degree to which something is present or related to something else"* (Terpend *et al.*, 2008, p. 29). This illustrates the difference between the two techniques: while the meta analysis is applicable for knowledge creation through the systematic, quantitative synthesis of primary research, the literature review technique employs a qualitative research approach.

Literature reviews published in current textbooks are usually written for the educational mass market. As books are restricted by space limitations these reviews seldom aim at presenting a holistic picture of past research. They rather target selected research aspects valued by the author as being relevant to an area of research. The literature findings are presented in a rather simplified narrative manner, with a clear focus on knowledge developments over time, sometimes portraying *"the importance of a few key individuals in the style of the 'Great Man' theory of history"* (Briner and Denyer, 2012, p. 335). In contrast to formal full-length literature reviews by academics, these reviews do not have to withstand a strict test for quality and adequacy, exemplified, as they do not elaborate on the review methodology (Boote and Beile, 2005).

The fifth type of literature reviews, *reviews in popular management books*, is targeted at practitioners. These books are characterized by presenting presumably new, "leading edge" management techniques which *"are not well-established enough to have been well-researched"* (Briner and Denyer, 2012, p. 336). Similar to reviews in current textbooks the literature reviews in management books are lacking a thorough description of the used review methodology. In addition, they do not follow a systematic, transparent approach and do not undergo a peer-reviewed quality assessment. As selected research findings are presented as "evidence" if they support the author's argumentation to underline the featured management technique, these books are of little academic value (Rousseau, 2006).

As outlined previously, a key characteristic for the reliability of the sciences is the replicability of research results (Meredith, 1998). Pursuing a scientific perspective, this dissertation employs a transparent, repeatable research design through application of the systematic literature review methodology, focussing on *argument/thematic reviews* being a part of *formal full-length literature reviews by academics*. Therefore, *literature reviews motivating empirical studies*, as well as *reviews in current textbooks* and *reviews in popular management books* will not be addressed further. In addition and as highlighted elsewhere (Seuring and Gold, 2012, Tranfield *et al.*, 2003) the application of *meta analysis* may not be suitable for summing up knowledge due to the SCM discipline being in its infancy (Barratt, 2004) and the resulting heterogeneity of the field.

The selection of the systematic literature review approach in this dissertation is also motivated by the idea that the application of the systematic literature review approach, being a scientific technique (Tranfield *et al.*, 2003), is perceived to have great potential in regard to the development of management. The rationale being that the "science of management" since its inception, postulated in the "principles of scientific management" work by Taylor (1911, 1914), has continuously been criticized for being rather "unscientific" compared to other traditional sciences such as medicine or engineering (Freedman, 1992; Ghoshal, 2005; Pilkington and Liston-Heyes, 1999). On a granular level, this is especially evident in regard to the field of SCM, whose legitimacy of constituting an own academic and scientific discipline, separated for example from logistics, has been questioned (Cousins *et al.*, 2006).

A key aspect of management science criticisms is linked to the way research is conducted in management. Thus, research is to a high degree based on case studies, as continuously reported by a range of authors (e.g. Burgess *et al.*, 2006), and rarely conducted for instance in a controlled environment, such as a laboratory. It is common understanding that the rather young management discipline requires a substantial utilization of the case based research method in order to address the variety of aspects within this diverse field (Eisenhardt, 1989), which cannot be conducted in a laboratory environment. However, this preference and focus on case study research represents a major challenge, as the replicability of case study results, due to the unique character of each case setting, is only of theoretical nature (Otley and Berry, 1994). However, the general understanding across research disciplines is that a scientific method is characterized by its clearly documented and most importantly replicable research process, which would allow other researchers to get to the same results (Krippendorff, 2012; Meredith, 1998). Although attempts have been made to "upscale" the case study methodology towards being accepted as a scientific method (Lee, 1989; Meredith, 1998), most notably through the use of rigorous documentation procedures, the replicability issues persist. Thus, the case study method, despite being one of the –if not the– most utilized research method in management, is not yet widely accepted by other sciences.

As the characteristics of the scientific method are paramount to the systematic literature review approach, a rigorous application of the systematic literature review methodology could thus add to increase overall acceptance and relevance of the SCM discipline as being regarded as an academic, scientific management discipline in its own right. This links well into the thinking of Harland *et al.* (2006) who argue that the research quality in SCM needs to be improved. Thus, the systematic literature review approach could present a powerful countermeasure against the demise of SCM (Fawcett and Waller, 2014). In addition, it may not be too far-stretched to assume that if other management disciplines would make increased use of such systematic and scientific approaches, this in general would elevate the way other scientific disciplines view the management discipline. This aspect portrays one of the underlying motivations for this dissertation, which aims to advance and develop the management sciences, in particular SCM, by promoting the use of the systematic literature review methodology.

The above presented overview of literature reviews provided a thorough foundation for the application of the systematic literature review methodology in the latter part of the work. Highlighting the role and potential of literature reviews not only from a SCM perspective but also from a discipline of management point of view, the detailed presentation of the literature review methodology is motivated by its use as being the key research method in the desk research part of this thesis.

3.2 Content analysis

To offset the challenges associated with systematic literature reviews as described above, various researchers (Hazen *et al.*, 2012; Seuring and Gold, 2012) have proposed the use of content analysis to conduct literature reviews more rigorously and get useful insights into the SCM body of knowledge (Burgess and Singh, 2006). Neuman (2006) explicitly highlights the good applicability of content analysis for research problems involving large amounts of text.

Two types of content can be differentiated in content analysis application, manifest as well as latent content. As such, the analysis of manifest content as introduced by Berelson (1952) focusses on uncovering the *"objective, systematic and quantitative description of the manifest content of communication*" (Berelson, 1952, p. 18). Manifest content in this definition is described as being visible and directly obvious from the document. In addition, content analysis can also be applied on content of latent nature, where the meaning of the content is not apparent at first. To assess the meaning, this type of content requires an interpretation of the content to derive the underlying and inferred meaning embedded in the document (Kondracki *et al.*, 2002). The analysis of latent content is beneficial if the researchers aim to assess the existence or absence of a certain idea or theory which is usually only accessible if content is set in context (Graneheim and Lundman, 2004).

Providing a sound definition under consideration of manifest and latent content, Krippendorff (2012) defines content analysis as being *“a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use”* (p. 24). Extending Berelson’s (1952) definition, and following Holsti (1968), Krippendorff (2012) argues that the explicit focus of content analysis on quantitative (text) content only, does omit the fact that content analysis has also proven successful in a range of qualitative research studies such as political analysis in propaganda.

Content analysis is generally is known *“to quantify content in terms of predetermined categories and in a systematic and replicable manner”* (Bryman and Bell, 2003, p. 193) without being rigid (Abbasi and Nilsson, 2012). In addition, Graneheim and Lundman (2004) state that correct application of content analysis ensures that results are trustworthy, based on credibility, dependability and transferability. According to Stock and Boyer (2009), content analysis can be classified as a type of conceptual analysis, whereby key concepts or forms are evaluated. Frankel *et al.* (2005) found content analysis to be a suitable method for data analysis; but could be considered a “white space” in logistics methods usage when compared with other research methods, especially survey- or case-based research.

Underlining the applicability of content analysis in management research, Seuring and Gold (2012) propose the use of content analysis in literature reviews. With a special focus on supply chain management, their research highlights the value of content analysis as being an excellent tool to conduct rigorous, systematic and reproducible literature reviews. Adding to Holsti’s (1968) and Krippendorff’s (2012) arguments who suggested that content analysis could utilize both qualitative as well as quantitative elements, Seuring and Gold (2012) conclude that the strength of content analysis stems from the ability to *“combine qualitative approaches retaining rich meaning with powerful quantitative analysis”* (Seuring and Gold, 2012, p. 546) at the discretion of the researcher.

Based on Mayring (2003, p. 54), Seuring and Gold (2012, p. 546) distill the following four core steps of qualitative content analysis:

- *Material collection:* definition of scope and selection of the material,
- *Descriptive analysis:* assessment of characteristics of the material required for the content analysis,
- *Category selection:* development and selection of categories against which the material is coded,
- *Material evaluation: a*nalysis of the coded material based on the categories selected.

The detailed description of the individual steps of the content analysis approach put forward by Mayring (2003, 2010) is outlined in chapter 5 (p. 64). For reasons of clarity the author has chosen to present the individual four steps as they are operationalized to guide the reader through the systematic literature review research process.

3.3 Contingency analysis

The application of content analysis generates an array of information which is embedded in the coded categories. However, these coded findings alone are of limited value when purely seen as individual items. To draw higher-level conclusions from the individual codings, it is paramount to compare category items. A range of researchers, such as Gold and co-authors (2010) as well as Krippendorff (2012), have proclaimed the use of the contingency analysis methodology as a suitable tool to detect association patterns and links between pairs of categories. This analytical methodology, which originates from the social sciences, was developed by Osgood and co-authors (1956) based on the *“observation that symbols often occur in pairs of opposites, that concepts or ideas form clusters”* (Krippendorff, 2012, p. 203). The value-add of this technique is thus based on the identification of category pairs *“which occur relatively more frequently together in one paper than the product of their single probabilities would suggest”* (Gold *et al.*, 2010). The underlying idea is that these relationships remain undetected if analyzed individually (Kremic *et al.*, 2006), with potentially important hidden links not being uncovered. As such, the contingency analysis method is found suitable for making sense of the content analysis findings.

From a methodological point of view, the contingency analysis methodology is based on the analysis of contingency tables, which are also known as cross tabulations

(Pearson, 1904; Everitt, 1992). These tables, which may also be displayed in matrix format, are commonly used to show the frequency distribution of variables. The variables in a contingency table can be scrutinized “*to assess the significance of a difference between the proportions in the two groups”* (Sereetrakul *et al.*, 2013, p. 72). The significance of the difference between two items is calculated with the use of the *p*-value. This parameter measures the probability or likelihood of receiving a test statistic, which is similar to the values actually observed in the frequency distribution of variables (Goodman, 1999) under the assumption that the null hypothesis of independence is true. The test of statistical significance is conducted using a range of statistical tests including *Pearson's Chi-squared Test* (Andrews, 1988; Pearson, 1904) and *Fisher’s Exact Test* (Fisher, 1922; Upton, 1992). In general, the individual characteristics of the contingency table –for example the size of the datasets being either large or small, or if the data is equally or unequally distributed across cells– govern the selection of the most applicable statistical method.

As such, Fisher’s Exact Test is best utilized to assess two-by-two contingency tables with small frequency counts (Mehta and Patel, 1983; Routledge, 1998). The test has proven most applicable for categorical data where a variable is selected from a range of predetermined, fixed number of values (Altham, 1969). Being the only precondition to obtain exact test results, it is important for the application of Fisher’s Exact Test to regard both sets of marginal totals as fixed (the row and column totals) in the experimental table, as this is required for the correct calculation of the *p*-value (Agresti, 1992).

The degree of association between two variables in Fisher’s Exact Test can be measured via a number of coefficients, with the Phi coefficient (ϕ) being the simplest measure. Backhaus *et al.* (2008) outline that, as a rule of thumb, a ϕ value larger 0.3 indicates a statistically relevant link. However, this should only be seen as a rough guideline as the selection of the most appropriate ϕ value for the definition of a strong link can vary and is ultimately subject to the researcher’s inherent intention (Lambdin, 2012; Rice, 1989).

In case of the assessment of larger datasets where the data is rather equally distributed among the cells of the table, the application of Pearson's Chi-squared Test (χ^2) instead of Fisher’s Exact Test is advisable (Cochran, 1952). However, although this test also supports continuous, non-predetermined variables (Pittet *et al.*, 1994), the proper use of Pearson's Chi-squared Test is, in contrast to the rather robust test by Fisher, more challenging. As such, it needs to be pointed out that the significance value, which is calculated by the Chi-squared Test can only serve as an approximation, as the sampling distribution of the test statistic is only approximately equal to the theoretical chi-squared distribution (Larntz, 1978). The approximation increases with smaller sample sizes and a growing unequal data distribution among the cells of the table. The result being that the cell counts which are predicted on the null hypothesis, thus representing the "expected values," are low (Haberman, 1988). This poses a major pitfall of Pearson’s Chi-square Test, as small or unbalanced datasets lead to very different exact and asymptotic *p*-values, ultimately resulting in improper and even opposite conclusions concerning the hypothesis (Larntz, 1978).

In this thesis the contingency analysis method, using Fisher’s Exact Test, will be operationalized to draw conclusions from and make sense of the content analysis findings. It thus adds to validate the findings and yield a better understanding of their interrelations. In addition, the application of the standardized statistical contingency analysis approach enables a mathematically sound justification of interrelationships.

3.4 Research quality considerations

This dissertation is conducted with utmost care towards strict consideration and adherence to quality criteria –validity and reliability–, as being key aspects in every research process (Morse *et al.*, 2008). As such, validity is the key driver leading to the acceptance of research results as being true. The concept of reliability is the key measurement metric for empirical confidence of scientific research. Hence, the *“research procedure is reliable when it responds to the same phenomena in the same way regardless of the circumstances of implementation”* (Krippendorff, 2012, p. 267). Accordingly, in order to ensure compliance with highest academic standards of quality, these quality criteria will be considered and carefully applied in every part of the analysis. However, following the work of Mayring (2010), the applicability of these classical quality criteria may be sometimes difficult to achieve. This is especially the case in regard to their applicability on qualitative content analysis, as the fulfillment of criteria –such as “distance to the research subject” and “communicative validation of results”–, proves a challenge. Thus, it needs to be considered that the to-be-analyzed content material is composed of written communication in terms of secondary literature, which is generally not approachable for validation exercises (Mayring, 2010). To overcome these issues, Krippendorff (2012) proposed a typology of specific quality criteria for content analysis, which however are also applicable to any other research method. The typology of criteria provides an excellent overview to rigorously structure research, following the multiple elements of validity and reliability (Figure 3.1, p. 32). In order to secure the applicability of the research process design and the findings of this research, the research will be conducted with a strong focus on quality criteria compliance, such as content, construct, internal, and external validity, as well as reliability. The application of the quality criteria to the research process will be presented in detail in the discussion part of the thesis (section 7.3, p. 198ff).

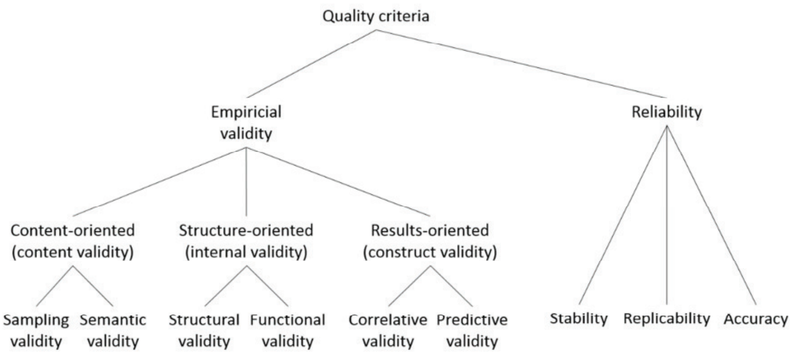


Figure 3.1: Typology of empirical quality criteria
(Source: Author, based on Krippendorff, 2012, pp. 270ff, 334)

This chapter outlined the methodological background of the applied research methods. The selected research methods, namely systematic literature review, content analysis, and contingency analysis, are presented and vindicated against the research aim. In addition, the rationale for the integration and systematic leverage of the three research methods is explained in order to conduct transparent, replicable research. Furthermore, the chapter reflected on the role of research quality criteria in order to lay the foundation for an in-depth application of research quality considerations in the discussion part of the thesis.

The next chapter, chapter 4, will prepare the grounds for the application of the systematic literature review approach. Accordingly, a conceptual framework of major aspects of SCM will be developed which is a prerequisite for the category selection (step three) in the content analysis process.

4 A conceptual “framework map” of SCM

Taking a holistic perspective on SCM, chapter 4 showcases vital frameworks outlining the essence of SCM. By condensing these key frameworks, a conceptual framework of SCM, comprising six distinctive dimensions and 26 categories, is developed (section 4.1). As content analysis requires the application of analytical categories in the coding process, this framework serves as the foundation which guides the content analysis approach applied to the literature reviews. In addition, this chapter contains a detailed presentation of each of the six dimensions and 26 categories (section 4.2). Enhancing the validity of the 26 categories, a major focus of this section is on the thorough grounding of the categories in extant SCM theory.

4.1 Development of the classification framework

As content analysis requires the application of analytical categories in the coding process, a conceptual theoretical framework of major aspects of SCM was deductively developed from the existing body of SCM research, which is in line with disseminating and advancing SCM theory. This follows Mayring’s (2010) recommendation to increase validity of the categories by linking the analytical pattern with existing constructs. The presented framework development approach is motivated by research from Choi and Wacker (2011), calling for integration of multiple perspectives of SCM in order to advance the existing body of literature. This builds upon Stock and Boyer’s (2009) work, who state that as SCM is a rather young management discipline disagreement regarding *“to what SCM is and what functions and/or processes to include exists”* (p. 708). In consequence, and as theorizing involves imagination disciplined by the process of artificial selection and rejection of existing constructs steered by the researcher (Weick, 1989), the research is based on other researcher’s work, condensing major core SCM models and frameworks into one umbrella framework of SCM. As SCM builds upon the logistics and production framework (Harrison and van Hoek, 2008), selected SCM, logistics, production management, and operations management journals (Table 4.1, p. 34) were considered to include appropriate and acknowledged SCM models and theoretical frameworks. Operations research journals were not considered in the framework as the focus was on aspects of SCM as related to empirical research.

Journal	Article	Elements used in the framework
International Journal of Logistics Management	Cooper *et al.* (1997)	Business functions involved in SCM
International Journal of Operations & Production Management	Beamon (1999)	Supply chain performance measurements
International Journal of Physical Distribution & Logistics Management	Stevens (1989)	Supply chain integration levels
International Journal of Production Economics	Beamon (1998)	Supply chain design and analysis
	Naylor *et al.* (1999)	Supply chain strategies
Journal of Business Logistics	Mentzer *et al.* (2001)	SCM activities
Journal of Operations Management	Chen and Paulraj (2004)	Research framework of SCM
	Frohlich and Westbrook (2001)	“Arcs of integration” model
Supply Chain Management: An International Journal	Barrat (2004)	Supply chain collaboration

Table 4.1: Selected journals and articles for framework development
(Source: Author)

The journals were chosen as they are highly ranked and have been repeatedly used by other researchers in SCM and logistics (e.g. Babbar and Prasad, 1998a; Hazen and Byrd, 2012). To ensure only well-known and generally accepted models or frameworks of SCM have been selected for this framework, the journals were analyzed with Harzing’s Publish or Perish software[1], which is using data from Google Scholar. Enhancing validity of the selected papers, the most appropriate and highly cited conceptual SCM or logistics paper in each journal was selected, the exception being the Journal of Operations Management where two papers were equally high-ranked and accordingly selected. The rationale for the applied selection approach being that the citation score presumably is an indicator of the paper’s scientific value or at minimum that the paper’s content is accepted among other researchers. A highly ranked, often cited paper could be considered fundamental and thus offers a good foundation for the framework (Fabbe-Costes and Jahre, 2008).

Each article was read in detail, and the containing models or frameworks were thoroughly extracted. The frameworks identified in the papers were mapped out in a tree structure. The branches of the individual frameworks were analyzed according to similarities between frameworks, re-integrated according to best fit, and placed into one conceptual framework of major SCM aspects (Table 4.3, p. 37). Adding to theory building, as called for by Sutton and Staw (1995), this framework was further

[1] http://www.harzing.com/pop.htm, last accessed November 18th, 2014

enhanced and supplemented with additional theoretical papers, identified as relevant through discussions with researchers (for example Burgess *et al.*, 2006; Stewart, 1997). Other established SCM models (e.g. SCOR 9.0) were added, where appropriate, to complete the picture and ensure inclusion of major models important to SCM. Finally, the framework was discussed through iterative review cycles with other researchers and fine-tuned where appropriate.

Granting scientific validity, utmost care was taken to ensure that the framework taxonomy was internally consistent and did not mix different levels of abstraction. This was achieved through clustering, identifying similarities within the individual frameworks, and grouping similar aspects within the frameworks under the same heading. Through this clustering approach, following other authors' recommendations (Green *et al.*, 1967; Nairn and Bottomley, 2003), all aspects of the new framework can be regarded as mutually exclusive while being collaboratively exhaustive. The result is a holistic "framework map" of major aspects of SCM, thoroughly linked to previous published and acknowledged scholarly SCM research, centered around the following six core dimensions: "Level of SCM analysis," "Orientation of SCM," "Functional scope of SCM: Collaboration/Integration," "Functional scope of SCM: Risk/Performance," "Functional scope of SCM: Strategy," and "Theoretical foundation".

Promoting a more in-depth analysis of the distinctive core categories, the six dimensions, resembling the first level of the framework, were further broken down into 26 categories in the framework development process as outlined above. Resembling the second level of the framework, each category represents certain special items of the governing first level core dimension.

Further developing the framework, the categories, where found appropriate, were broken down into various items, which detailed the governing category. The 70 identified items will be labelled level three sub-categories. It needs to be mentioned that some sub-categories could be further split into even more granular items, which represent level four or five of the framework. The cascading level hierarchy of the framework in regard to dimensions, categories, sub-categories as well as even more granular items is displayed in Table 4.2 (p.36).

Level hierarchy	Description label
Level 1	Dimension
Level 2	Category
Level 3	Sub-category
Level 4 / Level 5	Further items (if applicable)

Table 4.2: Level hierarchy as applied in the framework
(Source: Author)

The breakdown of the items into lower level categories, sub-categories and granular items was conducted based on the respective theory, as will be further elaborated in the course of this dissertation.

Following the thinking of Weick (1989), the framework allows the extraction of “interesting” connections between categories based on a comparison of past experience –manifested through literature reviews– as means to develop theory. The beauty of the concept is that although some of the constructs seem to be obvious to the reader, this should not hinder an open-minded analysis as a means to generate a new understanding in line with the thinking of Homans (1964) where constructs *“often go unnoticed and unstated because they seem simple and obvious”* (Weick, 1989, p. 526). Accordingly, a major rationale for this work is to expose links between categories by shedding light on presumably obvious aspects, thereby enabling a differentiated, more complete view towards SCM.

Table 4.3 (p. 37) lists the items in detail, presenting dimensions and categories, but omitting sub-categories and further levels of detail for reasons of clarity.

Dimension Category	Dimension Category
1 Level of SCM analysis	***5 Functional scope of SCM: Strategy***
1.1 SCM view of literature	5.1 Supply chain planning
1.2 Conceptual framing of SCM	5.2 Innovation
1.3 Business functions involved in SCM	5.3 Customer focus
2 Orientation of SCM	5.4 Top management support
2.1 Types of flow	5.5 Competitive advantage
2.2 Direction of flow	5.6 Information technology
3 Functional scope of SCM: Collaboration / Integration	5.7 Lean and agile supply
3.1 Collaboration	5.8 Sustainability
3.2 Integration	5.9 Outsourcing
3.3 Information-sharing	***6 Theoretical foundation***
3.4 Process improvement orientation	6.1 Economics theory
3.5 Leadership	6.2 Strategic management theory
4 Functional scope of SCM: Risk / Performance	6.3 Operations management theory
4.1 Supply chain risk	6.4 Psychological / sociological theory
4.2 Rewards-sharing (benefits)	
4.3 Supply chain performance	

Table 4.3: A holistic “framework map” of major aspects of SCM
(Source: Author)

In the next section, the composition of the categories will be explained, embedding them in respective theory as a means to justify the selection.
For structural reasons the detailed tabular overview along each category’s individual hierarchical level structure, also including the levels 4 and 5, is outlined with the content analysis findings (chapter 6), most notably Table 6.2 to Table 6.18.

4.2 Dimensions of the “framework map“

4.2.1 Dimension: Level of SCM analysis

Aiming to embrace organizational and definitional aspects of SCM research, the dimension “Level of SCM analysis” condenses three structuring parts included in literally every piece of SCM research: 1) the scoping to levels within the supply chain, 2) the perspective the research takes in regard to the conceptual picture of SCM, and 3) the business functions involved in operationalizing SCM.

SCM view of literature: As outlined by Tranfield *et al.* (2003), it is important to scope research to maintain a clear focus. In this light, Halldórsson and Arlbjørn (2005) postulated that supply chain management can be differentiated on five distinctive levels, namely function, firm, dyad, chain, and network. Expanding from a functional focal view including interactions with external organizations towards the network perspective, their approach allows the structuring of SCM research along a fictitious supply chain. Being somewhat of a fundamental element in SCM research, basically every research, maybe with the exception of purely conceptual and theoretical work which does not always adhere to this level structure, can be placed somewhere in the theoretical model by Halldórsson and Arlbjørn (2005). Given the structural simplicity and general applicability of the model it is included in the proposed conceptual framework.

Conceptual framing of SCM: As outlined by Stock and Boyer (2009) a plethora of definitions exists in SCM. According to Burgess *et al.* (2006) a possible reason for the heterogeneity of definitions may be rooted in the lack of a unified conceptual understanding of SCM. Aiming to address this issue, they propose a conceptual model to “frame” SCM in four categories, ranging from micro to macro perspectives: activity, process (chain of activities), system (multiple related processes), and others (sociological, psychological, and philosophical concepts). A fundamental aspect of the model, underlining its importance, draws on the self-conception of SCM as constituting a management stream of its own separated for example from logistics, a discussion led by academics since the emergence of SCM (Cooper *et al.*, 1997; Cousins *et al.*, 2006; Harland *et al.*, 2006). As such, simply regarding *“SCM as an activity could lead to it being viewed as a minor operational function”* (Burgess *et al.*, 2006, p. 708), neglecting its integrative value as an overarching function. The model thus builds a foundation to assess the value of SCM in the management sciences. In addition and in line with developing SCM theory further, a deeper view into the conceptual framing could be leveraged to understand the constructs influencing SCM practice.

Business functions: According to Stewart (1997) a supply chain consists of a *“series of simple, compartmentalized business functions”* (p. 62). In the early years of SCM research the focus was on the physical distribution and transportation business functions which represented the nucleus of SCM research (Houlihan, 1984), placing SCM in logistics theory. However, this rather narrow view has been expanded over time, developed into the overarching SCM paradigm, spanning across a multitude of key business processes (Lambert *et al.*, 1998). Cooper *et al.* (1997) theorize that the following business functions are essential for SCM: Purchasing, Materials Management, Production, Physical Distribution, Marketing and Sales. Stevens (1989) takes a similar view, extending the range of business functions to also include the

Finance function. Picking up on this view, the category combines the models of Cooper *et al.* (1997) and Stevens (1989). Nevertheless, as companies realized that essentially every business function is in some sense a valuable driver for SCM, other functions and departments may also be added to this list including Research and Development (R&D), Engineering, Human Resources, and Legal Services. However, as generally accepted theoretical models describing these functions are lacking, they are omitted from the category.

4.2.2 Dimension: Orientation of SCM

A core pillar of SCM is its rooting in the concept of flow management, which originates in manufacturing management, as outlined in the work of Ohno (1988) and Drucker (1990). The concept, being formalized in the “Theory of Swift, Even Flow” (Schmenner and Swink, 1998), features various types of flow as well as a multi-direction flow pattern which will be used to describe the “Orientation of SCM” dimension.

Type of flow: The SCM concept as a whole is largely build on the seamless flow of goods and information, from raw material suppliers, to end customers (Towill, 1997; Ellram and Cooper, 1990). Stock and Boyer (2009) in their encompassing definition of SCM identified four main types of flow, which this work will draw upon, namely the *“flow of materials, services, finances and information”* (p. 706). Underlining the integrative philosophy of SCM, the various flows should not be regarded as separate as they have been reported to be connected and thus interfere with each other (Lee *et al.*, 1997).

Direction of flow: Initial SCM research focused purely on the flow of materials and information from suppliers to end users as outlined by Mentzer *et al.* (2001). Stevens (1989) was the first scholar to extend supply chain theory from the mere chain of production and distribution steps, to include the originating upstream raw material suppliers and the downstream final consumer. This end-to-end understanding of supply chain flows has been reported to be most commonly used in SCM. The direction of flows can also be utilized as an enabler for postponement, linking to the de-coupling point approach required in a push-pull setup (Olhager, 2003). In addition, Cooper *et al.* (1997), based on a review of SCM literature, pointed towards some types of flows such as products and information, as flowing in a bi-directional manner.

Accordingly, these three types of flow, namely upstream, downstream and bi-directional, will be featured in this category, following the models by Stevens (1989) and Cooper *et al.* (1997).

4.2.3 Dimension: Functional scope of SCM: Collaboration/Integration

The goal of SCM, as outlined by Harrison and van Hoek (2008), is to focus on linking processes and extending the single company view of the logistics framework to the overall alignment of the chain of companies. This requires companies to collaborate, eventually becoming increasingly integrated. As a prerequisite, the companies need to share essential information such as production schedules and inventory figures. Allowing for a streamlined coupling of production, such actions also reduce wasteful activities and free up resources for value-added activities. Elevating SCM to become *“a key resource of competitive excellence”* (Frohlich and Westbrook, 2001, p. 197), companies are advised to cooperate in improving processes in a cross-company fashion, requiring them to think outside of their own realm, viewing improvement opportunities more holistically from one end of the supply chain to the other. For the application of such an open-minded approach, a whole new way of thinking needs to be embedded in the participating companies’ culture. This endeavor can only be successful if accepted throughout the company and driven by the leadership team. All of the aforementioned constructs describe the collaborative and integrative philosophy of SCM (Ellram and Cooper, 1990). This justifies a clustering into a single overarching category coined “Integration/Collaboration,” an approach also taken by other researchers (Burgess *et al.*, 2006).

Collaboration: Collaboration between entities, being the paramount core principle in Supply Chain Management (Horvath, 2001), is required to leverage the power of all parties along the supply chain for the benefit of all parties (Slone *et al.*, 2007; Lambert and Cooper, 2000, Andraski, 1998). Barrat (2004) in his work on the meaning of collaboration for SCM states that collaboration was very limited in the early times of SCM. This was mainly due to challenges with implementation of supply chain collaboration (Sabath and Fontanella, 2002), often driven by technology issues (McCarthy and Golicic, 2002). The acceptance of the collaboration model is also closely linked to the required corporate mindset shift. The complexity of managing modern supply chains has increased over the years, driven by aspects of globalization and digitalization; and it is now rather supply chains competing against supply chains or even supply networks against supply networks instead of simply business against business (Bitran *et al.*, 2007; Williams *et al.*, 2002; Christopher, 2010). This shift has forced companies to optimize their internal business processes and overall supply chains in the perpetual endeavor to become more responsive and efficient, enabled through collaboration or partnering (Wagner and Bode, 2008; Christopher and Towill, 2000). In contrast, viewing a company as an isolated entity will result in the company *“facing an uphill battle just to stand still”* (Barrat, 2004, p. 31).

As collaboration is driven by relationships, Burgess *et al.* (2006) in their “Constructs of SCM” model extracted intra- and inter-organizational relationships as being a soft aspect of SCM. Following the idea of their model, the second-level category labelled “collaboration” will differentiate between intra-organizational collaboration (internal, within a company) and inter-organizational collaboration (external, between companies).

Integration: Efficient alignment and integration of the interacting entities (Barratt, 2004) is required in supply chains to reduce *“friction, and thus waste of valuable resources,* [which] *results when supply chains are not integrated, appropriately streamlined, and managed”* (Lambert and Cooper, 2000, p. 81). In addition, effective supply chain integration has been found to be a source for competitive advantage (Naylor *et al.*, 1999). Extending Forrester and Drexler’s (1999) view, who first proclaimed that interdependent functional parties need to be aligned in regard to e.g. performance, some researchers have evaluated how intra-organizational or cross-functional integration and close departmental relationships can be leveraged to the benefit of all parties. However, they usually focus on operational aspects (e.g. reward systems) of a pair-wise functional construct, such as marketing/R&D (Gupta and Rogers, 1991) or marketing/logistics (Ellinger, 2000) without extending to all functions involved in the internal supply chain.

As over the past decade supply chains increasingly became leaner and agile or more responsive to up-to-date customer demands (Christopher and Peck, 2004; Christopher and Towill, 2000), the integration aspect gained importance. This was mainly fuelled by the developments in information technology, which transformed supply chains towards becoming virtual “e-enabled” supply chains (Agarwal and Shankar, 2003; Christopher, 2000).

For the theoretical framework the umbrella term “supply chain integration” will be used to cluster types of integration such as baseline, functional, internal, and external as included in the four-stage evolutionary model by Stevens (1989). The model describes a scalable roadmap approach for companies aiming to succeed in integrating with partners, outlining key characteristics of the evolutionary stages in a checklist. The first stage depicts the “baseline” approach, where de facto independent departments act as single entities within the company. This “silo” mentality and the lack of synchronized activities lead to excess waste of resources, e.g. in terms of buffer inventory between departments. Stage two is characterized by time phase planning of functionally aligned departments, enabled by material resource planning systems. However, coordination between these functions is lacking, leading to inadequate planning and low performance as a result of missing visibility. It is not until stage 3 that internal integration is achieved, which features an outward flow-oriented manufacturing approach synchronizing all other departments under the control of the company with the help of an overarching integrated planning and control system. Full advantage of synchronized demand and supply is taken in stage 4 where the internal supply chain is externally integrated outside of the focal company. This should be seen as more than an expansion of scope as it requires *“a change in attitude, away from the adversarial attitude of conflict to one of mutual support and cooperation.”* (Stevens, 1989, p. 8). According to Pagell (2004), no universal definition of the integration construct exists. Thus, Stevens’ model was altered and combined with the “Arcs of Integration” approach. This approach, presented by Frohlich and Westbrook (2001), offers possibilities for a more detailed analysis of external integration, including supplier-facing, customer-facing, periphery-facing, and outward-facing integration viewpoints.

Where the first two approaches expand the integration view from the focal company to include either the supplier side (supplier-facing integration) or the customer side (customer-facing), the periphery-facing view was extended to include the first tier upstream and downstream entities of the supply chain. The outward-facing integration, representing the highest degree of integration, is not limiting the scope on the neighboring interfaces, as it spans past first tier suppliers and customer and aims to include all relevant supply chain members.

The differentiated views of Frohlich and Westbrook (2001) ensure that this category enables a deep analysis of the facets of integration as proposed in the conceptualization by Stevens (1989).

Information-sharing: According to the conceptualization of Mentzer *et al.* (2001) information-sharing in supply chains should be understood as entities giving other entities access to strategic and tactical data, which could comprise inventory levels, forecasts, and market strategies, among other things. Information-sharing between parties has been repeatedly identified by researchers as being paramount for a streamlined execution of SCM, leading to improved performance, responsiveness, and flexibility, while reducing uncertainties among supply chain partners (Zhang *et al.*, 2011; Stevenson and Spring, 2007). As found by Stock and Boyer (2009), SCM functions best when resources are shared, underlining the collaboration aspect of SCM. This, however, requires a certain level of trust among participating members (Jain *et al.*, 2009) as an open sharing of information, such as proprietary data of production processes and specifications, bears substantial risks. To address this issue, companies are making trade-offs between the benefits they gain from sharing information with others, considering the risk a shared information may represente if information is leaked, for example, to competitors.

For defining this category the framework of Mentzer *et al.* (2001) will be utilized, although various scholarly frameworks in regard to information-sharing in the supply chain exist. The rational is that Mentzer *et al.* (2001) were the first who explicitly embedded information-sharing into a comprehensive theoretical framework of SCM, regarding it as a component equal to other SCM core paradigms such as collaboration.

Process improvement orientation: The improvement of processes through streamlining operations, limiting errors, and reducing waste in the manufacturing environment has long been a major focus of production management, having its roots in the continuous improvement program as part of the Toyota Production System (Shingo, 1989). Cooper and Ellram (1993) highlight the longitudinal character of process improvement programs which involves constant planning and monitoring of to-be-optimized processes. As found by Stewart (1997), in his work on the “Supply Chain Operations Reference”-model (SCOR), process improvement in SCM is not limited to a single function or to a focal firm as the goal is to strengthen the whole chain, which sometimes requires single activities to compromise on own improvements towards the big picture.

Accordingly, the process improvement concept depicted in the SCOR approach aims at continuously and simultaneously improving all processes, covering aspects of internal improvement as well as external improvement (Stewart, 1997). In this setup, the internal perspective spans across the dyadic supply chain relationship, covering entities *“from immediate supplier to immediate customer”* (Stewart, 1997, p. 64), whereas the external improvement configuration extends this view further into the supply chain also including *“immediate supplier’s supplier and immediate customer’s customer in a ‘chain of chains’”* (p. 64f). Following the structure of the model by Stewart (1997) the category will be split into an internal improvement and external improvement section.

Leadership: Although SCM has been a key topic for executive management in most companies for years, supply chains too often still fail to deliver against expectations, probably because issues around supply chain leadership and functional alignment remain unsolved (Youn *et al.*, 2012; Stevens, 1989). Yet it is an important aspect, due to the importance of leadership as an organizational steering function within and across supply chains.

The inter-organizational supply chain leadership construct is likely to require intra-organizational leadership constructs, dealing with how the different functions within these single companies are best coordinated, aligned and steered on a micro level (Lambert and Cooper, 2000). From a business perspective this is required as, in order to understand the inter-organizational aspects of supply chains, it first needs to be understood how to best manage intra-organizational aspects of the supply chain (Mentzer *et al.*, 2001). Having a leader who promotes the concept of supply chain management within the company is to be seen as an economic necessity, rather than a luxury, and every employee is required to understand the supply chain concept and act accordingly in order to reap the economic benefits of the supply chain (Trent, 2004).

Burgess *et al.* (2006) integrated the leadership dimension into their framework of “Constructs of SCM,” underlining the importance of leadership for defining and characterizing SCM. Sharing this view the category in this work has its basis in the theory outlined by Burgess *et al.* (2006).

4.2.4 Dimension: Functional scope of SCM: Risk/Performance

Due to the collaborative and integrative nature of the supply chain, challenges faced by a single company, such as inventory stock outs or a supplier’s bankruptcy, are likely to also affect other parties of the chain. To reduce the impact of materialized risks on the chain, the monitoring of potential risks and the development of risk

mitigation plans is required as part of a supply chain-wide risk management approach, which should ideally be a coordinated action (Tang, 2006). In addition, an integrated supply chain setup requires companies not to only optimize their own processes but to adopt a systems thinking approach, viewing optimization as a means to improve the performance of the whole supply chain. In consequence, this may mean that certain parts of the supply chain are on purpose not as lean or effective as they could be, but de facto aiding overall supply chain efficiency. However, to ensure the buy-in of all parties, this approach calls for a mandatory fair sharing of rewards and benefits including the risks and costs associated.
The category “Risk/Performance” combines the three major concepts of supply chain management touched above: Approaches for supply chain risk management (Tang, 2006), rewards-sharing or benefits sharing as proposed by Mentzer *et al.* (2001), and aspects of supply chain performance as outlined by Beamon (1999) and Chen and Paulraj (2004).

Supply chain risk: Supply chains have become more integrated to reap the fruits of streamlined cross-company operations as a response to the changing business environment. The interconnected nature of supply chains increases the risk of disruptions cascading throughout the chain, impacting on every entity, as even the *“most carefully controlled processes are still only as good as the links and nodes that support them”* (Christopher and Peck, 2004, p. 1). In essence, the more integrated and focused a supply chain becomes, often with vital company functions like R&D and manufacturing outsourced to specialized partners, the more its fragility and vulnerability to disruptions increases (Wagner and Bode, 2008; Norrman and Jansson, 2004). Supply chain risk management has been proposed as a requirement in every firms’ strategy to deal with challenges arising from supply chain risks; and a growing stream of research has focused on the management of risks in supply chains (Christopher and Peck, 2004; Colicchia and Strozzi, 2012; Jüttner *et al.*, 2003; Kleindorfer and Saad, 2005; Manuj and Mentzer, 2008; Pfohl *et al.*, 2010; Tang, 2006). Accordingly, various approaches and frameworks in regard to supply chain risk management have been showcased, however the common understanding of authors is that risk management in regard to supply chains is a rather new but emerging area (Colicchia and Strozzi, 2012; Faisal *et al.*, 2006; Jüttner *et al.*, 2003). Jüttner *et al.* (2003), underlining the many facets of risks, identified the connected material, product, information or financial flows within a company or between organizations as a potential source of risk due to their boundary-spanning nature. Linking to collaborative and integrative aspects as previously outlined, Lee (2002) lists some case examples where the exchange of information is used in a collaborative setup to reduce the risk of supply failure. Taking this a step further, Christopher and Peck (2004) coined the term “supply chain intelligence,” advocating for an exchange of upstream and downstream risk profile information among supply chain members to reduce associated risks.

However, as it is virtually impossible for a supply chain or even a company to be prepared for all kinds of risk imaginable, due to financial and organizational reasons, the management of harmful unexpected incidences becomes a key aspect of supply chain management. This drives the necessity to manage and mitigate supply chain risks through the development of resilient supply chains, which are less vulnerable to external factors (Christopher and Peck, 2004). The robustness of a supply chain can be achieved through robust processes as well as a certain degree of flexibility, such as the adaptability of the supply network to switch to backup suppliers in case of disruptions (Pettit *et al.*, 2010; Ponomarov and Holcomb, 2009).

An excellent overview of supply chain risks outlined along the physical, financial, and information flows within a supply chain has been provided by Tang and Nurmaya Musa (2011).

A well-accepted and detailed theoretical model has been presented by Tang (2006), where risks are mitigated based on four dimensions, namely supply management, demand management, product management, and information management. According to the model, supply chain risk mitigation strategies are concerned with supply network design, supplier relationship, as well as aspects of the supplier selection process, through to the supplier order allocation, including problems arising from uncertainty. Demand management risks are linked to the challenge of predicting future demand. As a robust forecast is in most cases not applicable, the risk management approach focusses on mitigation through managing and thus steering demand across the dimensions of time, markets and products. Risks associated with product management can be reduced through application of postponement strategies or by adjustment of the production process, a technique known as process sequencing. For the dimension of risks tied to information management, Tang proposes a differentiation into fashion and functional products where functional product risks in particular are effectively mitigated via the use of information-sharing, advanced inventory models such as vendor managed inventory, or collaborative forecasting schemes.

The four-dimensional model by Tang (2006), as described above, serves as the theoretical foundation for this category due to its detailed yet comprehensive approach.

Reward-sharing (benefits): Optimized inventories, enhanced logistics modes and increased performance in the supply chain lead to an overall reduction of cost, which could generally not be achieved if companies venture on their own. However, not all companies along the chain are equally affected by costly improvement measures. In addition, it may well be that certain companies, if viewed as separate entities, do not benefit as much as others from optimization programs (Ballou *et al.*, 2000).

To overcome these imbalances Mentzer *et al.* (2001), based on other researchers' work (Cooper and Ellram, 1993) proposed a system of mutually sharing rewards along the chain, which also needs to include a sharing of risks and costs associated with the collaborative effort. Given the investments required by cooperating parties before any measurable benefits can be generated, a program to share rewards and cost requires a long time horizon. The longitudinal character, however, represents a mixed blessing: On the one hand, the long pay-off timelines ensure that companies stay committed to the supply chain network as they expect a payout including profit which would be compromised if the network is exited before payments are due. On the other hand, a commitment over a couple of years might deter a party's willingness to engage in such a commitment despite the potential benefits. For the definition of the category “reward sharing,” the theoretical framework of Mentzer *et al.* (2001) will be followed, as it neatly places the reward sharing dimension as equal to other “SCM activities” in an encompassing theoretical framework of SCM.

Supply chain performance: As outlined previously, interdependent functional parties in a supply chain need to be aligned to leverage individual company's performance improvements for the benefit of all parties (Forrester and Drexler, 1999). However, overall performance improvement of the chain as a whole is always considered more important than performance gains at a single entity's end but without performance improvement to the whole chain (Stevens, 1989). In line with this understanding, the model by Chen and Paulraj (2004) roughly subdivides supply chain performance into supplier performance and customer performance.

In order to evaluate the performance of single entities in the supply chain as a means to assess their impact on the whole chain, a procedure important, for example, for rewards-sharing allocation, various measurement systems have been developed. Beamon (1999) presented an encompassing overview and evaluation of the performance measurements used in supply chain models. Starting off from the existing models she developed a framework to aid the selection of performance measurements, identifying the three dimensions of “resources,” “output,” and “flexibility”. The three dimensions and their respective third-level sub-categories are outlined in the following, being the basis of the category “supply chain performance”.

Resources are critical to every company within the supply chain and their deliberate management is vital for a company’s profitability. Beamon operationalized the “resources” dimension through allocation of a variety of costs including total cost, distribution cost, manufacturing cost, and costs associated with held inventory. In this setup, the return-on-investment (ROI) represents the ultimate unit of measurement of resources through indication of profitability.

Output stands for the final product the supply chain produces, also being the only aspect the customer is directly confronted with. Thus, the “output” dimension is of key importance, highlighting the operations and customer-oriented view of the supply chain. In this logic, sales, profit, fill rate, manufacturing lead-time, shipping errors, and the amount of backorders/stock outs all represent units of measurement utilized to evaluate the operational performance. From the front-end, the performance of the supply chain is measured against the customers’ expectations, manifested through the amount of on-time deliveries, the customer response time, and the number of customer complaints. This highlights the use of quality to serve as a viable unit of performance measurement.

The last dimension of performance measurements –“flexibility”– summarizes the need for the supply chain to address changing environmental conditions through measuring changes in output levels (volume flexibility), delivery dates (delivery flexibility), and product mix changes (mix flexibility). Showcasing the holistic view of Beamon’s (1999) performance measurement system, the units of supply chain measurement are functionally linked, most notably as new product flexibility, a unit of measurement from the product design phase, is embedded in the flexibility performance measurements section.

4.2.5 Dimension: Functional scope of SCM: Strategy

A key aspect of supply chain management is its orientation towards an overarching supply chain wide strategy concept, which also differentiates SCM from logistics (Bechtel and Jayaram, 1997). Accordingly, effective SCM requires the parties involved to view SCM with a strategic goal in mind, moving away from the limited view of functional silos. As a prerequisite, the strategic nature of SCM needs to be aligned and embedded in the overall business strategy of the company. The need for integration along the supply chain has been described as a facilitator for supply chain strategy (Frohlich and Westbrook, 2001). The dimension “strategy”, as portrayed in this work and outlined below, subsumes a multitude of items which are all of strategic importance to the supply chain but also from a company’s single point of view.

Supply chain planning: As stated by Meyr and Günther (2009), *“supply chain planning has emerged as one of the most challenging problems in the industry”* (p. v). This has largely to do with the shift of focus from company operations towards the formation of an integrated network, spanning activities across suppliers and customers. The multitude of parties within the network requires an orchestrated approach, ensuring that the resources of every entity are utilized as effectively as possible towards the overall supply chain goal. On a corporate level, supply chain planning is concerned with various key business functions, which are integrated and linked through integrative technology solutions, such as advanced planning systems (Stadtler, 2005).

From an organizational viewpoint, planning activities are conducted through a phased approach, ranging from high level long-term planning, through a more defined mid-term planning, to a detailed short term planning (Gupta and Maranas, 2003; Stadtler, 2005). These systems aid decision-making activities at various levels of the corporate supply chain, namely the strategic, tactical and operational decision levels (Meyr and Günther, 2009).

As a key theoretical framework around supply chain planning could not be identified from the extant literature, the definition of the supply chain planning category will borrow from the authors as outlined above, largely based on the highly cited “midterm production planning” work of Gupta and Maranas (2003) as well as Stadtler’s (2005) supply chain planning matrix.

Innovation: The shift of focus towards a network structure of companies in an integrated supply chain is also affecting the management of innovation, which is increasingly moving away from a pure focus on internal R&D towards incorporation of the supply chain view (Christensen *et al.*, 2005). As such, collaboration between supply chain partners has been reported to have a positive impact on the innovativeness of a supply chain, as every entity’s core competencies and resources can be leveraged in an optimized way, thus supplementing each other (Håkansson and Waluszewski, 2002). Especially the involvement of suppliers in the innovation process, largely in new product development projects, has been repeatedly found to be a key driver of supply chain success (Wynstra and Pierick, 2000). This ultimately enables the parties to increase their business share as a reduction of the time-to-market speed, fostered through the collaboration in innovation, and increases throughput in the departments involved, for example in R&D. The resources freed up in the departments through the speeded-up innovation process can then be dedicated towards other value-adding activities.

The theoretical foundation for this category is given by the work of Chesbrough *et al.* (2007), who characterize open innovation along the direction of flow of the knowledge creation process drivers, namely outside-in processes, inside-out processes and a joint approach. In the outside-in process approach, knowledge is brought into the company through suppliers, customers and even competitors. Enkel *et al.* (2009) point to the use of innovation intermediaries, companies that specialize in matching knowledge partners and transferring knowledge. This links to the inside-out process approach, which focusses on selling knowledge to other parties. Companies that venture on this path may want to leverage their external network to bring products to market faster than they could on their own. In addition, this approach allows generating revenue through licensing fees from markets not yet penetrated by the out-licensing company. Being the third knowledge creation process, the coupled approach links the outside-in and inside-out approaches. This concept describes the typical value co-creation situation of an alliance or joint venture built on a “give and take” concept, designed to develop and commercialize innovation in a cost-saving collaborative manner.

Customer focus: As a supply chain can be described as a chain of supplier-customer relations, Lee (2002) postulated that effective supply chain management should be customer-centric, underlining the customers’ prime position in the chain as ultimately influencing the success of the product in the market place. In essence, the customer is the only reason for the existence of the supply chain (Hoekstra and

Romme, 1992). As supply chain value creation is inevitably bound to the customers’ needs, the supply chain needs to match supply with the customers’ real demand (Mentzer, 2004). Analyzing the reciprocal supplier-customer relationship, Carson and co-authors (1998) highlight that clearly identified customer needs pave the way for higher sales throughout the chain. As outlined by Ellinger and others (1999) this ultimately results in increased customer loyalty.
The theoretical grounding of this category is based on Chen and Paulraj (2004) who developed a conceptual framework of supply chain management, in which the element of *“customer focus, in terms of satisfying needs and providing timely service, is a key driving force of effective supply chain management”* (p. 122).

Top management support: A managerial commitment to the supply chain management paradigm (Fawcett *et al.*, 2007), combined with “*the need for senior management team to be proactively involved”* (Burgess *et al.*, 2006, p. 709) is required for supply chain management to function, paying tribute to the strategic nature of supply chain management.
The category “top management support” is closely linked to the previously outlined “leadership” category as it builds on the underlying notion of leadership, pinpointing the need for an overarching steering function. However, marking the divide between the two categories, the “top management support” category is more concerned with the managerial enablement of organizational structures, acting as a high-level support function, removing obstacles and providing the optimal conditions for business functions to excel in supply chain activities. In contrast, the “leadership” category focusses on an approach of guidance where a leading entity actively promotes and implements the concept of supply chain management in a holistic way, both within the company and across the supply chain, not just limiting its operations mode to a supporting function.
The top management support for effective supply chain management is of supreme importance as it can provide a supply chain vision (Mentzer *et al.*, 2000), defining the company’s strategic direction relevant for long-term planning and decision-making (Pettit and Beresford, 2009), thus influencing the firms’ competitiveness in the market. The unique position calls for top management to be closely linked with the business functions, getting precise input on functions’ real needs and requirements in order to enable and monitor proper allocation of personnel and financial resources (Jones and Riley, 1985). A deliberate, allotted involvement of top management

aiming to ease functions’ work processes has been reported to have a positive influence on supply chain performance (Tan *et al.*, 1999). In addition, in some cases the support of the senior management team should also be proactive, including direct involvement and dedication of top management in relationship building with key supply chain partners (Monczka *et al.*, 1993).
This category follows the understanding as described in the conceptual framework of supply chain management by Chen and Paulraj (2004) where “top management support” constitutes the *“time and resources contributed by the top management to strategic purchasing, supplier relationship development and adoption of advanced information technology”* (Chen and Paulraj, 2004, p. 123).

Competitive advantage: The key reason for companies to adopt a strategic view towards SCM is the recognition of SCM as being a driver of competitive advantage (Li *et al.*, 2006). Outlining the integrative nature of SCM, Spekman *et al.* (1998) in their research of supply chain partnerships identified that substantial competitive advantages can be derived for the participating parties venturing on a collaborative mode. As such, the configuration of the supply chain, making use of the parties’ unique qualities, enables a differentiation from the competition (Tracey *et al.*, 1999). Mason-Jones and Towill (1997) analyzed how an information-enriched supply chain improves the competitiveness of the actors, concluding on a positive correlation between information-sharing and competitiveness. Sheffi (2005) highlighted the impact of supply chain resilience on a firm’s competitiveness.
Probably the major competitive advantage of SCM is its impact on overall company performance (Li *et al.*, 2006). Aiming to reveal how supply chain practices and competitive advantage impact on company performance, especially market and financial performance, Li *et al.* (2006) developed a theoretical framework categorizing various competitive advantages, potentially derived from SCM, along the five dimensions of price/cost, quality, delivery dependability, product innovation, and time to market. In their model, the competitive advantage is dependent on –and highly influenced by– the right choice of strategic suppliers and partnerships, the customer relationships, the level and quality of information-sharing, and the adoption of certain supply chain strategies such as postponement. Due to the depth of the framework it will serve as a foundation for the “competitive advantage” category.

Information technology: The first use of information technology (IT) in supply chains is linked to the Efficient Consumer Response (ECR) program (Kurt Salmon

Associates, 1993), implemented by the apparel and grocery industry, using IT to foster visibility along the supply chain (Morton, 1991). In fact, according to Lee and Whang (2000), it is largely due to advanced information systems that partners achieve collaboration across company boundaries, where these systems provide the platform required for data exchange. Accordingly, from an organizational point of view, information technology can be seen as a driver of collaboration, pushing companies to cooperate in order to evolve their IT processes towards boundary-spanning inter-organizational systems, defining common exchange interfaces and transforming processes (Chen and Paulraj, 2004).

From a production management perspective the implementation of IT systems bears the potential to support collaborative planning across the chain. It aims at a reduction of demand amplification (Christopher and Peck, 1997) and streamlining processes, allowing for the whole supply chain to respond quickly to changes in demand. To achieve this goal, it is crucial that all parties have access to information on real-time demand fluctuations, which can be facilitated through IT (Christopher and Towill, 2002).

The use of sophisticated IT is often seen as a panacea for flexibility (Skjøtt-Larsen *et al.*, 2007). However, the potential of IT in SCM should not be overvalued as the success of implementation heavily depends on the equal alignment of two basic factors: the organizational understanding, such as relationships, mindsets or corporate culture, and the underlying supporting technologies. Organizational understanding in this case determines the capability of the company to adapt to new challenges, often triggered by its environment. The underlying technology layer will help the company to change, improve and conduct tasks accordingly (Handfield and Nichols, 2002).

The decision as to what kind of supporting IT to implement is of a strategic nature and needs to be well considered, as defective and non-functional implementations may have severe business implications due to the role of IT being the information backbone of a supply chain (Burgess, 1998).

Based on a review of literature on IT usage in SCM, Gunasekaran and Ngai (2004) proposed a conceptualization for the development of IT for effective SCM. The concept framework allows the identification of the implications and applications of IT in SCM governed along six dimensions, namely (1) Strategic Planning of IT, (2) Implementation of IT, (3) Virtual Enterprise, (4) E-Commerce, (5) Knowledge and IT

Management, and (6) Infrastructure. The single dimensions each depict separate IT capabilities and components, which are required for IT-enabled SCM. Despite all dimensions being important, the Strategic Planning and Infrastructure dimensions are the core aspects of IT-enabled SCM as they frame the systems potential, while at the same time constrain the systems development possibilities. As the framework holistically subsumes the dimensions of IT usage in SCM, it will function as the theoretical basis of this category.

Lean and agile strategies: The concept of lean thinking, introduced by Womack *et al.* (1990), based on Krafcik (1988), constitutes one of the milestones of supply chain management theory. Deriving from lean manufacturing techniques and developed by the automotive industry, most notably known as the Toyota Production System, the focus of the lean concept in supply chain management is on efficiency, achieving more with less. Its overall goal is the constant reduction and elimination of wasteful activities ("muda") that add no value (Ohno, 1988). Thus the concept aims to simplify, optimize and streamline the whole supply chain from raw material supplier to end customer in order to build superior competitiveness (Hines *et al.*, 2000).

It is suggested that the lean concept is best applied on functional, low variety products with a long life cycle, where demand forecasting is relatively predictable, thus allowing for continuous improvement of the supply chain (Christopher and Towill, 2000). Furthermore, stable demand is the prerequisite for the use of various tools, such as just-in-time (JIT) with Kanban or increased quality awareness through application of total quality management (TQM), acting as stepping stones in order to aid the purpose of the lean strategy in creating value for the customer (Hayes and Pisano, 1994). This ultimately drives down cost, one source of waste (Hines *et al.*, 2004). However, reducing cost in the manufacturing process while maintaining a level production schedule creates inter-departmental as well as inter-organizational disputes. This is especially true between marketing, production and material management (Towill, 1996), as all parties strive to achieve inventory minimization. This eventually jeopardizes the efficiency of the whole chain (Christopher, 2010). To overcome this misunderstanding of the lean concept, companies and departments are required to think and act as a whole, and not as competing individual units (Lowson *et al.*, 1999).

The concept of agility as a manufacturing strategy, coined by Nagel and Dove (1991), is often used in this context as a possible solution, depicting a "*business-wide* *capability that embraces organisational structures, information systems, logistics processes and, in particular, mindsets*” (Towill and Christopher, 2002, p. 301). Earliest application of the agile paradigm in supply chains can be traced back to the Efficient Consumer Response (ECR) program, designed to move manufacturing closer in time to the customer’s buying decision, eliminating the bullwhip effect and reducing the lead time gap (Christopher and Peck, 1997) to satisfy growing customer demand for higher product variety and higher customizability (Lampel and Mintzberg, 1996). The core idea behind the concept is outlined by Hiebelar *et al.* (1998) as allowing a rapid response to quickly changing demand patterns in a volatile market, caused by the customer either within the supply chain or at the end. This adaptability and sensitivity to changing market demand through flexibility is the major differentiation between the nimble agile supply chain approach and the lean paradigm, also affecting the definition of waste (Christopher and Towill, 2000). In contrast to the lean paradigm, the agile supply chain is best applied when manufacturing innovative, high variety products with unpredictable demand and a short life-cycle for a volatile market, such as customized products (Fisher, 1997). The resulting unstable supply process, which is in contrast with the stable lean supply, forces companies to use risk-hedging in conjunction with responsive strategies (Lee, 2002). The strategy of postponing the final product assembly as close to the customer order point as possible is considered to be suitable for this cause (Pagh and Cooper, 1998). This is executed through the use of strategic supply chain stocking points, thereby increasing the chance of meeting real customer demand and reducing the guesswork. Advantages of the postponement strategy include the reduction of stock-keeping variants leading to smaller inventory and greater flexibility. This is due to modular platform concepts and higher accuracy of forecasts on the module level as opposed to finished goods level (van Hoek, 1998).

The strategy of the agile supply chain has often been proposed as an alternative, more modern approach to lean thinking. While some researchers state that lean and agile should not be seen in progression (Naylor *et al.*, 1999), it is said elsewhere that leanness as a prerequisite lays the foundation for agility (Christopher and Peck, 1997; Lamming *et al.*, 2000). Furthermore, both concepts should be supporting each other and not be seen as opposing paradigms (Mason-Jones *et al.*, 2000). Thus, the creation of a hybrid supply chain, linking the efficient lean supply part with the effective agile supply part would allow companies *“to obtain the best from both* *worlds,”* (Childerhouse *et al.*, 2002, p. 685) forming a profitable supply chain strategy while increasing the responsiveness of the system.

The key aspect for hybrid supply chain design lies in the strategic positioning of an order penetration point, commonly known as the de-coupling point. The material de-coupling point separates the supply chain, splitting the parts of the chain that focus on efficiency –the lean part– from the parts that aim to satisfy customers' orders through flexibility, known as the agile part (Hoekstra and Romme, 1992). Ideally, this material de-coupling point should be positioned as far downstream as possible in the chain in order to leverage maximum flexibility through postponing final product customization until real customer demand is visible (Pagh and Cooper, 1998). The positioning of the de-coupling point highly influences the physical form of inventory, for example raw or finished. In addition, the existence of a second decoupling point, known as the information de-coupling point, has been acknowledged (Christopher and Towill, 2003). Being equally important to the material de-coupling point, it determines the point in the upstream part of the supply chain where information of final real demand penetrates.

The category labelled “lean and agile supply strategies” will be based on the model proposed by Naylor *et al.* (1999), using the lean and agile paradigms to develop the leagility dimension, as a means to achieve flexibility in the supply chain. In addition, the model also provides a theoretical foundation for the strategy of postponement via de-coupling points.

Sustainability: Sustainability, being a prerequisite for continued growth, has long been a core pillar of companies' business models and overall corporate strategy. Sustainability in SCM, however, can be regarded as a rather new but steadily emerging area (Carter and Easton, 2011). Seuring and Müller (2008a) define sustainable supply chain management (SSCM) as *“the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account which are derived from customer and stakeholder requirements”* (p. 1700). The definition builds upon the three pillars of sustainability which are outlined in the Triple Bottom Line approach put forward by Elkington (1997) being a key paradigm in SSCM. Thus, the challenge in SSCM requires companies to find a way how to operate in an economic way, while at the same time adhering to environmental as well as social standards.

Collaborative approaches have been developed in this light, driven by the dilemma that a supply chain is not fully sustainable unless each party acts according to sustainable practices. The transformation of a supply chain to become sustainable is a time consuming and costly endeavor, which requires the selection of suitable partners to be successful (Bai and Sarkis, 2010). Striving for long term relationships, this also includes the development of partners to conform to sustainability practices (Zhu *et al.*, 2008).

In line with the broader goal of sustainability, which focusses on the conservation of resources, the closed loop supply chain concept (CLSC) has been developed (Guide *et al.*, 2003). This concept is characterized through application of remanufacturing (Savaskan *et al.*, 2004), re-using as much resources as possible in subsequent production cycles, thus limiting a negative impact of production on all aspects of the Triple Bottom Line (Jayaraman *et al.*, 1999).

SSCM is a necessity in today’s market environment as customers are increasingly environmentally cautious, which ultimately guides their buying behavior. Accordingly, businesses react to this change and are greening their supply chains (Walton *et al.*, 1998). The advantages of SSCM for companies materialize through enhanced competitiveness (Markley and Davis, 2007), as well as overall supply chain performance improvements, mainly driven by collaboration (Hervani *et al.*, 2005).

Seuring and Müller (2008a) found in their review of SSCM *“that research is still dominated by green/environmental issues. Social aspects and also the integration of the three dimensions of sustainability are still rare”* (p. 1699). Aiming to test the literature sample also in accordance to this statement the “sustainability” category will be assessed utilizing Elkington’s (1997) Triple Bottom Line approach as being a fundamental paradigm in SSCM (Beske and Seuring, 2014).

Outsourcing: Outsourcing describes the purchasing of a certain service by a company that has previously conducted that particular service in-house (Prencipe, 1997). The basic idea of outsourcing is that the company focusses on its core competencies, the part of the business it executes best and is most knowledgeable about (Quinn, 1999). The rational is that a focused approach towards a certain product or service delivery is likely to result in benefits such as the company achieving higher levels of performance, driven by increased learning and accumulated process experience. The improved performance affects profitability and results in a higher profit margin, which offsets the expenditures for outsourced functions and ultimately drives growth. The motivation for companies to outsource has been reported to be either cost driven, strategy driven, or politically motivated (Kremic *et al.*, 2006). From a supply chain perspective the concept of outsourcing fits well into the overall concept. It provides a framework for the collaborating companies to increase overall growth, given that parties focus only on their core competencies, thus outsourcing non-value adding processes and capabilities with low entry barriers for competitors (Cox, 1999).

Despite the advantages of an outsourcing strategy, potential pitfalls need to be considered by candidate companies and the process needs to be managed properly as the complexity of the process is prone to a variety of risks. Kremic *et al.* (2006) surveyed a variety of corporations, finding that risks may materialize through unrealized savings or hidden costs (Alexander and Young, 1996), a poor contract or poor selection of partners (Lee and Kim, 1999), the loss of control or core competences (Lonsdale, 1999), security issues (Graham, 1996), or even the creation of additional competitors (Klopack, 2000). In the case of an outsourcing failure, the option to reverse the outsourcing, for example by in-sourcing the outsourced functions, may not always be an option due to the erosion of outsourced skills over time in the parent organization (Lafferty and Roan, 2000). Careful selections of the to-be-outsourced functions as well as constant monitoring of the outsourced function are strategies for minimizing the risks associated with outsourcing (Weimer and Seuring, 2009).

Supporting the complex system of outsourcing decision-making, Kremic and Tukel (2006) developed a decision framework used to evaluate potential functions within an organization to be outsourced. The theoretical framework takes into account the potential benefits and risks as described above; but also caters for a suitability assessment of functions to be outsourced, based on a set of factors, which need to be considered. These factors include the complexity of the function, its degree of integration within the company, strategy, cost, as well as possible interdependencies among functions. Due to the degree of detail, the framework will serve as the theoretical underpinning of the “outsourcing” category.

4.2.6 Dimension: Theoretical foundation

The aim of theory has been described in such a way as to order the understanding of the world (Dubin, 1976). Theory is of special importance in the sciences as it provides systematic structure to the field of research, paramount to explain and predict phenomena (Hunt, 1971). As such, the type of theoretical grounding chosen by a researcher has a strong influence on his interpretation of the results, an aspect briefly touched upon in section 2.2 (p. 12). Theory can manifest itself in a variety of forms, ranging from *“minor working hypotheses, through comprehensive but vague and unordered speculations, to axiomatic systems of thought”*, and could be synthesized as being a *“logically interconnected sets of propositions from which empirical uniformities can be derived”* (Merton, 1967, p. 39).

It has been reported that newly emerging disciplines tend to borrow theories from other, more mature disciplines (Halldórsson and Arlbjørn, 2005). This approach of borrowing theories bears three advantages, namely (1) learning from others' experiences, (2) accelerated knowledge creation, and (3) strengthening of the links between disciplines through joint theory usage (Stock, 1997). These approaches are applicable to SCM, which is known to have borrowed and integrated theories from a variety of disciplines, such as economics and behavioral sciences (Mentzer and Kahn, 1995). In their review of different theories in SCM and logistics, Defee *et al.* (2010) identified 180 different theories being used in SCM and logistics research. However, they found that only about every second article reviewed made use of theory, therefore identifying a need for more theory-based research as a means to advance the body of knowledge in SCM.

The dimension “Theoretical foundation” as presented in this work adds to this by providing a structured overview of theory usage in SCM literature. Although other researchers have proposed more detailed classification frameworks (Defee *et al.*, 2010), this is done along the lines of the theoretical classification framework outlined by Burgess *et al.* (2006), based on Amundson (1998), which allows for an excellent structuring of the theories along “functional” dimensions. Accordingly, the classification scheme comprises economic theory, strategic management theory, and psychological/sociological theory, supplemented by operations management theory (Schmenner and Swink, 1998).

Economics theory: As stated by Bartels (1962) the discipline of business has its roots in economics theory. Building on this, the classification framework by Burgess *et al.* (2006) differentiates between two types of economics theory usage in SCM: transaction cost economics (TCE) theory, and other theories, which include agency theory. As the “economics theory” category will follow the structure of the framework by Burgess *et al.* (2006) the types of economics theory will be outlined briefly.

In its original form, TCE provides a theoretical framework designed to justify the existence and location of company boundaries (Ghoshal and Moran, 1996; Williamson, 1981). In this context *“TCE tries to explain how trading partners choose, from the set of feasible institutional alternatives, the arrangement that offers protection for their relationship-specific investments at the lowest total cost”* (Shelanski and Klein, 1995, p. 337). Agency theory is rooted in information economics, and focusses on the “agency problem”, a phenomenon featuring a principal party, delegating work to an agent party, which performs the work on the principal’s behalf (Eisenhardt, 1989). In essence, the concept describes the parties’ possibly different perception of goals and risks while interacting under a contractual agreement, bearing potential for conflict (Jensen and Meckling, 1976).
The theories above are well suited to be used in an SCM context as they provide the framework to guide decision-making and explain the relationships in cooperative structures, especially considering aspects of risk sharing (Zsidisin and Ellram, 2003).

Strategic management theory: Strategic management theory is concerned with providing an answer to the questions of why some companies are more successful than others, theorizing that decisions at firm level, like the strategic orientation of the company, are key drivers of success (Chandler, 1962). The analytical perspective taken by strategic management, focussing on the nucleus of businesses, the single company, provides a perspective which can also be utilized in SCM theory building (Ketchen and Giunipero, 2004). Burgess *et al.* (2006) identified two types of strategic management theory to be applicable in SCM, namely the resource based view of the firm (RBV), and competitive advantage theory.
The RBV, which has been described as being the prime perspective in strategic management theory (Ketchen and Giunipero, 2004), is characterized by its focus on the firm’s resources, centering on strategic assets, which are rare, valuable, and hard to imitate (Barney, 1991). Some researchers (Eisenhardt and Schoonhoven, 1996) describe the RBV and TCE as competing theories, as both claim to provide an explanation for the performance of the firm. Amundson (1998) outlines that the strategic resources need to be leveraged in order to create a distinct, in some cases unique, competitive advantage. This neatly links the RBV to competitive advantage theory as proposed by Porter (1980). In this regard, knowledge as a special strategic resource has been identified, being a key enabler to drive competitive advantage (Grant, 1996) as it satisfies the characteristic criteria describing strategic assets.

From a supply chain perspective the importance of knowledge as a strategic asset, also referred to as the knowledge based view (KBV) (Felin and Hesterly, 2007), is evident in the coordinating function of knowledge for the chain. The theory suggests that the intensity and organizational degree of knowledge exchange between supply chain partners directly impacts on the overall performance of the supply chain.
Taking into account the various theories described above, and considering their impact if seen in a SCM context, the category “strategic management theory“ will focus on the theories of the RBV and related theories which are enablers of the firm’s competitive advantage.

Operations management theory: Operations management, being a vital part of every company, is largely concerned with aspects such as capacity planning, forecasting, maintenance, and process design, to name a few (Chase and Zhang, 1998; Olhager *et al.*, 2001). In essence, operations management applies *“analytical tools and frameworks to improve business processes that cross internal functional boundaries”* (Mentzer *et al.*, 2008, p. 36). Despite the importance of operations management for the success of the firm, researchers struggled to define a unifying theory of the subject, a possible reason being the multitude of aspects which need to be included (Swink and Way, 1995). Schmenner and Swink (1998) claimed to propose a notable conceptual theory of operations management which is well respected in academia. Their “Theory of Swift, Even Flow” aims to explain *“cross-factory productivity differences”*, while their “Theory of Performance Frontiers” *“addresses even broader measures of across-factory performance”* (Schmenner and Swink, 1998, p. 112).
In detail the Theory of Swift, Even Flow portrays the connection between easing the flow of material through a process and the productivity of that same process. Increased speed of flow, combined with a reduction of process variability, fostered through a reduction of bottlenecks, are key levers to achieve operational excellence within the production system. Expanding this thinking, taking into account a multi-plant setup, the Theory of Performance Frontiers provides guidance on whether the firm’s focus should be on improving individual processes performance, or to foster a cumulative improvement approach, aiming to improve efficiencies in infrastructure and operations, for example though quality improvements. The underlying rationale would be that performance cannot be superior in all dimensions at the same time, which requires trade-offs in balancing performance.

Flow management is a fundamental aspect in the theories outlined by Schmenner and Swink (1998). SCM links to operations management, as it build on the concept of flow management, a key aspect of operations management (Waller and Waller, 1999). Thus, as the theories may also be applicable in an SCM context, as showcased by Seuring (2009), they are included in the category "operations management theory".

Psychological/sociological theory: The framework by Burgess *et al.* (2006) splits the psychological/sociological theory section in regard to SCM into the subsets of organizational learning theory, and inter-organizational network theory.

The process of learning within organizations is characterized by *"encoding inferences from history into routines that guide behavior"* (Levitt and March, 1988, p. 319). Borrowing loosely from Amundson (1998), organizational learning (OL) theory and SCM show various similarities, which justify an application of organizational learning in a SCM context. As such OL takes a dynamic perspective towards the company, driven by the constantly changing company environment, which requires constant adaptation. In addition, OL employs the concept of learning routines, which is similar to processes in SCM, and OL compares aspects of individual learning to viewing learning as a company overarching value. The importance of learning in SCM, aiming for supply chain excellence, is highlighted by Spekman *et al.* (2002), indicating a positive correlation between learning and supply chain performance. Implementing organizational learning by establishing a "process of learning" can be regarded as a key lever to build a market-focused supply chain, ultimately influencing customer satisfaction. This also means that the more integrated the supply chain is, the more sophisticated the structure and mechanisms enabling organization learning need to be on a corporate level in order to allow for streamlined exchange of knowledge. Collaboration thus plays a crucial role in this setup, being a prerequisite for learning in a supply chain. This links organizational learning theory to inter-organizational network theory. Inter-organizational network theory provides a basis to explain organizational practices, theorizing that networks between companies are based on external social ties (Kraatz, 1998). However, these ties do not necessarily constitute an ownership structure (Ghoshal and Bartlett, 1990). The sociological aspect of the value of personal ties between supply chain partners has always been at the heart of SCM, underlining its collaborative nature, best known under the labelling of relationships (Harland, 1996; Cooper *et al.*, 1997).

The category “psychological/sociological theory” builds upon organizational learning theory and inter-organizational network theory as they provide a sound foundation to explain SCM from a psychological and sociological point of view, bridging to key aspects of SCM exemplified through integration and collaboration.

Chapter 4 presented in detail the development process of the classification framework, based on acknowledged, highly cited SCM frameworks, covering six dimensions and 26 categories. Furthermore, the chapter outlined the individual theoretical foundations of each of the dimensions and categories, adding to the increase of transparency in the overall research process. This serves as the foundation guiding the content analysis approach which will be executed in the next chapter, chapter 5.

5 Content analysis application using the “framework map”

Chapter 5 builds upon the conceptual framework as developed in chapter 4. Applying the framework, chapter 5 describes the thorough execution of the systematic literature review process through application of the four-step content analysis approach based on Mayring (2010). This is based on the idea that content analysis is a suitable means for conducting systematic literature reviews in SCM, as stated in section 3.2 (p. 27ff). By working through each of the content analysis steps, namely material collection (section 5.1), descriptive analysis (section 5.2), category selection (section 5.3), and material evaluation (section 5.4), the role of every step of the content analysis is laid out. In addition, first results of the content analysis are presented as obtained through the descriptive analysis.

5.1 Material collection

Sizing the research sample through setting limits is paramount for empirical research, especially for literature analysis, allowing for a targeted in-depth analysis of a subject as framed in a broader context (Tranfield *et al.*, 2003). In this dissertation these limits were operationalized through the following steps: The review focuses on peer-reviewed, English-speaking journals with a clear focus on SCM and logistics content covering the period from 1989 to 2012. Only scholarly journals were included, which excludes publications aiming at a practitioner or managerial audience. The starting year was set to 1989, as an initial database search did not identify any literature reviews published prior to 1989, the year the first review appeared by Anderson *et al.* (1989). The cut-off date for material collection was set to December 31st 2012, which means that all articles included in journals published prior to and on this date were considered as potentially relevant.

The following ten academic journals were considered as leading in the field, which for structural reasons are grouped into SCM journals (SCM) and operations management journals (OPS), based on their target research focus:

SCM journals: *International Journal of Logistics Management, International Journal of Physical Distribution & Logistics Management, Journal of Business Logistics, Journal of Supply Chain Management,* and *Supply Chain Management: An International Journal.*

OPS journals: *International Journal of Operations & Production Management, International Journal of Production Economics, International Journal of Production Research, Journal of Operations Management, and Production and Operations Management.*

The split into SCM journals and OPS journals allows for a detailed comparison of the two subsets in the analysis section of the research, where appropriate, aiming to detect potential differences in regard to publication preferences of literature reviews on SCM (Kache and Seuring, 2013a; Kache and Seuring, 2013b). The selected journals have repeatedly been used in literature reviews in SCM, logistics, and operations management (e.g. Giménez and Lourenço, 2008; Mollenkopf *et al.*, 2010; Zhang *et al.*, 2011), and are particularly known as high-quality sources of empirical SCM research.

The systematic literature review approach was initiated with the identification of keywords as recommended by Tranfield *et al.* (2003). Resulting from discussions with other researchers, the author selected the keywords “supply chain,” “literature,” and “review,” which provided a good foundation for selecting suitable articles. The keywords were applied to *title*, *abstract*, and *keywords* of all articles in the selected journals. It should be noted that these keywords all needed to appear in a publication, although the order of keywords did not matter. Easing the data collection procedure, the author made extensive use of the databases and library services ProQuest, Emerald, EBSCO Host, and Wiley. These search engines were found to be of great practicality by other researchers for conducting SCM and logistics searches (Fabbe-Costes and Jahre, 2007). The keyword search was repeatedly applied to the journals during the 16-month research process to ensure actuality and accuracy of the search results. This was necessary as it was observed during the data collection process that some databases seemed to have removed articles from the result list. Nevertheless, to include as many potentially relevant papers as possible, it was decided to keep articles once found through the keyword search although they might not be included in follow-on searches.

In total, 851 full-text articles were identified. Every article was manually reviewed by the author of this dissertation, following a two-step approach to determine its relevance for the review: First, the article abstract was scrutinized to determine if the article really constituted a literature review, considering the literature review classification as outlined in section 3.1 (p. 21ff). This reduced the sample size by more than 80%, resulting in 142 articles to be assessed in the second step. The high proportion of removed articles can be justified as follows: although the removed articles basically all contained the tag word “literature review” they did not fulfill the criteria for being a literature review as defined earlier in this dissertation. Second, a full-text review of the article was conducted to assess if the article qualified for being kept in the final population sample. As a criterion for the inclusion of articles into the sample, the literature review had to be the central methodology applied in the article, and not only a narrative starting point motivating empirical research. A total of 98 articles satisfied the above criterion and thus represent the core population of literature reviews.

To further increase the relevance of the dataset and to include as many relevant papers as possible which were not covered in the initial database searches, the snowballing-technique was utilized (Greenfield and Braithwaite, 2008). This technique was found suitable by other researchers for advanced literature review studies (Jalali and Wohlin, 2012). A reason for non-inclusion of a relevant paper in the database result set may be that the paper was not tagged correctly in the database and thus did not respond to the search string. By “snowballing” through all reference lists of the 98 articles five additional literature review papers on SCM were identified as being suitable for inclusion in the final sample. This resulted in a total of 103 literature review articles. A schematic overview of the sample population selection process is outlined in Figure 5.1 (p. 67). Appendix A (p. 399) contains a detailed reference list of all 103 articles used in the review of literature review assessment.

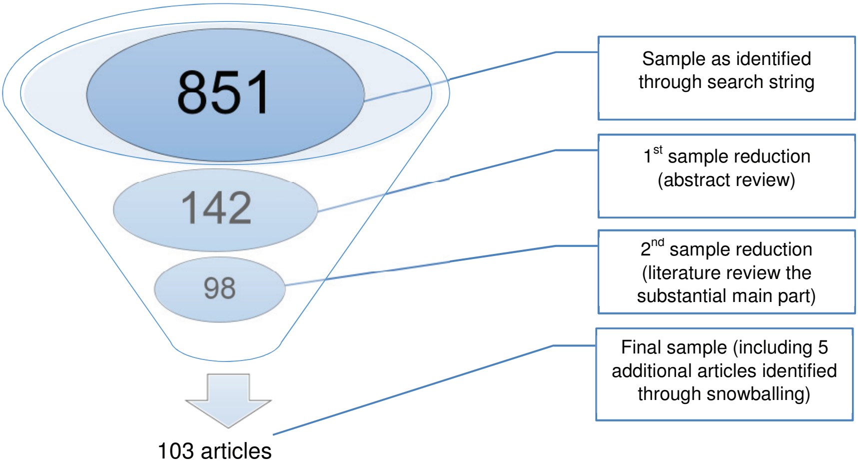


Figure 5.1: Schematic selection process of sample
(Source: Author)

Following other researchers’ suggestions to increase coder reliability (Burgess *et al.*, 2006) while paying tribute to resource restrictions, the selection was double checked in border-line cases by a second researcher. Disputes were settled through discussions until an agreement between the researchers was reached. The procedure of not having coded all of the articles in full by a second researcher may be judged as being prone to researcher bias. However, the “light” version of ad-hoc inclusion of a second researcher, as described above, provided a best fit approach, balancing resource limitations –such as restricted time and financial resources– with academic research quality requirements.

5.2 Descriptive analysis

Providing the basis for subsequent content analysis, formal aspects of the individual literature review papers have been assessed, allowing for insights into the literature sample of each single article selected for this literature review. Highlight findings will be presented in conjunction with analytical findings, giving an overview regarding the approaches and methodologies used.

5.2.1 Distribution of articles across journals and years

The reviewed articles are found to be unevenly distributed across the ten journals (Table 5.1, p. 68).

Journal	1989	1995	1996	1998	2001	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
IJLM									1	1	10	2	1	1	2	18
IJOPM		1	1	1			2		2	3		1		1		12
IJPDLM				1		1	1	1		3	2	3	2	4	3	21
IJPE				1		1			1	1	1	1	1	3	5	15
IJPR								1		2		1	2			6
JBL								1	1		1	1				4
JOM	1			1	1			1					1			5
JSCM						1					2			2		5
POM								1	1		1					3
SCMIJ									2						12	14
Total	1	1	1	4	1	3	3	5	8	10	17	9	7	11	22	103

Table 5.1: Distribution of articles across journals and years
(Source: Author)

Legend – International Journal of Logistics Management (IJLM), International Journal of Operations & Production Management (IJOPM), International Journal of Physical Distribution & Logistics Management (IJPDLM), International Journal of Production Economics (IJPE), International Journal of Production Research (IJPR), Journal of Business Logistics (JBL), Journal of Operations Management (JOM), Journal of Supply Chain Management (JSCM), Production and Operations Management (POM), Supply Chain Management: An International Journal (SCMIJ).

Within these ten journals, five journals account for 80 articles (78%) alone (IJPDLM, IJLM, IJPE, IJOPM, and SCMIJ). A split into OPS and SCM journals shows that SCM journals dominate in regard to publication of SCM literature reviews in this top group as well as across the total sample. Accordingly, 39 articles were published in two SCM journals (21 articles in IJPDLM and 18 in IJLM) making theses journals prime outlets for SCM literature reviews. Based on the assessment of the historical figures it can be assumed that SCM journals have a higher tendency to publish literature reviews. However, as OPS journals are lacking behind, it may be a feasible option for researchers to tailor a literature review in SCM for publication in an OPS focused journal. IJPE and IJOPM are recommended as suitable outlets for such an endeavor, based on the fact that 27 papers of all 41 articles published in OPS journals appear in these two journals alone. The assessment indicates that the articles are also unevenly distributed over time. Interestingly, over 80% of all literature reviews were published since 2006. The reason may be that the amount of SCM publications needed to reach a certain threshold, reached around the year 2006, before a condensed assessment in the form of a literature review made sense. Analyzing the distribution on an annual basis some distinctive conclusions can be derived: From 1989 to 2007 all journals combined spawned an annual maximum of ten reviews. The years 2008 and 2012 seem to be unique with a peak of 17 literature reviews (2008) and 22 literature reviews (2012), respectively. A closer analysis indicates that the increase in these years was driven by a special journal issue of IJLM (10 reviews), calling for theory development in business logistics through literature reviews (2008, Vol. 19 No.2), as well as two special issues (12 papers) following the SCMIJ call for systematic literature review research (2012, Vol. 17, No. 4 and 5). This might also be seen as a justification for the research presented here, as the IJLM call was for theory, but researchers predominantly turned to literature reviews for implementing this. However, from 2009 to 2011 the number of annual literature reviews across all journals (seven to eleven reviews) is higher compared to the 1989 to 2007 period. This may indicate that the call for theory in IJLM in 2008 may have had some impact on the other journals to push for publication of literature reviews, exemplified for instance by the 2012 special issue in the SCMIJ, dedicated to literature reviews in SCM only.

5.2.2 Distribution of journals included in literature reviews of sample

In order to get a better understanding of the sample of 103 literature reviews included in the analysis, it seemed reasonable to check each article regarding its usage of journals in its own review sample. This approach allows ex post for a justification of the journal selection sample used in this dissertation, adding to internal validity.

The analysis revealed that 40 articles did not disclose any information on which journals they used to extract their research sample. This applies to articles in SCM journals as well as in OPS journals with 20 articles each. In some cases this can be based on the fact that a full database search was conducted, not limited to certain journals (Labro, 2006), or other types of literature were utilized for reviews, e.g. doctoral dissertation (Zachariassen and Arlbjørn, 2010). In some cases an explicit justification with regard to why no journals were disclosed was given (Selviaridis and Spring, 2007). However, the majority of researchers lacked any rationale regarding why they decided to follow a rather non-transparent research path not disclosing the journals used. Accordingly, for the analysis of the distribution of the literature reviews’ sample the sample of 103 articles will be reduced to those 63 papers which disclosed the journals used. These 63 papers include 42 papers belonging to the SCM subset and 21 articles from the OPS subset.

The analysis revealed that a total of 256 different journals have been scrutinized by the 63 papers. Interestingly only about ten percent of all journals (24) have been used more than ten times (Figure 5.2, p. 70). Fourteen journals appeared less than ten times, but more than five times, and 61 journals between five and two times. As literature reviews due to their nature can have a narrow research focus, 157 journals were found being used only once, which represented the majority of journals.

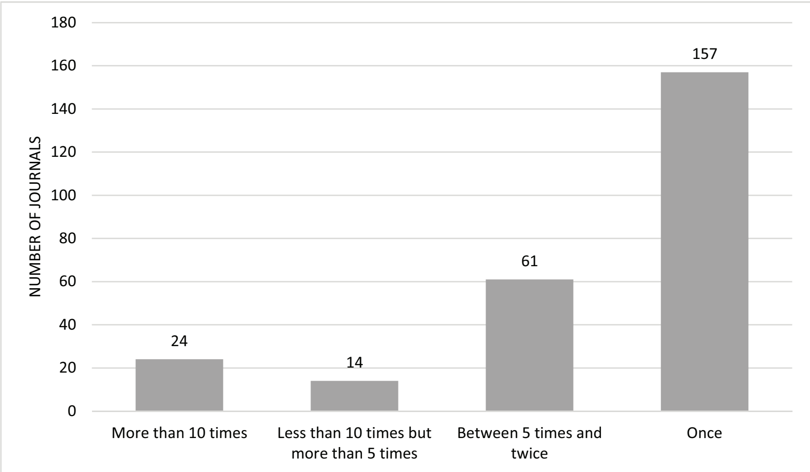


Figure 5.2: Frequency of journal usage within the sample of 103 literature reviews
(Source: Author)

The journals utilized most often are shown in Table 5.2 (p. 71). The most frequently used journal is the IJPDLM (used in 44 literature reviews), followed by the IJLM (37).

Despite POM, the ten journals mentioned most often were the same journals as included in this work’s sample. This is of interest for two reasons: First, it proves the relevance of the journals used in the sample of this literature review study from a validation standpoint. Second, this finding builds the foundation to test if authors preferred to include the journal in which the literature review article was to be published, as a means to increase the possibility of being published.

As on average 56% of analyzed literature reviews published in any journal stated to primarily include articles from that journal in their sample, it cannot be denied that the sample choice used in this dissertation had some biasing influence on the ranking of the distribution of journals included in the analyzed literature reviews as displayed in Table 5.2 (p. 71). Nevertheless, a review of the raw numbers showed that the journals greatly vary in regard to the usage of same journal articles (Table 5.3, p. 72) with the IJPE (67%), IJPDLM (62%) and IJLM (61%) being the leading journals.

Journal name	Count
IJPDLM - International Journal of Physical Distribution & Logistics Management	44
IJLM - International Journal of Logistics Management	37
JOM - Journal of Operations Management	35
IJPE - International Journal of Production Economics	33
JBL - Journal of Business Logistics	32
IJOPM - International Journal of Operations Production Management	29
SCMIJ - Supply Chain Management: An International Journal	28
JSCM - Journal of Supply Chain Management	26
IJPR - International Journal of Production Research	25
MS - Management Science	23
EJOR - European Journal of Operational Research	21
TRE - Transportation Research Part E: Logistics and Transport Review	20
POM - Production and Operations Management	19
DS - Decision Science	18
Omega - International Journal of Management Science	15
HBR - Harvard Business Review	14
IMM - Industrial Marketing Management	14
TJ - Transportation Journal	14
PP&C - Production Planning & Control	11
JPSM - Journal of Purchasing and Supply Management	11
IJLRA - International Journal of Logistics: Research and Applications	11
SMJ - Strategic Management Journal	10

Table 5.2: Distribution of journals included in literature reviews of 103 articles
(Source: Author)

Journal	Distribution of sample articles across journals	Number and percentage of sample articles which used their publishing journal as prime source of literature **(as indicated in the analyzed literature reviews)**	
IJLM	18	11	61 %
IJOPM	12	5	42 %
IJPDLM	21	13	62 %
IJPE	15	10	67 %
IJPR	6	1	17 %
JBL	4	3	75 %
JOM	5	1	20 %
JSCM	5	4	80 %
POM	3	2	67 %
SCMIJ	14	8	57 %
Total	103	58	56 %

Table 5.3: Distribution of articles across journals and their usage of the same journal included in literature reviews of sample
(Source: Author)

Assuming that authors in the samples had a preference to include the journal in which they intend to get published in as a means to increase publication relevance, the results from the journals which appeared in the sample only a couple of times have been neglected in the further steps of the analysis. This applies to the JBL, JOM, JSCM, as well as POM. The rationale is that these journals, considering the above assumption, would have blurred the results of the whole analysis, driven by the fact that the literature sample contains a relatively small number of articles in these journals, combined with a –in comparison– high usage of same journal sample articles.

5.2.3 Formal aspects of the 103 literature review articles (transparency)

An important aspect of a literature review, especially of the systematic literature review approach, is the transparency and repeatability allowing other researchers to re-run the analysis as outlined in section 3.1 (p. 21). Accordingly, the design of each of the literature review articles was analyzed towards conformance with the transparency paradigm.

Of the 103 papers only fifty-three fulfilled the above criteria, stating both keywords as well as journals used during the literature review process. Some articles did not limit their search towards selected journals, but instead opted to conduct a literature review on complete databases (Colicchia and Strozzi, 2012; Giménez and Tachizawa, 2012). Although this approach can be regarded as very open, not per se excluding potentially useful journals, it requires the author to limit the research scope at a different end, namely the database selection.

Twelve additional papers revealed either keywords (6) or journals (6), but not in a combined fashion. A total 37% of all literature reviews analyzed did not give any information on the use of keywords or journals, which therefore does not allow for an objective review of the findings by other scientists. These literature reviews can be regarded as being of a rather narrative kind.

It is worth mentioning that in selected cases (Beamon, 1998; Delbufalo, 2012), where keywords and journals were not or only partially formally listed, the authors chose to offset the disclose of keywords and journals by inclusion of a complete list of the articles used in the main text. Although allowing for a high degree of transparency, this detailed approach, however, was rarely used. A reason may be assumed in regard to the page space required to list dozens of papers in detail as this collides with the restrictions on article length usually imposed by journals editors. From the readers’ perspective, the approach of listing all articles in the main text could be described as rather inconvenient, as the lists included in the text were organized by references only, not directly disclosing the journal the article was published in. The interested reader would be required to extract the names of the journals used from the list of references, which is a rather time consuming task.

In line with the paradigms governing the definition of a “good review,” as outlined previously, it can be concluded that the 103 paper research sample only partially fulfilled the criteria for transparency. However, a trend towards more stringent adherence to transparency and replicability can be observed in recent publications, as almost half of the articles fulfilling the criteria were published in 2011 or 2012.

5.2.4 Origin of analytic categories for analyzing the contents of the 103 articles (deductive / inductive)

As the categories against which to code the samples are a central aspect of a literature review (Tranfield *et al.*, 2003), the articles were reviewed according to the applied research approach. In particular, the articles were checked in regard to the origin of the categories used, being either deductively or inductively derived, or constituting a mixed approach.

The application of purely deductive category development was found to be most common when conducting literature reviews in SCM, as 53 of 103 literature reviews utilized this approach. In contrast, only 19 papers were exclusively based on inductive approaches. This is in line with findings from other authors (Kovács and Spens, 2005), who identified a dominance of deductive research in logistics, proclaiming that for theory development in logistics more inductive research is required. Nevertheless, the reason for researchers’ preferences of the deductive approach may well be founded in taking advantage of increased coding reliability inherent to this approach. Thus, as the work is rooted in established research, the validity of the category selection is enhanced.

Twenty papers applied a combined two-way approach, which is also followed in this dissertation, with deductively derived categories being inductively refined during the coding process. Eleven articles did not disclose how the categories were derived. In most cases this was due to the fact that the articles did not even state the categories used, as they constituted a rather narrative review which makes a check of the analysis literally impossible.

5.2.5 Type of data analysis use in literature review sample (qualitative / quantitative)

This assessment aspect links to the discussion on qualitative and quantitative methodology usage as put forward in section 2.2 (p. 12ff), highlighting a substantial lack of qualitative methodology usage in supply chain and logistics research. Aiming to support or contrast the above view, the literature was assessed in order to determine if the literature reviews utilized qualitative or quantitative approaches as means to analyze the literature under review.

The result of the assessment shows that an easy segmentation of the articles in either one type of approach is far from simple. Although some rare articles explicitly apply only one type –in the examples found this was the quantitative-, the majority does not explicitly disclose any details regarding methodology usage in the article text. Having reviewed the articles regarding their wider research methods usage it can be claimed that almost all articles (101) show a mixed approach, thus combining qualitative and quantitative research methods. This is usually based on some sort of qualitative method where the literature was presented in the way of a narrative review as an introduction to the research issue (Defee *et al.*, 2010; Sachan and Datta, 2005). Sometimes this serves as a preparatory step to aid the development of a model in a subsequent application of quantitative research (Hazen and Byrd, 2012).

Quantitative methods were found to be generally limited to rudimentary statistical datasets, such as frequency of articles and categories, the use of percentages, as well as ranking scores. These methods were used to support the general arguments of the articles, allowing a structured presentation of the findings through graphs or tables. Only two examples of applied advanced statistics were identified in the sample. As such, Williams and Tokar (2008), in their review of inventory management research in major logistics journals, conducted the Mann-Whitney-U-Test; and Kremic *et al.* (2006) utilized Excel cross-tabulations and chi-square testing to aid identification of relationships among categories. The only reviews found which build exclusively on the quantitative approach were the studies by Carter *et al.* (2007), who conducted a quantitative cluster analysis, and the article by Charvet *et al.* (2008), focussing on multidimensional scaling, clustering, and factor analysis.

Attempting to assess if authors supported either the qualitative or the quantitative side, one could argue that authors discussing more technical, mathematically driven articles, such as Glock (2012) in his review on the joint economic lot size problem, were found to be more inclined to use quantitative methods to review their sample population. The general low consideration of qualitative methodology usage, evident in supply chain and logistics research (Frankel *et al.*, 2005), cannot be confirmed based on the sample of 103 literature reviews. In fact, the most common approach observed follows the mixed model research paradigm, utilizing qualitative and quantitative approaches in a supplementing fashion (Creswell, 2013).

5.2.6 Multivariate data analysis method usage in literature review sample

The selection of a suitable data analysis method needs to be made with care by the researcher, as it constitutes a fundamental element of the research design. In general, the range of possible data analysis methods is governed by the research method applied. Therefore, and as the scope of this research was limited to the literature review research method, it was assumed that the authors of the literature reviews utilized data analysis tools linked to the literature review method. Confirming the assumption, it was found that the researchers applied various tools and methods to execute the literature reviews, largely relying on bibliometric analyses, for instance content analysis, citation analysis, or cluster analysis. In rare cases these analyses were used in conjunction, e.g. supplementing content analysis findings through subsequent citation analysis (Hazen *et al.*, 2012). Interestingly, a large portion of the reviews (43) was of a rather narrative type, not utilizing any method of data analysis.

The explicit use of content analysis to structure and summarize the content of the literature was outlined in thirteen reviews. As content analysis can be generally defined as providing “*aggregate accounts of inferences from large bodies of data that reveal trends, patterns, and differences”* (Krippendorff, 1989, p. 404), it is not surprising that in fact a further 58 articles were identified as applying the method without naming it, showing traits of a content analysis as they develop and utilize classification categories to distill the deeper meaning of their sample. The core theorems of content analysis found are the approaches by Krippendorff (2012) and Mayring (2010). However, only few researchers explicitly stated the use of these theorems, most notably Hazen and Byrd (2012), Hazen *et al.* (2012), as well as Seuring and Gold (2012).

The citation analysis method aims to assess if certain types of papers, such as theory-based papers, are preferably cited in a certain outlet, e.g. more often than other types. Based on the results, conclusions for such a preference could be drawn from the literature review. Eight articles featured a citation analysis, which in the article by Hazen *et al.* (2012) was used to search for possible additional literature in the literature review stage of the research process in order to broaden the literature base. Greening and Rutherford (2011) took this approach a little further, combining traditional contextual analysis with citation analysis and co-citation analysis.

A manual check of the citations in a citation analysis is very time consuming and not efficient. Thus, the application of supporting technology for citation analysis was proposed by Colicchia and Strozzi (2012), conducing a citation network analysis using the software *Pajek*; whereas Chicksand *et al.* (2012) utilized the *SCOPUS* database to identify the impact of the selected articles.

Five articles were found to apply the data analysis method of meta-analysis. Some researchers, for example Wong *et al.*, 2012, conducted a meta-analysis, based on the resultant empirical findings from the systematic literature review. Fabbe-Costes and Jahre (2008) underline the feasibility of such an approach, highlighting the advantage of the meta-analysis method to increase the validity of the findings.

The least often used type of multivariate data analysis found in the 103 articles was the cluster analysis (2 articles), used in the literature review by Carter *et al.* (2007) on behavioral supply management. In this case a cluster analysis was combined with the Q-sort methodology to develop a taxonomy of judgment and decision-making biases. Kremic *et al.* (2006) combined the cluster analysis with a cross-tabulation analysis with the aim to uncover links between categories.

As a key take away, the assessment of the methods of data analysis utilized by the sample articles found that the content analysis is widely being used in supply chain literature reviews although usually not being explicitly outlined. Nevertheless, in recent years the citation analysis as well as the meta-analysis method seem to gain ground in regard to literature review usage as the majority of articles were published in 2011 or 2012. However, given its predominance in contrast to other data analysis methods the content analysis could be viewed as the standard method of data analysis.

5.2.7 Quality measures applied in literature review sample

As the articles analyzed for this dissertation were all published in top ranking academic journals, it can be assumed that the articles are of a high standard and the research presented was carefully conducted by the researchers. Linking to the discussion on transparency, as outlined previously (section 3.1), a literature review should apply a certain set of measures to ensure that a high standard of quality is met throughout the research process. Accordingly, the sample of 103 literature reviews was scrutinized, assessing if the authors outlined issues concerning reliability and validity of their work, thereby following the recommendations for applied measures of quality as outlined by Krippendorff (1989).

Aspects of reliability were mentioned in 27 articles only, usually focussing on methodological standards used in the coding process of articles, aiming to reduce researcher bias. As such, the use of multiple researchers (Duriau *et al.*, 2007) to code articles into categories was most commonly mentioned. However, only a few articles involved more than two researchers (Burgess *et al.*, 2006; Chicksand *et al.*, 2012; Defee *et al.*, 2010; Tavares Thomé *et al.*, 2012; Terpend *et al.*, 2008; Zhang *et al.*, 2011).

A common approach found was the use of trail coding, where each author completes an individual review of a few selected articles with a subsequent comparison of the results. Essentially required to ensure that the authors have a comparable understanding of how to code the articles, this procedure was coined by Seuring and Gold (2012) as *“discursive alignment of interpretations”* (p. 548). The advantage of this approach is based on the idea that once the two coders are aligned on how to code, assuming that their individual coding results are equivalent to their combined coding results, the to-be-coded sample can be split between the researchers, resulting in an acceleration of the often lengthy coding process.

Of the 27 articles containing information on reliability, twelve further detailed their methodology used, also disclosing the inter-rater reliability measures used. Aiming to maximize replicability of the results, the authors applied a variety of measures such as Cronbach's coefficient alpha (Carter and Easton, 2011), Krippendorf's alpha (Hazen and Byrd, 2012), and Cohen’s kappa (Tavares Thomé *et al.*, 2012). These details of the reliability measurements enable other researchers to interpret the accuracy of the coding process where multiple researchers have been involved, while adding to increased validity of the whole research.

Validity, being a core aspect of research, was explicitly mentioned in 29 articles. Not providing fruitful insights, the articles usually only addressed validity through emphasizing that solely published peer-reviewed articles were used in the literature reviews. A breakdown into the various aspects of validity, such as internal and construct validity, was only done by a minority of researchers, for example by Terpend *et al.* (2008).

In general, it can be concluded that only a fraction of the literature reviews addressed aspects of research quality. Nevertheless, the reviewed sample of literature reviews shows an overall positive trend over time towards being more stringent in displaying quality measures, such as reliability and validity, which adds to the overall development and maturity of SCM.

5.2.8 Grounding of the 103 literature review articles in streams of literature

As explained in section 5.1 (p. 64), the systematic literature review search process was restricted to articles conducting a literature review with a focus on the keyword “supply chain”, not limiting the string towards “supply chain management” or “supply chain strategy,” for instance. Accordingly, the articles found addressed various facets of management but always with a close connection to “supply chain” as an overarching theme (Table 5.4, p. 79). The identification of the multitude of streams of literature the articles were based on may promote a better understanding of the research sample under review.

As all articles were published in journals focussing on supply chain management (78%), operations management (63%), and logistics (54%) in a wider sense, these groups also represent the largest streams of literature, which can be seen as foundational for this review of literature reviews. Naturally, articles published in SCM journals tended to be rooted in SCM (81%) and logistics (68%), whereas articles found in OPS journals had a strong hold in operations management topics (85%). Purchasing, strategy, and marketing / services all counted for about a fourth of the total populations’ background with articles being predominantly found in SCM journals.

Being a somewhat unexpected finding, the assessment revealed that 12% of the OPS articles were based in psychology / sociology streams of literature, especially behavioral science, whereas only 6% of the SCM articles covered this area. A rationale for this unbalanced usage may be that OPS journals focus on the operational corporate level, where aspects of behavioral science, e.g. managerial implications and employee retention, are a greater concern at the rather tactical and strategic SCM level.

Aspects	Count all articles (n=103)	% of all articles	Count SCM articles only (n=62)	% of SCM articles	Count OPS articles only (n=41)	% of OPS articles
Articles based in theory of	**103**	**100%**	**62**	**100%**	**41**	**100%**
Supply chain management	80	78%	50	81%	30	73%
Operations management	65	63%	30	48%	35	85%
Logistics	56	54%	42	68%	14	34%
Purchasing	27	26%	19	31%	8	20%
Strategy	24	23%	16	26%	8	20%
Information / communication	22	21%	13	21%	9	22%
Marketing / services	16	16%	12	19%	4	10%
Psychology / sociology	9	9%	4	6%	5	12%
Finance / economics	7	7%	5	8%	2	5%

Table 5.4: Grounding of articles in streams of literature
(Source: Author)

5.2.9 Limitations identified in sample literature reviews

In earlier research, Fabbe-Costes and Jahre (2008) found that research papers in SCM were largely lacking detailed discussions regarding limitations of the data under research. The article sample was analyzed accordingly. Only 42 of 103 papers included a section outlining the limitations of the research. The use of secondary data as well as the focus of the research scope to certain –usually English-speaking–

outlets were commonly mentioned limitations. Metters and co-authors (2010) discussed a potential lack of generalizability of the literature review findings. Pointing towards a general problem in science, Colicchia and Strozzi (2012) highlight the limiting issues of objectivity when selecting articles for a literature review, the reason for which may be found in the researchers’ varying *“level of knowledge in a field* [which] *may lead to different sets of items”* (p. 414). Thus, almost 60% of all articles did not outline any limitations. From a literature review methodology perspective it was also observed that many reviews did not adhere to a transparent research process. In a range of reviews which were scrutinized, the research design was not presented in detail. In addition, the names of the journals scrutinized in the data collection phase were not mentioned or the timeframe of the sample was not disclosed.

Following the recommendations for systematic literature reviews proposed by Tranfield *et al.* (2003) future researchers making use of the systematic literature review methodology are thus encouraged to clearly communicate possible limitations, outlining in detail their way of thinking and the methodological steps applied in order to increase research transparency.

5.3 Category selection

Merging *“the strength of firm theoretical grounding with general openness towards unexpected findings”* (Seuring and Gold, 2012, p. 552), a two-step approach was applied to develop the analytic categories within the six dimensions. A conceptual comprehensive framework of major aspects of SCM was deductively developed as presented earlier (section 4.1, p. 33), based on existing research. In the second step the framework’s dimensions categories were inductively refined during the coding process to optimize the framework as new, previously unidentified aspects emerged from the literature under review. In addition, aspects were broken down into various items and sub-items, as outlined previously in section 4.1. The applied approach, portrayed in Figure 5.3 (p. 81), follows the process model for inductive category development and refinement as outlined by Mayring (2010).

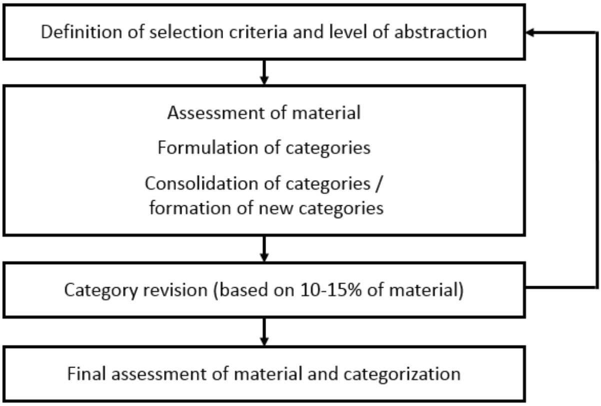


Figure 5.3: Inductive category development and refinement process
(Source: Author, adapted from Mayring, 2010, p. 84)

Aspects of inter-coder reliability, while developing the coding framework, have been addressed as a second research was included to check cross-coding results in a phased approach.

5.4 Material evaluation

The core research sample of 103 papers was coded and analyzed, according to first level dimension, second level category, and third level sub-category fit, utilizing the theoretical framework as developed in chapter 4 (p. 33). A paper could fit multiple categories or sub-categories if found appropriate.

In order to operationalize the material evaluation, the frameworks items outlined above are added as individual rows to the Excel sheet, which was developed in the material collection phase (section 5.1, p. 64). In total, the sheet comprised 161 assessment rows, each representing either a dimension, category, or sub-category. It should be noted that some sub-categories were further split down into more-detailed items. Each article needed to be carefully coded against every single dimension, category, or sub-category, following a cascading matching approach. The coding will be exemplified in the following for explanatory purposes.

First, an assessment in regard to a match on dimension level was conducted. The assessment was executed as the author scrutinized each paper for inclusion of a keyword where the keywords were comprised of the respective dimension labels provided in Table 4.3. Using the “integration” dimension for example, the author checked each paper manually for the appearance of the phrase “integration” within the article. For this assessment of manifest content it was, however, not sufficient if the phrase “integration” was only mentioned as a side line, for instance in the introductory section, as the phrase needed to occur on a regular basis in the main body of the article. In cases where the phrase “integration” could be identified as a reappearing item in the text, the author verified the latent content, checking if the article was subject to substantial “integration”-related content. If this was confirmed, the article was coded as part of the “integration” dimension. In addition, if the article did not contain the “integration” keyword, it was still checked for “integration”-related content on a latent level and considered relevant.

In the case of a positive match, the appropriate category level match in that particular dimension was determined (in the case of the “integration” example the “integration” category). Upon determining the best-fit category, it was checked if the item would fit into a sub-category of the appropriate category (“inward-facing,” or “external integration”. This procedure was deliberately reapplied, until the article under assessment was checked in regard to all dimensions, corresponding categories, sub-categories as well as the more granular levels 4 and 5 codings.

In cases where a manifest coding on dimension and / or category level was not possible (for example at the “Level SCM analysis” dimension and the “SCM view of literature” category), the author tested the articles’ relevance on a sub-category level, in that case “function,” “firm,” “dyad,” “chain,” or network”. In the case of adherence to any of these sub-categories, the article was considered as being also applicable to the respective higher level category and dimension, using a bottom-up clustering approach, following the hierarchical clustering order.

The combined approach of content assessment on a manifest and latent dimension enabled a thorough and systematic coding of the articles. This rigorous but time-consuming approach ensured that each article was scrutinized in great depth, providing the author with a very valuable detailed list of every article’s content.

Figure 5.1 (p. 67) showcases a simplified snapshot featuring the “integration” assessment rows of the Excel table used for coding.

As outlined above, the categories used for the coding are theory-based and clearly defined, thus increasing the objectivity and transparency of the research process while enhancing coding reliability. Internal validity is established, as a second researcher was involved in the coding process and the results were discussed with other researchers. The coding process was executed only on the review part of the literature reviews. Introductory or concluding sections of the papers, such as “future research recommendations” or “research gaps”, were not categorized as this would have blurred the results of the analysis. Every paper would have then fit into basically the same categories, as a gap found in the sample of a literature review is often mentioned in the future research part. A detailed mapping of the articles to the 26 categories is provided in Appendix B (p. 406).

This chapter outlined the thorough execution of the systematic literature review process through application of the four-step content analysis approach as proposed by Mayring (2010), namely material collection, descriptive analysis, category selection, and material evaluation. First results of the content analysis are presented as obtained through the descriptive analysis.

The next chapter, chapter 6, presents the findings from the systematic literature review approach, where the identification of current shortfalls in the literature provides the foundation for a precise definition of the under-represented areas of research in SCM. In addition, a contingency analysis is applied to strengthen the content analysis results and to assess possible interrelations between the dimensions and categories.

		FUNCTIONAL SCOPE OF SCM (INTEGRATION / COLLABORATION)									
			SC INTEGRATION								
				Inward-facing			External integration				
Citation (short)	Journal				Functional integration	Internal integration		Periphery-facing	Supplier-facing	Customer-facing	Outward-facing
Anderson et al. (1989)	JOM	Y	Y	Y			Y				
Aronsson and Brodin (2006)	IJLM	Y	Y								Y
Ashby et al. (2012)	SCMIJ	Y	Y				Y				
Beamon (1998)	IJPE	Y	Y	Y		Y	Y				
Blankley (2008)	IJLM	Y	Y	Y	Y		Y		Y	Y	
Caridi et al. (2005)	IJPR	Y	Y				Y				Y
Carter and Ellram (2003)	JSCM	Y	Y		Y		Y				
Carter et al. (2007)	IJPDLM	Y	Y						Y		
Carter and Rogers (2008)	IJPDLM	Y	Y	Y		Y	Y				Y
Cheng and Grimm (2006)	JBL	Y	Y	Y		Y	Y	Y	Y	Y	Y
Chicksand et al. (2012)	SCMIJ	Y	Y								
Colicchia and Strozzi (2012)	SCMIJ	Y	Y				Y				
Crum and Poist (2011)	IJPDLM	Y	Y				Y				

Figure 5.4: Example snapshot of Excel table used for coding
(Source: Author)

6 Findings from the literature review

In order to enable an objective assessment of the six dimensions, categories and their respective sub-categories, a frequency analysis was conducted. The resultant frequency of use of the categories is summarized in Table 6.1 (p. 85).

Dimension (level 1) Category (Acronym) (level 2)	**Count all articles (n=103)**	**% of all articles**	**Count SCM articles (n=62)**	**% of SCM articles**	**Count OPS articles (n=41)**	**% of OPS articles**
1 Level of SCM analysis						
1.1 SCM view of literature (SCV)	98	95%	58	94%	40	98%
1.2 Conceptual framing of SCM (CFR)	95	92%	57	92%	38	93%
1.3 Business functions involved in SCM (BSF)	94	91%	55	89%	39	95%
2 Orientation of SCM						
2.1 Types of flow (TFW)	72	70%	40	65%	32	78%
2.2 Direction of flow (DFW)	57	55%	29	47%	28	68%
3 Functional scope of SCM: Collaboration / Integration						
3.1 Collaboration (COL)	89	86%	53	85%	36	88%
3.2 Integration (INT)	82	80%	50	81%	32	78%
3.3 Information-sharing (IFS)	52	50%	30	48%	22	54%
3.4 Process improvement orientation (PIO)	54	52%	23	37%	31	76%
3.5 Leadership (LSP)	23	22%	11	18%	12	29%
4 Functional scope of SCM: Risk / Performance						
4.1 Supply chain risk management(RSK)	77	75%	43	69%	34	83%
4.2 Rewards-sharing (benefits) (RWS)	42	41%	23	37%	19	46%
4.3 Supply chain performance (PER)	83	81%	50	81%	33	80%
5 Functional scope of SCM: Strategy						
5.1 Supply chain planning (PLN)	29	28%	19	31%	10	24%
5.2 Innovation (INO)	38	37%	24	39%	14	34%
5.3 Customer focus (CUF)	48	47%	28	45%	20	49%
5.4 Top management support (TMS)	18	17%	14	23%	4	10%
5.5 Competitive advantage (CPA)	55	53%	29	47%	26	63%
5.6 Information technology (IT)	68	66%	40	65%	28	68%
5.7 Lean and agile supply (LAS)	73	71%	40	65%	33	80%
5.8 Sustainability (SUS)	40	39%	30	48%	10	24%
5.9 Outsourcing (OUT)	39	38%	23	37%	16	39%
6 Theoretical foundation						
6.1 Economics theory (ECT)	32	31%	20	32%	12	29%
6.2 Strategic management theory (SMT)	28	27%	21	34%	7	17%
6.3 Operations management theory (OMT)	8	8%	3	5%	5	12%
6.4 Psychological / sociological theory (PST)	28	27%	21	34%	7	17%

Table 6.1: Summary statistics of literature reviews based on proposed classification framework
(Source: Author)

Building on the detailed justification and the theoretical grounding of the dimensions and categories as presented in section 4.2 (p. 37), the next section discusses the findings from the frequency analysis along the six framework dimensions (sections 6.1 to 6.6). The presentation of the results is enhanced through references and citations from the respective literature sample. References which are not taken from the sample of 103 literature reviews are explicitly labeled to ease differentiation between sample papers and for example papers used in the underlying conceptual framework. The results aim to showcase “key research areas”, most favored by researchers, as well as the more or less “under-represented” areas, which are seemingly less interesting to researchers. Through the identification of these under-researched areas, the findings may thus be of value to direct future research initiatives in the SCM field. In addition, in order to enhance the validity of the findings and as a means to assess possible interrelations between the dimensions and categories, a contingency analysis is applied to the content analysis results (section 6.7).

6.1 Dimension: Level of SCM analysis

Covering structural and definitional aspects of SCM research, the dimension “Level of SCM analysis” presents findings from the literature reviews in regard to their scoping of SCM, the conceptual perspective taken towards the big picture of SCM, and their outlined business functions involved in operationalizing SCM.

6.1.1 SCM view of literature

Various views towards the composition of the supply chain exist in the literature, as outlined by Halldórsson and Arlbjørn (2005), who suggested that SCM can be viewed on five levels, namely the “function,” the “firm,” the “dyad,” the “chain,” and the “network” level. Ninety-eight articles in the review follow the use of views (Table 6.2, p. 88) as proposed by Halldórsson and Arlbjørn (2005), whereas the “chain view” and the “focal firm view” were used most frequently across the sample with 87 and 82 articles, respectively. The dominance of the “chain view” confirms the findings from a previous study by Halldórsson and Arlbjørn (2005), reviewing three logistics journals in regard to their supply chain perspective. The “function view” (60) and “network view” (57) were regularly mentioned in the full sample. In contrast, the “dyad view,” which in this work’s definition also encompasses triadic relationships, was only present in 27% of the papers (28 articles). Taking the few representations into account, the author argues that the dyadic view of SCM, as seen through literature reviews, is less relevant to understanding SCM from a researcher perspective, maybe because other fields of management (e.g. marketing, institutional economics) have studied the dyad in greater detail. Nevertheless, from a research point of view a dyadic relationship, although not being addressed as often as other views in the literature sample, could –as the dyad is the smallest possible chain–, still provide good research opportunities for SCM researchers within a limited, yet sufficient scope. However, the “dyad” view is used least often in the literature reviews under consideration, underlining researchers’ interest in multi-echelon relationships which provide greater research opportunities on supply chain networks (Gunasekaran and Ngai, 2007; Naim and Gosling, 2011), also enhancing the validity of researcher’s studies.

A closer look into the two subsamples of SCM and OPS journals reveals that their view towards SCM is less homogeneous than indicated at first glance by the full sample. The articles published in SCM journals have a tendency towards the “focal firm view” (52 articles, 84%); a reason may be tied to researchers preferring to analyze single firms due to scope and timing reasons. In contrast, the literature reviews in OPS journals view SCM rather on the chain level (38 articles, 93%). This serves as a justification for the dominance of the “chain view” and the “focal firm view” in the complete sample. In general, SCM journals seem to favor a single company to bi-polar view to SCM, manifested in SCM journals’ preference of the „function,“ „firm,“ or „dyad“ view. OPS journals show a clear trend towards focusing on multi-polar SCM, thus viewing SCM more from a „chain“ or a „network“ perspective, underlining the importance of production networks (Lee and Lau, 1999). This is surprising, as SCM is usually more concerned about managing entities along the chain or network, while OPS has its roots in the „functional” area, thus being concerned with managing flows across functions within the company (Schmenner and Swink, 1998). The findings are diametric to traditional expectations. A justification may be that SCM literature reviews published in operations management journals are probably developing away from the traditional operations management approach towards a broader supply chain view.

Nevertheless, the findings outlined above open opportunities for further research, using for example a dyadic relationship as a research sample in SCM research which is intended for publication in OPS journals.

Category (level 2) Sub-category (level 3)	Count all articles (n=103)	% of all articles	Count SCM articles only (n=62)	% of SCM articles	Count OPS articles only (n=41)	% of OPS articles
1.1 SCM view of literature	**98**	**95%**	**58**	**94%**	**40**	**98%**
Function	60	58%	42	68%	18	44%
Firm	82	80%	52	84%	30	73%
Dyad	28	27%	21	34%	7	17%
Chain	87	84%	49	79%	38	93%
Network	57	55%	33	53%	24	59%

Table 6.2: SCM view of literature
(Source: Author)

6.1.2 Conceptual framing of SCM

Burgess *et al.* (2006) presented a schematic categorization to "frame" SCM into the categories "activity," "process," and "system". Applying their scheme, the dimensions of the scheme are apparent in 95 articles of the total sample (Table 6.3, p. 89). Most researchers use the "process" concept in their reviews (88 articles). In contrast to the findings by Burgess *et al.* (2006), the analysis revealed a higher usage of the "activity" concept (65 articles) and a lower utilization of the "system" concept (27 articles). The reason for the differing results may be that Burgess *et al.* (2006) reviewed *"100 randomly selected refereed journal articles"* (p. 703), not basing the sample selection on articles with a SCM or logistics focus only as shown in the analysis. As the "process" dimension was the prime dimension most commonly used, it was analyzed in more depth, using the supply chain operations reference model (SCOR) described by Stewart (1997) as a suitable guiding framework. The SCOR model was developed along a standardized production cycle and comprises the phases of "plan," "source," "make," "deliver," and "return". As it is a widely accepted model for describing supply chain processes (Huan *et al.*, 2004) the papers were analyzed according to their SCOR level fit. Most papers fit the "deliver" (48) and the "plan" level (40). "Source" and "make" accounted for 34 and 36 articles, respectively. The "return" level was only mentioned in 18 articles. Within the "deliver" level, the articles most frequently discussed in decreasing order are issues regarding transport management, warehousing management, or customer service management. The dominance of the "process" dimension in the analysis, compared to the "system" dimension, may be rooted in researchers' potential preference for scaling their research focus on a manageable-sized construct, in this case the process, allowing for better sample control. However, a process can be seen as part of a system, which follows the argumentation from the work by Mentzer and co-authors (2001), who stated that SCM makes use of the *"systems approach"* (p. 7). Researchers should strive to analyze SCM accordingly; taking the process approach may be seen as a suitable first step, especially in regard to the "deliver" and "plan" processes. Nevertheless, these processes then need to be linked to enable a holistic view of SCM as a system.

On a subset level the articles in OPS journals showed a higher utilization of the "make" level (46% of articles) within the "process" dimension compared to articles in SCM journals (27%), the reason for which is to be found in the production oriented nature of operations management. The initial "plan" (15) and "source" (14) steps were lagging behind in frequency in OPS journals, maybe because these are less executional from a production perspective.

The sustainability aspects of closed loop supply chains or product recovery are not as prominent as other processes in supply chain literature reviews, as the "return" phase was only discussed in eight OPS reviews and ten articles in SCM journals. This is somewhat surprising, as especially operations management has various points of contact with "return" topics, such as product lifecycle management (PLM). However, as the importance to *"reuse the entire product, selected modules, components, and / or parts"* (Atasu *et al.*, 2008) gains increasing attention, this may provide good research opportunities for researchers.

Category (level 2) Sub-category (level 3)	**Count all articles (n=103)**	**% of all articles**	**Count SCM articles only (n=62)**	**% of SCM articles**	**Count OPS articles only (n=41)**	**% of OPS articles**
1.2 Conceptual framing of SCM	**95**	**92%**	**57**	**92%**	**38**	**93%**
Activity	65	63%	42	68%	23	56%
Process	88	85%	52	84%	36	88%
Plan	40	39%	25	40%	15	37%
Source	34	33%	20	23%	14	34%
Make	36	35%	17	27%	19	46%
Deliver	48	47%	27	44%	21	51%
Return	18	17%	10	16%	8	20%
System	27	26%	18	29%	9	22%

Table 6.3: Conceptual framing of SCM
(Source: Author)

6.1.3 Business functions involved in SCM

According to Stewart (1997), a supply chain on corporate level is made up of various business functions, which Cooper *et al.* (1997) and Stevens (1989) identified as

Purchasing, Materials Management, Production, Physical Distribution, Marketing and Sales, and Finance. Following the philosophy of SCM, each business function is required to *"produce an overall supply chain strategy that ultimately enhances firm performance"* (Giunipero *et al.*, 2008, p. 66). 94 articles (91%) involved at least one of these business functions as outlined in Table 6.4 (p. 91). As SCM builds upon the logistics framework (Houlihan, 1984), the Materials Management (or Logistics) department was a commonly mentioned business function found in the literature reviews (72 articles). The Purchasing / Procurement function, being at the forefront of the production process, was at focus as often as Materials Management (72 articles) across the full sample, driven by OPS journals where 76% of articles dealt with the Purchasing / Procurement function. This was expected due to the origin of SCM as having its base in logistics and supply management (Kraljic, 1983). In terms of Purchasing / Procurement, the management of buyer-supplier relationships (van der Vaart and van Donk, 2008) through trust (Sarkis *et al.*, 2011), supplier involvement (van Hoek, 2001), and long-term commitment (Mills *et al.*, 2004) was the prime topic.

Interestingly, about half of the SCM journals published literature reviews on buyer-supplier relationships compared to only a quarter of OPS journals, although a higher percentage of articles on Purchasing / Procurement was published in OPS journals. A reason may be found in the collaborative nature of SCM as presented in SCM journals where the management of inter-company relationships is a key aspect (Chan and Chan, 2010)

A closer look at the subset split of this function showed that within the articles in OPS journals the functions Materials Management / Logistics (27 articles) and Production (26 articles), being the executional core of operations management, were less interesting to researchers compared to Purchasing. A reason may be that SCM researchers in operations management took the seemingly easier route to explain SCM phenomena through the obvious purchasing link instead of venturing into the more complex aspects of how manufacturing related departments are interacting across companies.

Production and Physical Distribution (or Transportation) functions were mentioned regularly in the full sample (60 and 51 articles, respectively), underlining the integrated nature of SCM research. Nevertheless, only 25 papers discussed other functions including Research and Development (R&D), Engineering, Human Resources, and Legal. This is surprising as functions such as R&D and Engineering play a vital role to *"create unique and individualized sources of customer value"* (Mentzer *et al.*, 2001, p. 7), following the SCM philosophy. However, especially the business function of Human Resources (HR) may be of future interest. Being mentioned rarely (four articles), compared to the other functions, the reviewed literature did not pay tribute to the fact that SCM literature in the past may have been predominantly focused on physical and technical "hard" factors of SCM, potentially neglecting the human "soft" factors, confirming a research gap also highlighted by Sweeney (2013). As these soft factors can be seen as a facilitator to SCM success (Ellinger *et al.*, 2013), more literature in operations management would be beneficial in order to investigate how these functions' hidden potential may be leveraged in a SCM context.

Category (level 2) Sub-category (level 3)	**Count all articles (n=103)**	**% of all articles**	**Count SCM articles only (n=62)**	**% of SCM articles**	**Count OPS articles only (n=41)**	**% of OPS articles**
1.3 Business functions involved in SCM	**94**	**91%**	**55**	**89%**	**39**	**95%**
Purchasing / Procurement	72	70%	41	66%	31	76%
Materials Management / Logistics	72	70%	45	73%	27	66%
Production	60	58%	34	55%	26	63%
Physical Distribution	51	50%	32	52%	19	46%
Marketing and Sales	33	32%	21	34%	12	29%
Finance	8	8%	6	10%	2	5%
Other	25	24%	14	23%	11	27%

Table 6.4: Business functions involved in SCM
(Source: Author)

6.2 Dimension: Orientation of SCM

Harnessing the concept of flows, as portrayed by Schmenner and Swink (1998), findings outlining the literature reviews' orientation towards SCM are presented in this section, with a focus on the types of flow and the direction of flows.

6.2.1 Types of flow

As stated by Stock and Boyer (2009) in their encompassing definition of SCM, a key element of SCM is to manage the *"flow of materials, services, finances and information from the original producer to final customer"* (p. 706). To gain a deeper understanding of the type of flows described and utilized in the SCM literature, the literature reviews in the sample population were analyzed according to their types of flow usage, following the categorization described by Stock and Boyer (2009). This approach, also being the first comprehensive assessment of types of flow in SCM literature to the author's knowledge, allows the determination of whether a certain type of flow is given preference in the SCM literature.

A total of 72 papers made references to the types of flow (Table 6.5, p. 93). Material / physical flow (66) can be regarded as the prime flow being mentioned in basically every paper, although various terms were used interchangeably for "material" such as "good" (Cheng and Grimm, 2006), "product" (Defee *et al.*, 2010) or "production" (Gosling and Naim, 2009), and "freight" (Aronsson and Brodin, 2006). The predominance of the material / physical flow type may be traced back to the roots of SCM as being closely linked to the physical distribution and transportation theory of logistics (Houlihan, 1984).

As the exchange of information between parties is paramount for SCM to function, as showcased by Lee *et al.* (2000), almost half of all articles (47) discussed the flow of information within the supply chain, making this the second most common type of flows found.

Trade always involves financial transactions of some kind. Therefore, it is an interesting finding that the "financial flow" is mentioned in less than every sixth paper (14 articles), which however may be explained by the original founding of SCM in logistics rather than financial theory. Nevertheless, as the solid financial standing of the partners in a supply chain is a requirement for the chain's overall business success, the assessment of financial flows may provide hints which could be used in terms of an early warning system to identify a partner's financial problems. As the impact of a financial crisis, initiated for instance by a partner's bankruptcy, could quickly impact on the entire chain, monitoring and timely action would reduce risks before damage can materialize.

As according to Constantinides (2006) *"the service and the personalised client approach have become imperatives"* (p. 431) for SCM, 15 papers explicitly focus on the customer-centric view of SCM (Lee, 2002). Portraying the long proclaimed shift from the traditional setup of goods-manufacturing towards the service economy (Ellram *et al.*, 2004), the majority of articles covering the flow of services were published in SCM journals as opposed to the more manufacturing-oriented OPS journals.

The article by Wong *et al.* (2012) includes "knowledge" as a type of flow, as this resource could be cross-functionally exchanged between business functions and firms. Tokman and Beitelspacher (2011) add "skills" to the set of flows, although they do not explicitly label it as a "flow". The leverage of cross-functional knowledge flow should not be underestimated, as in an integrated supply chain the coordinated exchange of skills and knowledge may be a true competitive advantage for the participating entities (Wong *et al.*, 2012).

The analysis may indicate that a more balanced view towards flows is required in SCM research, moving away from the dominance of the single use of the material / physical flow, also including the under-represented flows, as outlined through the above section. In general, the focus on single flows, despite the advantage of allowing more in-depth research, bears the risk of losing the view towards the big picture as the various flows are connected and thus affect each other (Lee *et al.*, 1997).

Category (level 2) Sub-category (level 3)	**Count all articles (n=103)**	**% of all articles**	**Count SCM articles only (n=62)**	**% of SCM articles**	**Count OPS articles only (n=41)**	**% of OPS articles**
2.1 Types of flow	**72**	**70%**	**40**	**65%**	**32**	**78%**
Material / physical flow	66	64%	35	56%	31	76%
Financial flow	14	14%	8	13%	6	15%
Information flow	47	46%	23	37%	24	59%
Service flow	15	15%	12	19%	3	7%
Other flows	10	10%	5	8%	5	12%

Table 6.5: Aspects of types of flow
(Source: Author)

6.2.2 Direction of flow

In contrast to the types of flow, the direction of flow was only discussed in about half of all articles (Table 6.6, p. 94). Upstream and downstream flows were almost equally often mentioned with 49 and 44 articles, respectively, indicating an interesting preference of certain parts of the SCM research community towards upstream and downstream oriented research. However, this needs to be taken carefully as not every paper outlined the type of flow analyzed, which in most cases was due to the simple fact that the reviews did not discuss empirical research but rather turned to hypothesizing.

Ensuring that the divide between the dimensions could be observed in a neat and structured way, the articles were also coded in regard to bi-directional flow, featuring both directions of flow for the same type of flow. Ten articles feature a bi-directional flow, where a combination of up and downstream flows was explicitly stated. Overall, the bi-directional flow was largely found to be influenced by the type of flow, which in most cases was the material / physical flow type. As an example of this, Kleindorfer *et al.* (2005) in their review of sustainable operations management discuss how the downstream flow of material needs to be supplemented by a reverse flow of used material.

One article was identified as taking a different view to flow management. As such, van Hoek (2001) discusses the use of a “mid-stream” position in the flow, positioned between the upstream and downstream flow. Following van Hoek’s understanding, this element may serve as an enabler for postponement, linking to the de-coupling point approach required in a push-pull setup as proposed by Christopher (2000).

Category (level 2) Sub-category (level 3)	**Count all articles (n=103)**	**% of all articles**	**Count SCM articles only (n=62)**	**% of SCM articles**	**Count OPS articles only (n=41)**	**% of OPS articles**
2.2 Direction of flow	**57**	**55%**	**29**	**47%**	**28**	**68%**
Upstream	50	49%	24	39%	26	63%
Downstream	47	46%	23	37%	24	59%
Bi-directional	10	10%	9	15%	1	2%
Other	1	1%	0	0%	1	2%

Table 6.6: Aspects of direction of flow
(Source: Author)

6.3 Dimension: Functional scope of SCM: Collaboration / Integration

Borrowing from the “Constructs of SCM” concept (Burgess *et al.*, 2006), aspects of leadership, collaboration, process improvement orientation, information-sharing, and integration were combined and grouped under the overarching term “Integration / Collaboration”. These constructs provide the basis for an in-depth presentation of the review findings as they are essential aspects depicting the functional collaborative and integrative philosophy of SCM.

6.3.1 Collaboration

Based on Burgess *et al.* (2006) the analysis differentiates between intra-organizational collaboration (internal, within a company) and inter-organizational collaboration (external, between companies). The importance of collaboration is reflected in the research sample with 89 out of 103 articles discussing collaborative approaches (Table 6.7, p. 96). Only 14 articles did not discuss collaboration, focussing on methods and theory usage in SCM (Frankel *et al.*, 2005) not directly linked to collaboration aspects. A study by Gubi *et al.* (2003), reviewing literature in the 1990 to 2001 period, revealed that researchers tended to focus on the functional and firm perspective, while largely neglecting inter-organizational levels of collaboration. The literature review sample was reviewed accordingly. It was found that this focus has changed since 2003, when the majority of reviews (82) started discussing inter-organizational relationships or aspects of external collaboration (e.g. inter-corporate). The result can be justified, as in the 2000 to 2010 decade corporations started to realize that external collaboration is a key for supply chain success. In contrast, intra-organizational relationships or internal collaboration (e.g. inter-functional) was discussed in half of the papers only, confirming findings of Zhang *et al.* (2011), who found in their literature review on supply chain management and performance that only few authors discussed internal collaboration. However, as it may be the case that internal collaboration on the functional level serves as a prerequisite for excelling in external collaboration efforts, the assessment of the literature reviews may indicate that more research might be required to understand how internal and external collaboration influence each other, e.g. how internal collaboration fosters external collaboration.

Although operations management was expected to have a focus on internal collaboration, a higher application of external collaboration was found in OPS journals (76%), which may be driven by research on collaboration with external parties such as suppliers (e.g. Gosling and Naim, 2009; Jain *et al.*, 2009). If intra-organizational collaboration is discussed, the focus is often on operational aspects of collaboration, for instance horizontal collaboration within the firm in regard to S&OP (Tavares Thomé *et al.*, 2012). Strategic aspects of intra-organizational collaboration are neglected in the literature under review. A justification for the low usage of the internal collaboration paradigm in operations management research may be found in the nature of SCM as having a more holistic, company-overarching view, compared to the rather "narrow", firm-focused view of operations management.

The review by Chan and Chan (2010) highlights the importance of external collaboration, stating that "*coordination is an important ingredient to improve the performance of supply chains subject to the presence of system dynamics"* (p. 2793). However, Hassini *et al.* (2012) identify potential *"incompatibilities between the known principles of performance measures and supply chain dynamics"* (p. 69) which could hinder collaboration. The use of information systems and technology, such as agent technology, is proposed in this respect by some researchers (Akyuz and Erkan, 2010; Jain *et al.*, 2009). This would allow for web-enabled collaboration among supply chain partners, resulting in a virtual integration of the supply chain comprising of a network of partnering firms and customers (Gunasekaran and Ngai, 2007) where all members of the supply chain work towards a common goal (Glock, 2012).

Category (level 2) Sub-category (level 3)	Count all articles (n=103)	% of all articles	Count SCM articles only (n=62)	% of SCM articles	Count OPS articles only (n=41)	% of OPS articles
3.1 Collaboration	**89**	**86%**	**53**	**85%**	**36**	**88%**
Internal collaboration (inter functional)	47	46%	31	50%	16	39%
External collaboration (inter corporate)	82	80%	51	82%	31	76%

Table 6.7: Aspects of collaboration
(Source: Author)

6.3.2 Integration

Supply chain integration depicts "*the connections and inter-relationships between component parts and the supply chain"* (Stevens, 1989, p. 8). Focussing on linking processes and extending the single company view of the logistics framework to the overall alignment of the chain of companies, supply chain integration is a key factor for competitive success (Giunipero *et al.*, 2008).

In total, eighty-two articles were identified as including integration aspects (Table 6.8, p. 98). As the integration of internal core business processes is a prerequisite for successful integration with supply chain partners (van Hoek *et al.*, 2008), it is surprising that only about a third of all integration papers (36) focused on the inward-facing perspective, discussing integration aspects within a single company. Thus, they focus on seamless "internal integration" (25 articles) –or alignment– of core business processes within a company as well as purely "functional integration" (16 papers), where a process is optimized but still decoupled from neighboring processes and hence lacks demand visibility. The review by Akyuz and Erkan (2010) highlights the recognition that the involvement of people at all levels is paramount to achieve "functional integration" as a prerequisite step for "internal integration". To elevate the "functional integration" as a driver to achieve "internal integration", the literature study by Kleindorfer *et al.* (2005) postulated the use of supporting management systems and strategies such as total quality management (TQM) or just-in-time (JIT), which require integration in line with the company strategy. Internal integration can also be achieved by vertical integration, allowing for higher levels of *"control on operations and to be able to make fast adjustments due to market changes"* (Minner, 2003, p. 267).

Linking to the findings from the "Collaboration" section above (section 6.3.1, p. 94), external integration, that is extending the view of the company to include customers and suppliers, was the most commonly mentioned integration type (62), compared to the “inward-facing” viewpoint. Papers mainly focused on integration of either suppliers (30) or customers (21).

Van der Vaart and van Donk (2008) found that the integration with suppliers has a measurable direct impact on the focal company’s performance. On the “customer-facing” end, the integration of specialized customer teams into business processes has been described in the review by Gunasekaran and Ngai (2007) as being fruitful. Going one step further, in an ideal scenario, the whole “outward-facing” supply chain should be synchronized (Caridi *et al.*, 2005) in order to enable a seamless flow of material and information across all entities. Such a scenario requires a leading party, a “channel leader,” which was found to be a vital enabler of integration and collaboration along the chain (Cooper *et al.*, 1997). Such an instance drives the coordination of decisions across supply chain partners (Childerhouse and Towill, 2011), but SCM researchers have yet to apply that knowledge for the effective management of the supply chain (Stock *et al.*, 2010).

Outward integration, containing the integration of the complete supply chain, was the research subject in 22 papers. As a majority of reviews was published since 2008, it seems as if researchers have added more focus on this type of integration, which provides excellent opportunities in regard to multi-echelon supply chains. Accordingly, Giménez and Lourenço (2008) in their review on the internet's impact on supply chain processes proposed that collaborative planning plays a critical role and needs to be included as one aspect of outward integration.

In contrast, the periphery-facing view (15) was of little interest in the papers under reviews, confirming previous research by van der Vaart and van Donk (2008), as reviewers strive to *“measure the extent of integration in a company’s relationships with all of its suppliers and / or customers”* (p. 48).

Nevertheless, the predominance of external collaboration aspects, as shown in the previous section, blends well with the finding that researchers focus on external integration since these two paradigms are closely related (Barrat, 2004). However, as internal integration is a prerequisite for optimized leverage through external integration, further research is suggested to tap the full potential of the “inward-facing” perspective.

Category (level 2) Sub-category (level 3)	Count all articles (n=103)	% of all articles	Count SCM articles only (n=62)	% of SCM articles	Count OPS articles only (n=41)	% of OPS articles
3.2 Integration	**82**	**80%**	**50**	**81%**	**32**	**78%**
Inward-facing	36	35%	21	34%	15	37%
Functional integration	16	16%	10	16%	6	15%
Internal integration	25	24%	13	21%	12	29%
External integration	62	60%	32	52%	30	73%
Periphery-facing	15	15%	10	16%	5	12%
Supplier-facing	30	29%	19	31%	11	27%
Customer-facing	21	20%	13	21%	8	20%
Outward-facing	22	21%	13	21%	9	22%

Table 6.8: Aspects of integration
(Source: Author)

6.3.3 Information-sharing

Information-sharing between parties is required for the streamlined execution of SCM, resulting in improved performance, responsiveness and flexibility while reducing uncertainties among supply chain partners (Mentzer *et al.*, 2001; Stevenson and Spring, 2007; Zhang *et al.*, 2011). The importance of information-sharing between firms in a supply chain in regard to inventory levels, forecasts, and strategies was first highlighted by Mentzer *et al.* (2001). Better decision-making on corporate level, enabling minimization of the implications of supply chain dynamics such as the bullwhip effect, are key benefits of information-sharing (Chan and Chan, 2010). Van Hoek *et al.* (2008) outlined in his review that the value of information-sharing is its role in fostering collaboration. Hazen and Byrd (2012) add to this in their review work, underlining the importance of information-sharing for relationship-building. This builds upon the literature study by Chan and Chan (2010), who highlight the application of information technology in order to increase visibility along the chain at low cost. In addition, information-sharing enables companies to leverage potential integration benefits, especially if data is shared electronically (Cheng and Grimm, 2006). As found by Stock and Boyer (2009), SCM functions best when resources are shared, underlining the relevance of collaboration for SCM. Therefore, a certain level of trust among participating members is required (Jain *et al.*, 2009). Concerning the collaborative nature of SCM, Gunasekaran and Ngai (2007) propose in their review that apart from existing information being shared, companies should also team up to create knowledge. The sharing of information could even be considered a business requirement from an operations management perspective, depending on the industry, in order to comply with international regulatory requirements (Sarkis *et al.*, 2011). Given the wealth of research on information-sharing in supply chains, researchers need to question why such a fundamental SCM paradigm was only found in every second literature review (52 papers). One reason may be that mutual trust, as the main prerequisite for information-sharing, lacks objective research criteria in SCM, and researchers thus struggle to pinpoint the essence of information-sharing. However, as companies increasingly treat information as a strategic resource, a change long expected in academia (Mason-Jones and Towill, 1997), developing ties of trust may not be sufficient to convince partners to share information. If a party has superior knowledge that others are dependent on, information may well have the potential to become a trading good between supply chain entities. This may be especially the case in flexible distributed global supply networks where trust is of limited use as trustful relationships are difficult to establish due to the constantly changing composition of partners. In addition, as advances in information technology boost the possibilities to apply analytics to historical customer data, enabling the identification of marketable customer behavioral patterns which can be turned into business opportunities, the willingness to share today's seemingly uncritical information may unfold into a future business opportunity which in the worst case nurtures competitors. Given these implications, and considering the findings from the literature review that the role of information-sharing in the supply chain has not been assessed in the light of these developments, the information-sharing topic provides a wealth of opportunities for researchers.

6.3.4 Process improvement orientation

Continuous optimization of processes is a core task for supply chain managers. Stewart (1997) described a dual process improvement approach, including internal and external improvement, where the internal perspective focuses on intra-company processes while the external view includes inter-company supply chain processes.

A process improvement orientation was found in 54 reviews (Table 6.9, p. 101) with a view fairly evenly divided between internal improvement (35 papers) and external improvement practices (31 papers). The focus of OPS journals in regard to internal / external improvement is balanced, discussing techniques with a process improvement character such as TQM and JIT, which is not surprising as operations management has its root in manufacturing. Articles in SCM journals were found to be more focused on internal processes. Improvement potentials discussed in the literature include a vast array of topics, mainly focussing on process improvement through postponement (Boone *et al.*, 2007), or improvement through technology (Blankley, 2008). In addition, the review by Gosling and Naim (2009) underlines the usefulness of process improvement for new product development. Especially supply chain thinking is required to improve overall processes as found by Mills *et al.* (2004). On a functional level, Rao and Goldsby (2009) identified the Purchasing function as a driver for internal process improvements. Linking process improvement in SCM to the previous categories of collaboration and integration, Gunasekaran and Ngai (2007) found that the integration of people and information technology / information systems is required for improving company performance. In this light it is interesting that only half of the literature reviews dealing with collaboration and integration touch aspects of process improvement. However, as 87% of the literature reviews discussing aspects of process improvement were published after 2005, it seems as if research publications dealing with process improvement in SCM have reached the "critical mass" and are thus increasingly being investigated and assessed through literature reviews.

Historically, process improvement has its roots in OPS literature, with the continuous improvement concept being the most prominent example, depicted in the review by Babbar and Prasad (1998a). This is reflected in the findings, where 76% of all papers in OPS journals touched the subject, compared to only 37% of articles in SCM journals. However, as process improvement is also an important tool for SCM, suitable for enhancing the robustness of single processes and of the supply chain as a whole, more research is called for to understand how supply chain overarching processes can be improved. This is in line with the thinking of Slone *et al.* (2007), claiming that a supply chain is only as robust as its weakest element. The systematic education of supply chain partners in adopting process improvements, extending process excellence from one entity to the whole chain, may serve as a starting point in this endeavor. Nevertheless, as this procedure requires a high degree of trust among partners, it seems to be imperative that supply chain partners are already integrated to a certain degree. From this perspective, research linked to assessing the reciprocal relationship between process improvement and supply chain integration (section 6.3.2, p. 96) may provide further insights into the dynamics of process improvement in a supply chain context. This may well provide an answer to the questions of whether process improvement is a result of supply chain integration, or if supply chain integration is a by-product of supply chain process improvement.

Category (level 2) Sub-category (level 3)	Count all articles (n=103)	% of all articles	Count SCM articles only (n=62)	% of SCM articles	Count OPS articles only (n=41)	% of OPS articles
3.4 Process improvement orientation	**54**	**52%**	**23**	**37%**	**31**	**76%**
Internal improvement	35	34%	18	29%	17	41%
External improvement	31	30%	14	23%	17	41%

Table 6.9: Aspects of process improvement orientation
(Source: Author)

6.3.5 Leadership

A supply chain requires *"leadership in order to develop and execute strategy"* (Cooper and Ellram, 1993, p. 17), and ensure common goals are met (Spekman *et al.*, 1998). Given these statements reflecting the importance of leadership, 22% of the reviews discussed aspects of leadership (23 papers). Within the "leadership" category the literature reviews followed two "schools of thought" (Table 6.10, p. 103). The intra-organizational leadership school, with a focus on functional corporate leadership, understands leadership as a structuring instance within the firm (van Hoek *et al.*, 2008), relevant for long-term planning and decision-making (Pettit and Beresford, 2009). In contrast, the inter-organizational leadership construct portrays a governing role of certain companies within the supply chain network which initiate and drive development activities (Blankley, 2008). Following Lambert and Cooper (2000), it can be argued that the inter-organizational supply chain leadership construct should not be seen in opposition to the intra-organizational leadership construct, which is fundamental in coordinating, aligning, and steering the different functions within these single companies on a micro level.

The assessment of the literature reviews revealed that research in regard to inter-organizational leadership dominates, as two thirds of the literature reviews made use of this concept.

Research into intra-organizational functional leadership was mainly linked to HR theory, focussing for example on the personal values of employees involved in supply chain decision-making (Sharif and Irani, 2012), or the analysis of various leadership styles (Williams *et al.*, 2002).

Yin *et al.* (2011), focussing on inter-organizational leadership, highlighted the development of specific leadership policies for serial supply chains. Other authors (Defee *et al.*, 2009; Defee and Stank, 2005) explicitly focused on inter-organizational leadership and mainly targeted a macro-organizational perspective. They portrayed a leadership-followership context where a supply chain leader coordinates inter-organizational alignment of single companies along the supply chain. Such a "channel leader" has been found to be a vital enabler of integration and collaboration along the chain (Cooper *et al.*, 1997) as outlined in section 6.3.2 (p. 96), driving the coordination of decisions across supply chain partners (Stadtler, 2005). Taking this a step further, Bitran *et al.* (2007) argued for inclusion of a third-party instance to help in coordinating supply chain governance efforts. This extends the inter-organizational leadership construct, linking it to the domain of supply chain governance. Various examples from the extant supply chain governance literature indicate the importance of leadership support for supply chain success (Ghosh and Fedorowicz, 2008; Fawcett *et al.*, 2007), which could be leveraged through "executive governance circles" or "partner advisory councils". The advantages of an orchestrated supply chain leadership approach, evident in performance improvements and cost savings, were mapped out by Pilbeam *et al.* (2012). However, despite the benefits of inter-organizational supply chain leadership, Hassini *et al.* (2012) in their review constitute the *"lack of an oversight agency that controls the whole supply chain"* (p. 76) as being a common problem in supply chain management. This awareness is shared by Jain *et al.* (2009), who found that in a supply chain *"cooperation is through negotiation rather than central management and control"* (p. 3013). Outlining a general shortcoming of the SCM leadership literature, Burgess *et al.* (2006) point towards low coverage of psycho-sociological elements of leadership, such as power differentials, trust or cooperation.

On the subset level, aspects of intra-corporate as well as inter-corporate leadership were found to be more prominent in OPS journals, which published about a third more articles containing leadership aspects compared to SCM journals. However, intra-organizational leadership is a prerequisite for effective integration and collaboration within the supply chain in order to initiate and drive development activities across multiple partners and thus *"should be a constituent core part of supply chain practice"* (Sharif and Irani, 2012, p. 66).

Research into how the role of leadership can be leveraged to foster integration and collaboration in the supply chain, with a special focus on the effect of different leadership models on supply chain integration, covering functional leadership as well as supply chain leadership, is recommended to determine best-fit approaches. The use of contingency theory (Fiedler, 1965), seems to be beneficial in this regard, providing the theoretical underpinning to assess the behavioral determinants of leadership. The applicability of this theory will be further elaborated in regard to SCM theory usage in section 6.6.4.

Category (level 2) Sub-category (level 3)	Count all articles (n=103)	% of all articles	Count SCM articles only (n=62)	% of SCM articles	Count OPS articles only (n=41)	% of OPS articles
3.5 Leadership	**23**	**22%**	**11**	**18%**	**12**	**29%**
Intra-corporate leadership (functional)	8	8%	3	5%	5	12%
Inter-corporate leadership (supply chain)	15	15%	8	13%	7	17%

Table 6.10: Aspects of leadership
(Source: Author)

6.4 Dimension: Functional scope of SCM: Risk / Performance

This section presents and discusses the findings from the frequency analysis of the "Risk / Performance" dimension, combining three major concepts of supply chain management outlined in the extant literature, namely supply chain risk management, rewards or benefits sharing, and aspects of supply chain performance.

6.4.1 Supply chain risk management

Following the approach by Tang (2006), grouping risks and associated mitigation strategies in various dimensions, namely supply management, demand management, product management, and information management, the sample contained 77 articles linking to at least one type of supply chain risk (Table 6.11, p. 105). Although supply and demand are the predominant themes in supply chain management as outlined by Stock and Boyer (2009), supply management was identified as the prime domain in literature reviews (27 articles); in most cases covering aspects of supplier management, such as single sourcing (Waters-Fuller, 1995) or outsourcing (Mills *et al.*, 2004). In comparison, supply chain risks tied to demand (13), product (10), or information management (5) were largely under-represented in the literature. However, companies operating in an integrated and focused supply chain are advised to view risk management from a holistic perspective (Slone *et al.*, 2007), embracing the supply chain but also internal processes. As such, to include the dimensions of product management, demand management or information management, more literature reviews in operations management journals would have been expected from the author's point of view. This under-representation of the three strategies in the literature reviews may well be linked to the origin of SCM, which historically has been focused on securing supply, neglecting its further potential in regard to other functions in the early days.

Nevertheless, as demand is the initial trigger for supply in a supply chain (Thonemann, 2002), risks tied to the forecasting of future demand need special attention as the optimal supply chain configuration needs to be driven by demand and forecasts (Christopher, 2000).

From a product risk perspective, it is suggested that opportunities to research product risks may be found in aspects such as new product development, thus collaborating along the chain to reduce the likelihood of product malfunctions, while managing product variation and reducing time-to-market pressure.

The low consideration of information risks in the literature is especially concerning as information is a strategic asset (Mason-Jones and Towill, 1997) and a vital resource required for decision-making (Kleinsorge *et al.*, 1989). Special emphasis should be given to the investigation of risks tied to information in supply chains since information risks such as risk aversion in managerial decision-making (Carter *et al.*, 2007), or security concerns of shared data (Schoenherr, 2009), may have a negative impact on supply chain collaboration. Nevertheless, research into neglected research areas such as information management is a promising field of study. As such, information bears potential for strategic leverage (Constantiou and Kallinikos, 2014), although the timely flow of information between entities has never been more vital for supply chains due to their increasing vulnerability to disruptions (Wagner and Bode, 2008).

Some researchers highlighted the use of strategies for the management of risks, such as *“shifting risks by delaying the purchase of raw materials up to the point of production”* (Boone *et al.*, 2007, p. 598), or utilizing risk assessment systems to detect risks early on (Ellis *et al.*, 2011). Terpend and co-authors (2008), following Mentzer *et al.* (2001), discussed the effects of cooperation on risk management in their review, recommending sharing risk among supply chain members for the benefit of all partners. A comparison of articles in SCM and OPS journals indicates that supply chain risks are more prevalent in OPS journals, probably due to the direct production impacts of risks, elevating the role of risk management to become a necessity of every business.

Category (level 2) Sub-category (level 3)	**Count all articles (n=103)**	**% of all articles**	**Count SCM articles only (n=62)**	**% of SCM articles**	**Count OPS articles only (n=41)**	**% of OPS articles**
4.1 Supply chain risk management	**77**	**75%**	**43**	**69%**	**34**	**83%**
Product management	10	10%	6	10%	4	10%
Supply management	27	26%	15	24%	12	29%
Demand management	13	13%	10	16%	3	7%
Information management	5	5%	4	6%	1	2%
Environmental uncertainty	54	52%	26	42%	28	68%
Supply uncertainty	16	16%	9	15%	7	17%
Demand uncertainty	28	27%	9	15%	19	46%
Technological uncertainty	3	3%	1	2%	2	5%
Supply chain resilience	17	17%	12	19%	5	12%

Table 6.11: Aspects of supply chain risk management
(Source: Author)

Risks in supply chains have their root in uncertainties which stem from environmental parameters (Ghadge *et al.*, 2012; Christopher and Lee, 2004). According to the literature review on the responsiveness of supply chains by Reichhart and Holweg (2007), uncertainty can be seen as the *"root cause for becoming flexible or responsive"* (p. 1153). Utilizing the framework by Chen and Paulraj (2004), the sample was reviewed according to the three dimensions of environmental uncertainty: Supply, demand, and technology uncertainty (Table 6.11, p. 105). Fifty-four papers were found to discuss these issues, demand uncertainty and supply uncertainty being the most often mentioned types (28 and 16 articles).

This is reflected in the work by Jain *et al.* (2009), contending that visibility towards customer demand is the major challenge to supply chains. Others (Babbar and Prasad, 1998a) posited in their literature study that demand uncertainty leads to excess inventory; but as Li *et al.* (2008) state in their review, demand uncertainty can also act as a driver for agility, which in turn fosters supply chain flexibility. Purchasing strategies, such as direct material sourcing with distant suppliers, were identified in the review on supply disruption risks by Ellis *et al.* (2011) as a reason for supply uncertainty and increased complexity. The analysis of the sample shows that in particular demand and supply uncertainty can be reduced through collaboration, as almost all reviews dealing with collaboration (section 6.3.1, p. 94) also discuss the positive side effects of reduced demand and supply uncertainty. Information-sharing between partners was also found to be a key success factor aiming to reduce uncertainty, although to a lesser degree compared to collaboration.

Interestingly, only three articles mentioned uncertainties linked to technology usage. However, given the pace of technological advancements applicable in a supply chain context, such as the Radio Frequency Identification (RFID) technology (Ashton, 2009), the dependency on technology increases for every supply chain entity. In addition, the uncertainty in regard to technology implementation is fuelled by the difficulty for management to decide which solution to implement to secure future competiveness, also considering aspects of systems upgradeability. Under these circumstances, Yang *et al.* (2004), following Hatfield *et al.* (2001), outlined in their literature review that *"companies may delay their commitment to a single technology by pursuing simultaneous commercialization of two or more competing technologies, as opposed to simply waiting to enter later until the dominant design emerges"* (p. 479). Given the financial investments required to pursue such a strategy, applicable only to a small portion of companies, further research is required to equip companies with tools and methods enabling them to handle and eventually reduce the uncertainties tied to the selection of the most promising technologies.

Against the background of risks and uncertainty, Christopher and Peck (2004) introduced the need for a supply chain to be resilient, which describes the *"ability to react to unexpected disruption and restore normal supply network operations"* (Williams *et al.*, 2008, p. 262). This also covers an up-skilling of the supply chain capabilities in order to become more flexible and responsive to future disruptions (Christopher and Peck, 2004). The concept is a suitable means to deal with increasing fragility and vulnerability to disruptions, the side effects of supply chain integration and networked systems, as presented in some review articles (Boone *et al.*, 2007; Norrman and Jansson, 2004). The analysis found that the concept of supply chain resilience was discussed in 17 reviews with a focus on SCM journals. As the resilience of a supply chain is in essence determined by the individual company's systems' and process' resilience, it is surprising that only few articles viewed this topic from an operations perspective. This is interesting as in particular operations yield a multitude of possibilities for establishing resilience, for example through redundancy and flexibility of production equipment, as presented in the review by Greening and Rutherford (2011).

Given this analysis, supply chain risks, especially supply management risks, can be linked to a lack of demand knowledge, such as visibility of future demand. Supply management risks were the most prominent risks mentioned, while demand uncertainty was the dominant theme in the uncertainty cluster. As such, a lack of demand visibility proves to be a challenge for supply management within supply chain entities. From an operations management perspective, it might be interesting to investigate how technological uncertainty, in terms of the employment of the "right" production technology, is connected to supply chain risks related to product management activities, such as product design and new product development.

6.4.2 Rewards-sharing (benefits)

Mentzer *et al.* (2001) postulated that *"reward sharing is important for long-term focus and cooperation"* (p. 8). As Fabbe-Costes and Jahre (2007) state in their literature review on supply chain integration and performance, the benefits of collaboration are not always shared equally among supply chain participants, and at times, benefits are not even shared proportionally. The sharing element between risks and rewards is a key aspect in the review by Blankley (2008). Companies therefore need to develop *"reward systems that are contingent upon joint effort"* (van Hoek *et al.*, 2008, p. 125). In addition, supply chain partners should not only share benefits among each other but also ensure that all benefiting parties share the costs associated, a critical aspect identified in the review by Pettit and Beresford (2009). Outlining the importance of rewards-sharing, 42 papers were found to discuss rewards-sharing, or more general "sharing of benefits". Similar to "information-sharing," as discussed earlier (section 6.3.3, p. 98), the level of trust between partners may be the main factor determining if and how benefits are shared among partners. As true collaboration between partners requires open sharing of rewards, research into how a lack of rewards-sharing impacts negatively on collaboration efforts represents a gap as identified through the assessment of literature reviews. Such research would also be interesting from a balance of power perspective, investigating how companies with less power in a supply network manage to overcome the imbalance of power, enabling them to secure a fair share of rewards.

6.4.3 Supply chain performance

Aspects of supply chain performance were evident in eighty-three manuscripts, highlighting the value and maturity of this dimension in the research community (Table 6.12, p. 111). Following the model of Chen and Paulraj (2004), the supply chain performance papers could be roughly subdivided into the supplier performance group (19 papers) as well as the customer performance group (5 papers). The area of customer performance in particular is under-represented here, and seems to offer a variety of research opportunities, such as the inclusion of payment-related measurements. As multiple assignments to categories were possible in the coding process, forty-five papers in total presented other performance attributes which do not fit the model of Chen and Paulraj (2004). In 38 cases, the focus was on the company level. “Firm performance” (e.g. Cheng and Grimm, 2006), as a single general term, was mentioned most often in the literature reviews (14 articles) and thus seems to be a core aspect of research on supply chain performance. This focus comes as no surprise, as the joint performance of multiple entities in a supply chain is difficult to measure; and the findings show that researchers seem to prefer the easier approach of measuring single firm performance. From a corporate point of view it is paramount to have an understanding of the company performance, which is the base line for competitive benchmarking of the firm’s own market position. However, the performance of multiple partners in a supply chain is hardly the sum of every single entity’s performance. In order to assess the contribution of each partner’s performance on the overall supply chain performance, research into measuring supply chain performance is important. Accordingly, seventy-three articles mentioned aspects of supply chain performance measurements. Beamon (1999) developed a measurement system for supply chain performance, structured along the dimensions of “resources,” “output,” and “flexibility”, which was used to analyzed the reviews accordingly.

A majority of 52 articles were found to touch aspects of the “resources” dimension, representing the input factors determining performance. Units of measurements related to “total cost” (44 articles) and “inventory” (41) were most commonly mentioned. In particular, in regard to the “total cost” approach a multitude of cost dimensions can be identified, such as total cost of ownership (Labro, 2006) or inventory cost (Terpend *et al.*, 2008). Hazen *et al.* (2012) make a case for linking the cost dimension with sustainability, proposing to measure the cost for remanufacturing of products.

Aspects of the measurement dimension of “output” were found in 45 reviews, largely focussing on manufacturing and supplier lead time (24), or profitability (24) reviews. Customer response time and customer complaints were on the whole neglected by the literature. This is a critical finding as customer feedback through customer complaints provides valuable input required to optimize processes and ultimately improve the customer experience. As the customer is the ultimate driver of demand and thus of the supply chain as a whole, research is recommended in regard to how performance metrics tied to customer satisfaction can be leveraged to ultimately improve the customer experience. Shipping errors as a measure of output, determining the number of incorrect shipments made, was detected in only four reviews. However, many companies today operate in a globalized manufacturing environment, often relying on time-critical delivery. Despite industry efforts, production delays due to shipping errors, especially in distributed supply networks, are commonly reported. Thus, the measurement of shipping errors seems especially important, calling for further research to reduce the amplifying impact of shipping errors on the supply chain.

The value of quality as an excellent metric to measure output performance was evident in 64 reviews. Although not constituting a unit of measurement in the system proposed by Beamon (1999), it fits well into the output dimension and was added accordingly. In most reviews, especially in the 40 reviews published in SCM journals, general service quality (e.g. Sachan and Datta, 2005; Selviaridis and Spring 2007; Tokman and Breitelspacher, 2011; van Hoek *et al.*, 2008) or customer service quality (Li *et al.* 2008) were key aspects. A focus on product or material quality (e.g. Glock, 2012; Tavares Thomé *et al.*, 2012; Waters-Fuller, 1995), and process quality (Anderson *et al.*, 1989) was predominantly found in OPS journals, where a range of articles referred to TQM as a means to improve quality performance. Linking to sustainability aspects, some authors (Atasu *et al.*, 2008; Hazen *et al.*, 2012) discussed the importance of the return quality of products for the remanufacturing process. In a similar direction, but focussing on environmental sustainability practices, Miemczyk *et al.* (2012), building on Handfield *et al.* (2002), outlined the need to push *"suppliers to undertake measures that ensure environmental quality of their products"* (p. 484), being an enabler for environmental performance improvements at the supplier side. An interesting aspect was identified by Sarac *et al.* (2010), pointing to the importance of data quality in their review on the impact of RFID technologies on supply chain management. In contrast to the relatively easy measurement of product quality, Gravier and Farris (2008) made a case for assessing the quality of less tangible assets, such as measuring the quality in logistics education as being a key to higher performance. In a similar direction, Schoenherr (2009) proposed measuring the *"quality of interaction between buyers and suppliers"* (p. 7)

Lastly, "flexibility" (44) was the least mentioned measurement dimension. Flexibility can be seen as a measurement of agility, following the review by Li *et al.* (2008). Beamon's measuring scheme specifically identified volume flexibility (15 articles) and delivery flexibility (13 articles), which is reflected by other literature. Thus, the literature review by Pazirandeh (2011) links delivery flexibility with supplier flexibility. Efficient contracting can be a suitable way to achieve volume flexibility (Gahdge *et al.*, 2012), but various other factors such as cultural factors should be considered. Although being a fundamental core element of almost every company, the product flexibility unit of measurement was found in only six literature reviews, largely focussing on supply chain flexibility as a driver of sustainability. Paying tribute to this important and emerging area, research could work towards the development of performance measurements, allowing the assessment of the performance of the planning and introduction of new products in a supply chain with de-centralized manufacturing partners, also considering sustainable manufacturing practices. In this light, the author of this dissertation proposes adding "sustainability" as a new unit of measurement in the "flexibility" dimension of Beamon's model, the rationale being that sustainability capabilities, or their lack, increasingly impact on the future performance of firms and supply chains.

Category (level 2) Sub-category (level 3)	Count all articles (n=103)	% of all articles	Count SCM articles only (n=62)	% of SCM articles	Count OPS articles only (n=41)	% of OPS articles
4.3 Supply chain performance	**83**	**81%**	**50**	**81%**	**33**	**80%**
Supplier performance	19	18%	11	18%	8	20%
Customer performance	5	5%	3	5%	2	5%
Other performance	45	44%	23	37%	22	54%
Performance measurements	74	72%	45	73%	29	70%
Resources	52	50%	33	53%	19	46%
Total cost	43	42%	26	42%	17	41%
Distribution cost	17	17%	13	21%	4	10%
Manufacturing cost	16	16%	13	21%	3	7%
Inventory	41	40%	24	39%	17	41%
Work in progress (WIP)	10	10%	6	10%	4	10%
Finished goods	10	10%	4	6%	6	15%
Return on investment (ROI)	13	13%	7	11%	6	15%
Output	45	44%	26	42%	19	46%
Sales	20	19%	9	15%	11	27%
Profit	24	23%	13	21%	11	27%
Fill rate	10	10%	4	6%	6	15%
Cycle time	19	18%	8	13%	11	27%
On-time deliveries	19	18%	8	13%	11	27%
Backorder / stock-out	14	14%	6	10%	8	20%
Customer response time	10	10%	2	3%	8	20%
Manufacturing lead time	24	23%	13	21%	11	27%
Shipping errors	4	4%	1	2%	3	7%
Customer complaints	2	2%	1	2%	1	2%
Quality	64	62%	40	65%	24	59%
Flexibility	44	43%	23	37%	21	51%
Volume flexibility	15	15%	5	8%	10	24%
Delivery flexibility	13	13%	6	10%	7	17%
Mix flexibility	7	7%	1	2%	6	15%
New product flexibility	6	6%	1	2%	5	12%

Table 6.12: Aspects of supply chain performance
(Source: Author)

6.5 Dimension: Functional scope of SCM: Strategy

The “Strategy” dimension presents the findings from a multitude of aspects, ranging from planning through innovation to outsourcing, all of strategic importance to the single company but also in a supply chain context.

6.5.1 Supply chain planning

Supply chain management requires an orchestrated approach to ensure that the resources of every entity are utilized as effectively as possible towards the overall supply chain goal (Slone *et al.*, 2007). Recognizing the importance of a coordinated approach, the term supply chain planning subsumes techniques providing the means to enable collaboration on a macro level (cross-company), as well as on the micro level structure (functional). These joint planning efforts have been described in the review by Selviaridis and Spring (2005) as a key success factor for supply chain planning. Companies can achieve a sustainable competitive advantage through implementation of an effective SCM strategy where supply chain planning is a necessary step to developing a SCM strategy, as highlighted by Giunipero and co-authors (2008). The analysis of all articles in regard to supply chain planning revealed that less than a third of all papers (29 articles) touched aspects of supply chain planning.

Following the frameworks by Gupta and Maranas (2003) as well as Stadtler (2005), the articles were assessed from an organizational point of view, assuming that planning activities are conducted through a phased approach, ranging from the strategic high-level long-term planning, through the more defined tactical mid-term planning, to detailed operational short-term planning.

The strategic implications of high-level supply chain planning are outlined in the excellent review by Anderson *et al.* (1989). In general, core aspects of high-level planning are concerned with setting the path for long-term decisions, which can hardly be reverted at a later stage in the planning process without incurring excess cost. Accordingly, the high-level plan touches fundamental business aspects such as logistics network planning (Aronsson and Brodin, 2006) as well as the planning of an appropriate sourcing mode (Minner, 2003). Sarac *et al.* (2010) added from their review that high-level supply chain planning could be facilitated by the use of integrated IT and historical data, which increases the robustness of the plan.

It is surprising that despite the wealth of articles covering the strategic high-level dimension of supply chain planning, no articles could be identified from the sample population that focussed on the tactical mid-term planning or the operational short-term planning dimensions. A reason for the lack of papers dealing with aspects of the two dimensions may be that such focus is typically the strength of OR models. As OR models are usually not published in the journals included in the sample, the tactical and operational planning phases could not be identified. Nevertheless, as the current single-dimension view of published articles on supply chain planning allows only an incomplete picture of the potential of supply chain planning this can be seen as being a research gap in SCM and OPS journals. Accordingly, the relevance of the tactical and operational dimensions of supply chain planning, for the supply chain justifies focused research in this area. A further interesting finding is evident as supply chain planning was only found in conjunction with other topics in SCM, with no review being identified to solely focus on supply chain planning. This is somewhat strange, given the relevance of supply chain planning as a key concept in SCM; yet until now researchers did not seem to be tempted to address the topic via a literature review approach.

The analysis of the review articles covering supply chain planning allows the reasoning that supply chain planning, being part of the "Strategy" dimension in this research, can be linked to the dimension of "Risk / Performance". This is most evident in the review by Blankley (2008), who outlines that supply chain planning, especially the use of *"supply chain planning tools (forecasting, planning, and business strategy)"* (p. 166), has a positive effect on company performance. This linkage between the two dimensions is also shared by other authors covering supply chain planning. For example, Rao and Goldsby (2009) advise that aspects of industry uncertainty need to be considered in supply chain planning, whereas Williams *et al.* (2008) explicitly state, based on their review, that supply chain planning needs to cater for possible disruptions as effective planning significantly reduces the effects of risks (Natarajarathinam *et al.*, 2009).

6.5.2 Innovation

The ability to develop unique and innovative products is a corporate requirement paramount for market success. Due to the complexity and cost involved with new product development, innovation is increasingly a result of joint research efforts between companies as highlighted in the review by Miemczyk and co-authors (2012). Accordingly, existing innovation management approaches should be extended towards incorporation of the supply chain view, embracing suppliers' as well as customers' expertise (Christensen *et al.*, 2005).

Mirroring the relevance of the topic for SCM, innovation was a topic in 37% of all literature reviews (38 articles). As SCM is still predominantly production-focused, product innovation was the main subject of the discussion (e.g. Ellis *et al.*, 2011; Gunasekaran and Ngai, 2004). In many reviews the focus extended towards the inclusion of other areas, such as sustainability or technology, which is reflected in environmental innovation (Ashby *et al.*, 2012) or technological innovation (Cheng and Grimm, 2006; Sarac *et al.*, 2010). Utilizing the theoretical classification put forward by Chesbrough *et al.* (2007), as outlined in section 4.2.5, the articles were assessed according to the direction of intellectual knowledge flow described, namely the outside-in process approach, the inside-out process approach, and the coupled approach.

It needs to be mentioned that the author of this dissertation is aware that the term “knowledge flow” within the “innovation” category bears some potential for being confused with the “flow of skills and knowledge”, outlined as a research gap in the “type of flow” category (section 6.2.1). The use of the word “flow” in regard to the innovation concept was not found in a single literature review on innovation, as the papers representing the flow of skills and knowledge as depicted in the “types of flow” category (Tokman and Beitelspacher, 2011; Wong *et al.*, 2012) did not deal with innovation. Nevertheless, paying tribute to the terminology in innovation theory (Chesbrough *et al.*, 2007), the frequency analysis was conducted with the view that a reference to “innovation” in a certain article inherently included some hints towards knowledge transfer flows, although not explicitly stated by the author. This is the rationale for the presentation of flow in the “innovation” category.

The benefits of the outside-in process approach of knowledge flow where innovation is outsourced, i.e. knowledge is brought into the company through suppliers, customers and even competitors, has been well described in the review by Mills *et al.* (2004). In particular, the importance of suppliers in delivering innovation is a key focus found in the review samples (e.g. Carter *et al.*, 2007). Schoenherr (2009) outlines the risk of reduced innovativeness when suppliers get too complacent in a relationship. This is in line with research by Fabbe-Costes and Jahre (2008), who stated that integration, if not managed well, may have a negative impact on the innovativeness of a supply chain.

Depicting the benefits of the inside-out process approach, which focusses on selling knowledge to other parties, Kleindorfer *et al.* (2005) highlight the advantage of a first-mover approach for sustainable innovations in their review, which offers the opportunity to out-license proprietary technology. Apart from increased revenues incurred through licensing fees, investments in technological leadership through enhanced research allow for *“a head start on the next generation of technologies, including the creation of proprietary information that would provide competitive advantage”* (Kleindorfer *et al.*, 2005, p. 485), thus being a potential source for subsequent licensing royalties.

As a rare representative of the third concept, the coupled approach, the literature review by Selviaridis and Spring (2005) showcases how a collaborative approach in third party logistics may potentially result in the emergence of new competences and innovations, thus benefiting all parties.

It needs to be pointed out that the majority of articles on innovation is rather generic and unspecific in regard to the direction of intellectual knowledge flow and thus does not fully fit the above classification. Nevertheless, these contributions add to the understanding of innovation in supply chains. For example, the review study by Rao and Goldsby (2009) views innovation from a risk point of view, pointing to risks stemming from an interwoven industry structure. In such a scenario, product innovation has the potential to change an industry's production process and ultimately impact on the configuration of complete supply chains, which in essence may result in companies exiting the market. This is driven by the reconfiguration of existing networks as companies monitor and adapt their sourcing and supply approach if required. This bears the potential to foster the emergence of new competitors, which previously were mere suppliers but used the innovation shift in the industry to move up one step in the chain. Other authors (Anderson *et al.*, 1989; Li *et al.*, 2008) highlight the competitive advantage of innovations, especially in operations and process technology, which enable the company to become more flexible and respond faster to changing market patterns (Zhang *et al.*, 2011). Portraying a key problem for innovation in a collaborative environment, Akyuz and Erkan (2010) discuss issues with measuring innovation. In the same direction, understanding that the ability to measure innovation is a prerequisite for commercialization, Gunasekaran and Kobu (2007) propose adding innovation as a metric to business performance reporting in the balanced score card.

6.5.3 Customer focus

Effective SCM should always start with the customer (Kouvelis *et al.*, 2006). As such, SCM needs to be customer-centric as the customers' prime position in the chain ultimately influences the success of the product in the market place (Jain *et al.*, 2009; Stevenson and Spring, 2007).

Underlining the customer's prime role, almost every second article (48 articles) covered aspects linked to the customer focus category. The articles were analyzed following the theoretical grounding by Chen and Paulraj (2004), where a customer focus is characterized through a) satisfying customers' needs, and b) through the provisioning of timely service. Achieving customer satisfaction can be a complicated endeavor (Beamon, 1998), as customers may be highly sensitive to product quality, service quality and price, as stated in the review by Sachan and Datta (2005). Harrison and van Hoek's (2008) work outlined how value creation in the supply chain is tied to fulfilling customers' needs, which guides aspects such as functionality, quality, and service (Labro, 2006;

Tavares Thomé *et al.*, 2012). This is reflected in the literature review sample, as the majority of authors focused on customer needs (e.g. Boone *et al.*, 2007) or general customer demand (e.g. Gubi *et al.*, 2003), with some researching a specific type of customer demand, for example the customer demand for reused, recycled, or remanufactured products (Hazen *et al.*, 2012). In certain cases, it may be necessary to explain the value proposition of a product to customers, for example for green or sustainable products which often incur a price premium, as identified by Hassini *et al.* (2012). As customers expect timely service, companies are required to *"increase their responsiveness to customer needs by offering high product variety with short lead-times"* (Reichhart and Holweg, 2007, p. 1144). Other authors postulated the application of postponement strategies (Yang *et al.*, 2004; van Hoek, 2001) or outsourcing (Kremic *et al.*, 2006) to speed up customer service time.

Providing a link from the customer focus category to the dimension of collaboration, in line with the framework presented in this work, Williams and Tokar (2008) proposed in their review that *"collaboration, both internal and external, is key to improving a firm's customer service"* (p. 220). In a similar direction, but more on a micro level, van Hoek *et al.* (2008) argued that an integration across functional boundaries within a company is required to increase customer service. Discussing the required techniques to aid such integration, Keller and Ozment (2009) outlined the importance of appropriate concepts, such as customer relationship management as well as customer service management, for the supply chain.

Interestingly, only the literature review by Cheng and Grimm (2006) mentioned potential pitfalls arising from customer focus for companies such as the inefficient use of resources through *"giving inordinate attention to customer needs"* (p. 8). As customer involvement in SCM has the potential to impact on supply chains in multi-dimensional ways, namely vertically, horizontally and geographically (Giunipero *et al.*, 2008), it would be expected that more pitfalls exist which present a risk to customer retention if not managed properly.

6.5.4 Top management support

The importance of top management support for effective supply chain management has its foundation in top managements' governing position, providing the supply chain vision as postulated by Mentzer and co-authors (2000). Despite the value of support by top or senior management, aiming to ease subordinate functions' work processes and thus having a positive influence on overall supply chain performance (Tan *et al.*, 1999), only

17% of all articles discussed the subject, which represents the lowest category representation in the “Strategy” dimension.

The eighteen articles were analyzed using the conceptual framework of supply chain management by Chen and Paulraj (2004), roughly classifying the support of top management into a) time and resource commitment, b) support in supplier relationship development, and c) the dedication of top management to implement advanced information technology.

Top management’s time and resource commitment is dedicated to its role in aligning the corporate business strategy with the supply chain strategy as an enabler to achieve supply chain collaboration. This can be facilitated, for example, through supporting corporate communications, showcasing the importance of the company’s supply chain orientation through their own example (Wong *et al.*, 2012). Van Hoek *et al.* (2008) explicitly outlined in their review that a lack of senior management involvement, or even indifference, often constitutes one of the reasons for a potential lack of alignment between logistics and other peer functions. The analysis of all articles found that the majority of articles dealt with how top management commitment can ease cross-departmental cooperation through aligning and approving resources to support business processes (e.g. Blankley, 2008; Labro, 2006; Pettit and Beresford, 2009), such as the risk management process (Ellis *et al.*, 2011). However, as stated in the review by Keller and Ozment (2009), organizations should not just take a passive role, waiting for top management to offer support, as top management may not be aware of a need for support. Instead, in the case of demand for support, the organization should proactively approach top management to request specific involvement for the benefit of the company.

The value of top management support in developing supplier relationships, especially in regard to factors influencing success in international sourcing, was extensively researched by Babbar and Prasad (1998a). However, despite the importance of top management interaction in shaping sourcing deals, they are the only authors to touch this element of Chen and Paulraj’s (2004) framework.

For the implementation of advanced information technology, especially for logistics information systems, a dedicated participation of top management is also paramount for success (Babbar and Prasad, 1998a). Accordingly, the review by Waters-Fuller (1995) identified that the lack of top management support is a major problem when implementing technology support systems, exemplified in his review on JIT purchasing system implementation.

As managerial commitment to supply chain management (Fawcett *et al.*, 2007) is a necessity for operational supply chain management, it is surprising that aspects of "top management support" were only found in 10% of literature reviews in OPS journals compared to 23% in SCM journals. The question arises as to whether top management support is of lesser relevance in operations management compared to SCM. Aiming to provide an answer, the above finding is contrasted to the findings from the "leadership" section (section 6.3.5), as top management support and leadership in general depict similar characteristics, e.g. a higher level governing instance within the company. The result was that articles on "leadership" were primarily published in OPS journals (29%) compared to SCM journals (18%), which is diametric to the findings from the "top management support" section.

A possible reason for the contradictory results may be that OPS journals are focussing on a different type of "leadership" compared to SCM. As such, articles in OPS journals target a "leadership" of line managers compared to the "top management" of middle and senior managers in SCM. Nevertheless, potential future research in regard to the role of top management support could combine these findings and pose the question of whether top management support is of lower importance in supply chain management from an operations management point of view.

6.5.5 Competitive advantage

The recognition of SCM as being a facilitator of competitive advantage (Liao-Troth *et al.*, 2012), impacting on overall company performance, can be described as the key reason for companies to adopt a strategic view towards SCM (Li *et al.*, 2006). The finding that more than every second article (55 papers) had a view towards the competitive advantages tied to adopting a supply chain orientation underlines the recognition of competitive benefits derived from SCM in the research community. Utilizing the theoretical framework proposed by Li *et al.* (2006) the findings are discussed along the five dimensions of price / cost, quality, delivery dependability, product innovation, and time to market.

In regard to the price / cost dimension, the review by Ashby *et al.* (2012) stated that a reduction in resource usage required for production can improve the competitive position of a company as it leads to cost savings and thus ultimately enables flexible pricing policies while maintaining the set profit margin. A sustained competitive advantage can especially be gained if the resources used for production are *"valuable, rare, inimitable and non-substitutable"* (Barney, 1991, p. 99) as this hinders competition. A reduction of cost, however, is not always the most feasible strategy to improve the competitive position. The review study by Abbasi and Nilsson (2012) indicated that in some cases, for example in order to reduce uncertainties in the supply chain, it pays off for companies to invest more. This, however, is only feasible if it leads to a reduction of uncertainties which then materialize in an improved competitive position.

A focus on quality as an enabler of competitiveness was found in two reviews only (Giunipero *et al.*, 2008; Gunasekaran and Kobu, 2007), being largely linked to the development of long-term collaboration between buyers and sellers within the supply chain. This unique collaborative structure in turn can become a source for competitive advantage as it is hard to imitate by competitors.

Delivery dependability is a key competitive advantage in an integrated supply chain setup (Gligor and Holcomb, 2012). The majority of articles dealt with this subject, mostly focussing on agile work and network design (Li *et al.*, 2008), flexibility, and responsiveness (Gunasekaran and Ngai, 2004; Naim and Gosling, 2011). The network structure was commonly stated in this context, with Greening and Rutherford (2011) highlighting its value as a competitive advantage buffering production shortfalls in case of disruptions. Other literature studies outlined the use of third party logistics (Selviaridis and Spring, 2007), or the use of integrated inventory management (Glock, 2012), as suitable tools to increase overall delivery dependability throughout the supply chain.

The innovativeness of a supply chain determines its long-term success, and product innovation is a source of competitive advantage as outlined in section 6.5.2. Given the necessity for companies to innovate and implement up-to-date practices such as reverse logistics, Sarkis and co-authors (2011) also indicated in their review that the required resources and capabilities need to be available in order to turn innovation into a competitive advantage. Aiming to leverage a competitive advantage, for example through newly developed technology, the literature work by Kleindorfer *et al.* (2005) found that companies also lobby for governmental regulations in order to protect the new business area from entry of followers. Underlining the competitive value of innovation, Gunasekaran and Ngai (2007) concluded, based on a literature review, that *"the ability to manage and exploit knowledge will be the main source of competitive advantage for the manufacturing industry of the future"* (p. 2395). The integration of social and environmental resources may strengthen this development, as it makes a replication of the supply chain by competitors more difficult (Carter and Rogers, 2008).

A reduction of time-to-market enables companies to shorten their production pipeline adding to overall profitability. Schoenherr (2009) as well as Keller and Ozment (2009) found in their literature reviews that the integration of information technology in logistics management has become a competitive advantage in many industries. This is especially driven by the fact that such systems cannot be easily copied by competitors due to the complexity of such systems (Zhang *et al.*, 2011). Taking the case of RFID implementation, for example, the implementation challenges are not restricted to technology changes only. The supply chain may also require a redesign to fully support technological changes and achieve a competitive advantage (Visich *et al.*, 2009). Adding to the overall complexity, this raises the bar for the reproduction of these capabilities through competitors and thus represents a true competitive advantage. Labro (2006) states that process improvements represent the other source of competitive advantage to reduce time-to-market. Ultimately, process improvements foster a synchronization of the supply chain, which, according to Jain *et al.* (2009) *"is fast becoming the most important way to develop higher levels of supply chain competitive advantage"* (p. 3015).

Concluding, the assessment of the "competitive advantage" category revealed that, while a wealth of articles could be codified to the dimensions of price / cost, delivery dependability, product innovation, and time-to-market, the dimension of quality was apparently of less interest in the literature studies under review. As the value of the quality dimension for the competitive position of the company should not be underestimated, more research in regard to the potential of quality in enhancing the competitive position of the supply chain is recommended.

6.5.6 Information technology

The use of information technology (IT) and information systems, covering aspects of communication both within and between organizations, has been discussed among academics as being imperative to the concept of SCM (Cachon and Fisher, 2000). This is reflected in the review of the literature sample, as about two thirds (66%) of all articles refer to IT usage in SCM, the second highest frequency count in the "Strategy" dimension.

The review findings will be outlined based on the theoretical framework for the development of IT for effective SCM, as developed by Gunasekaran and Ngai (2004). It allows the identification of the implications and applications of IT in SCM governed along six dimensions, namely Strategic Planning of IT, Implementation of IT, Virtual Enterprise, E-Commerce, Knowledge and IT Management, and Infrastructure.

Strategic Planning of IT: Displaying the overall value of IT in a supply chain context, Keller and Ozment (2009), linking IT to the previous category of competitive advantage, highlighted that IT has *"advanced to become a competitive advantage for many industries"* (p. 388). However, companies need to be aware of the role of IT as being an enabler of business processes (Tavares Thomé *et al.*, 2012) and a driver of organizational change (van Hoek, 2008), which might spread well beyond SCM processes. A fundamental aspect of IT planning and implementation in the supply chain is the availability of IT related skills in the workforce, which needs to be considered in IT planning to avoid operational risks, as found in the review by Gravier and Farris (2008).

Implementation of IT: Various literature review authors (e.g. Cheng and Grimm, 2006) pointed towards the efficiency benefits of IT implementation such as *"ordering cost reductions, and hence smaller batches; lead time reduction, and thus stocks savings"* (Miragliotta, 2006, p. 371). The Electronic Data Interchange (EDI) technology was most often mentioned as an example of successful IT implementation (e.g. Skipper *et al.*, 2008; Terpend *et al.*, 2008), also being suitable in combination with vendor-managed inventories (VMI) (Kanda and Deshmukh, 2008). This can be justified, as EDI was one of the first applications of IT in a SCM context. However, the literature assessment revealed that since 2008, the application of radio frequency identification (RFID) technology (Sarac *et al.*, 2010; Gubi *et al.*, 2003) and web-based applications (Blankley, 2008), being rather new compared to EDI, are gaining ground. The infancy of these technologies explains the shortfalls in research which, according to the review by Rao and Goldsby (2009), have not been assessed in regard to bearing potential supply chain risks. Pinpointing a general issue inherent to the implementation of information systems across companies, Stevenson and Spring (2007) stated in their literature study that a certain degree of commitment is required by all parties, while the flexibility of such systems tends to be overvalued. This may hinder collaboration across independent enterprises, an issue already pertaining since the early days of SCM (Houlihan, 1985). Linking the IT category to the "integration" category (6.3.2), Fabbe-Costes and Jahre (2008) found that *"the IT / systems layer is not included as part of supply chain integration in many papers, whereas others point to this as a major aspect of such integration"* (p. 143).

Virtual Enterprise: Globally dispersed supply chain networks depend on IT to monitor the supply chain activities (Stock and Boyer, 2009). Schoenherr (2009) depicted the core value of IT, enabling the management of data flows between entities, as being a key success factor and facilitator for global SCM. In fact, the evolution of IT, especially in business communications technology, promoted the emergence of flexible organizational structures and can thus be regarded as the prime reason for the development of virtual enterprises (Pilbeam *et al.*, 2012).

E-Commerce: A variety of authors were identified as focussing on the role of E-Commerce in SCM, usually with an inter-company focus where the applicability of marketplace trading and business-to-business (B2B) setups were most prominent (e.g. Giménez and Lourenço, 2008; Giunipero *et al.*, 2008). Portraying the need for dynamic and flexible structures in E-Commerce, Jain and co-authors (2009) outlined the supporting role of internet-enabled trading platforms for tailored purposes such as e-procurement and e-fulfillment.

Knowledge and IT Management: Although knowledge is a key resource and a driver of competitive advantage through innovation, as presented in previous chapters throughout this work, few articles dealt with this aspect. Being a rare case, Afshin Mansouri and co-authors (2012) outlined how IT supports knowledge development and thus may be leveraged to aid strategic decision-making. In regard to IT management, Cantor (2008) was the only author identified to point towards the use of IT as being an enabler of corporate security.

Infrastructure: Hazen and co-authors (2012) highlighted the importance of a functioning IT landscape and the right IT infrastructure, presenting an example for companies aiming to set up reverse logistics activities. In this light, the design of the IT infrastructure is a key question to be considered in the IT landscape planning phase as it provides the framework for future business practices, such as sustainability activities (Hassini *et al.*, 2012), ultimately determining the framing possibilities to implement such practices.

Nevertheless, given the plethora of research on IT in supply chain, some authors (Zachariassen and Arlbjørn, 2010) concluded from their literature review that *"information systems […] continue to be researched infrequently"* (p. 335). This can be confirmed through the findings above, where Implementation of IT through EDI and RFID, as well as E-Commerce are most commonly discussed in SCM literature reviews, while aspects of Infrastructure, Strategic planning of IT, Virtual Enterprise, and Knowledge and IT Management are lagging behind. More research is recommended in these areas due to their governing importance for the whole system. In particular, the question of how IT can best be leveraged to support knowledge exploitation and conservation in a supply chain is expected to be an interesting research subject, given the value of employees' knowledge as being the "capital" of a supply chain. However, IT innovation cycles are increasingly shorter, putting companies under pressure to prevent their system from becoming technically obsolete. This makes it difficult for researchers to investigate these areas as research findings are quickly outdated and of little value as technology changes with increasing pace. Justifying the research gap from the literature review research, this may be tied to the complexity of these systems, which evolve over time within an organization and usually are customized to the specifications of that organization. This hinders comparability of the research subjects and results in a lack of generalizable findings. Due to the above challenges arising from researching IT in real life organizations, the literature study may promote the view that researchers may be tempted to turn to presumably less complex subjects for research.

6.5.7 Lean and agile supply strategies

An environment of constantly changing market demand is a challenge for every supply chain, as it requires the supply chain to constantly absorb and adapt to these changes, while at the same time pushing for simplification, optimizing processes, and streamlining the whole supply chain to remain competitive. The application of lean and agile supply strategies provides suitable toolkits to achieve the desired mix of efficiency (leanness) and flexibility (agility) within the supply chain, as proposed by Christopher and Towill (2000).

Underlining the value of these strategies for SCM, this category was found to be most often referred to in the "Strategy" dimension, identified in 71% of all articles. A possible explanation for the predominance of lean and agile strategies in supply chain literature is given by Chicksand *et al.* (2012), stating that *"in the early days of the field it appeared that lean and agile supply techniques might provide the intellectual basis for the discipline"* (p. 463). The literature review findings add to this as through the process of knowledge creation, which builds on other researchers' work, the two concepts seem to have been cemented into the research community, thus being continuously utilized to explain various phenomena in SCM. The articles falling into the "lean and agile supply strategies" category are assessed following the model proposed by Naylor *et al.* (1999), differentiating between lean, agile, and leagile supply strategies. In addition, an assessment on the journals subset level is conducted, analyzing the articles with a view towards their publication in either SCM or OPS journals, as a means to identify valuable findings. This assessment revealed that lean and agile supply strategies are present in 80% of literature reviews in OPS journals, indicating that lean and agile paradigms are predominantly driven by operational needs. Table 6.13 (p. 128) provides a statistical overview of the sub-categories along which the 103 literature reviews were assessed.

Lean supply strategy: The process improvement and streamlining focus of the lean supply strategy, focussing on operating efficiency (Tang and Nurmaya Musa, 2011), is visible in the literature review sample as the number of articles published on this subject in OPS journals exceeds the number published in SCM journals by more than 50%. Thus taking the operations perspective, van Hoek *et al.* (2008) in their review work pointed to the importance of aligning business functions, such as logistics and R&D, in implementing a lean strategy as being an enabler to reduce the waste of resources in the launch phase of new products. The work of Delbufalo (2012) adds to this view, although taking a supply chain perspective, stating that an implementation of the lean strategy requires trust between partners, as information needs to be shared across company borders to enable synchronization of production schedules. The examples above all target to increase the efficiency of the whole chain (Christopher, 2010). In this light, Mills *et al.* (2004) found in their review study that two major foci could be distinguished in lean production literature, which both are affected by SCM practices, namely a focus on performance as well as a focus on processes. Within the literature sample under review, especially the focus on processes was identified to play a key role, most notably through the reduction of lead time, as portrayed in the review by Cheng and Grimm (2006). A suitable way to reduce lead time is presented by Kanda and Deshmukh (2008), where the key driver is the integration of processes. On the performance side, lead time reduction is seen as a necessity to increase the responsiveness to customer needs (Reichhart and Holweg, 2007) where especially the product design phase offers streamlining opportunities (Gunasekaran and Ngai, 2004). As stable demand is the prerequisite for the use of various production concepts, such as just-in-time (JIT), acting as stepping stones in order to aid the purpose of the lean strategy, an increased focus on customers in the supply chain over time, linked to value creation, was identified by Hazen *et al.* (2012). Accordingly, Gosling and Naim (2009) in their review article on engineer-to-order supply chain management outlined that the lean strategy concept is evolving from a pure application in manufacturing operations to the supply chain or enterprise level. Miemczyk *et al.* (2012) even regarded it as a necessity to consider the whole supply chain when implementing lean strategies as JIT strategies expand beyond the operational focus of a company and require collaboration between parties. This development can also be observed when reviewing the distribution of articles on JIT across SCM and OPS journals. As such, JIT was a topic in 54% of all articles in SCM journals, compared to 27% in OPS journals.

Agile supply strategy: The agile supply strategy is the most often referred to within the “lean and agile supply strategies” category (48 articles). This may be explained through the findings in the work of Gligor and Holcomb (2012), researching the roots of agility and concluding that the concept of agility in SCM *“has primarily been explored in the literature by focusing on* […] *lean manufacturing”* (p. 438), thus building on the established, “older” lean concept. Somehow opposing to the lean strategy findings, the agile strategy shows a stronger grounding in SCM journals, with 55% of all articles in SCM journals dealing with agile strategy. A reason may be that, although lean strategies increasingly progressed from being purely operations focused towards overall supply chain usage, as indicated by Gosling and Naim (2009), journals seem to still prefer submissions within “their” domain, i.e. SCM journals focussing on agility, instead of lean, as agility may be valued being more of a “supply chain topic” in a broader sense.

A key requirement for the application of an agile supply strategy is the existence of a robust supply chain, in the sense that the supply chain is flexible to respond to changes or disturbances (Naim and Gosling, 2011). The benefits of agility, providing a distinctive competitive advantage, are outlined by a variety of authors (e.g. Gunasekaran and Ngai, 2004; Li *et al.*, 2008). However, despite the many benefits, the concept of agility is a complex one, as it usually expands across company borders. Accordingly, a multitude of authors have researched various facets of agility. As such, the review by Babbar and Prasad (1998a) outlines the enabling role of logistics for agile supply chains, while others (Ghadge *et al.*, 2012) highlight the potential of agile supply strategies for utilization as a risk mitigating strategy. Calling for a balanced approach towards agility, Fabbe-Costes and Jahre (2008) argue that the integrating nature, which is required in an agile manufacturing environment, may at a certain point impact on agility in a negative way. Supply chain agility therefore requires firms to balance risks and chances, which essentially includes a trade-off between flexibility and uncertainty (Stevenson and Spring, 2007).

Leagile supply strategy: Few authors (7 articles) were found to research the concept of leagility, depicting a hybrid supply strategy. The article distribution across journals, although somewhat balanced, shows a light tendency in favor of OPS journals. This is interesting, as from the author's point of view, it was expected that SCM journals would lead the way, as leagility is deeply based on agile supply strategy, an area where SCM journals dominated. Authors generally did not go beyond stating that the concept of leagility exists, which in most cases was justified through the theoretical lens of the model by Naylor *et al.* (1999), which also provides the theoretical framework for the category in this dissertation. Being most specific, Yang *et al.* (2004) in their review on postponement literature identified the core dilemma of the leagile supply strategy, which is manifested in the challenge to identify the right balance *"in which upstream activities in the supply chain are performed using lean / standardization / centralisation and downstream activities are postponed until customer orders are received"* (p. 475). Recommending that leagile supply strategies can be used to reduce supply chain risks, the review by Rao and Goldsby (2009) underlined the value of leagile supply strategies in increasing the responsiveness of the supply chain by postponing product customization, therefore resembling a suitable means to accommodate uncertainties. In return, the increased responsiveness of the supply chain ultimately enables flexibility (Gunasekaran and Ngai, 2005).

Postponement: Achieving flexibility in a supply chain, however, is not limited to the three strategies as outlined above, although these have been proclaimed as being the three core strategies. The strategy of postponement, which utilizes inventory de-coupling points to delay product customization, is considered a suitable tool, which could supplement the core strategies (Pagh and Cooper, 1998). As such, especially the strategies utilizing agile concepts, which encompasses leagile concepts, require tight integration with the postponement strategy to function, as outlined in a range of reviews (e.g. Li *et al.*, 2008; Yang *et al.*, 2004). In regard to the leagile concept, the analysis found that articles on leagility also had a strong postponement strategy footprint, accounting for 29 articles, thus confirming a link between the two aspects as suspected by Pagh and Cooper (1998).

Aiming to mitigate the supply-demand coordination risk (Cantor, 2008), the most common types of postponement discussed were time and form postponement, using modular production techniques (e.g. Dasaklis *et al.*, 2012; Gunasekaran and Ngai, 2005). In contrast, the advantages of place postponement, where goods are stored at central locations in the supply network and only finalized based on specific customer orders, drew minor attention in the literature and were only mentioned in the postponement literature review by van Hoek *et al.* (2008).

The review by Visich *et al.* (2009) described the benefits of supporting postponement through technologies such as RFID. In general, articles outlining how technology can be leveraged to support postponement strategies are scarce. Given the trend towards geographically dispersed supply chains, in conjunction with advancements in information technology, research focussing on place postponement strategies as well as supporting technologies is expected to offer fruitful insights on how global production networks could be managed in the future. As the advantages of the postponement strategy include the reduction of inventory-related costs, due to a better matching of supply to demand, leading to smaller inventory and greater flexibility, the postponement strategy also requires tight alignment with inventory strategies (van Hoek, 1998; Kouvelis *et al.*, 2006).

Inventory management: The assessment of the literature revealed that inventory management is largely an operations management topic as every second review in OPS journals dealt with this subject (Table 6.13, p. 128). The review by Babbar and Prasad (1998b) already indicated that in order to be most efficient, the management of inventory should be viewed from both levels, namely the macro supply chain view level, and the micro company view level. On the micro level, the integration of inventory management with other business functions, e.g. procurement, is required for resource planning and effective inventory control (Afshin Mansouri *et al.*, 2012). Inventory management in SCM, the macro level, which is considered an important driver of competitive advantage within strategy (Cheng and Grimm, 2006), is largely concerned with coordinating inventory allocation across company boundaries (Kanda and Deshmukh, 2008; Caridi *et al.*, 2005; Mills *et al.*, 2004). However, to determine best inventory allocation across parties, it is paramount to have inventory visibility (Blankley, 2008), which is also a fundamental element for application of inventory strategies such as a temporary shift of inventories to suppliers (Waters-Fuller, 1995). A major requirement for cross-company inventory reduction is the availability and use of enabling information technology such as EDI (Labro, 2006), RFID (Sarac *et al.*, 2010), or internet technology (Gunasekaran and Ngai, 2005), which, in recent years, have developed into a vivid field of SCM research.

A discussion on the role of inventory management in postponement strategies also needs to consider the function of the material de-coupling point in leagile supply chains. The material de-coupling point represents a major inventory stocking point, where a product is kept in generic form, until customer demand through orders is visible (Stevenson and Spring, 2007). As the de-coupling point is used in leagile supply chains (Hoekstra and Romme, 1992), only authors discussing leagile supply chains were found to touch this aspect. A fruitful discussion, however, was limited to two reviews: Gosling and Naim (2008) outlined that the strategic positioning of the de-coupling point is critical for optimal application of lean and agile strategies, which in return are highly influenced by the type and purpose of product and supply chain such as engineer-to-order (ETO) or make-to-order (MTO) setups. From a production end, Yang *et al.* (2004) underlined the importance to consider lead times required to meet customer demand when positioning a strategic de-coupling point.

A comparison of the "lean and agile supply strategies" category with other coding categories within the "Strategy" dimension revealed, that the lean and agile paradigms and IT were the prime categories based on their frequency count. This is no coincidence, as these two areas are interlinked. As such, the use of sophisticated IT has been classified by authors as being a major requirement for application of the agile paradigm (Hewitt, 1999), although sometimes over-rated as a panacea in striving for flexibility (Yang *et al.*, 2004).

Category (level 2) Sub-category (level 3)	**Count all articles (n=103)**	**% of all articles**	**Count SCM articles only (n=62)**	**% of SCM articles**	**Count OPS articles only (n=41)**	**% of OPS articles**
5.7 Lean and agile supply strategies	**74**	**72%**	**40**	**65%**	**33**	**80%**
Lean Manufacturing / Lean Supply	27	26%	13	21%	14	34%
Just-in-time (JIT)	39	38%	17	27%	22	54%
Lead time reduction	29	28%	11	18%	18	44%
Agile Manufacturing / Agile Supply	48	47%	34	55%	14	34%
Leagility	7	7%	3	5%	4	10%
Postponement	29	28%	13	21%	16	39%
Inventory management	44	43%	23	37%	21	51%

Table 6.13: Aspects of lean and agile supply strategies
(Source: Author)

6.5.8 Sustainability

Research at the crossroad of SCM and sustainability, known as sustainable supply chain management (SSCM), while being in its infancy, is quickly gaining ground in the research community (Linton *et al.*, 2007; Seuring and Müller, 2008b). This is evident in the literature sample as more than a third (38%) of all literature reviews analyzed were found to include some content in regard to sustainability in supply chains, with three quarters of the reviews on sustainability being published in SCM journals. Focussing on articles in OPS journals, 22% of the papers (9 articles) were found to discuss aspects of sustainability, mainly environmental sustainability, which may be rooted in the nature of operations to focus on production technology. The research sample was analyzed in accordance to sustainability category fit, following Elkington's (1997) Triple Bottom Line (TBL) approach, being the fundamental paradigm in SSCM. The results of the frequency analysis as outlined in the following are presented in Table 6.14 (p. 132).

The TBL approach was used as a structuring instance in the majority of the articles on sustainability, highlighting the value of this approach in a SCM context. Interestingly, three times more articles portraying the TBL were published in SCM journals, compared to OPS journals, which hints towards the excellent use of the TBL approach in a supply chain setting. Nevertheless, as the dimensions of the TBL could also be beneficial in a manufacturing setup, more research is called for to cover this aspect from an operations point of view. The divide between SCM and OPS journals in terms of TBL usage, as outlined above, was also evident throughout all of the three dimensions of sustainable development. In the economics and social dimension, the split was even more distinct, with only every sixth paper appearing in OPS journals. The "environmental" dimension was the exception to this trend, being the most often mentioned in OPS journals.

The economics dimension was of lowest interest to researchers, found in eleven papers only. Most authors approached this dimension by mentioning for example *"economic issues in the management of the organization's external resources"* (Miemczyk *et al.*, 2012, p. 489), although without specifying exactly what kind of economic issues they are referring to. The few who were most specific focus on the cost side of sustainable supply chains, either through waste management or general environmental programs (Hazen *et al.*, 2012), arguing that cost be seen as a core obstacle of the economic dimensions (Aronsson and Brodin, 2006).

The environmental dimension, which could be seen as the historical foundation of the sustainability concept (Linton *et al.*, 2007), was identified in the review as being the most often discussed dimension of the TBL. This confirms and updates the findings from previous literature reviews on sustainable supply chain management (Ashby *et al.*, 2012; Seuring and Müller, 2008a), which especially identified the environmental dimension as being the dominating area of sustainability research. A reason for the dominance of environmental discussion may be linked to environmental purchasing as the final product of a supply chain can at best be only as eco-friendly as the input. Accordingly, the role of purchasing in achieving environmental sustainability has gained considerable attention since the second half of the 1990s, as highlighted in the review by Carter and Ellram (2003). Nevertheless, as found through the literature research by Hazen *et al.* (2012), environmental sustainability is lacking a tight integration into a holistic sustainability strategy at corporate and supply chain level. The result being that environmental concerns, such as recycling or energy conservation practices (Rao and Goldsby, 2009), are given cursory examination at best when selecting business partners, which may be linked to the cost associated with partners' sustainability assessment (Jensen, 2012).

However, given overall increasing raw material prices and supply shortages of rare resources, these costs are miniscule when seen in comparison to the benefits of a sustainable supply chain, as the reuse and conservation of resources can be turned into a distinctive competitive advantage.

Portraying its potential, the development of "reverse logistics systems" or "closed loop supply chains" is the second most often utilized aspect in the sustainability category cross journals (Abbasi and Nilsson, 2012; Cantor, 2008; Minner, 2003). Within these systems, used products are either recycled or refitted for consumption, aiming to reduce waste of resources as outlined by Hassini *et al.* (2012) and Kleindorfer *et al.* (2005). Especially the design phase of a product was identified by a variety of authors as a key area affecting the product's prolonged lifecycle (Giménez and Lourenço, 2008; Hazen *et al.*, 2012). Reserve logistics and closed loop supply chains are the prime dimension of OPS articles on sustainability, as every article in the sustainability category published in OPS journals discussed these topics. Given the strong footprint in operations management, the link between the sustainability category and the lean category (presented in section 6.5.7, p. 123) could be drawn in regard to closed loop supply chains. The rationale being that, following the thoughts of Kleindorfer *et al.* (2005), similarities between green manufacturing and lean manufacturing are evident as both aim to reduce waste while achieving more with less. This is supported by the research from Hassini *et al.* (2012) who found evidence in the literature to claim *"that companies that adopt lean manufacturing strategies are more likely to adopt sustainability practices"* (p. 71). Accordingly, it can be argued that lean manufacturing may therefore be seen as a prerequisite for sustainability, which should be tested through further research.

Going one step further, extending from lean manufacturing to the agile manufacturing paradigm, the review by Aronsson and Brodin (2006) acknowledged that aspects of postponement could be considered in a sustainability context. Providing practical guidance they advised that the applicability of the postponement strategy should be evaluated, aiming to balance the environmental impact of geographically dispersed logistics concepts and strategies with economic necessities.

The social dimension of sustainability can be described as a rather soft dimension, dealing with health and safety concerns (Kleindorfer *et al.*, 2005), aiming for the well-being of the society (Miemczyk *et al.*, 2012) where in an ideal scenario all members of society have equal access to resources and opportunities (Ashby *et al.*, 2012). In general, research on socially sustainable practices could benefit from more focussed research, which is also evident throughout the literature review findings. As a recent example, Ashby *et al.* (2012), reviewing literature on sustainable supply chain management, stated that a discussion on social sustainability is too often focussing on single aspects only, such as the implementation of fair trade practices, while generally lacking a holistic view. Bridging to the concept of Corporate Social Responsibility (CSR), the review by Giménez and Tachizawa (2012) adds to this, highlighting that if the social dimension is covered by researchers *"it has been under the umbrella of CSR practices (which covers both social and environmental issues)"* (p. 532). These CRS practices in a supply chain context include corporate activities not required by law with the goal to further social good (Sarkis *et al.*, 2010). Although, following theory (Robins, 2006), a motivation for companies to adopt the social dimension should not be influenced by the financial interest of the firm, companies usually do not become socially sustainable without a reason. Adhering to the principles of economics, the company's investments into a socially sustainable production process need to pay off in the end. Accordingly, as summarized in the review by Hazen *et al.* (2012), investments in the social dimension are usually linked to an expected increase in profits as customers might prefer companies which they perceive to act in a socially responsible manner. The risks tied to this approach, e.g. attempts to "green-washing" a product without really adhering to a socially sustainable production process, are major obstacles, whose mitigation requires strict certification and monitoring by independent parties. Surprisingly, no article was found to explicitly discuss the risks tied to the social dimension ("CSR risks") nor to any other TBL dimension, which thus represents a major research gap in sustainable supply chain literature reviews. In addition, it seem as if the social TBL dimension is predominantly a supply chain topic, which is reflected in the fact that the publication of CSR literature is basically limited to SCM journals. However, one would expect that a socially responsible supply chain consist of parties that for themselves have installed socially responsible processes with a special focus on operations and suppliers. Thus, it is somewhat surprising that only one review was published in an OPS journal. Nevertheless, the review by Sarkis and co-authors (2011), published in IJPE could be seen as a first step towards a stronger consideration of sustainable supply chain management in operations management, however, more research is required to leverage the social potential of the TBL.

Lastly, it needs to be mentioned that the results from a previous category's assessment ("Conceptual framing of SCM" in section 6.1.2, p. 88), which outlined that sustainable supply chain practices were least often reported in the literature reviews, shown through the frequency of articles mentioning the "return" process in SCM, are not to be seen in contrast to the findings above. As such, the "conceptual framing of SCM" category focussed on the "environmental" aspect of the "return" process, while the "sustainability" category is extending the view beyond the "return" process, also including the "economic" and "social" dimensions of the TBL approach. As the scope of the "sustainability" category expands, in comparison to the mere "return" phase view, this serves as a rationale for the deviation in the frequency of articles found.

Category (level 2) Sub-category (level 3)	**Count all articles (n=103)**	**% of all articles**	**Count SCM articles only (n=62)**	**% of SCM articles**	**Count OPS articles only (n=41)**	**% of OPS articles**
5.9 Sustainability	**39**	**38%**	**30**	**48%**	**9**	**22%**
Triple Bottom Line (TBL)	34	33%	25	40%	9	22%
Economic	11	11%	10	16%	1	2%
Environmental	30	29%	21	34%	9	22%
Reverse logistics / Closed loop supply chains	20	19%	11	18%	9	22%
Social	16	16%	14	23%	2	5%
Corporate Social Responsibility	11	11%	10	16%	1	2%

Table 6.14: Aspects of sustainability
(Source: Author)

6.5.9 Outsourcing

The concept of outsourcing fits well into the supply chain picture, providing a framework for the partnering companies to increase overall growth, as entities can focus their resources on their core competencies while outsourcing non-value adding processes and capabilities with low entry barriers for competitors (Cox, 1999). The results from the outsourcing category are presented, following the outsourcing decision framework proposed by Kremic and Tukel (2006), which considers the potential benefits and risks of outsourcing and allows the evaluation of a function's "outsourcing fit".

Underlining the general acceptance of an outsourcing strategy in SCM research, an outsourcing orientation was identified in 39% of all articles. Authors agreed that the key benefit of outsourcing is the coordination of processes through leveraging synergies, which in the end positively influence the outsourcing firm's cost structure (e.g. Reichhart and Holweg, 2007). Outlining another positive side of outsourcing, Ellis *et al.* (2011), linking outsourcing to the dimension of supply chain risk in their review, highlighted the use of outsourcing "*to mitigate risks stemming from internal and external sources of uncertainty"* (p. 66). However, outsourcing is not always the best strategy as – from an economical perspective –, outsourcing can only be justified if the relationship transaction costs are lower than the internal costs of the firm (Sarkis *et al.*, 2011). This is supported by the review of Defee and co-authors (2010) who identified the theoretical foundation for outsourcing to be rooted in the theories of economics. As mentioned by Tang and Nurmaya Musa (2011), despite the various benefits of outsourcing e.g. to low cost countries, also the challenges and risks represent an area for vivid discussions and should thus not be underestimated. Accordingly, various alternatives to outsourcing have been proposed, as described by Metters *et al.* (2010), which are influenced by geographical factors. Accordingly, outsourcing is dominating in the Western countries, whereas Asian counterparts prefer vertical integration as a cost reduction strategy.

The global aspect of outsourcing, comprising longer lead times and more complex supplier relationships, is seen as the major risk of outsourcing (e.g. Ghadge *et al.*, 2012; Williams *et al.*, 2008). Issues around the sharing of business practices, being the collaborative prerequisite of outsourcing, should also not be taken easily as the sharing of process knowledge cannot be reverted (Jiang *et al.*, 2007). In addition, the review by Stevenson and Spring (2007) identified a major concern of outsourcing companies, as they increasingly become dependent on other parties, for example on service providers and sources of supply, without being able to execute full control over those parties. However, such dependencies may also be beneficial: In some cases where heightened ethical standards are demanded by authorities, companies may be tempted to "piggy-back" on the good reputation of other companies by outsourcing the governance of the

network to this multi-stakeholder entity, which in an optimal scenario has a high level of consumer trust (Pilbeam *et al.*, 2012).
The assessment of the suitability of potential functions to be outsourced should govern every outsourcing decision. The authors following closest the “outsourcing fit” evaluation part of the framework by Kremic and Tukel (2006). They conducted a sample study on agency theory with the goal to provide guidance on the process of outsourcing partner selection, which also included aspects of maintaining relationships between the client firm and its outsourcing service provider. Considering the complexity of functions, Pettit and Beresford (2009) advised in their review not to outsource core functions, as the corresponding risks outweigh the benefits in the long run. Being considered the prime function with potential for outsourcing, seven articles explicitly mention the logistics function which could benefit from the use of third party logistics to perform logistics operations more cost effective than most in-house alternatives (e.g. Kouvelis *et al.*, 2006; Liao-Troth *et al.*, 2012; Meixell and Norbis, 2008; Schoenherr, 2009). Only few other authors discussed other functions’ outsourcing potential, such as IT (Cheng and Grimm, 2006) and services (Choi and Wacker, 2011). As functions are increasingly integrated and connected within a company, outsourcing decisions should consider the degree of integration with other functions. Depending on the interdependencies among functions and the functions’ complexity, it may be suitable to outsource a complete business process to maintain the functionality of that process (Rao and Goldsby, 2009). From a strategic perspective, the work by Gunasekaran and Ngai (2005) is interesting in this regard. They proposed the use of a build-to-order supply chain to leverage flexible global outsourcing through the sourcing of modularized services from supply chain partners on a pay-per-use basis as required; under consideration of the products’ specification.
Kremic *et al.* (2006) outlined in their review that politics is a major category of motivation for outsourcing. This is somehow missing in the framework by Kremic and Tukel (2006). Interestingly, after having assessed the review sample in accordance to the political dimension of outsourcing, no literature review was found to discuss this issue which therefore represents a research gap. Given the political implications such as the installation of trade barriers for the outsourcing decision, research on the political dimension may offer fruitful insights to guide future supply chain outsourcing decisions.

6.6 Dimension: Theoretical foundation

The “Theoretical foundation” dimension leverages the sample of literature reviews in order to extract theories on which a discipline of SCM is based on. This is conducted along the lines of the theoretical classification framework outlined by Burgess *et al.* (2006), based on Amundson (1998), comprising economic, strategic management, and psychological / sociological theories, supplemented by operations management theories (Schmenner and Swink, 1998). The discussion of the theoretic foundation of SCM in this dissertation is motivated by the work of Arlbjørn and Halldórsson (2005), who found that the theoretical foundation of SCM is unquestioned from a philosophy of science perspective whereas emerging theory follows practice. This relates to the early days of SCM where the development of SCM was predominantly driven by practitioners with theory development to follow (Burgess *et al.*, 2006; Frohlich and Westbrook, 2001). As theory is of particular importance in the sciences, following Dubin (1976), the literature review aims to provide structure to the field of theory usage in SCM. Although the value of theory in SCM, as proclaimed by Mentzer *et al.* (2008), is acknowledged in academia, only few reviews on theory usage have been conducted by SCM researchers, often with a focus on a specific topic without claiming to provide a holistic view towards SCM theory usage (Chen and Paulraj, 2004; Choi and Wacker, 2011; Das *et al.*, 2008; Denk *et al.*, 2012; Liao-Troth *et al.*, 2012; Simangunsong *et al.*, 2012; Vonderembse *et al.*, 2006). The general aim of these papers is to distill the essence of focussed theory usage in SCM. With the exception of the articles by Burgess *et al.* (2006) and Defee *et al.* (2010), who developed an inventory of the available theory in logistics and SCM research, no article maps the breadth of SCM theory usage in a systematic manner. In addition, no published review addresses theory usage through the lens of SCM literature reviews, although the application of this rigid research approach enables the gaining of a distilled perspective on theory usage within a broad scope of topics.

Closing this gap, the assessment of the 103 literature reviews revealed that about 70% of the articles contained some kind of theory application. The number of articles without a discernable theory (33 papers) is roughly in line with other reviewers’ results (Burgess *et al.*, 2006). However, in contrast to the findings in the review paper by Burgess and co-authors (2006), who identified that articles rarely utilized a multi-theory basis, the current assessment of the literature sample produced 55 articles to exploit multi-theory usage as a means to explain SCM phenomena. An explanation for the divergent findings may be found in the composition of review samples: the sample of Burgess *et al.* (2006) was randomly selected and did not explicitly target literature reviews. As literature reviews naturally focus on a greater depth of articles, instead of focussing on a breadth of topics, this could justify the amount of papers found harnessing a multi-theory perspective.

6.6.1 Economics theory

According to Zsidisin and Ellram (2003), economics theories are well suited in a SCM context, providing the framework to guide decision-making, while explaining cooperative relationship structures. The finding that transaction cost economics (TCE) theory was identified as the guiding economics SCM theory in the majority of papers supports the above statement (Table 6.15, p. 137). This also mirrors the results by Defee *et al.* (2010), who assessed theory usage in logistics and SCM research covering the 2004 to 2009 period. As TCE theory is concerned with company boundaries (Ghoshal and Moran, 1996), which often are the weakest link between partners in a supply chain, more than two thirds of all TCE papers were published in an SCM journal, aiming to increase the solidity of cross-boundary links. The remaining third of articles, published in OPS journals, underline the applicability of the TCE theory to intra-corporate boundary structures, which may provoke additional research into how TCE in regard to intra-corporate boundaries can be beneficial for managing inter-corporate relationship structures.

In addition, other economics theories were utilized by authors such as “institutional economic theory” and “expected utility theory” (Carter *et al.*, 2007) to explain behavioral supply management, or “activity-based costing theory” and “economic order quantity theory” (Liao-Troth *et al.*, 2012), viewing SCM from an operations perspective. However, these theories were not used with the aim to extend SCM theory but rather with an individual paper-supporting rationale in mind. Although Defee and co-authors (2010) in their review of theory usage in SCM, identified only about 2% of the papers to discuss agency theory, the present literature review assessment revealed that 13 of the 103 articles (12%) made use of the concept, featuring a principal party, delegating work to an agent party (Eisenhardt, 1989). A justification for the deviation being that the current study’s sample is built on a larger journal scope, featuring 10 journals instead of five. In addition, it covers a broader timeframe (1989-2012), compared to Defee *et al.* (2010), who only included articles published in the six years between 2004 to 2009. It is worth mentioning that, although the authors essentially referred to the principal agent theory, no common understanding in terms of wording was found. The authors of the literature reviews assessed used a variety of interchangeable terms such as “agency approach”

(Jain *et al.*, 2009), “principal agent theory” (Carter *et al.*, 2007) or “(principal)-agency theory” (Fayezi *et al.*, 2012). As Defee *et al.* (2010) only checked their sample for the term “agency theory”, not covering similar terms as outlined above, this may also justify the deviation between the findings of Defee *et al.* (2010) and the findings of the on-hand literature review. Nevertheless, following Stock and Boyer (2009), a unifying definition is essential to avoid confusion and prevent unguided theory development, thus emphasizing the need for a common accepted term.

The range of economics theories is supplemented by game theory, which was inductively identified in the literature review process. Originating from the mathematical theory of economic and social organization, based on the *Theory of Games of Strategy* (von Neumann and Morgenstern, 1945), it essentially shows traits of a strategic theory, which would classify it for being part of the “strategic management theory” category. However, due to its decision-making perspective, which according to Zsidisin and Ellram (2003) is part of the economics theory, it also fits well into the economics theory cluster. Game theory was the second most popular economics theory identified (17% of all articles), although authors often only stated its applicability in SCM without being more specific. Accordingly, the potential of game theory in SCM, suitable to explain a party’s behavior when balancing trust with economic return in information-sharing, provides great potential to examine how game theory can add to overall SCM theory building. The paper by Lee and Whang (2000) may be useful here, despite not being part of the review sample, as it provides first hints on how game theoretical thinking may be beneficial in terms of information-sharing in SCM, although not disclosing more than mere starting points.

Category (level 2) Sub-category (level 3)	**Count all articles (n=103)**	**% of all articles**	**Count SCM articles only (n=62)**	**% of SCM articles**	**Count OPS articles only (n=41)**	**% of OPS articles**
6.1 Economics theory	**32**	**31%**	**20**	**32%**	**12**	**29%**
Transaction cost theory	25	24%	18	29%	7	17%
Other theories (e.g. Agency)	14	14%	9	15%	5	12%
Game theory	17	17%	9	15%	8	20%

Table 6.15: Aspects of economics theory
(Source: Author)

6.6.2 Strategic management theory

Strategic management theory is an essential part of the SCM paradigm, as SCM is to some parts rooted in the strategic management discipline (Halldórsson and Arlbjørn, 2005; Ketchen and Giunipero, 2004). This view is shared by more than a fourth of all articles, being assigned to the strategic management theory group (Table 6.16, p. 138). Having assessed all papers in regard to their strategic management theory usage, it can be assumed that papers which contain the appropriate theory have a higher chance of being published in SCM journals compared to OPS journals, as a core aspect of SCM is its collaborative nature, which requires more strategic alignment of entities.

Category (level 2) Sub-category (level 3)	Count all articles (n=103)	% of all articles	Count SCM articles only (n=62)	% of SCM articles	Count OPS articles only (n=41)	% of OPS articles
6.2 Strategic management theory	**28**	**27%**	**21**	**34%**	**7**	**17%**
Resource based view theory	21	20%	16	26%	5	12%
Resource dependence theory	8	8%	6	10%	2	5%
Competitive advantage theory	9	9%	8	13%	1	2%
Systems theory	8	8%	6	10%	2	5%
Dynamic capabilities theory	7	7%	7	11%	0	0%
Network theory	5	5%	5	8%	0	0%
Knowledge-based view theory	3	3%	3	5%	0	0%
Resource advantage theory	3	3%	3	5%	0	0%
Stakeholder theory	3	3%	2	3%	1	2%

Table 6.16: Aspects of strategic management theory
(Source: Author)

Contrasting to the findings from Burgess *et al.* (2006), the resource-based view (RBV) was the most often used theoretical approach in the strategic management theory cluster, which is in line with the thinking of Ketchen and Giunipero (2004). Extending the findings from Defee and co-authors' (2010) study on theory usage in SCM, the assessment revealed that the popularity of the RBV theoretical approach in SCM research increased over time as about 75% of al RBV articles were published since 2008. The year 2012 shows the highest peak, accounting for 24% of all RBV theory articles alone. This underlines the topicality of the theory in an SCM context, which may be driven by recent developments in global trade, as the increasing scarcity of resources forces companies to shift their views towards resource management. As such, firms and supply chains started to treat resources as strategic assets rather than – often inexpensive – commodities, a view whose importance was postulated by Barney (1991) already over two decades ago. In this light, it is promising that a range of authors made use of the resource dependency theory in an SCM context, which implies the view that companies *"cannot be fully self-sufficient with regards to strategically critical resources for survival"* (Sarkis *et al.*, 2011, p. 4). Thus, the collaborative nature of this theory underlines its excellent use in SCM theory development.

Building on previous scholar's ideas (Amundson, 1998), and linking the RBV to aspects of competitive advantage (see section 6.5.5, p. 118), the review by Chicksand and co-authors (2012) advised that companies need to ensure not to outsource functions that add to the corporation's competitive advantage. Although the use of competitive advantage theory was evident in 24% of the papers in the study by Burgess *et al.* (2006), the frequency in the current sample was considerably lower at 9%, mostly rooted in SCM journals. The difference is justified through the less focussed research sample in the comparative study.

The required competitive advantage in a supply chain environment is achieved through leveraging the best from every party in order to create a unique supply system, thus linking into resource dependency theory. Building on the system paradigm, a variety of reviews (e.g. Miragliotta, 2006; Choi and Wacker, 2011) portrayed the usefulness of systems theory in an SCM context. This "systems thinking" approach (Katz and Kahn 1966; Thompson, 1967), further advanced through the industrial dynamics work portrayed by Forrester (1958), highlights the need for holistic comprehension and systematic knowledge to understand and manage the dynamics within a system. Pointing to the complexity of systems, the literature work by Tang and Nurmaya Musa (2011) identified system dynamics as one of the driving forces, adding to the intricacy of managing supply chain risks (Ellis *et al.*, 2011). Nevertheless, the systems view is a requirement in developing competitive supply chains. As found by Hazen and Byrd (2012) the use of IT offers leverage to reduce the complexity of these systems. A commonly referred system in SCM is the network of companies. Thus, it may be feasible to bridge systems theory to network theory. However, as the corresponding network theory is used only by a minority of authors, it can be argued that the systems theory is seemingly more applicable and attractive to authors in describing the concept of SCM, although a thorough justification is lacking.

Being used in one out of four strategic theory papers, the application of a company's "dynamic capabilities" in a supply chain context, thus following a theory of dynamic capabilities (DC), is increasingly popular in SCM literature reviews (e.g. Chicksand *et al.*, 2012; Greening and Rutherford, 2011; Li *et al.*, 2008). A rationale for the frequent use of DC theory, in comparison to other strategic management theories, may be found in the development of DC as having its roots within the resource-based view of the firm (Teece, 2007). This is confirmed as the analysis showed a matching pattern where all articles utilizing DC theory also made use of RBV theory. Curiously, despite the operational character of the approach, no literature review was published in an OPS journal.

The review identified a variety of rarely used strategic management theories, almost all published solely in SCM journals, such as “knowledge based view theory” (Carter and Easton, 2011; Defee *et al.*, 2010; Liao-Troth *et al.*, 2012), “resource advantage theory” (Hazen and Byrd, 2012; Defee *et al.*, 2010; Liao-Troth *et al.*, 2012), and “stakeholder theory” (Carter and Easton, 2011; Defee *et al.*, 2010; Sarkis *et al.*, 2011). As especially the knowledge based view and the resource advantage theory are expected to offer great potential to increase the theoretical understanding of SCM, in particular in an environment where resources are increasingly scarce and thus provide the opportunity to turn sustainable resource usage into a business advantage, their usage in SCM research is strongly recommended (Hunt and Davis, 2008). This is in line with the understanding that knowledge is a special strategic resource, enabling coordination in the supply chain and essentially being a key enabler for the driving of competitive advantage (Grant, 1996).

6.6.3 Operations management theory

For some reason the 103 literature reviews assessed did not include any of the theories outlined by Schmenner and Swink (1998), namely the Theory of swift and even flow or the Theory of performance frontiers. Nevertheless, as a database search using Google Scholar revealed, a range of well-cited SCM research articles using these theories exist, underlining their suitability in explaining SCM phenomena. However, these articles were not covered as samples in any of the literature reviews examinied for this work and thus are not part of the assessment. A thorough review of the literature reviews’ samples showed potential reasons for non-inclusion of these articles in the sample literature reviews. Either the subject of the article using Schmenner and Swinks’ approach did not fit any of the literature reviews’ scope (e.g. Seuring, 2009), or the publication date of the articles was beyond the timeline scope of the literature review (e.g. Yoho and Simons, 2013).

Although not fitting into the Theory of swift and even flow or the Theory of performance frontiers, eight articles containing "other theory" were found to fit the operations management theory group (Table 6.17, p. 141).

Category (level 2) Sub-category (level 3)	**Count all articles (n=103)**	**% of all articles**	**Count SCM articles only (n=62)**	**% of SCM articles**	**Count OPS articles only (n=41)**	**% of OPS articles**
6.3 Operations management theory	**8**	**8%**	**3**	**5%**	**5**	**12%**
Theory of swift and even flow	0	0%	0	0%	0	0%
Theory of performance frontiers	0	0%	0	0%	0	0%
Other theory	8	8%	3	5%	5	12%

Table 6.17: Aspects of operations management theory
(Source: Author)

These articles describe fundamental aspects inherent to operations management, such as "bullwhip theory" (Mills *et al.*, 2004), "general inventory theory" (Defee *et al.*, 2010), or the "theory of multi-objective optimization," outlined by Afshin Mansouri *et al.* (2012). As it can be argued that these theories aim to explain phenomena on which Schmenner and Swink's theory is rooted in, they essentially supplement the two major theories. Especially the theory of constraints (TCO), being the most often referred to operations management theory in the literature reviews (Chicksand *et al.*, 2012; Jain *et al.*, 2009; Liao-Troth *et al.*, 2012), is well in line with the thinking of Schemmer and Swink, who explicitly outlined the use of the "law of bottlenecks", being a fundamental paradigm of the tactical TCO approach as proposed by Goldratt (1989). In essence, the TCO portrays a concept of ongoing improvement in the management of flows, where the identification and exploitation of bottlenecks is utilized to improve overall system performance.

In terms of journal publications, the assessment found that the majority of literature reviews was published in OPS journals, underlining the origins of operations management theory. However, the management of flows and performance improvements, especially quality, should be a core consideration and a major focus of every supply chain operation. The use of operations management theory in an SCM context may thus be a suitable means to foster SCM theory building. It can be noted that although the use of the Schmenner and Swink's theories is not evident in the literature under review, some fundamental aspects of these theories were well covered as part of other operations management theories. Nevertheless, although it is unquestionable that the set of theories by Schmenner and Swink provides valuable explanations on supply chain aspects, especially concerning the measurement of across-factory performance required for the installation and execution of supply chain rewards as well as incentive structures, the theories' contribution in advancing SCM theory is still to be assessed.

6.6.4 Psychological / sociological theory

Underlining the importance of the personal relationship level in SCM, for example in developing mutually beneficial, trustful relationships, highlighted by a range of articles (e.g. Golicic *et al.*, 2003; Hammervoll, 2011; Pettit and Beresford, 2009), a vivid use of psychological and sociological theory usage is apparent in the literature reviews, accounting for roughly a quarter of all reviews (Table 6.18, p. 142).

Category (level 2) Sub-category (level 3)	Count all articles (n=103)	% of all articles	Count SCM articles only (n=62)	% of SCM articles	Count OPS articles only (n=41)	% of OPS articles
6.4 Psychological / sociological theory	**28**	**27%**	**21**	**34%**	**7**	**17%**
Organizational learning theory	4	4%	2	3%	2	5%
Behavioral science theory	6	6%	6	10%	0	0%
Contingency theory	7	7%	5	8%	2	5%
Inter-organizational networks	9	9%	7	11%	2	5%
Other theory	11	11%	8	13%	3	7%

Table 6.18: Aspects of psychological / sociological theory
(Source: Author)

This contrasts with the findings by others (Burgess *et al.*, 2006) who identified psycho-sociological theories as being the least featured theories in SCM research. The reason may be found in the breadth of the research sample of the on-hand study, as a large portion of literature reviews also discussed aspects of collaboration between individuals within the supply chain (refer to section 6.3.1, p. 94) or in regard to leadership (see section 6.3.5, p. 101), which all show links to psychological and sociological theory.
The application of organizational learning theory (OL), which depicts the concept of learning routines, aiming for the streamlined exchange of knowledge, was evident in four articles only. The articles containing OL largely focussed on aspects of company overarching learning, which Terpend *et al.* (2008) identified as a key enabler for the success of buyer-supplier relationships. In a similar direction, Sarkis *et al.* (2011), although referring to "inter-organizational learning theory", gave special consideration to the collaborative aspect of SCM. The low frequency of OL theory usage is in line with previous findings where OL theory was found to be under-represented (Burgess *et al.*,

2006). Nevertheless, this raises the question as to why the ideas of OL theory are apparently getting little attention by SCM researchers, although the importance of learning in SCM is long known. Thus, learning can act as a suitable vehicle to equip the workforce with higher levels of supply chain competence (Bessant *et al.*, 2003), which in turn is a prerequisite for increasing overall supply chain performance. Researchers are therefore encouraged to make increased use of OL theory in an SCM context, for example through harnessing the collaborative possibilities of social software in an enterprise environment (Görtz, 2011), which is expected to potentially optimize the exchange of knowledge in distributed global supply networks.

Six articles made use of the theory of behavioral science, which aims to describe why people behave the way they do. Given the fundamentality of this question, behavioral science theory has long been an integral aspect of a variety of disciplines such as medical education (Jackson, 1997). Simon (1959) was the first do describe the applicability of behavioral science theory in an economics context, where the impact of the human decision-making was a focal point. However, the articles making use of behavioral science theory rarely discussed this aspect. Coming closest, the importance of decision theory with regard to behavioral supply management was outlined in the review by Carter and co-authors (2007) who developed a taxonomy of judgment and decision-making biases. Links to game theoretical approaches, as described in section 6.6.1, are evident in this regard, as parties tend to leverage their knowledge only for their own benefit, rarely reverting to altruistic behavior. Other authors (Defee *et al.*, 2010) identified a range of theories from the behavioral sciences applicable in SCM, such as behavioral decision theory, strategic behavior theory, and the theory of channel behavior, although without providing further details on how to apply these theories in a SCM context. In contrast, being a very specific example, Williams *et al.* (2008) highlighted the value of social behavior and socialization theory for addressing supply chain security issues.

As the behavior of humans is hard to predict, it is – from a supply chain perspective – important to understand and manage this source of uncertainty in order to reduce risks. Especially the role of the customer, being the ultimate governing entity of the supply chain (Lee, 2002), needs to be considered here. Given the opportunities, which unfold from integrating customer data from loyalty programs with information technology, such as data analytics, the application of behavioral science theory provides a powerful tool box. This should be leveraged by researchers and practitioners alike, working towards a better understanding of buying behavior which, through the application of mathematical models on ever growing datasets, eventually allows to "predict" the customers future behavior based on past behavior. Ultimately, this vision bears great potential for deriving a distinctive, unique competitive advantage for the supply chain.

Contingency theory usage was mentioned in a comparably large section of all theory-oriented articles (24% of all theory articles), which mirrors the findings by Defee *et al.* (2010). The rationale of contingency theory is that no best way of organizing a company exists, and that the right choice of actions to take appropriate decisions is contingent, meaning dependent, on the situation at hand (Fiedler, 1965). Portraying the links of the theory to the leadership paradigm (see section 6.3.5, p. 101), an effective leader intuitively utilizes the right leadership style in the right situation. The usefulness of contingency theory in a business context has been described by a range of authors who underlined its role in describing behavioral patterns, adding to theory development in accounting (Otley, 1980) and management strategy (Hofer, 1975). Taking a supply chain view, the sample of literature used in the review by Defee *et al.* (2010) highlighted the use of contingency theory, especially in inter-corporate relationship related areas of business, most notably within the buyer-supplier relationship of the purchasing function. This view was shared by other literature reviews (Chicksand *et al.*, 2012; Terpend *et al.*, 2008). Thus, the explicit value of contingency theory in SCM is evident through the application of contingent leadership support which is crucial in determining the *"timing and extent of supplier integration in new product development"* (Parker *et al.*, 2008, p. 71), or in resolving conflicts in buyer-supplier communication (Claycomb and Frankwick, 2004).

Building on the collaborative nature of SCM which is fuelled by inter-organizational networks, based on external social ties between employees (Kraatz, 1998), the theory of inter-organizational networks was identified as the most frequently used theory in SCM literature reviews, shared by a third of the psychological / sociological theory reviews. This contrasts the findings by Burgess *et al.* (2006), presumably based on research sampling reasons; but is in line with the review results by Defee *et al.* (2010), stating that theories of organization were among the most frequently used in SCM and logistics research.

The emergence of the inter-organizational network theory can be traced back to the social network theory (Simmel, 1950) and social exchange theory (Emerson, 1976), used in the social sciences to explain social behavior and social dynamics in relationships between entities (Brass *et al.*, 1998; Sih *et al.*, 2009). Within the management sciences, an early focus was to advance the inter-organizational network theory, moving beyond dyadic relationships in networks towards a multi-part network of relationships (Rowley, 1997). This multi-relationship approach justifies the applicability of the theory in a supply chain environment. The applicability is underlined by the previously outlined results from the “SCM view of literature” category (section 6.1.1, p. 86) which highlighted SCM researchers’ interest in multi-echelon relationships, whereas dyadic relationships gained little interest (e.g. Gunasekaran and Ngai, 2007; Naim and Gosling, 2011).

On a detailed level, the review by Babbar and Prasad (1998b), following an approach by Thorelli (1986), utilizes organizational network theory with regard to purchasing and inventory management, in order to aid in assessing the right level of supply chain control. Outlining the value of inter-organizational network theory in increasing the security of supply, Greening and Rutherford (2011) built a case to aid understanding and minimize disruptions in supply networks, an area of considerable economic importance and high sensitivity to human error.

Taking a more holistic perspective, it can be argued that the value of inter-organizational networks theory, being rooted in collaboration as the very foundation of SCM, can be linked to the idea that collaboration within a supply chain entity is crucial for organizational learning. This is of growing interest as the networks extend beyond the dyad, which makes a dissemination of knowledge increasingly more challenging. The effect is expected to intensify the more nodes are included in knowledge-sharing. Organizational learning theory has mapped a variety of tools to enable distributed learning as outlined above. However, interestingly, although inter-organizational network theory and organizational learning theory are both dependent on the collaborative paradigm, no literature review article could be identified to deal with the question of how inter-organizational network theory and organizational learning theory can be linked to provide a theoretical framework for distributed collaborative learning and knowledge-sharing in a supply chain environment. Although this is a rather “soft” topic of SCM, following Ellinger and co-authors (2013), the potential of harnessing the distributed knowledge of the employees is not to be underestimated. As such, distributed learning, which is essentially knowledge sharing, increases work force productivity by reducing duplicate work, which saves costs and ultimately impacts on company performance, aspects long-known to SCM researchers in regard to the sharing of information (Mentzer *et al.*, 2001).

Summing up the findings from the "Theoretical foundation" dimension and following the ideas of Eisenhardt and Schoonhoven (1996), who postulated that the RBV and TCE theories could be seen as the most prominent but also competing theories explaining the performance of the firm, the literature review provides analytical proof as the RBV and TCE were identified as the most frequently used theories in SCM-focused literature. Following similar results from other authors (Defee *et al.*, 2010), it can be argued that these theories form the core theoretical foundation of SCM from a literature point of view.
However, as the *"pre-occupation with a few existing theories (in their singular form) may not be sufficient to describe the field* [of SCM] *completely"* (Burgess *et al.*, 2006, p. 717), the sample was assessed to distill other theories used in the realm of SCM, not previously identified to be included in the clusters of economic, strategic management, psychological / sociological, and operations management theory. As a result, a range of theories was inductively identified during the review as presented in the above sections. Aiming to formalize the loosely connected nature of supply networks, some literature reviews proposed the application of a range of structuring theories such as "chaos theory" (Ellis *et al.*, 2011; Liao-Troth *et al.*, 2012), "complexity theory" (Ghadge *et al.*, 2012; Sarkis *et al.*, 2011), "control theory" (Akyuz and Erkan, 2010; Chan and Chan, 2010), "conflict theory" (Terpend *et al.*, 2008), or "coordination theory" (Kanda and Deshmukh, 2008, Skipper *et al.*, 2008). The use of these theories was rather sporadic and limited to single papers. However, given the research problems which are inherent to an unstructured subject of research, such as supply networks, these structuring theoretical concepts, which are tightly linked to the structuring theorem of Hunt (1971), could help to formalize the dynamics in distributed networks. Based on such formalized descriptions, researchers would be able to develop models which might in the end provide answers or even predictions towards the question as to why companies engage in cooperating with certain other companies, e.g. what is the "secret formula" in supply chain collaboration. As supply chains increasingly fragment into networks of specialized entities, such research could well be beneficial to help solve problems tied to partner allocation optimization, supporting the matching of companies, aiming to extract the

"best company fit", which in return reduces the risk of mismatched partnerships and cost associated.

From the author's perspective the above presented theories are likely to provide fruitful insights to aid the general progression of SCM into a discipline, driven by the understanding that SCM is of over-arching nature (Ellram and Cooper, 2014) and thus perfectly suited to make use of neighboring disciplines' theoretical constructs. The in-depth investigations into how the theories can be leveraged in order to develop a "theory of SCM" required for SCM to develop into a discipline of its own (Chicksand *et al.*, 2012), however, are left to further research and are thus not the subject of this work.

6.7 Contingency analysis

In the previous chapters, the various categories and sub-categories were presented and extensively assessed using content analysis. This allowed for a mapping of topics within SCM, outlining the key research areas in SCM, but also highlighting areas which provide fruitful starting points for further in-depth investigation. However, until now the categories were – apart from a few exceptions as presented throughout chapter 6 – only assessed by viewing them as largely isolated stand-alone units. This procedure holds true for both categories and sub-categories. Although this stand-alone assessment via the content analysis methodology already yielded a plethora of results, it is substantially limited in supporting a holistic, multi-dimensional view towards the assessment of the categories. A systematic analysis of potential interrelations between the categories, which would overcome these limitations, thus requires the application of a more differentiated assessment method.

In order to detect association patterns and links between pairs of categories, various authors, for example Gold *et al.* (2010) and Krippendorff (2012), have proclaimed the use of the contingency analysis methodology. In essence, the application of contingency analysis allows to distill "interesting" connections (Weick, 1989) between categories, based on a comparison of past experience. This underlines the enabling character of the contingency analysis method in regard to the development of theory.

In a broader sense, the application of contingency analysis links to previous scholars' work who have long strived to formulate unifying statements about the interrelationship of a range of elements of SCM, but without reaching consent and general acceptance within the scientific community. Focussing for example on the long-suspected interrelationship of the two elements of supply chain integration and supply chain performance, Fabbe-Costes and Jahre (2007) pinpoint the problems associated to the interrelationship by stating that *“integration as well as performance is defined, operationalised and measured in different and often limited ways”* (p. 835). Further suspected links between elements of SCM, such as the reciprocal relationship between supply chain performance and supply chain collaboration through coordination, highlighted in the literature review by Chan and Chan (2010) and indicated in section 6.3.1, also lack a statistically sound foundation.

The application of contingency analysis to the categories, as presented later in this work, may yield a better understanding of the elements and their interrelations.

However, it needs to be stated that the connection between constructs as identified for example in literature reviews is of limited informative value to explain the connection of these constructs in a real-world example as it rather constitutes a theoretical, interpretive connection. Thus, the application of the standardized contingency analysis approach enables a mathematically and statistically sound rationale of the interrelationships from a theoretical literature-based point of view, thereby closing a research gap while contributing to theorizing in SCM along the 26 categories.

Due to the characteristics of the research sample, following other researchers’ example (Gold *et al.*, 2010), and based on common statistical theory (Mehta and Patel, 1983; Routledge, 1998), Fisher’s Exact Test of statistical significance will be applied along with the assessment of the ϕ-value (section 3.3, p. 29ff). The rational for the application of Fisher’s Exact Test being that the sample size of 103 literature reviews is relatively small, the data is unequally distributed across the cells in the table (representing the six dimensions, 26 categories and 68 sub-categories) and the row and column totals are fixed (as no new reviews will be added to the dataset during the contingency analysis phase).

6.7.1 Application of contingency analysis to literature review dataset

The dataset derived from the content analysis codings included 26 categories (level 2) which account for 325 category pairs (this can be calculated by the use of the binominal coefficient $\binom{26}{2} = \frac{26!}{2!\,24!} = 325$). Thus, each category from every dimension was compared, even across dimensions, in order to generate potentially meaningful insights with regard to the interrelations of the categories. In addition, this approach seemed suitable as potentially aiding the validation of the previously conducted category’s clustering into the respective dimensions.

In the first step of the contingency analysis, the 325 category pairs were assessed for statistical significant correlations. Each pair was analyzed one by one using the “Crosstabs” function of the statistical software package SPSS 16.0, which supports the application of Fisher’s Exact Test of statistical significance. For the aim of this study the author was interested in answering the question as to whether the categories were interrelated or not. Thus, only *p*-values of one-sided Fisher’s Exact Test were provided.

Backhaus and co-authors (2008) postulated that ϕ-values larger than .300 indicate relevant links. Following their recommendation the assessment of the results was focussed on the category pairs with a ϕ-value equal or greater than .300, and *p*-values of Fisher’s Exact Test less or equal than the one-sided significance level 0.05. Accordingly, the 304 category pairs with a non-significant result of Fisher’s Exact Test or ϕ values below .300 were omitted from further analysis as they did not yield a relevant correlation as per the above definition. The resulting final set of 38 category pairs showed a substantial spread, ranging from $\phi = .300$ to $\phi = .610$. For better clarity the relevant pairs are outlined in Table 6.19 (p. 151).

Dimension cluster	Category pairs*	Expected relative frequency count (%)ª	Observed relative frequency count (%)ª	Exact significance (one sided)	Phi coefficient (ϕ)
Level of SCM analysis	SCV - CFR	90.4 (87.77)	94 (91.26)	.000	.610
Theoretical foundation	ECT - SMT	8.1 (7.86)	18 (17.48)	.000	.486
Level of SCM analysis & Collaboration / Integration	BSF - COL	81.2 (78.83)	86 (83.50)	.000	.479
Orientation of SCM	TFW - DFW	39.8 (38.64)	51 (49.51)	.000	.475
Level of SCM analysis & Collaboration / Integration	SCV - COL	84.7 (82.23)	88 (85.44)	.001	.438
Collaboration / Integration & Strategy	COL - IT	58.8 (57.09)	66 (64.08)	.000	.433
Collaboration / Integration	COL -INT	70.9 (68.83)	77 (74.76)	.000	.432
Level of SCM analysis	CFR - BSF	86.7 (84.17)	90 (87.38)	.002	.424
Level of SCM analysis & Collaboration / Integration	CFR - COL	82.1 (79.71)	86 (83.50)	.001	.414
Level of SCM analysis	SCV - BSF	89.4 (86.80)	92 (89.32)	.004	.410
Level of SCM analysis & Risk / Performance	CFR - PER	76.6 (74.37)	81 (78.64)	.001	.408
Collaboration / Integration	COL - IFS	44.9 (43.59)	52 (50.49)	.000	.400
Strategy	CPA - IT	36.3 (35.24)	46 (44.66)	.000	.398
Collaboration / Integration & Risk / Performance	COL - PER	71.7 (69.61)	77 (74.76)	.001	.378
Orientation of SCM & Risk / Performance	TFW - PER	58.0 (56.31)	65 (63.11)	.000	.374
Level of SCM analysis & Orientation of SCM	CFR - TFW	66.4 (64.47)	71 (68.93)	.001	.363
Theoretical foundation	SMT - PST	7.6 (7.38)	15 (14.56)	.000	.362
Orientation of SCM & Collaboration / Integration	DFW - IFS	28.8 (27.96)	38 (36.89)	.000	.360
Collaboration / Integration	IFS - PIO	26.8 (26.02)	36 (34.95)	.000	.359
Level of SCM analysis & Risk / Performance	SCV - PER	79 (76.70)	82 (79.61)	.005	.346
Level of SCM analysis & Orientation of SCM	SCV - TFW	68.5 (66.50)	72 (69.90)	.002	.344
Strategy	PLN - TMS	5.1 (4.95)	11 (10.68)	.001	.337
Collaboration / Integration & Strategy	LSP - IT	15.2 (14.76)	22 (21.36)	.000	.335
Risk / Performance & Strategy	PER - LAS	58.8 (57.09)	65 (63.11)	.002	.334
Level of SCM analysis & Risk / Performance	CFR - RSK	71 (68.93)	75 (72.82)	.003	.332
Collaboration / Integration & Risk / Performance	IFS - RWS	20.7 (20.1)	29 (28.16)	.001	.329
Level of SCM analysis & Strategy	CFR - IT	62.7 (60.87)	67 (65.04)	.002	.328
Strategy	CUF - CPA	25.6 (24.85)	34 (33)	.001	.327
Orientation of SCM & Strategy	TFW - LAS	51.0 (49.51)	58 (56.31)	.002	.325
Risk / Performance & Strategy	PER - IT	54.8 (53.20)	61 (59.22)	.003	.321
Strategy	INO - LAS	26.9 (26.11)	34 (33)	.002	.313
Collaboration / Integration & Strategy	COL - LAS	63.1 (61.26)	68 (66.01)	.004	.307

Dimension cluster	Category pairs*	Expected relative frequency count (%)ª	Observed relative frequency count (%)ª	Exact significance (one sided)	Phi coefficient (ϕ)
Collaboration / Integration & Strategy	LSP - TMS	4.0 (3.88)	9 (8.73)	.004	.306
Level of SCM analysis & Collaboration / Integration	CFR - INT	75.6 (73.39)	79 (76.69)	.008	.303
Strategy & Theoretical foundation	INO - SMT	10.3 (10)	17 (16.5)	.003	.302
Orientation of SCM & Risk / Performance	DFW - PER	45.9 (44.56)	52 (50.48)	.005	.300
Collaboration / Integration & Risk / Performance	INT - PER	66.1 (64.17)	71 (68.93)	.005	.300
Strategy	CUF - IT	31.7 (30.77)	39 (37.86)	.003	.300

ª Figures are rounded.
* Acronym codes:

Code	Category	Code	Category	Code	Category
BSF	Business functions involved in SCM	INT	Integration	PST	Psy. / soc. theory
CFR	Conceptual framing of SCM	IT	Information technology	RSK	Supply chain risk
COL	Collaboration	LAS	Lean and agile supply	RWS	Rewards-sharing / benefits
CPA	Competitive advantage	LSP	Leadership	SCV	SCM view of literature
CUF	Customer focus	OMT	Operations mngt theory	SMT	Strategic management theory
DFW	Direction of flow	OUT	Outsourcing	SUS	Sustainability
ECT	Economics theory	PER	Supply chain performance	TFW	Types of flow
IFS	Information-sharing	PIO	Process improvement orientation	TMS	Top management support
INO	Innovation	PLN	Supply chain planning		

Table 6.19: Contingency analysis results (ϕ-values ≥ .300)
(Source: Author)

In order to prepare for a systematic assessment of the category pairs and to structure the results of the contingency analysis, it seemed reasonable to apply a three-layer correlation grading to the ϕ-values (Table 6.20, p. 151).

Correlation grading	Associated Phi (ϕ) range
Strong correlation	.330 ≤ ϕ ≤ 1
Moderate correlation	.300 ≤ ϕ < .330
No / weak correlation	ϕ < .300

Table 6.20: Correlation grading scale used for contingency analysis
(Source: Author)

The design of the applied correlation grading, used for the assessment of the contingency analysis, was governed by the idea to cluster the distribution of ϕ-values, thereby supporting a more structured assessment of the category pairs. In addition, the increased granularity enables a more focussed assessment of the specific drivers within each group, also allowing for a comparison between the groups in order to derive further insights. Following this balanced approach, three clusters were defined:

- All category pairs with no or only a weak correlation were collected in one group, where no or a weak correlation is defined by ϕ-values below .300.
- A moderate correlation is apparent when the ϕ-value is equal or larger than .300 but smaller than .330. Fourteen category pairs qualify for this correlation grading.
- The remaining pairs (24 pairs) showed a strong correlation as per definition ($\phi \geq .330$) and were categorized accordingly.

The author is aware that the chosen correlation grading may represent a source of bias and potentially limit further analysis. Nevertheless, the author followed the recommendations of Lambdin (2012) and Rice (1989) whereas the selection of the most appropriate ϕ-value for the definition of a relevant link is ultimately subject to the researcher's inherent intention. In this case the cut-off ϕ-value for category pair inclusion was set to ≥ .330 as this provided a sufficient yet manageable amount of interesting category pairs for further analysis (24 pairs). However, although the inclusion of all ϕ-values below a .330 threshold would likely lead to more granular results, the potentially limited increase of detail did not justify the inclusion of all ϕ-values from a resource perspective. Nevertheless, an exception to the .330 threshold was made as two moderate correlations were included in the final set (Information-sharing and rewards-sharing: $\phi = .329$; Integration and performance: $\phi = .300$). The rationale being that these two pairs were identified as probably being relevant from a "functional scope of SCM" perspective within the correlation network of categories, also providing valuable insights on a sub-category assessment level as identified during the assessment process. Furthermore, the grading was deemed necessary in order to provide a structure required for the subsequent assessment of correlated category pairs. Allowing for a more granular assessment of category correlations, the author analyzed the respective sub-categories of strongly and moderately correlated category pairs. This was conducted as the second step of the contingency analysis, aiming to derive more precise information regarding the exact position of an identified category interdependency. For each of the pairs the statistical significance was calculated with the help of SPSS using Fisher's Exact Test, following the procedure as described previously.

In total, 533 sub-category pairs were assessed as the 26 relevant category pairs (24 strong and two moderate correlations) each contained up to 65 level three sub-category items, following the level hierarchy structure as outlined in Table 4.2 (p. 36). To fully leverage the value of the sub-categories in the subsequent assessment, all sub-categories with a statistically significant *p*-value of Fisher's Exact Test and a ϕ-value equal or greater than .300 were considered for further analysis. The resultant set of 33 sub-category pairs, along with the 26 higher level "parent" category pairs, 24 strong and two moderate correlations (Information-sharing – Rewards-sharing; Integration – Performance) will be presented in section 6.7.2 (p. 153ff). For reasons of clarity and to ease the flow of the subsequent presentation, the category and sub-category pairs have been grouped according to their governing literature review dimensions, resulting in the formation of dimension clusters (see Table 6.19, p. 151). However, putting the results into perspective and as outlined by Diekmann (2002), it should be noted that a statistically significant association between two categories does not automatically constitute a semantic association within the 103 sample literature reviews.

6.7.2 Results and findings of the contingency analysis assessment

The results of the contingency analysis will be outlined in the following along the dimension cluster structure as presented in Table 6.19 (p. 151).

Dimension cluster "Level of SCM analysis"

The contingency analysis indicates the strongest correlation of all assessed category pairs in the "Level of SCM analysis" dimension, most notably between the SCM view of literature category and the applied conceptual framing of SCM (ϕ = .610). To determine the exact drivers of the correlation, an in-depth analysis of this category pair at its sub-categories was conducted. The results (Table 6.21, p. 154) revealed that the statistical significance of the correlation is strongest in two areas, namely between viewing SCM from the "network" perspective, as proposed by Halldórsson and Arlbjørn (2005), while depicting its framing as a holistic "system" (ϕ = .413), and to a lesser degree between the view of SCM as being a "chain" and its "process" character (ϕ = .355). These findings underline the integrative overarching character of SCM (Burgess *et al.*, 2006), adding to justify its positioning as an own area of research among the management disciplines, as proclaimed by authors such as Cousins *et al.* (2006).

Following Cooper *et al.* (1997), business functions are essential for successful SCM. The value of the business functions within the SCM concept is apparent in the contingency analysis results, as the business functions involved in SCM are tightly correlated to the conceptual framing of SCM and the SCM view of literature within the

“Level of SCM analysis” dimension (ϕ = .424 and ϕ = .410, respectively). The sub-category analysis highlights, that the main statistically significant connection between the categories is through the business function of “production”, which sums up all manufacturing related aspects. The contingency analysis results support the view that the production function is best leveraged when the production activities are “process”-oriented (ϕ = .320) and executed in a “chain” environment (ϕ = .344). This is well in line with the development of SCM, as the advantages of SCM were first operationalized through the application of process-oriented manufacturing techniques. The focus on operating efficiency eventually triggered a closer engagement across company boundaries as companies began to realize that the key to market success required a chain-oriented view to manufacturing, utilizing special capabilities for the benefit of all (Tang and Nurmaya Musa, 2011). From a structural point of view, the high density of statistically significant category pairs in the “Level of SCM analysis” dimension may be rooted in the nature of this dimension as somehow “setting the scene” in research projects, providing foundational aspects upon which the other dimensions in the literature reviews assessed were built on.

Dimension cluster	Category pairs*	Sub-category pairs (where applicable)*	Expected relative frequency count (%)[a]	Observed relative frequency count (%)[a]	Exact sig. (one sided)	Phi coefficient (ϕ)
Level of SCM analysis	SCV - CFR		90.4 (87.77)	94 (91.26)	.000	.610
		network - system	14.7 (14.27)	24 (23.3)	.000	.413
		chain - process	74.3 (72.13)	79 (76.69)	.002	.355
	CFR - BSF		86.7 (84.17)	90 (87.38)	.002	.424
		process - production	51.3 (49.8)	57 (55.33)	.001	.320
	SCV – BSF		89.4 (86.80)	92 (89.32)	.004	.410
		chain - production	60.8 (59.02)	66 (64.07)	.004	.344

[a] Figures are rounded.
* Category acronym codes:
BSF Business functions involved in SCM | CFR Conceptual framing of SCM | SCV SCM view of literature

Table 6.21: List of statistically significant correlations in the dimension cluster “Level of SCM analysis”
(Source: Author)

Dimension cluster “Level of SCM analysis & Collaboration / Integration”

Accordingly, the “Level of SCM analysis” dimension shows links to the “Collaboration / Integration” dimension. Thus, the type of collaboration between entities within a supply chain is largely defined by the business functions involved (ϕ = .479) as well as being influenced by the setup of the overall supply chain, namely the view (ϕ = .438) and the framing (ϕ = .414) of the supply chain (Table 6.22, p. 155).

Whereas the "production" business function was a main interconnecting aspect between the categories within the "Level of SCM analysis" dimension, as outlined above, this does not hold true when assessing cross-dimension interdependencies for example between the "Level of SCM analysis" dimension and the "Collaboration / Integration" dimension. As such, a connection between the two dimensions is manifested at sub-category level through the "materials management and logistics" business function, which has a key role in fostering collaboration, most notably internally between departments (ϕ = .334). This is in line with the finding that especially internal collaboration is driven by the functional levels (ϕ = .342). The overarching process of SCM execution, however, requires a certain degree of external collaboration, supported by the analysis which revealed a significant correlation between the conceptual framing and collaboration categories (ϕ = .338).

Dimension cluster	Category pairs*	Sub-category pairs (where applicable)*	Expected relative frequency count (%)ª	Observed relative frequency count (%)ª	Exact sig. (one sided)	Phi coefficient (ϕ)
Level of SCM analysis & Collaboration / Integration	BSF - COL		81.2 (78.83)	86 (83.50)	.000	.479
		material logistics - internal	32.2 (31.26)	40 (38.83)	.001	.334
	SCV - COL		84.7 (82.23)	88 (85.44)	.001	.438
		function - internal	26.3 (25.53)	35 (33.98)	.000	.342
	CFR - COL		82.1 (79.71)	86 (83.50)	.001	.414
		process - external	70.1 (68.05)	75 (72.81)	.002	.338

ª Figures are rounded.
* Category acronym codes:
BSF Business functions involved in SCM
SCV SCM view of literature
CFR Conceptual framing of SCM
COL Collaboration

Table 6.22: List of statistically significant correlations in the dimension cluster "Level of SCM analysis & Collaboration / Integration"
(Source: Author)

Dimension cluster "Level of SCM analysis & Risk / Performance"

The chosen conceptual framing of the supply chain as well as the supply chain view impact on overall supply chain performance (ϕ = .408 and ϕ = .346), thus linking the "Levels of SCM analysis" and "Risk / Performance" dimensions (Table 6.23, p. 156). However, the analysis did not yield additional statistically significant details at sub-category level. Thus, no results can be obtained on how exactly the conceptual framing impacts on supply chain performance. Accordingly, due to the lack of specifying data, it will be argued that a correlation between the categories exists, but rather at a more holistic category level.

Dimension cluster	Category pairs*	Sub-category pairs (where applicable)*	Expected relative frequency count (%)ª	Observed relative frequency count (%)ª	Exact sig. (one sided)	Phi coefficient (ϕ)
Level of SCM analysis & Risk / Performance	CFR - PER		76.6 (74.37)	81 (78.64)	.001	.408
	SCV - PER		79 (76.70)	82 (79.61)	.005	.346

ª Figures are rounded.
* Category acronym codes:
CFR Conceptual framing of SCM | PER Supply chain performance | SCV SCM view of literature

Table 6.23: List of statistically significant correlations in the dimension cluster "Level of SCM analysis & Risk / Performance"
(Source: Author)

Dimension clusters "Orientation of SCM & Risk / Performance" and "Orientation of SCM"

The performance of the supply chain is subject to the respective type of flow between supply chain partners (ϕ = .374), which in return is associated with the direction of flows (ϕ = .475) within the "Orientation of SCM" dimension (Table 6.24, p. 157). As material and information are key flows within a supply chain, these were also found to be the bridging aspects between the type of flow and direction of flow categories, showing a statistically significant correlation in both up and downstream directions (material: upstream ϕ = .363, downstream ϕ = .361; information: upstream ϕ = .319, downstream ϕ = .335). In terms of financial flow, a positive correlation could only be identified in the downstream direction (ϕ = .319). This is somewhat surprising as financial flows, as opposed to for example the materials flow, would have been expected by the author to be rather upstream-focused. The rationale is that in an usual business setup money is exchanged for goods and thus travels upstream to the goods-providing party. An explanation for this unusual finding may partially be rooted in the business practice of a range of companies as they bundle product sales with financing services, in essence providing loans to the purchasing company in order to drive their own sales. Such services, however, constitute rather a kind of indirect financial flow, as no funds are transferred directly to the goods receiving company.

Dimension cluster	Category pairs*	Sub-category pairs (where applicable)*	Expected relative frequency count (%)ª	Observed relative frequency count (%)ª	Exact sig. (one sided)	Phi coefficient (ϕ)
Orientation of SCM & Risk / Performance	TFW - PER		58.0 (56.31)	65 (63.11)	.000	.374
Orientation of SCM	TFW - DFW		39.8 (38.64)	51 (49.51)	.000	.475
		material - upstream	32 (31.06)	41 (39.8)	.000	.363
		material - downstream	30.1 (29.22)	39 (37.86)	.000	.361
		information - downstream	21.4 (20.77)	30 (29.12)	.001	.335
		information - upstream	22.8 (22.13)	31 (30.09)	.001	.319
		finance - downstream	6.4 (6.21)	12 (11.65)	.001	.319

ª Figures are rounded.
* Category acronym codes:
DFW Direction of flow | PER Supply chain performance | TFW Types of flow

Table 6.24: List of statistically significant correlations in the dimension clusters "Orientation of SCM & Risk / Performance" and "Orientation of SCM"
(Source: Author)

Dimension cluster "Orientation of SCM & Collaboration / Integration"

Interestingly, the analysis highlights how the direction of flow is significantly correlated with the degree at which information is shared between partners (ϕ = .360). A closer look at the results at sub-category level shows that this is primarily the case when information is shared in the downstream direction (ϕ = .439), although the upstream sharing of information is also evident but to a less significant degree (ϕ = .340) (Table 6.25, p. 158). In a supply chain setup, vital information is usually shared upstream, for example sales and production forecast data on which partners build their production schedule. Thus, it would have been expected by the author that the upstream sharing of information is correlated to a more significant degree than the downstream sharing of information. The dominance of the downstream direction in information-sharing may be explained as parties utilize their position and power in the supply chain, pushing upstream parties to provide up-to-date data on their stock to the downstream party as a means of control to prevent stock-outs, which could cause havoc at the downstream end (Lee *at al.*, 1997). This control function, however, could also be outsourced to the upstream party, which is then contractually obligated to manage the downstream and upstream sharing of information between the parties. Such a procedure is common across a range of industries such as the automotive industry, which makes extensive use of the vendor-managed inventory (VMI) technique where the vendor takes full responsibility of his stock at the seller's site including restocking in due course for downstream production. As this requires upstream party's insights into downstream party's material requirements, this can only function if the parties have established a certain degree of trust as well as compatible data exchange mechanisms (Handfield and Bechtel, 2002).

Dimension cluster	Category pairs*	Sub-category pairs (where applicable)*	Expected relative frequency count (%)ª	Observed relative frequency count (%)ª	Exact sig. (one sided)	Phi coefficient (ϕ)
Orientation of SCM & Collaboration / Integration	DFW - IFS		28.8 (27.96)	38 (36.89)	.000	.360
		downstream - IFS	23.7 (23)	35 (33.98)	.000	.439
		upstream - IFS	25.2 (24.46)	34 (33)	.001	.340

ª Figures are rounded.
* Category acronym codes: DFW Direction of flow | IFS Information-sharing

Table 6.25: List of statistically significant correlations in the dimension cluster "Orientation of SCM & Collaboration / Integration" (Source: Author)

Dimension cluster "Level of SCM analysis & Orientation of SCM"

A significant correlation also indicates that the type of flow is closely linked to the chosen conceptual framing of the supply chain (ϕ = .363) as well as the supply chain view (ϕ = .344) (Table 6.26, p. 159). As such, the contingency analysis at sub-category level between the categories revealed that the link is strongest in a process environment where the focus is on the flow of material (ϕ = .437), supporting other authors' view that the process environment, which in essence consists of a chain of activities, is a major aspect of SCM (Lambert *et al.*, 2005). The analysis identified three statistically significant correlations between the received view of SCM and the type of flow. If SCM is viewed at the network level, it can be claimed from the results, that the flow of information is most relevant (ϕ = .409), adding to the picture that in a distributed system with loosely connected parties it is of utmost relevance to exchange information in order to enable trade (Cachon and Fisher, 2000). If SCM is viewed on the chain level only, however, the exchange of material is the key consideration as the parties are largely dependent on each other and possibilities to switch suppliers may be constrained (ϕ = .349).

In contrast and being a curious finding, the results show – if the supply chain is viewed on a function level – that the flow of services is of some importance (ϕ = .357). Aiming for a possible explanation, one could argue that this finding reflects the important role of "service" functions such as Logistics and Transportation, which provide a distinctive, yet vital service to other functions, thus ensuring overall functions' operability.

Dimension cluster	Category pairs*	Sub-category pairs (where applicable)*	Expected relative frequency count (%)ª	Observed relative frequency count (%)ª	Exact sig. (one sided)	Phi coefficient (ϕ)
Level of SCM analysis & Orientation of SCM	CFR - TFW		66.4 (64.47)	71 (68.93)	.001	.363
		Process - material	56.4 (54.75)	64 (62.13)	.000	.437
	SCV - TFW		68.5 (66.50)	72 (69.90)	.002	.344
		network - information	25.6 (24.85)	36 (34.95)	.000	.409
		function - services	8.6 (8.34)	15 (14.56)	.000	.357
		chain - material	55.7 (54.07)	62 (60.19)	.001	.349

ª Figures are rounded.
* Category acronym codes:
CFR Conceptual framing of SCM | SCV SCM view of literature | TFW Types of flow

Table 6.26: List of statistically significant correlations in the dimension cluster "Level of SCM analysis & Orientation of SCM" (Source: Author)

Dimension cluster "Collaboration / Integration"

Within the "Collaboration / Integration" domain three strong correlations were identified, underlining the reciprocal relationship between integration and collaboration (ϕ = .432), as well as the importance of information-sharing for collaboration (ϕ = .400). Especially the statistical link between integration and collaboration justifies ex post the clustering of these items into one construct (Table 6.27, p. 160). Being the foundation for supply chain wide integration, it is paramount that the partnering companies first integrate their own functions (ϕ = .447), fostering internal collaboration, especially at functional level (ϕ = .370), before venturing into external integration efforts. This prerequisite for external integration, already indicated in Stevens' work (1989), was evident in the contingency analysis findings at sub-category level, as the internal collaboration sub-category showed a strong statistical correlation with the external integration sub-category (ϕ = .411). In addition, external collaboration is a driver of external integration (ϕ = .327). External collaboration, in return does not function without the sharing of information between parties (ϕ = .415). However, information-sharing is not only relevant for collaboration, but also serves as a fundamental driver for process improvements (ϕ = .359), especially when aiming for cross-company improvements (ϕ = .480).

Dimension cluster	Category pairs*	Sub-category pairs (where applicable)*	Expected relative frequency count (%)ª	Observed relative frequency count (%)ª	Exact sig. (one sided)	Phi coefficient (ϕ)
Collaboration / Integration	COL - INT		70.9 (68.83)	77 (74.76)	.000	.432
		internal - inward facing	16.1 (15.63)	27 (26.21)	.000	.447
		Internal - inward facing (functional)	7.1 (6.89)	14 (13.59)	.000	.370
		internal - external	27.7 (26.89)	38 (36.89)	.000	.411
		external - external	49.4 (47.96)	56 (54.36)	.001	.327
	COL - IFS		44.9 (43.59)	52 (50.49)	.000	.400
		external - IFS	41.4 (40.19)	50 (48.54)	.000	.415
	IFS - PIO		26.8 (26.02)	36 (34.95)	.000	.359
		IFS - ext. process impr.	15.7 (15.24)	27 (26.21)	.000	.480

ª Figures are rounded.
* Category acronym codes:
COL Collaboration | INT Integration | IFS Information-sharing
PIO Process improvement orientation

Table 6.27: List of statistically significant correlations in the dimension cluster "Collaboration / Integration"
(Source: Author)

Dimension cluster "Collaboration / Integration & Strategy"

Links from the "Collaboration / Integration" dimension to the "Strategy" dimension are evidently based on the contingency analysis (Table 6.28, p. 161), represented through the vital role of information technology for coordination of collaboration efforts in distributed supply chains (ϕ = .433), as well as through the guiding role of leadership for the implementation and use of information technology (IT) solutions (ϕ = .335). IT in this case seems to be a major facilitator of internal collaboration ϕ = .397), while not showing a significant statistical correlation towards external collaboration. This is an interesting result as IT systems designed for external collaboration, such as EDI, are commonly used in SCM, nevertheless this is not reflected in the results.

Dimension cluster	Category pairs*	Sub-category pairs (where applicable)*	Expected relative frequency count (%)[a]	Observed relative frequency count (%)[a]	Exact sig. (one sided)	Phi coefficient (ϕ)
Collaboration/ Integration & Strategy	COL - IT		58.8 (57.09)	66 (64.08)	.000	.433
		Internal – IT	30.4 (29.51)	40 (38.83)	.000	.397
	LSP - IT		15.2 (14.76)	22 (21.36)	.000	.335

[a] Figures are rounded.
* Category acronym codes:
COL Collaboration | IT Information technology | LSP Leadership

Table 6.28: List of statistically significant correlations in the dimension cluster "Collaboration / Integration & Strategy"
(Source: Author)

Dimension cluster "Collaboration / Integration & Risk / Performance"

The "Collaboration / Integration" domain connects to the "Risk / Performance" domain (Table 6.29, p. 162), as the degree of collaboration within the supply chain impacts on overall supply chain performance (ϕ = .378). In addition, information-sharing showed a correlation to rewards-sharing (ϕ = .329), and integration seemed to have some impact on performance (ϕ = .300). However, despite these two items being of medium correlation only, they provide fruitful insights to understand the linkage between the "Collaboration / Integration" and "Risk / Performance" domain. Thus, as an exception to the rule governing the sole use of strong correlated categories (section 6.7.1), the author also decided to include the two medium correlated categories. Aiming to distill deeper insights along the exact links of these correlation pairs, the respective sub-categories were assessed. However, the link of collaboration and performance did not bring forth any significant indication in regard to whether internal or external collaboration is more relevant for the performance of the chain. As information-sharing and rewards-sharing were not classified into sub-categories in the contingency analysis, the assessment was in this case omitted. Only the more in-depth assessment of the link between integration and performance on a sub-category level yielded interesting insights and allowed for a more precise location of the exact link (Kache and Seuring, 2014c). As such, it was found that external, supplier-facing integration is strongly correlated to customer performance (ϕ = .361). In addition, using Beamon's (1999) measurement system for supply chain performance, structured along the dimensions of "resources", "output", and "flexibility", the contingency assessment revealed that for external integration the measurement of flexibility is most suitable (ϕ = .367). In contrast, for inward-facing internal integration, especially at functional level, the performance measurement of resources was identified as being most important (ϕ = .326).

Dimension cluster	Category pairs*	Sub-category pairs (where applicable)*	Expected relative frequency count (%)ª	Observed relative frequency count (%)ª	Exact sig. (one sided)	Phi coefficient (ϕ)
Collaboration / Integration & Risk / Performance	COL - PER		71.7 (69.61)	77 (74.76)	.001	.378
	IFS - RWS		20.7 (20.1)	29 (28.16)	.001	.329
	INT - PER		66.1 (64.17)	71 (68.93)	.005	.300
		external (supplier-facing) – customer	1.4 (1.36)	5 (4.85)	.001	.361
		external - measurement (flexibility)	25.9 (25.15)	1 (0.97)	.000	.367
		inward (functional) - measurement (resources)	7.9 (7.67)	14 (13.59)	.001	.326

ª Figures are rounded.
* Category acronym codes:

COL	Collaboration	IFS	Information-sharing	INT	Integration
PER	Supply chain performance	RWS	Rewards-sharing / benefits		

Table 6.29: List of statistically significant correlations in the dimension cluster "Collaboration / Integration & Risk / Performance"
(Source: Author)

Dimension cluster "Risk / Performance & Strategy"

A strong connection also exists between the choice of the best supply strategy and the performance of the supply chain (ϕ = .334), highlighting a link between the "Risk / Performance" and the "Strategy" dimensions (Table 6.30, p. 163). The contingency analysis assessment did not provide strong statistical proof of the correlation between these categories' sub-elements, although it can be noted that agile supply strategies were the strongest correlated, yet not bearing a strong statistical significance (ϕ = .256). This is in line with modern SCM thinking, as the flexibility of agile supply systems, utilizing postponement among other strategies, is an excellent solution which allows for a rapid response to quickly changing demand patterns in a volatile market (Hiebelar *et al.*, 1998).

Dimension cluster	Category pairs*	Sub-category pairs (where applicable)*	Expected relative frequency count (%)ª	Observed relative frequency count (%)ª	Exact sig. (one sided)	Phi coefficient (ϕ)
Risk / Performance & Strategy	PER - LAS		58.8 (57.09)	65 (63.11)	.002	.334

ª Figures are rounded.
* Category acronym codes:

LAS	Lean and agile supply	PER	Supply chain performance

Table 6.30: List of statistically significant correlations in the dimension cluster "Risk / Performance & Strategy"
(Source: Author)

Dimension cluster "Strategy"

Within the "Strategy" dimension two statistically significant correlations were identified, namely between the use of IT and the competitive advantage of a company (ϕ = .398), as well as between supply chain planning and the role of top management support ϕ = .337). A more in-depth assessment at sub-category level did not provide further insights. Nevertheless, the findings are in line with SCM theory, as it can be argued that IT adds to the competitive position of a company by increasing the delivery dependability and reducing time-to-market through increased process visibility fostered by higher levels of information-sharing (Li *et al.*, 2006). The importance of top management support for supply chain planning, indicated through the contingency analysis, is best shown when bearing in mind that the various corporate business functions often operate in a "silo" mindset, working towards different, in some cases contradicting targets, which require a governing overarching function. As such, the marketing function, being usually incentivized based on sales numbers, may target to increase sales volumes, although these volumes may vary based on the volatility of the market. Marketing thus requires certain levels of flexibility in adjusting volumes to maximize their incentive targets. In contrast, the purchasing function is usually incentivized based on savings gained from suppliers, which can be best achieved if orders are fixed long-term, and at an early stage with the suppliers. Order flexibility, as demanded by the marketing function is contradicting purchasing's target of maximum savings, as suppliers will demand a premium for short hand purchase volume deviations. In case the marketing function is receiving more support from their top management, the purchasing function may not operate efficiently. Accordingly, a balanced approach to supply chain planning, which needs to consider and align the different functions' targets, should be a key responsibility of top management.

Dimension cluster	Category pairs*	Sub-category pairs (where applicable)*	Expected relative frequency count (%)ª	Observed relative frequency count (%)ª	Exact sig. (one sided)	Phi coefficient (ϕ)
Strategy	CPA - IT		36.3 (35.24)	46 (44.66)	.000	.398
	PLN - TMS		5.1 (4.95)	11 (10.68)	.001	.337

ª Figures are rounded.
* Category acronym codes:
CPA Competitive advantage | IT Information technology | PLN Supply chain planning
TMS Top management support

Table 6.31: List of statistically significant correlations in the dimension cluster "Strategy"
(Source: Author)

Dimension cluster "Theoretical foundation"

From a theory perspective, the use of economics theory linked to strategic management theory (ϕ = .486) was identified as statistically significant. This underlines the influence these streams of theory exert on the comprehension of SCM. Being the prime theories in their categories, the role of the TCE theory in regard to resource-influenced theories, especially to the RBV and the resource dependence theory, is most prominent as they constituted the strongest statistically significant correlations between the two categories, with a ϕ value of .725 and .428, respectively. An explanation for this correlation may be found in the work of Eisenhardt and Schoonhoven (1996), who describe the TCE and the RBV as competing theories both claiming to provide an explanation for the performance of the firm, despite their very different units of analysis. This is evident in a range of literature reviews of the research sample where authors made use of both theories. In addition, the TCE theory usage showed statistically strong correlations to network theory (ϕ = .399) and dynamics capabilities theory (ϕ = .387), although to a lesser degree in contrast to the RBV and the resource dependence theory.

Strategic management theory is not only correlated to economics theory but is also used jointly with psychological / sociological theory to explain SCM phenomena (ϕ = .362). The sub-category assessment revealed a strong statistically significant correlation between competitive advantage theory and the interorganizational network theory (ϕ = .479). This mirrors the thinking that competitive advantage in a supply chain environment is dependent on collaboration, which is best applied by utilizing inter-organizational networks, moving beyond dyadic relationships in networks towards a multi-part network of relationships (Rowley, 1997).

Dimension cluster	Category pairs*	Sub-category pairs (where applicable)*	Expected relative frequency count (%)ª	Observed relative frequency count (%)ª	Exact sig. (one sided)	Phi coefficient (ϕ)
Theoretical foundation	ECT - SMT		8.1 (7.86)	18 (17.48)	.000	.486
		TCE - RBV	5.1 (4.95)	18 (17.47)	.000	.725
		TCE - resource dependence	1.9 (1.84)	7 (6.79)	.000	.428
		TCE - network	1.2 (1.16)	5 (4.85	.001	.399
		TCE - dynamic capabilities	1.7 (1.65)	6 (5.82)	.001	.387
	SMT - PST		7.6 (7.38)	15 (14.56)	.000	.362
		competitive advantage - interorganizational networks	0.9 (0.87)	5 (4.85)	.000	.479

ª Figures are rounded.
* Category acronym codes:

ECT	Economics theory	OMT	Operations mngt theory	PST	Psy. / soc. theory
SMT	Strategic management theory				

Table 6.32: List of statistically significant correlations in the dimension cluster "Theoretical foundation"
(Source: Author)

Despite the analytical advantages of the contingency analysis method, one downside of the approach is linked to the lengthy and difficult-to-read presentation of results as outlined in Table 6.21 to Table 6.32. As such, the method bears the risk that findings may remain undetected in the assessment and interpretation process. Aiming to overcome this obstacle and in order to distill further findings from the tabular contingency analysis, the results were visualized in a "heat map" structure (Figure 6.1, p. 167). This visualization allows to add another layer of assessment possibilities, fostering the detection of patterns in the category pairs, which may remain hidden if only viewed through the contingency table.

Accordingly, assessing the contingency analysis results through the lens of the heat map visualization, it becomes apparent that of all moderate to strong correlated category pairs ($\phi \geq 0.300$), the collaboration, performance, and IT categories as well as the lean and agile supply strategies category show the highest occurrence of all 26 categories assessed. The collaboration and performance categories have eight statistically significant links to other categories as identified in the contingency analysis. The IT category and the lean and agile supply strategies categories accounts for 6 and 4 links, respectively. Accordingly, it can be argued that the collaboration, performance, and IT categories as well as the lean and agile supply strategies category are, from a dimension perspective, the key contributors in the three functional scope of SCM dimensions. This finding will be further elaborated on in detail in section 6.7.3 (p. 168ff) of this thesis.

From a dimension perspective, the highest occurrence and density of correlated category pairs, calculated based on the relative size of the dimension to its significantly correlated individual items, is evident in the “Level of SCM analysis” dimension. The dimension, although consisting of three categories only, is involved in 15 category or sub-category pairs with a significant correlation. This is mainly driven by the conceptual framing of SCM (CFR) and the SCM view of literature (SCV) categories, which show the highest concentration of category pairs, accounting for eighth and five category links, respectively. The rationale for the high occurrence of significantly correlated categories is expected to be rooted in the supporting and scene-setting aspects of these two categories, which were, as outlined previously (section 6.1, p. 86) described in basically every literature review within the sample. Based on these observations, it can be argued that the “Level of SCM analysis” dimension may be viewed as an overarching category containing basic aspects paramount to almost every literature review.

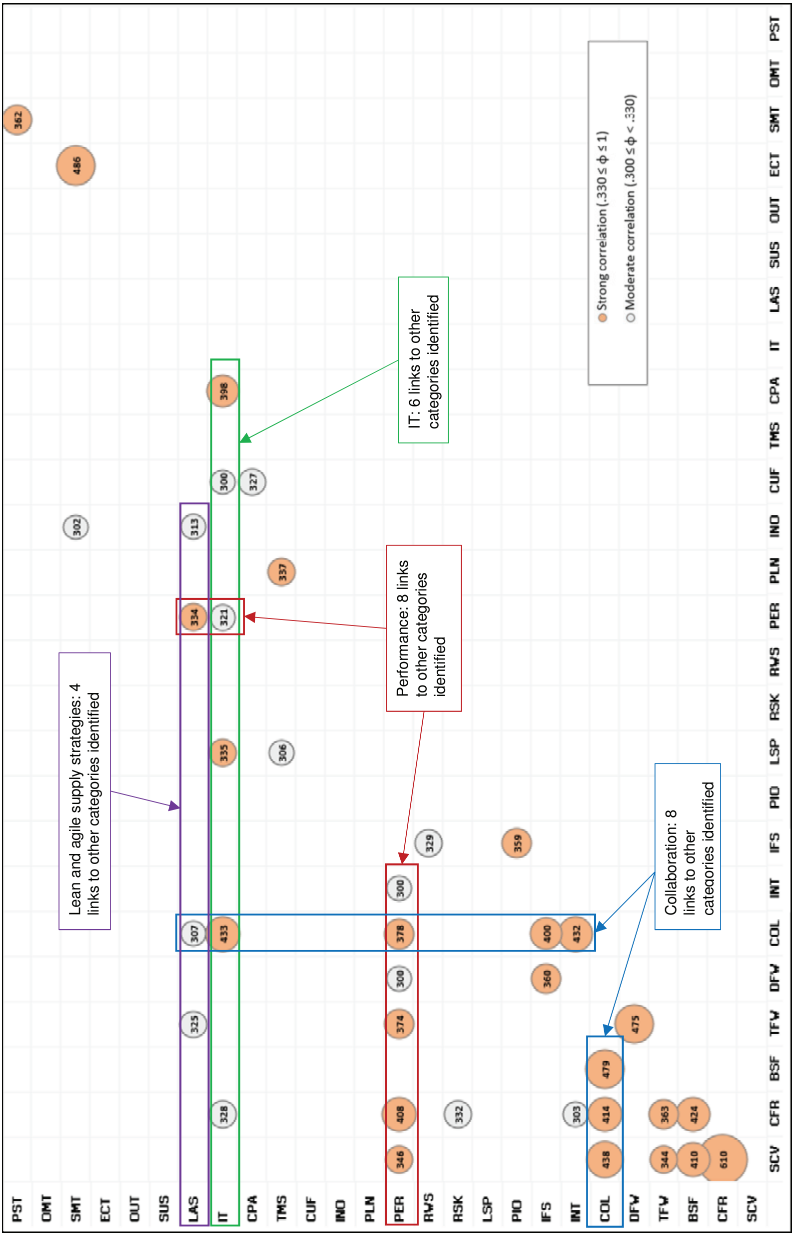
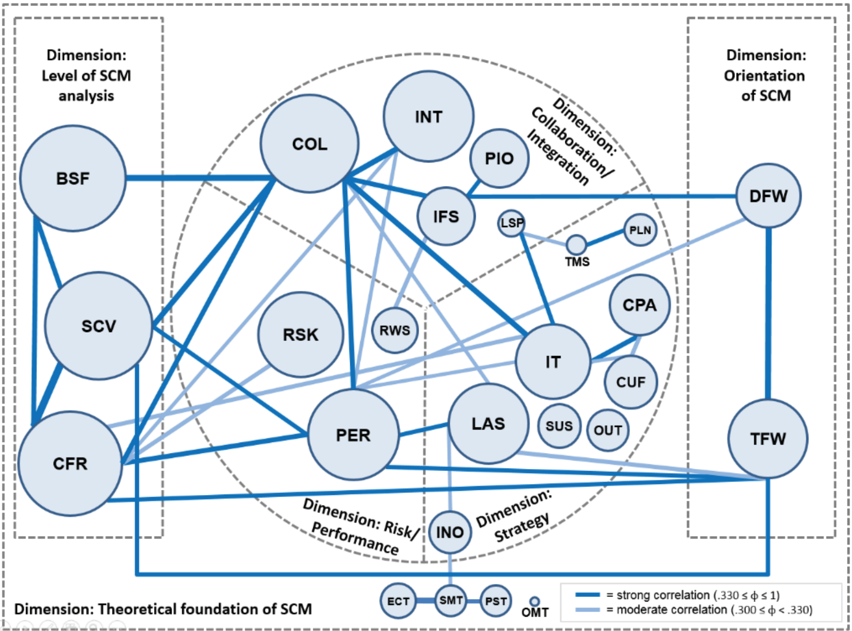


Figure 6.1: "Heat map" clustering of contingencies
(Source: Author)

6.7.3 Interpretation of category interdependencies and interrelations

It is paramount to point out that the following discussion and interpretation of the interdependencies and interrelations between categories needs to consider that the data used for the statistical assessment is entirely based on secondary text sources, assembled from literature reviews. The outcomes thus portray the world as seen through the artificial lens of literature reviews. Thus, an identified correlation between constructs reflects only the theoretical literature review perspective, yielding only limited, if any insights in regard to how the constructs are related in the real world. Nevertheless, under consideration of this limitation, the author is certain that the research provides valuable insights from a theory development perspective. Accordingly, relevant interdependencies are supplemented and related to extant theory where appropriate as indicated throughout the following sections.

Building on the findings of the contingency analysis and enabling an aggregated view of the interdependencies between the dimensions and categories, as refined through the review of literature reviews and confirmed by the insights from the consecutive contingency analysis of the category coding results, the category results have been integrated into a holistic “map of supply chain management” model as displayed in Figure 6.2 (p. 169). Tying up previous findings of the dissertation, this model holds the answer to the “interrelation” part of research question RQ 1 (“How can key conceptual elements of SCM be interrelated and integrated into one umbrella framework?”), outlining how key conceptual elements of SCM can be interrelated.



Category acronym codes:

BSF	Business functions involved in SCM	INT	Integration	PST	Psy. / soc. theory
CFR	Conceptual framing of SCM	IT	Information technology	RSK	Supply chain risk
COL	Collaboration	LAS	Lean and agile supply	RWS	Rewards-sharing / benefits
CPA	Competitive advantage	LSP	Leadership	SCV	SCM view of literature
CUF	Customer focus	OMT	Operations management theory	SMT	Strategic management theory
DFW	Direction of flow	OUT	Outsourcing	SUS	Sustainability
ECT	Economics theory	PER	Supply chain performance	TFW	Types of flow
IFS	Information-sharing	PIO	Process improvement orientation	TMS	Top management support
INO	Innovation	PLN	Supply chain planning		

Figure 6.2: Map of supply chain management (ϕ-values ≥ .300)
(Source: Author)

The visualization outlines the linkages between the dimensions, summarizing the previously discussed parts of the map of supply chain management. The graphical composition of the figure is guided by the following structure: The circle in the center represents the three core dimensions of “Collaboration / Integration”, “Risk / Performance”, and “Strategy”, which depict the functional scope of SCM. These do not build upon each other, but rather supplement and influence one another through the various aspects within these dimensions, as indicated through the contingency analysis findings. Adhering to the supplementing and influencing character, these three core dimensions are displayed in a pie-chart style as parts of a circle. The functional scope of SCM is shaped by the “Levels of SCM” (e.g. the conceptual framing of SCM or the business functions involved) and influenced by the “Orientation of the supply chain” (e.g. type of flow), which can be found on the left and right hand side of the diagram with the circle in between. All these dimensions are rooted in SCM theory, which is the underlying layer of all constructs, represented by the four theory elements at the bottom of the illustration. For clarity and completeness, all 26 elements within the six dimensions have been included in the figure, although not all show a significant correlation as defined by a ϕ-value ≥ .300. It should be noted that the bubble size of all items within the dimensions represents the frequency of literature review articles found, where a larger bubble indicates a greater amount of reviews identified in the respective area. The connecting lines linking the elements indicate some sort of correlation between these elements, where a thicker line represents a stronger relationship. However, in order to extract as much information from the contingency analysis as possible, the map is not only restricted to category pairs with a strong correlation (indicated by darker colored links); but also includes medium correlated category pairs (lighter colored links). The reasons being that although some of the interdependencies are weaker than others, it can still be argued that a medium correlation can also serve as a sound statistical basis indicating interdependencies between categories, although to a lesser degree than the strong correlations.

The graphical overview of the interrelationships (Figure 6.2) shows that some items are not linked, revealing a weak correlation. This is especially evident in the case of the outsourcing, sustainability, and operations management theory items. Considering the relative novelty of the outsourcing and sustainability items, which is reflected through the smaller numbers of reviews identified in these fields compared to other elements, and given the fact that the more mature items – such as collaboration and performance – are strongly linked, this is an interesting aspect. Accordingly, based on these findings, the author argues that the map of SCM provides an indicative overview of the maturity of the items within the “family of SCM items”.

As outlined earlier, the three rather underlying and supporting dimensions, namely “Level of SCM analysis”, “Orientation of SCM”, as well as “Theoretical foundation of SCM,” despite their importance for the understanding of SCM, do not represent the core of SCM from the author's perspective. Accordingly, it should be noted that the following discussion does not cover any of these three rather "supporting" dimensions. This, however, may be subject to future research. For now, the subsequent discussion purely focusses on the three functional scope dimensions of SCM, namely "Collaboration / Integration", "Risk / Performance", and "Strategy", as being key aspects of SCM. As a thorough presentation and discussion of the links and correlations between elements within a single dimension, following the dimension cluster structure, were already provided in the previous section 6.7.2, the current section will provide a more holistic picture. Thus, the key focus will be on identifying and discussing the interrelations and connections of dimension-overarching pairs of constructs, essentially pointing towards the categories which link the three functional scope dimensions of SCM.

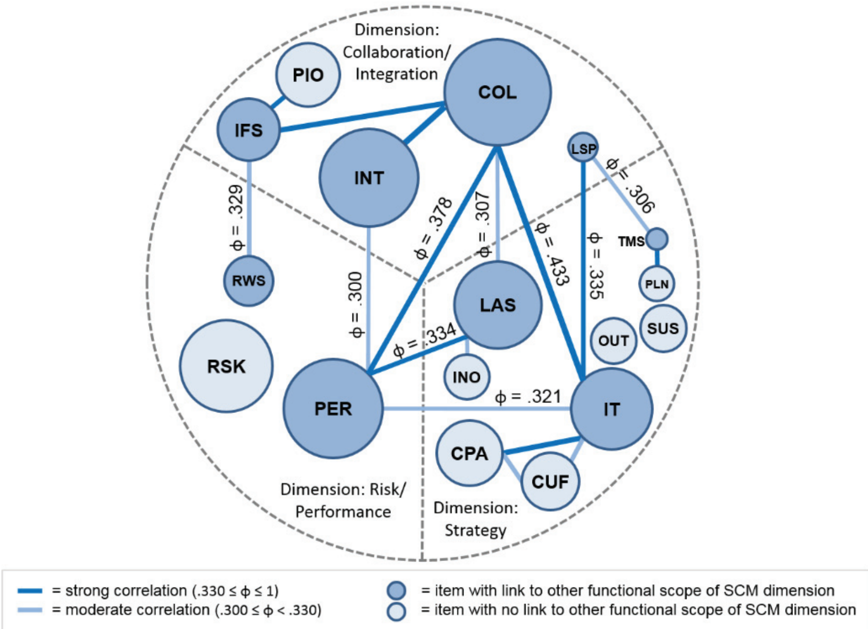
Interestingly, of all the "large" categories – based on the frequency count–, the supply chain risk category (RSK) is the only category not directly linked to another element within the three functional scope dimensions of SCM. This unexpected finding may provoke the statement that risk management in SCM is different to the other presented items. In particular, based on the findings and aiding to theory development in SCM, considering the grouping of supply chain risk to the performance dimension, the author argues that supply chain risk management is rather a prerequisite of sound supply chain operations than a driver of supply chain performance (Ghadge *et al.*, 2012).

In essence, the following nine interdependencies between the three functional scope dimensions of SCM have been identified based on Table 6.19 (p. 151), presented in descending ϕ-value order. It is assumed that a higher ϕ-value indicates a stronger correlation between two categories:

- Collaboration and IT (ϕ = .433)
- Collaboration and supply chain performance (ϕ = .378)
- Leadership and IT (ϕ = .335)
- Supply chain performance and lean and agile supply strategies (ϕ = .334)
- Information-sharing and rewards-sharing (ϕ = .329)
- Supply chain performance and IT (ϕ = .321)
- Collaboration and lean and agile supply strategies (ϕ = .307)
- Leadership and top management support (ϕ = .306)

- Integration and supply chain performance (ϕ = .300)

These interdependencies are visualized in Figure 6.3 (p. 172), which is in essence a simplified adaptation of Figure 6.2 (p. 169) with a focus on the three functional scope of SCM dimensions.



Category acronym codes:

COL	Collaboration	CPA	Competitive advantage	CUF	Customer focus
IFS	Information-sharing	INO	Innovation	INT	Integration
IT	Information technology	LAS	Lean and agile supply	LSP	Leadership
OUT	Outsourcing	PER	Supply chain performance	PIO	Process improvement orientation
PLN	Supply chain planning	RSK	Supply chain risk	RWS	Rewards-sharing / benefits
SUS	Sustainability	TMS	Top management support		

Figure 6.3: Construct interdependencies between the three functional scope dimensions of SCM
(Source: Author)

This illustration is designed to ease the understanding of the subsequent discussion by focussing on the aforementioned nine interdependencies (highlighted in dark blue) which are bridging the three functional scope dimensions of SCM. For a complete picture the links and correlations between elements within each single dimension have been included in the illustration, highlighted in light blue. Based on Figure 6.3 the author claims that the items of collaboration, performance, IT, and lean and agile supply strategies can be identified as the key anchoring items within the three dimensions of SCM. The rationale being that these items have the most interdependencies with other categories across boundaries within the functional scope dimensions, an argument which is also reflected in the findings from the heat map analysis (Figure 6.1, p. 167).

In the following, the overarching nine links between the dimensions of SCM as extracted from the literature review assessment will be discussed, starting with the stronger correlated interdependencies (ϕ-value ≥ 0.33), and continuing with the moderately correlated interdependencies (ϕ-value ≥ 0.30 and < 0.33). Special consideration will be given to the role of the four main items of collaboration, performance, IT, as well as lean and agile supply strategies in the SCM context as identified in section 6.7.2 (p. 153ff).

Collaboration and IT (ϕ = .433): The correlation between collaboration and IT is the main driver of interrelationships between the “Collaboration / Integration” and “Risk / Performance” dimensions. The importance of this link, which is also the strongest interdependency identified between any two items in the three functional scope of SCM dimensions, is based on the thinking that the implementation of IT is a key facilitator for corporate boundary-spanning collaboration. As such, these systems play a vital role in distributed production networks (Cachon and Fisher, 2000). However, the utilization of sophisticated IT systems may also pose a threat to collaboration, which is especially the case when systems required for collaboration are not compatible to partners’ systems. To overcome these issues, the standardization of interfaces between systems has been proposed to ensure a smooth exchange of data between companies (Skjøtt-Larsen *et al.*, 2003). In some cases, for instance in large multi-tier supply chains, the installation of a governing instance to coordinate IT initiatives between parties, such as the standardization of interfaces, may be beneficial. This is driven by the finding that corporations regularly tend to underestimate the magnitude of IT implementation, which is even more difficult when these networks need to be linked up into other parties’ technology landscape (Li *et al.*, 2009; Power, 2005). In general, the decision with regard to which IT system to implement within the company is of utmost strategic importance. Thus, the IT system selection decision has a great impact on future financial obligations, especially in terms of the funds required to keep the systems compatible with partners' systems.

Given the large resource investment in technology required, including financial, transformational as well as other resources, it is important that the benefits derived from the collaboration efforts in the supply chain are distributed in fair shares across all participating parties (Subramani, 2004). In addition, in order to ensure a sustainable basis for future collaboration and investments, it should be assessed on a regular basis if a certain party's investment in supply chain IT is in balance with its gained collaboration benefit. Concluding, as collaboration is at the heart of SCM, the applicability of IT is paramount for successful collaboration across the supply chain as showcased by the theoretical findings. Furthermore, from a practitioner's perspective, the role of IT in SCM is expected to play an even more important role in the future, driven for example through the emergence of messaging, mobile, and marketplace solutions, as this will inevitably impact on and change the way collaboration is executed and lived across the supply chain.

Collaboration and supply chain performance (ϕ = .378): Collaboration and supply chain performance were identified as key constructs, since the degree of collaboration within the supply chain impacts on overall supply chain performance. This builds on the findings by Chan and Chan (2010), elevating the role of collaboration and performance, as in essence *"coordination is an important ingredient to improve the performance of supply chains subject to the presence of system dynamics"* (p. 2793). It can be argued that these constructs are the drivers of interrelationships between the dimensions of "Collaboration / Integration" and "Risk / Performance". From an operational point of view this makes good sense as, according to Spekman, Kamauff, and Myhr (1998), SCM can be described as a concept of collaboration, required to achieve a competitive advantage. Li and co-authors (Li *et al.*, 2006) claim that the major competitive advantage of the SCM concept is its impact on overall company performance. Extending this thought in the light of the supply chain hypothesis (New, 1997), it may be argued that the constructs "Collaboration / Integration" and "Risk / Performance" are also connected through the aspect of competitive advantage. Putting this connection to the test, adding to a better understanding of the implications of competitive advantage on "Collaboration / Integration" and "Risk / Performance", the author assessed whether the individual categories in the "Collaboration / Integration" and "Risk / Performance" dimensions

showed a strong correlation to the element of competitive advantage. This assessment was possible as the category “competitive advantage” was already included in the content analysis and contingency analysis of the literature review section. However, as all of the categories within the “Collaboration / Integration” and “Risk / Performance” dimensions yielded ϕ-values below the .300 threshold, no evidence could be found for a significant correlation between the two dimensions on a theory level through the item of competitive advantage.
The analysis findings, based on literature reviews, may promote the theoretical conclusion that IT serves as an enabler for collaboration to impact on supply chain performance as the elements of collaboration and supply chain performance each show a strong correlation to the element of IT. This mirrors the findings by Iyer (2011), who assessed and highlighted the enabling role of IT in regard to collaboration and performance.

*Leadership and IT (*ϕ *= .335):* Being the second major link between the dimensions of “Collaboration / Integration” and “Risk / Performance”, a strong connection exists on the theoretical level between the elements of leadership and IT. This linkage may be driven by the fact that the implementation of IT systems is generally subject to buy-in from the leadership team. In return, purposefully installed IT systems are very effective in providing vital information, which are required for informed decision-making at leadership level. A key role of leadership is to provide a supply chain vision in order to steer business functions through transformational processes necessary to remain competitive (Venkatraman, 1994). In this light, supporting the challenging role of leadership in these processes, the installation of IT systems may also be seen as a facilitator and driver of organizational change (van Hoek, 2008). The rationale being that required changes in the corporate IT infrastructure may provide a justification for the implementation of sometimes difficult structural organizational changes.

Depending on the size of the supply network, it can be claimed that IT is a paramount factor, if not the key enabler, to govern a multitude of functions and entities across the supply chain. This is even more the case with increasing granularity of the supply network, as more entities are involved. Building on research by Hassini *et al.* (2012) who constituted a *“lack of an oversight agency that controls the whole supply chain”* (p. 76), it can be argued that the role of IT in fostering leadership, not only on an intra-organizational level, but in particular with regard to inter-organizational supply chain leadership, provides a critical aspect which needs to be considered in the supply chain design.

Supply chain performance and lean and agile supply strategies (ϕ = .334): A correlation was evident between the supply chain performance and the lean and agile supply strategies item. In addition, the link between the two elements was identified as being the main connector between the dimensions “Risk / Performance” and “Strategy”. Thus, it is of importance to understand how these dimensions are related. Adding to extant theory (for example Christopher and Towill, 2000; Hallgren and Olhager, 2009), a supply strategy which impacts on supply chain performance can be achieved in various ways: Either focussing on efficiency (leanness), for example through the reduction of “wastes”, or through flexibility (agility) within the supply chain, which is operationalized for instance through synchronization of cross-company production schedules. Furthermore, a combination of lean and agile strategies (leagility), as well as postponement and inventory management strategies, are known to be drivers which are impacting on supply chain performance (Childerhouse and Towill, 2000). Accordingly, based on the results of the theory-driven, literature-based contingency analysis, one may argue that this work contributes to SCM theory development by providing the missing statistical underpinning of extant SCM theory, where it has long been argued that the selection of the most appropriate supply strategy is directly impacting on the performance of a company and thus ultimately on the performance of the supply chain as a whole (Mason-Jones *et al.*, 2000). Although this is applicable to both lean and agile supply strategies, it may well be that lean strategies are affected to a greater extent, due to their stronger focus on performance optimization, outlined by Mills *et al.* (2004), as opposed to the rather flexibility-focussed agile supply strategies.

As highlighted by Cagliano *et al.* (2004), the operation of lean and agile strategies requires functions and parties to collaborate in order to improve supply chain performance. This is indicated through the contingency analysis results where both lean and agile supply strategies as well as performance are correlated to collaboration (ϕ-values .307 and .378, respectively). The literature study thus implies that collaboration is an underlying enabler for lean and agile supply strategies to increase the performance of the supply chain.

In addition to the four strong correlations as presented above, five moderately correlated interdependencies between dimension-spanning items have been identified, namely information-sharing and rewards-sharing, supply chain performance and IT, collaboration and lean and agile supply strategies, leadership and top management support, as well as integration and supply chain performance. Outlining their integrative role within the functional scope of SCM dimensions, these interdependencies will be presented in the following.

Information-sharing and rewards-sharing (ϕ = .329): Information-sharing between parties is required for streamlined execution of SCM, resulting in improved performance, responsiveness, and flexibility while reducing uncertainties among supply chain partners (Zhang *et al.*, 2011). In essence, a culture of information-sharing in the supply chain leads to an overall reduction of cost, which could generally not be achieved if companies venture on their own. However, not all companies along the chain are equally affected by the need to invest in technology required for streamlined information-sharing and it may be that corporate investments and benefits gained are not in balance. To overcome these imbalances Mentzer *et al.* (2001), based on other researcher's work (Cooper and Ellram, 1993), proposed a system of mutually sharing rewards along the chain, which also needs to include a sharing of risks and costs associated with the collaborative effort. The proclaimed correlation between information-sharing and rewards-sharing was proven through the presented literature review research to be an anchoring element linking the constructs of "Collaboration / Integration" and "Risk / Performance".

Supply chain performance and IT (ϕ = .321): The performance of a supply chain is influenced to a certain degree by the application of supporting IT systems. However, if viewed from a resource-based perspective, the performance of the supply chain is not automatically positively impacted through the adaptation of IT systems, as *"IT-enabled supply chain capabilities are firm-specific, and hard-to-copy across organizations"* (Wu *et al.*, 2006, p. 493). Nevertheless, a carefully tailored IT system, which considers the firms unique aspects, is well positioned for being an enabler of business processes excellence and in essence a catalyst of superior supply chain performance (Tavares Thomé *et al.*, 2012). Accordingly, a range of authors have researched the interdependencies between these items, although more from a conceptual point of view (Brynjolfsson and Hitt, 2000; Fawcett *et al.*, 2007; Jayaram *et al.*, 2000). Adding to theory development, the contingency analysis thus provides a first statistical confirmation of the interconnectedness of these items on a literature review basis, which also represent a main link between the "Risk / Performance" and "Strategy" dimensions, second to the correlation between supply chain performance and lean and agile supply strategies.

As outlined in previous sections of this chapter, the elements of supply chain performance and IT have both been found to be interrelated to the collaboration construct. Accordingly, backed by the strong correlations between collaboration and IT (ϕ = .433) and collaboration and supply chain performance (ϕ = .378), the author argues that the two elements supply chain performance and IT are not only directly linked, but are also connected via the element of collaboration. A scan of the available literature on the subject using the search engine ProQuest revealed that interchanging variations of these links have been assessed by researches, for example between collaboration and IT (e.g. Chae *et al.*, 2005; Pramatari, 2007), supply chain performance and IT (e.g. Wu *et al.*, 2006), and collaboration and supply chain performance (e.g. Cao and Zhang, 2011; Vachon and Klassen, 2008). Some papers could be identified to deal with the triadic relationship of the three items: Whereas Iyer (2011) researched the role of IT in regard to collaboration and supply chain performance, Sanders and Premus (2005) modelled the relationship between IT, collaboration and performance taking a capabilities view. Fawcett *et al.* (2011) assessed the relationships via dynamics capabilities theory, outlining that IT enables a dynamic supply chain collaboration capability which improves the performance of the chain. Nevertheless, no article could be identified to discuss the role of collaboration in regard to the connection between supply chain performance and IT. Enabling a more differentiated view to assess the reciprocal interdependencies between supply chain performance and IT, the outlined findings thus represent a first statistical indication towards an existing link between the two items via collaboration. The literature review findings thereby provide an empirical grounding for SCM theory development through further research, where the connection between the elements needs to be confirmed based on real-world data.

Collaboration and lean and agile supply strategies (ϕ = .307): The effective application of lean and agile supply strategies requires tight collaboration between partners, as the execution of these strategies is dependent on the exchange of vital business information across entities (Bruce *et al.*, 2004). Supporting extant theory

(Naylor *et al.,* 1999), this enabling role of collaboration from a strategy point of view is evident in the contingency analysis findings from a literature perspective as the items of collaboration and lean and agile supply strategies are correlated.

The correlation between these items may be driven from two directions: On the one hand, the existence of a collaborative mindset in the supply chain provides the information basis required to implement lean and agile strategies. On the other hand, however, it may also be likely that the need to adopt lean and agile strategies, driven for example by the economic need to improve performance, increases the willingness among supply chain partners to collaborate. The clarification of this "chicken-or-egg dilemma" may well provide further insights to understand the influence of strategy on driving collaboration across the supply chain.

As indicated previously, the item of lean and agile supply strategies is not only correlated with the collaboration item, but also with the element of supply chain performance. In addition, the interconnection between collaboration and performance has also been outlined above. Building on these aspects, and adding to other researcher's findings stating that the selection of the most appropriate supply strategy fosters collaboration and is directly impacting on the performance of a company (Cagliano *et al.*, 2004; Mason-Jones *et al.*, 2000), the analysis provides first statistical evidence on the grounds of literature reviews, indicating that lean and agile supply strategies are not only driven by performance, but that the element of collaboration may also play a vital role in the setup. As such, it can be argued that the selection of the right supply strategy is enabled by the availability of information, which is obtained through collaborative exchanges, and motivated by the economic requirement to increase the performance of the system. The author concludes that in addition to performance, as outlined in the previous section where the correlation between supply chain performance and lean and agile supply strategies was discussed, collaboration is also, at least from a theoretical literature review perspective, an underpinning major aspect governing the adaptation of lean and agile supply strategies.

Leadership and top management support (ϕ = .306): The connection between leadership and top management support represents the weakest significant correlation pair linking the dimensions "Collaboration / Integration" and "Strategy". The interdependency identified between the items points to the existence of the suspected link, as already indicated in section 6.5.4 (p. 116). It confirms general SCM theory, outlining that leadership and managerial support are key factors for the successful development and execution of supply chain strategies (Cooper and Ellram, 1993; Fawcett *et al.*, 2007). This is especially the case in regard to inter-organizational, boundary spanning supply chain activities which require an overarching leadership structure in order to ensure that the individual party's activities are steered with a common goal in mind (Hassini *et al.*, 2012). In an ideal supply chain world this governance function should be assigned to a board of top managers from all partnering companies, thereby ensuring a broad buy-in of all parties in terms of decision acceptance. This mixed board approach also allows to leverage best practices of leadership, which may already exist at intra-organizational, corporate level. Nevertheless, as outlined by Jain *et al.* (2009) the coordination of parties in a supply chain is often "*through negotiation rather than central management and control"* (p. 3013). Adding to advancing theory, the contingency analysis provides a first statistical hint, at least on the theoretical literature level, that the two items are directly correlated. Thus, it may well serve as a starting point to investigate why the implementation of inter-organization supply chain leadership structures, despite its benefits, is still experiencing resistance. This could be further leveraged for example by considering the role of psycho-sociological elements of supply chain leadership such as power differentials, trust or cooperation as proposed by Burgess *et al.* (2006), elements which are also of importance in regard to the understanding of top management.

Integration and supply chain performance (ϕ = .300): In the same way as with the last correlation pair, links between the dimensions are shown along the integration and performance items. Accordingly, on the basis of the literature reviews, the contingency analysis provides statistical evidence that supply chain performance is inevitably tied to supply chain integration; a connection also suspected by other researchers (e.g. van der Vaart and van Donk, 2008). Specifically, the dissertation indicates that external, supplier-facing integration is a topic being regularly researched in conjunction with customer performance, most notable in regard to its strong influence on the latter. However, increased integration of the supply chain calls for a clear measurement of the individual party's performance contribution as a means to allocate rewards and cost. Performance measurements can therefore be seen as a vehicle to govern the supply chain across the parties (Beamon, 1999). Developing theory, it may be claimed from a literature perspective, based on the statistical support given by the contingency analysis, that external integration is probably best measured by focussing on the degree of flexibility as a key parameter. In the case of functional integration, the parties could focus on a measurement of resources with a special focus on total cost components.

Summing up, the contingency analysis as presented throughout this section shows that the proposed six dimensions of SCM are interdependent and statistically correlated. This is indicated through the association of category pairs, most notably based on the categories of performance, collaboration, IT, lean and agile supply strategies, as well as on the conceptual framing of SCM. Furthermore, the results from the previous sections were disseminated into a holistic framework showing the interdependencies between the elements of SCM, especially on a functional scope of SCM level, as a means to theory development.

In the next section, section 6.8, a synopsis of the identified under-represented areas of research found in the six dimensions is presented as a structuring means to ease the selection of these areas for further, more focussed studies.

6.8 Summary of identified under-represented areas in the dimensions

As a synthesis of the literature review, outlining under-represented areas in SCM and acting as a guide motivating further research, the next section briefly lists the research gaps identified in the various categories (Table 6.33, p. 183). This overview provides a comprehensive and exhaustive list, which could be leveraged as a starting point for more in-depth studies of under-represented areas in SCM. In this light, the overview will also serve as the starting point for the empirical work presented in the course of this dissertation.

6.8.1 Dimension: Level of SCM analysis

SCM view of literature: The assessment revealed that only few literature reviews featured a dyadic perspective of SCM. From a research point of view there is no reason why the study of a dyadic relationship is less promising in comparison to, for example, the chain perspective. As the dyad is the smallest possible chain of segments, it provides good research opportunities for SCM researchers within a limited, yet sufficient scope. For instance, a potential research opportunity for dyadic research may be found in terms of assessing how trust works at an inter-company level, as a single company view – either buyer or supplier side – is not sufficient to capture the essence of trust development in SCM. In addition, the study found that potential publication opportunities may exists for dyadic relationship studies in an SCM context, especially if a publication in an OPS journal is intended.

Conceptual framing of SCM: As SCM makes use of the *"systems approach"* (Mentzer *et al.*, 2001, p. 7) more research is recommended to view SCM from a systems perspective, as this view has been neglected from a literature review perspective. The tighter integration of processes, which act as parts of a system, provides a good starting point, but these processes then need to be linked and interconnected to each other to enable a holistic view of SCM in a systems manner. Given the importance of sustainable management, a special focus could be on the return process, as the corporate product return capabilities are increasingly evolving from being an "order winner" to becoming a "market qualifier".

Dimension (level 1) Category (level 2)	Gap description
1 Level of SCM analysis	
1.1 SCM view of literature (SCV)	Dyadic relationship perspective, especially in OPS journals.
1.2 Conceptual framing of SCM (CFR)	Systems approach, integration of processes (return process).
1.3 Business functions involved in SCM (BSF)	Research and Development (R&D), Engineering, Human Resources (HR), and Legal to be assessed in SCM context.
2 Orientation of SCM	
2.1 Types of flow (TFW)	Role of finance flow and knowledge flow.
2.2 Direction of flow (DFW)	No gap identified.
3 Functional scope of SCM: Collaboration / Integration	
3.1 Collaboration (COL)	Research on how internal collaboration fosters external collaboration.
3.2 Integration (INT)	Research on inward-facing integration and integration of complete supply chain.
3.3 Information-sharing (IFS)	Information ownership and the potential to market information; development of trust.
3.4 Process improvement orientation (PIO)	Process improvement in supply chain driven by internal process improvements.
3.5 Leadership (LSP)	Role of leadership in fostering collaboration and integration.
4 Functional scope of SCM: Risk / Performance	
4.1 Supply chain risk management (RSK)	Demand, product, information risk; linking tech uncertainty with product risks; reduction of technology uncertainty.
4.2 Rewards-sharing /benefits (RWS)	Impact of a lack of rewards-sharing on collaboration.
4.3 Supply chain performance (PER)	Customer performance measures; measures for new product development, innovation.
5 Functional scope of SCM: Strategy	
5.1 Supply chain planning (PLN)	Tactical mid-term and operational short-term dimensions of supply chain planning from a SCM perspective (not only OR).
5.2 Innovation (INO)	Cross-company management of coupled approach.
5.3 Customer focus (CUF)	Customer-centric strategies; metrics to measure and benchmark customer satisfaction.
5.4 Top management support (TMS)	Role of top management in supporting all business functions; importance of top management support in SCM from operations management point of view.
5.5 Competitive advantage (CPA)	Potential of quality, innovation.
5.6 Information technology (IT)	Supply chain risks from new technologies (e.g. RFID).
5.7 Lean and agile supply (LAS)	Leagile supply chains; place postponement and use of IT to support postponement strategies.
5.8 Sustainability (SUS)	TBL in operations management; social dimension; risks in TBL.
5.9 Outsourcing (OUT)	Political dimension of outsourcing.
6 Theoretical foundation	
6.1 Economics theory (ECT)	TCE theory; agency theory; game theory.
6.2 Strategic management theory (SMT)	Knowledge based view; resource advantage.
6.3 Operations management theory OMT)	Theories' contribution / fit in regard to SCM theory.
6.4 Psychological/sociological theory (PST)	Organizational learning theory; behavioral science theory; linking inter-organizational network theory to organizational learning theory; use of structuring theories.

Table 6.33: Summary of research gaps identified
(Source: Author)

Business functions involved in SCM: The literature review findings highlight that the role of individual business functions in SCM research is not adequately addressed and overall lacks a balanced approach. The SCM literature reviews are predominantly assessing SCM issues with a focus on the Procurement function, while other business functions are scrutinized to a far lesser degree. A reason may be that SCM researchers took the seemingly easier route to explain SCM phenomena through the obvious purchasing link, instead of venturing into the more complex aspects of how other more inward-focussed departments may be leverage to foster cross-company interaction and add to competitive advantage. However, inward-focused functions such as Research and Development (R&D) and Engineering all play a vital role to *"create unique and individualized sources of customer value"* (Mentzer *et al.*, 2001, p. 7). Following the systems philosophy of SCM, more research is encouraged to investigate how these functions' hidden potential may be leveraged in a SCM context.

6.8.2 Dimension: Orientation of SCM

Types of flow: The role of financial flows in SCM was discussed in a few reviews only. Nevertheless, as a thorough financial standing in a supply chain is a requirement for the chain's business success, the focussed assessment of financial flows may provide hints, which could be used in terms of an early warning system to identify a partner's financial problems. As the impact of a financial crisis, initiated by a partner's bankruptcy, could quickly impact on the entire chain, research with regard to monitoring and mitigation strategies is encouraged. In addition, the flow of "knowledge" or "skills" offers fruitful research opportunities as these "soft" resources could be cross-functionally exchanged between business functions and firms. The coordinated exchange of skills and knowledge may be a true competitive advantage for the participating entities.

Direction of flow: As all directions of flow were covered in the literature review, no particular further research is needed.

6.8.3 Dimension: Functional scope of SCM: Collaboration / Integration

Collaboration: The research provided hints in the direction that internal collaboration on the corporate functional level may serve as a prerequisite to excel in external cross-functional collaboration efforts. For better validation of this assumption, further investigations are recommended into understanding how internal and external collaboration influence each other, e.g. how internal collaboration may foster external collaboration.

Integration: As internal integration is a prerequisite for optimized application of external integration, further research is suggested to understand if “inward-facing” integration bears hidden potential affecting external integration efforts. In addition, and as supply chain management is largely concerned with integrating all partners and functions along the chain, more research is advised towards the integration of the complete supply chain, also including collaborative planning as one aspect of outward integration.

Information-sharing: Research with regard to information-sharing, and more broadly to the role of information in supply chains, provides a wealth of opportunities for researchers considering the possibilities of information ownership and the potential to market information. This is predominantly driven by the changing role of information as being increasingly seen as a raw material and a strategic asset, which may have the potential to become a trading good between supply chain entities. Trust, especially the development of trust in partnerships, as the main prerequisite for information-sharing is an important aspect here and needs to be taken into account. Researchers are encouraged to develop objective research criteria in SCM to measure and manage trust in a standardized manner, thereby identifying the drivers and rationale behind information-sharing in the supply chain.

Process improvement orientation: The assessment revealed that research linked to an assessment of the reciprocal relationship between process improvement and supply chain integration may provide further insights into the dynamics of process improvement in a supply chain context. This aims at answering the question whether process improvement is a result of supply chain integration, or if supply chain integration is a by-product of supply chain process improvement.

Leadership: Research into how the role of leadership can be leveraged to foster integration and collaboration in the supply chain is recommended. A special focus should be on the effect of different leadership models on supply chain integration, covering functional leadership as well as supply chain leadership with the goal to determine best-fit approaches. The use of contingency theory (Fiedler, 1965), seems to be beneficial in this regard, providing the theoretical underpinning to assess the behavioral determinants of leadership.

6.8.4 Dimension: Functional scope of SCM: Risk / Performance

Supply chain risk: Research opportunities have been identified in regard to a more thorough assessment of demand risks, product risks, and information risks in SCM. As the optimal supply chain configuration needs to be driven by demand and forecasts, potential risks tied to the forecasting of future demand need special attention. This should include the development of mitigation actions. From a product risk perspective, it is suggested, that opportunities to research product risks may be found in aspects such as new product development, thus collaborating along the chain to reduce the likelihood of product malfunctions, while managing product variation and reducing time-to-market pressure. From an information risk perspective, special emphasis should be given to investigate risks tied to and stemming from the use of information in supply chains. This may include aspects such as risk aversion in managerial decision-making, or security concerns of shared data, as they may have a negative impact on supply chain collaboration. Research into the area of information management in SCM is likely to be a promising field, especially as companies operate in distributed global supply networks, where information and the timely flow of information between entities has never been more vital for supply chains. This is also driven by the increasing strategic value of information, where the selection of the "right" information has a great impact on corporate and supply chain decision-making capabilities.

From an operations management perspective it might be interesting to investigate how technological uncertainty in regard to the "right" production technology interacts with supply chain risks related to product management such as product design and new product development. From a technology uncertainty point of view, research is required to equip companies with tools and methods enabling them to handle and eventually reduce the uncertainties tied to the selection of technologies.

Rewards-sharing (benefits): As true collaboration between partners requires open sharing of rewards, research into how a lack of rewards-sharing negatively impacts on collaboration efforts constitutes an interesting topic for further research. Such research would also be interesting from a balance of power perspective, investigating how companies with less power in a supply network manage to overcome the imbalance of power, enabling them to gain a fair share of rewards.

Supply chain performance: The assessment identified the area of customer performance as being seemingly of little interest to researchers, which is surprising, given the customer-centric view required for effective supply chain management. As the customer is the ultimate driver of demand and thus of the supply chain as a whole, research is recommended in regard to how performance metrics tied to customer satisfaction can be leveraged to ultimately improve the customer experience.

Research efforts aiming to reduce the amplifying impact of shipping errors on the supply chain are recommended in order to reduce the impact of production delays due to shipping errors, especially in distributed supply networks.

In terms of performance measurements, the introduction of a new unit of measurement for new product flexibility is recommended. Operationalized as an extension to the framework by Beamon (1999), this would allow to assess the performance of the planning and introduction of new products in a supply chain with de-centralized manufacturing partners, considering sustainable manufacturing practices. In addition, an innovation performance metric to measure innovation may be useful, which could serve as a tool to manage the allocation of benefits based on the innovativeness of the company in the supply chain.

6.8.5 Dimension: Functional scope of SCM: Strategy

Supply chain planning: The often-found single-dimension view of published articles focussing on strategic long-term aspects of supply chain planning results in an incomplete picture of supply chain planning from a SCM point of view. Thus, the scope of SCM research should be broadened to incorporate the tactical mid-term planning and operational short-term planning dimensions of supply chain planning. As these planning dimensions are typically covered in OR-focused journals, taking the SCM perspective may invoke deeper levels of cross-discipline research between the disciplines, an aspect often called for in management research (Hitt *et al.,* 2007; Starkey and Madan, 2001).

Innovation: Research in regard to the coupled innovation approach, where the outside-in and inside-out innovation approaches are linked as both parties collaborate and participate from the exchange and development of innovation, is recommended. From a supply chain perspective it would be particularly interesting to gain a deeper understanding in regard to the opportunities and challenges tied to collaborative innovativeness. Research into how the innovation management process across multiple companies can best be organized and managed may also be promising.

Customer focus: Based on the literature study more focussed research is advised in regard to how companies can tweak their customer strategy and become more customer-centric, aiming to increase customer satisfaction. A suitable starting point may be the development of metrics to measure and benchmark customer satisfaction and initiate appropriate actions to increase customer loyalty. This should include a cross-company view as customer involvement in SCM has the potential to impact on supply chains in multi-dimensional ways, namely vertically, horizontally, and geographically.

Top management support: The value and role of top management support is mostly discussed in the SCM literature in regard to the purchasing paradigm, for example in terms of its role in supporting the development of supplier relationships. Although this focus is largely tied to the development of SCM, with its origin stemming from the purchasing function, other functions such as Marketing are also dependent on support by top management. More research is called for to investigate how top management can support other business functions as well, aiming for a more balanced support of top management. Building on the findings of the literature review, research could also provide answers to the question if top management support is of lower importance in SCM from an operations management point of view or if SCM from an operations point of view is more concerned with lower management as identified in the leadership section of this work.

Competitive advantages: Research opportunities exist in regard to understanding how collaborative quality improvement initiatives enhance the overall competitive position of the supply chain. In addition, it may be fruitful to assess how innovation approaches, such as the coupled approach, can be leveraged to achieve a competitive advantage. Other research possibilities may focus on developing best practice for supply chains to turn information into a competitive advantage.

Information technology: Although the advantages of IT applications in the supply chain have been exhaustively discussed in the literature reviews, it appears that especially supply chain risks stemming from new technologies, such as RFID and web-based services, have not been sufficiently researched. Given that IT is the backbone of cross-company collaboration in the supply chain, a closer look towards IT security is required to close some white spots. Reports of governmental covered surveillance activities, infiltrating IT infrastructure and corporate networks, underlined that the secure, unobstructed exchange of data between partners is a weak spot SCM. Therefore, research efforts need to be intensified, providing solutions with regard to how IT networks distributed across multiple partners can effectively be secured and guarded against unauthorized access. In addition, research on strategic planning of the IT infrastructure across multiple partners, as well as knowledge and IT management is lagging behind. Accordingly, more research is recommended in these areas due to their governing importance for the whole system. Especially the question how IT can be leveraged to support knowledge exploitation and conservation in a supply chain is expected to be an interesting research subject, given the value of employees' knowledge as being the "capital" of a supply chain, which needs to be retained.

Lean and agile supply strategies: Whereas the lean and the agile supply strategy are commonly used in SCM research, comparably fewer authors focus on the leagile supply strategy. This is interesting and may provide opportunities for research in this area, especially considering the benefits of the leagile supply paradigm, which leads to supply chain risk reduction, increased responsiveness and flexibility. The utilization of place postponement was identified as being a research gap in SCM. In addition, articles on how technology can be leveraged for postponement strategies are scarce. Given the trend towards geographically dispersed supply chains, in conjunction with advancements in information technology, research in place postponement strategies as well as supporting technologies is expected to offer fruitful insights, providing insights to the future management of global production networks.

Sustainability: The research revealed that the Triple Bottom Line (TBL) approach was utilized to guide the majority of the articles on sustainability. Interestingly, few articles were published in operations management journals compared to SCM focused journals. However, as the dimensions of the TBL could also be beneficial in a manufacturing setup, more research is called for to cover this aspect from an operations point of view. Thus, researchers are encouraged to consider publication of TBL articles in suitable operations management journals. Based on the review findings especially the social dimension of the TBL, which links into the area of Corporate Social Responsibility (CRS), provides promising aspects for further research and seems an under-represented aspect of SCM research. Furthermore, as the literature review yielded no article to explicitly discuss the risks tied to the social dimension or any other TBL dimension, this represents a major gap in literature reviews in sustainability and another potential area of future research.

Outsourcing: Given the political implications governing the outsourcing decision, such as the installation of trade barriers, research on the political dimension of supply chain outsourcing is expected to offer fruitful insights suitable to make more informed supply chain outsourcing decisions.

6.8.6 Dimension: Theoretical foundation

Economics theory: The review results highlighted the applicability of the transaction cost economics (TCE) theory to explain intra-corporate boundary structures. However, based on the literature sample no research was found to extend the scope further towards the inter-corporate dimension. Addressing this gap, additional research is recommended into how TCE theory with regard to intra-corporate boundaries can be beneficial for managing inter-corporate relationship structures.

The assessment of the literature reviews revealed that a multitude of definitions exists for the use of agency theory. As a unifying definition is essential to avoid confusion and prevent unguided theory development, researchers are encouraged to come up with a common accepted term.

Although game theory in SCM provides promising aspects to explain a party's behavior when balancing trust with economic return in information-sharing, thus adding to overall SCM theory building, more research is encouraged to fully leverage the potential of this theorem.

Strategic management theory: The knowledge-based view and the resource advantage theory are expected to offer potential to increase the theoretical understanding of SCM. Researchers may assess the value of these theories from an SCM perspective, in particular in an environment where resources are increasingly scarce and thus offer the opportunity to turn sustainable resource usage into a business advantage.

Operations management theory: As the orientation towards flows and performance improvements, especially quality, should be a core consideration and a major focus of every supply chain, the use of operations management theory in an SCM context seems a suitable means to foster SCM theory building. Although it is unquestionable that the set of theories, as proposed by Schmenner and Swink (1998), provides valuable explanations on supply chain aspects, especially concerning the measurement of across-factory performance required for the execution of supply chain rewards and incentive structures, researchers still need to assess the theories' fit and potential contribution in advancing SCM theory.

Psychological / sociological theory: The literature review findings indicate that organizational learning theory in an SCM context may provide rich research opportunities. A focus could be on the potential of distributed learning and education in SCM, for example through harnessing the collaborative possibilities of social software in an enterprise environment. This supports SCM theory development as it adds to optimize the exchange of knowledge in distributed global supply networks.

Given the opportunities, which unfold from integrating customer data from loyalty programs with information technology, such as data analytics, the application of behavioral science theory provides a powerful toolbox for advancing SCM theory. This should be leveraged by researchers and practitioners alike, working towards a better understanding of buying behavior, which, through the application of mathematical and statistical models, eventually allows to "predict" the customers future behavior based on past behavior. Ultimately, this vision bears great potential to derive a distinctive, unique competitive advantage for the supply chain.
Furthermore, research is recommended into answering the question as to how inter-organizational network theory and organizational learning theory can be linked to provide a theoretical framework for distributed collaborative learning and knowledge sharing in a supply chain environment. Potential research may include to understand how distributed learning, which is essentially knowledge sharing, increases the productivity of the work force by reducing duplicate work, which saves costs and ultimately impacts on company performance.

Based on the research findings within the "Theoretical foundation" dimension, the author encourages the community to make intensified use of structuring theories such as "chaos theory" (Ellis *et al.*, 2011; Liao-Troth *et al.*, 2012), "complexity theory" (Ghadge *et al.*, 2012; Sarkis *et al.*, 2011), "control theory" (Akyuz and Erkan, 2010; Chan and Chan, 2010), "conflict theory" (Terpend *et al.*, 2008), or "coordination theory" to understand and formalize the loosely connected nature of supply networks. These structuring theoretical concepts could help to formalize the dynamics in distributed networks, enabling researchers to develop models, which might in the end provide answers or even predictions towards the question of why companies engage in cooperating with certain other companies, e.g. what is the “secret formula” in supply chain collaboration.

Concluding, chapter 6 presented the findings from the literature review along the six dimensions. The identification of current shortfalls in the literature as outlined in this chapter provided the foundation for a precise definition of the under-represented areas of research in SCM. In addition, the applied contingency analysis enhanced the validity of the findings, also allowing to uncover possible interrelations between the dimensions and categories.

In the next chapter, chapter 7, the results from the contingency analysis are put into perspective, while special emphasize is given to map the interdependencies between the six dimensions of SCM through the development of a theoretical model of SCM.

7 Discussion of the dissertation's desk research part

The main aim of this chapter is to discuss and thus make sense of the implications of this study, showing how it contributes to the existing body of knowledge (section 7.1). Special consideration is given to addressing the research questions RQ 1 to RQ 3, as presented in section 1.2. In addition, the academic and managerial implications of the research (section 7.2), the strengths (section 7.3), as well as the limitations (section 7.4) of the study are addressed, uncovering future research opportunities (section 7.5). Section 7.6 bridges the systemizing desk research to the field research, thereby providing the transition link from the literature review part of this dissertation (chapters 3-7) to the exemplary assessment of a selected under-represented area of research in SCM (chapters 8-11).

7.1 Contribution

The contribution of the empirical desk research part of this work is derived from three major aspects. The first aim was to condense the key conceptual elements of SCM into a single conceptual classification framework map of SCM as outlined in chapter 4 (p. 33ff). This objective was achieved by combining the items of highly cited papers from leading journals in the field. The applied procedure invokes a certain amount of bias due to limiting the literature search to certain journals. Yet this was accepted by the author of this dissertation as a necessary step to scope the research process. Extending the review to include other journals would reduce bias and allow for a better validation of the findings, but the presented review already enabled the extraction of a great amount of potentially interesting issues which provides a great starting point for directed, future research endeavors.

The key conceptual elements were condensed into the overarching six dimensions, namely the "Level of SCM analysis," "Orientation of SCM," "Collaboration / Integration," "Risk / Performance," "Strategy," and "Theoretical foundation" of SCM, thereby moving beyond previous literature reviews. The novel approach of grouping the aspects of SCM into six distinctive dimensions with 26 categories and 68 sub-categories, contributes to SCM theory building by equipping the research community with a comprehensive list of SCM constituents. Answering the "integration" part of research question RQ 1 ("How can key conceptual elements of SCM be interrelated and integrated into one umbrella framework?"), the provided mapping of the SCM landscape, visualized in Table 4.3 (p. 37), enables researchers to better scale and modularize their own area of research, following the framework’s theory-based, multi-dimensional and comprehensive structure. The author admits that the items of the dimensions are not new and have been discussed in other, more focused reviews in greater detail as indicated throughout this work. Nevertheless, although the constructs importance seems to be obvious to the reader, as hypothesized by Fabbe-Costes and Jahre (2007), this should not hinder an open minded analysis of seemingly simple and obvious constructs as a means to generate new insights.

From a methodological point of view, the application of the systematic literature review approach in the dissertation underlines the value of this approach as being a scientific technique (Tranfield *et al.*, 2003), which is perceived to have great potential in regard to the development of the management disciplines. Accordingly, this aspect portrays one of the underlying motivations for this dissertation, aiming to advance and develop the management discipline, in particular in the field of SCM, by promoting the use of the systematic literature review methodology.

The second aim is linked to the empirical work presented in the form of a secondary data analysis, where a review of literature reviews around the six dimensions is presented, executed through content analysis. This allows for an assessment of a multitude of topics within the emerging field of SCM, moving beyond the single publications and outlining the key research areas in SCM. Thus, it provides the answer to research question RQ 2 “What have been key research areas in SCM in the past?”

Being the third aim of the research, a detailed list of under-represented areas in SCM (Table 6.33, p. 183) is developed, which serves as a fruitful starting point motivating further research at the gaps identified. This constitutes the answer to research question RQ 3 (“Are there research areas in SCM which are relevant yet under-represented, and thus offer promising future research directions?”).

Adding to the first and the second aim as presented above, the conceptual framework map as developed in section 4.1 (Table 4.3, p. 37) was advanced and empirically validated using contingency analysis. This seemed to provide a holistic, multi-dimensional view towards the assessment of the categories across the six dimensions. As a result, the contingency analysis revealed insights into category interdependencies on two levels as presented in Table 6.21 to Table 6.32 and summarized in the “map of supply chain management” visualization (Figure 6.2, p. 169):

First, a range of interdependencies between categories within single dimensions of SCM could be uncovered. This was the case within the dimension clusters “Level of SCM analysis,” “Orientation of SCM,” “Collaboration/ Integration,” “Strategy,” as well as “Theoretical foundation”. Surprisingly, the “Risk / Performance” dimension was the only dimension which did not yield a single statistically significant interdependency between two categories. Given the importance of risk and performance management in supply chains (Beamon, 1999; Tang, 2006) further investigations are required in order to understand this unusual and unexpected finding.

Second, a multitude of statistically significant category interdependencies between the single dimensions of the conceptual framework of SCM were identified (Table 6.19, p. 151). Answering the “interrelated” part of research question RQ 1 (“How can key conceptual elements of SCM be interrelated and integrated into one umbrella framework?”), this approach yields a better understanding of the elements and their interrelations and enables a more aggregate view in line with developing supply chain theory. This represents a key novelty of the research, based on the fact that none of the previous specialized in-depth literature reviews, as scrutinized in the literature review assessment, was found to discuss interdependencies or interrelations covering more than four different dimensions of SCM. Thus, it may be argued that previous reviews lack the broader picture which, however, would be required to understand synergies of aspects within and between the constructs in order to generate new theory. Accordingly, to overcome this gap, statistical evidence is provided in section 6.7.2 (p. 153), which outlines the main –statistically significant– links between the six dimensions, operationalized through 26 category correlation pairs (24 strong and two medium correlations), and 33 sub-category correlation pairs.

The interpretation of the interdependencies and interrelations between categories as identified through the contingency analysis assessment (section 6.7.3, p. 168ff) provides a new perspective to the relevant elements linking the three core dimensions of “Collaboration / Integration,” “Risk / Performance,” and “Strategy” which depict the functional scope of SCM. This may likely add to SCM theory development as it outlines the key linking items between the three functional scopes of SCM dimensions as viewed through the lens of the 103 literature reviews. Having assessed and discussed nine links across the dimensions, four items could be identified as being prime items, most notably performance, collaboration, IT, as well as lean and agile supply strategies. As the identified interdependencies are a direct result of the transparent research process comprising the literature review, the content analysis and the contingency analysis, it can be argued from a scientific point of view that the four items are the guiding elements of SCM, being of major importance for the general systems understanding of SCM from a literature perspective. It should be noted, however, that other items as outlined throughout the research are also of importance, although to a lesser degree.

From the author's point of view, the systems understanding of SCM materializes best if the four items are viewed from two different perspectives, namely interaction as well as differentiation among items:

Viewing the four items from the interaction perspective, collaboration can be seen as the enabler of SCM to achieve superior performance across the supply chain as a whole. In this equation, IT serves as a key facilitator of collaboration and ultimately supply chain performance, required to operate supply networks across companies in an increasingly globalized business environment. Given these parameters, the choice of the right strategy, which best suits the situation, is paramount for the creation of distinctive customer value by all business functions, ultimately leading to sustainable market success.

From the differentiation perspective, it can be argued that the differences among these four items, evident through their unique and prime role within the three individual dimension, as highlighted throughout sections 4.2.3 to 4.2.5 (pp. 40ff), underline the character of SCM as being a multi-dimensional research area. As such, the multiple dimensions of SCM, which can be portrayed as a range of modules, can be combined in a variety of ways and dosages to form a mix of items specifically tailored to the individual business function's needs. Thus, the scalability of SCM ensures an optimal fit of every business function within the set of functions, in order to enable the most efficient and effective flows of goods, material, and information required for the functions to operate at their best towards becoming one seamless entity.

Summing up the previous statements, the author concludes that the right composition of interplay between the four key items of performance, collaboration, IT, and lean and agile supply strategies, which are essentially applicable to every business function, serves as a great example and, in the end, explains how the interacting, overarching phenomena and orchestrating character of SCM makes it the value-creation engine of every company.

7.2 Academic and managerial implications

The academic implications of this work are best viewed from a methodology as well as theory development point of view. Taking a methodology perspective, the research builds a strong case for the application of the structured, systematic literature review methodology. In particular, the innovative mixed research approach combining a systematic literature review, content analysis, as well as contingency analysis provided a plethora of findings. Putting the use of the mixed research approach to the test, a key aim of the research was to give an overview of the landscape of SCM research in an academic context. This was achieved as knowledge gaps were identified leading to a range of potential research opportunities as outlined in section 6.7.3 (p. 168ff). Thus, based on the author's experience, the mixed research approach is recommended to the research community as a suitable tool for the structuring and exhaustive assessment of an area under research.
From a theory development viewpoint, the contingency analysis in particular was found to be a useful tool. It enabled an in-depth investigation of the hidden links identified, not only between the 26 categories and a multitude of sub-categories, but also in regard to extracting hidden links between the dimensions of SCM. Accordingly, following other researchers' calls for unifying theory development in SCM (e.g. Zacharia *et al.*, 2014), a range of categories could be identified which project the fundamental dimensions of SCM from a theory perspective. The proposed underlying map of SCM will serve as a fruitful starting point for research, motivating further investigations along the identified dimensions of SCM.

The implications of the research from a managerial or practitioner point of view are governed by the aspect that the literature review results allow for a condensed overview of the many areas which are concerned with SCM. The review thus serves as a "compendium of knowledge", suitable for practitioners to get quickly familiar with the multitude of aspects of SCM from a literature perspective. Another managerial implication of the literature review is motivated by the fact that SCM, due to its multi-disciplinary and collaborative philosophy, which essentially enables co-value creation, should be a concern of basically every business function, at least to some extent. In this light, the research work can be leveraged to provide knowledge to managers, answering the question how SCM is embedded in businesses as it is interwoven in the business structure, connecting the bits and pieces. Thus, the research helps to equip managers with the knowledge required to grasp the magnitude of SCM and understand its implications on the business from a holistic perspective.

7.3 Strengths of the desk research part

The next sections aim to highlight the strengths of the empirical desk research part and contrast the various shortfalls of the research requiring further investigation.

The main strength of the study lies in its unique character and contribution to the academic body of knowledge, evident in the methodological and theoretical contributions. The originality of this work stems from the aspect that although numerous literature reviews have been conducted in the field of SCM in the past, to the author’s knowledge, no full-scale comprehensive study, based on the innovative research approach of a review of literature reviews, with the aim to identify beacons of research as well as under-represented research areas, in the here presented form has yet been undertaken in SCM. Nevertheless, given the surge in literature review publications in SCM this seems to be required in order to map and assess the current status of SCM research and prepare the grounds necessary for the direction of focused future research initiatives. This was achieved as the scope of the study, which included all literature reviews on SCM published in 10 major journals, resulting in 103 reviews, allowed for a very open assessment of the SCM landscape as depicted through literature reviews.

From a methodological point of view, the application of the rather unusual and somewhat novel research concept, employing content analysis and contingency analysis to further leverage the literature base, represents a major strength of the research. As such, the author builds a case for future researchers to increase usage of the systematic literature review methodology, utilizing content analysis and contingency analysis as a pragmatic research method in SCM.

In order to secure the applicability of the research process design and the findings of this research, the research was conducted with a strong focus on quality criteria compliance, such as content, construct, internal, and external validity, as well as reliability (compare Figure 3.1, p. 32). In the following the adherence of the research concept to each of these aspects will be outlined in detail as it represents a major strength of the study.

Sampling validity is concerned with the representativeness of the sample. The main aspect is to ensure that the sample under analysis adequately represents the population being researched (Krippendorff, 2012). The adherence of the dissertation to sampling validity needs to be judged in regard to the different research methods applied, namely the framework development and the content analysis. As such, the development of the framework map was based on the most frequently cited articles containing a framework fundamental to the understanding of SCM, as outlined in section 4.1 (p. 33). As the citation count can be seen as an indicator for the general acceptance of the work in the research community, this approach can be regarded as fulfilling the requirements of sampling validity. The execution of the content analysis leveraged a full-sample approach on 10 target journals, considering all 103 literature reviews on the subject of SCM as contained in the journals. As the sample equals the full population in size, it clearly fulfills the criteria of sampling validity. Considering the two above mentioned aspects, it can thus be claimed that the research is valid from a sampling perspective.

Semantic validity describes whether the defined *“categories of an analysis of texts correspond to the meaning these texts have in in the chosen context”* (Krippendorff, 2012, p. 335). This validity measurement was taken care of as the design of the categories followed a dual approach for category development and refinement as outlined by Mayring (2010). Accordingly, the research categories were deductively developed through the conceptual comprehensive framework of major aspects of SCM –based on existing research–, and the framework’s dimensions categories were inductively refined during the coding process to optimize the framework as new, previously unidentified aspects emerged from the literature under review.

Structural validity assesses if the researcher is subject to interferences from the categorization and processing of texts (Krippendorff, 2012). The author was very cautious in treating each text in the same standardized manner, following a tested method already considered in the research design, thereby aiming to limit interferences from categorization and processing which may have resulted in variations of the coding process. Following Mayring (2010), special care was taken in the development of coding categories required for the content analysis as the analytical pattern was linked with existing constructs. To further increase the structural validity, the research process involved the checking of categories and coding results with the help of a second researcher, although only applied in rare cases where the first researcher experienced coding issues. Through the application of the above provisions, the author has ensured that the work is fulfilling the criteria governing structural validity.

In contrast to the test for structural validity, the test for *functional validity* assesses if the use of the constructs is justified. As outlined above, the constructs were deductively derived from highly cited papers, and further inductively supplemented as new constructs emerged from the text. The use of pattern matching between the various frameworks enhanced the structural validity and ensured that the final constructs used in the coding process were mutually exclusive and collaboratively exhaustive.

Internal validity, conveyed through structural as well as functional validity, was confirmed through intense discussion with other researchers, for example through regular doctoral seminars, where the current status of research and future research direction was presented by the author.

Construct validity, especially *correlative validity* has been catered for through the use of multiple sources of evidence, obtained through the application of the structured literature review methodology, content analysis as well as contingency analysis. In addition, draft framework designs and the corresponding constructs were extensively discussed in detail with research colleagues and repeatedly presented at conferences and seminars, thereby ensuring construct validity. In addition, the author took care to clearly outline his line of arguments, as outlined throughout the dissertation, which supported the interpretation of results.

The research fulfills the criterion of *predictive validity* only to a limited degree driven by the fact that the study is the first of its kind in a SCM context. Thus, although a range of future research recommendations are given as a result of the analyses, no statistically backed insights can be drawn in regard to the future development of the subject under research. Thus, considering a potential repetition of the research at a later point in time, an evaluation of predictive validity is subject to future research in the light of a longitudinal assessment of the development of the research field over time.

Some limitations are linked to the *external validity*, or generalizability of the research: As every single one of the 103 literature review had its own unique characteristics and way of presenting its individual review findings, drawing generalizable conclusions from these non-standardized formats presented a true challenge. The author has addressed this issue by developing a classification framework map as part of the content analysis, which allowed to code every literature review based on strict standardized, objective criteria.

In addition, further impacting on generalizability, the work is strongly influenced by theory extracted from the SCM literature reviews, providing the foundation for the development of the conceptual classification framework in chapter 4 (p. 33). This outside-in approach, using theory to develop a framework, is supplemented by the corresponding inside-out approach, as the de-contextualization of the theory in the discussion section led to abstractions of the content analysis outcomes, which allow for a certain degree of generalization and hence support external validity (Avenier 2010, Seuring and Gold 2012). However, not only the research outcomes add to external validity as the combined research approach comprising literature review, content, and contingency analysis was designed for generalizability. As such, the applicability of the research approach in a SCM context yielded rich datasets; but the application of the research approach is by no means restricted to SCM research only. Although the frameworks and constructs utilized have a clear SCM focus, the research setup is not inherent to SCM and could simply be tailored to basically any other research area, assuming that the frameworks and constructs are adapted to the new research area’s requirements. A prerequisite for a carry-over of the approach into other research areas would be that a sufficient number of literature reviews exists, which could be leveraged for extraction of insights.

A range of aspects govern whether the research is sufficient in terms of reliability, namely stability, replicability, and accuracy. The research was conducted with a strong focus on these aspects.

Aiming for *stability*, the author applied a rigorous research approach which followed a tested method and ensured that all steps as well as results are as transparent as possible. In some cases, for example with regard to the description of the category coding procedure as outlined in section 5.4, the transparent process was supported by an exemplified, descriptive step-by-step walk-through of the applied research procedure. Thus, it can be expected that a second assessment of the scrutinized literature would yield the same results, assuming that the same conceptual framework is applied. The research approach can therefore be considered stable.

The focus on transparency of the research process, achieved through in-depth documentation of the entire research process, caters for high levels of *replicability* as it enables other researchers to re-run the study. This open and repeatable research process is a driver of enhanced reliability of the research.

As the test for *accuracy* requires the results to be stable and replicable, it represents the strongest available test for reliability (Krippendorff, 2012, p. 271). The accuracy of the research process was ensured as a second researcher coded the literature reviews in borderline cases, following the derived categories, aiming to reach inter-coder reliability. Where differences occurred, these were solved through mutual consultations and agreeing upon a common definition. Further, categories were clearly defined in order to control the reliability of the coding (refer to section 4.2, p.37).

From an organizational point of view, the author ensured that the chapters of the dissertation followed a logical order, building upon each other. The incremental development of the research method –starting with the development of the conceptual framework map of SCM, through the content analysis and the contingency analysis, ultimately resulting in the dissemination of findings as presented in the “map of supply chain management”– supports the comprehension of this dissertation as it provides structural guidance to understand the aims of the research study. It therefore represents another strength of the study.

However, the strength of the research stems not only from its methodology, organizational aspects, or its strict adherence to validity and reliability criteria, but also from a clear focus of the research process towards inclusion and development of theory. This is evident in the deep grounding of the research in existing theory, most prominently through the development of the conceptual framework of SCM in chapter 4 (p. 33), which is based on existing highly cited SCM frameworks. The various dimensions of the framework map enabled the author to scale the research focus through the subsequent content and contingency analyses to a very granular level, while at the same time maintaining a clear view to the overarching aspects of SCM. In essence, the author always worked towards assessing all findings derived in the research process from a theory point of view, which led to the development of a “map of supply chain management”. Being another novelty in SCM research, this “map of supply chain management” enables further, more focused studies, especially starting out from the interfaces and links between the dimensions as outlined through the contingency analysis and discussed in the contribution chapter of this work.

7.4 Limitations of the desk research part

Despite the many strengths of the empirical desk research part with regard to methodological and theoretical contributions and enhanced by a strong focus on validity and reliability, some limitations prevail.

First of all, like all research endeavors, this dissertation was confronted with a resource challenge manifested in various resource constraints including time, finance, and human resources. Apart from these rather organizational issues other limitations are evident which will be structured and discussed in regard to the research methodologies used:

A major limitation of the content analysis is linked to the focus of the research on secondary data, exemplified through literature reviews. It needs to be mentioned that some excellent papers exist which discuss the relevance and role of theory usage in SCM, also addressing the question as to whether an individual “SCM theory” is needed at all (Cousins *et al.*, 2006). However, in most cases these papers do not constitute a literature review and thus were not included in the scope, following the paper selection process as outlined in section 5.1. Thus, the results of the literature review need to be viewed under consideration of this aspect.

Anticipated limitations of the research in terms of validity are rooted in the review of literature approach. The literature reviews included in the sample each had their own criteria for selecting appropriate journals and articles. Although it needs to be supposed that the authors of these reviews have taken utmost care, the author cannot exclude that they might have accidentally overlooked one or another paper in their reviews. Accordingly, this proves a challenge as this selection risk is continued in the review governing this dissertation, as being based on secondary sources. The application of content analysis to only peer-reviewed papers was successfully chosen to offset this issue.

Limiting the research focus to ten journals further impacts on the results, despite the fact that the selected journals are all of high academic value and thus constitute major outlets of SCM knowledge. However, the limitation to ten journals included in the research was deemed necessary in order to maintain a manageable scope for the research study population. In return, the limitation can be seen as a core aspect which enabled the desired level of in-depth analysis possibilities.

In addition, limiting the selection to sources of empirical SCM research only can be regarded as a major limitation. This is mainly a consequence of selecting a certain set of journals, which are more linked to empirical research than for example to more modelling or operations research based papers. Nevertheless, extending the review to include more and other journals would reduce bias and allow for a better validation of the findings, charting a course for further research.

The coding procedure of the articles to respective categories represents a source of limitations. Thus, the author points out that although the categories were introduced during the development process of the conceptual framework of SCM (sections 4.2.1 to 4.2.6), a more standardized coding approach using clear, explicit descriptions of each of the categories might have been an even better choice from a replicability point of view. In addition, the lack of clear coding rules may constitute a limitation. However, by outlining the coding approach along the manifest and latent content dimensions, using the “integration” example (section 5.4) the author showcased how the coding procedure was operationalized in detail, thereby aiming to mitigate this limitation. These insights provide the basis for the replicability of the review codings.

The contingency analysis was also subject to some limitations. In particular, the definition of the correlation grading scale used for the assessment of the contingency analysis, as outlined in Table 6.20 (p. 151), may be subject to criticism. However, as the design was governed by the idea to balance the distribution of ϕ-values in order to support a smoother, more structured and above all more directed analysis of the category pairs, ultimately resulting in rich datasets yielding new insights, the selected grading can be justified ex post.

The interrelationships and interdependencies between the various elements and dimensions as identified through the contingency analysis and presented in the “map of SCM” (Figure 6.2, p. 169) are also subject to limitations. As the links were identified on the basis of literature reviews, which do not always adequately represent the latest research in a given area, it may be that the identification of links is biased and influenced, at least to some extent. However, as the aim of the research study was to map the breadth of SCM research, this limitation was considered to be rather miniscule and thus accepted.

Furthermore, as the respective interpretation of statistical links between categories is entirely based on literature reviews, a major limitation is linked to the value of the category interdependencies and interrelations from a real-world perspective, as an identified statistical link does not necessarily constitute a semantic link. Thus, the links identified only reflect the theoretical literature review perspective, yielding only limited, if any, insights in regard to the relevance of the constructs’ interdependencies in the real world. However, despite this limitation, the research provides valuable insights from a theory development perspective as outlined in the contribution chapter.

In addition, the literature review only presents a snapshot of the SCM research landscape at a given time, covering the period 1989 until December 2012. Thus, the interdependencies are only representative for the stated timeframe. As new literature reviews are published constantly in the ten selected journals, these are impacting on the frequency distribution of the articles across the categories and dimensions. The accuracy and relevance of the research results is therefore subject to the natural process of ongoing development over time.

Lastly, the holistic map of SCM model developed in the contribution (Figure 6.2, p. 169) is itself subject to limitations. Although the systematic literature review in combination with content analysis provides a proven tool to ensure quality, enabling inclusion of all relevant aspects of SCM in the model, the author cannot guarantee that aspects are missing. Thus, the research community is encouraged to extend the model if found appropriate.

7.5 Recommendations for further research

As indicated throughout the study, a multitude of recommendations for further research could be derived from the subject under study, covering both methodology as well as content directed recommendations.

From a methodological point of view, the application of the transparent research concept, employing content analysis and contingency analysis, to further leverage the literature base, builds a case for future researchers to increase usage of the systematic literature review as a pragmatic research method in SCM. In line with this statement, and as it was observed during the literature review assessment that many reviews did not adhere to a transparent research process and thus did not explicitly outline their research design, the author encourages the research community to outline clearly the methodological steps in future reviews. Aiming to increase research transparency, these improvement possibilities also include the communication of possible limitations, the presentation of the journal names scrutinized in the data collection phase, or the disclosure of the sample timeframe under review.

Apart from the methodological recommendations, a range of content-focused recommendations for future research can be derived. The research recommendations are presented from multiple perspectives as every analysis provided a different view towards the subject, which in turn yielded the identification of under-represented areas and gaps. As such, a plethora of research possibilities was identified through the content analysis. As the identified research gaps were extensively outlined in detail throughout section 6.7.3 (p. 168) and summarized in Table 6.33 (p. 183), they will thus not be discussed any further.

In addition, the assessment of interdependencies using the contingency analysis (section 6.7.2, p. 153) provides potential for leverage in further research. As such, the assessment itself provides research opportunities, linked to the fact that the analysis did cover only three of the six dimensions of SCM, namely the three functional scope dimensions of “Collaboration / Integration,” “Risk / Performance,” and “Strategy”. The three supporting dimensions “Level of SCM analysis,” “Orientation of SCM,” and “Theoretical foundation” were not included in the discussion of overarching links between the dimensions of SCM as outlined in section 6.7.3 (p. 168). Accordingly, future research should pay tribute to the inclusion of these three dimensions thereby embracing the full breadth of overarching links between the dimensions of SCM.

On a more granular level, additional research may scrutinize the various links between the dimensions as outlined in section 6.7.3 in more depth. This could include a thorough assessment of indirect links between elements via mediating elements such as the link between supply chain performance and IT through collaboration.

Portraying another example, research opportunities exist in providing guidance on how IT can best be leveraged from an organizational perspective as an enabler for collaboration and as a means to driving supply chain performance.
As some categories, such as the risk category, in contrast to expectations, did not yield strong links towards other categories they may attract the interest of future researchers to explain the rationale behind such phenomena.
Nevertheless, as the correlations between elements as discussed in section 6.7.3 are theory-based evidence only, being solely extracted based on secondary literature reviews, it seems beneficial to prove their existence using primary data sources. The application of case study research would provide a suitable tool to verify the category correlations from a real-world perspective.
Lastly, some research possibilities can be derived from the "map of supply chain management" framework as the author argues that the "map of supply chain management" provides an indicative overview of the maturity of the items within the "item family of SCM". By considering the time dimension, this view may provoke additional in-depth research opportunities. In this light the current research as outlined in this dissertation serves as a snapshot in time of the current status of SCM research as portayed through literature reviews. This provides an excellent basis for a longitudinal assessment of the development of the field of research over time, also enabling an evaluation of the predictive validity of the research presented. Thus, following the proven methodology as presented in this research, the inclusion of additional literature reviews as published within the ten journals into the "review of literature reviews" enables future researchers to monitor how the various aspects within SCM change over time. Such monitoring also includes the integration process of new items into the "item family of SCM". From the author's point of view, this represents a great future research opportunity, being a fruitful vehicle for SCM theory development operationalized through the continuous mapping of SCM's journey towards developing into a discipline of its own.

7.6 Putting theory into practice: An exploratory approach for the assessment of an exemplary under-represented area

In the previous part of this dissertation, a systematic literature review was presented by the author as a means to map and assess the landscape of current research in SCM, represented through 103 literature reviews. As a result, a holistic map showing the interdependencies between the items of SCM as a means to theory development was derived. In addition, a range of under-represented areas were identified, promoting further future research opportunities.

Aiming to add rigor to the theory-based literature review work, the following chapters will focus on the practical application of the research findings. Addressing research question RQ 4 ("How can exploratory research help to address under-represented areas of SCM research"), an empirical field research study will be employed with the goal of outlining how gaps could be addressed through exploratory research. However, given resource limitations as stated above, it is by no means possible to assess all under-represented areas as identified through this work in this study. Thus, following a pragmatic approach, the author chose to focus on the assessment of one exemplary under-represented area only.

The selected under-represented area, which was identified in section 6.7.3 (p. 168), is linked to the information risk perspective. In particular, as highlighted in the literature review findings, it will be of special concern to investigate the value and role of information in supply chains, driven by the fact that a lack of understanding of this important element increasingly poses a risk for corporations and ultimately to the supply chain. Due to the lack of comparable material on the role and value of information, especially at the crossroad of SCM and the digital business transformation agenda, the author approaches the topic in an experimental fashion. This is operationalized on a granular level through the application of research question RQ 5 ("*What are the implications of Big Data Analytics on information usage at corporate and supply chain level, especially with regard to information identification required for decision-making?*").

The next chapter, chapter 8, lays the theoretical foundation for the field research part of the dissertation, thereby providing a sound justification for the selection of this under-represented area. In a snapshot, the chapter outlines the role and value of information in a business function context under consideration of the digital transformation perspective in general and the Big Data Analytics perspective in particular.

8 The digital transformation of businesses: Big Data Analytics and the role of information

This chapter presents the rationale for the selection of the exemplary under-represented area as utilized in the later part of the dissertation, focussing on the role and value of digital information in a business function context. The relevance of the under-represented area, driven by the digital transformation of the business landscape (section 8.1), is outlined along the intersection of SCM and the digital transformation agenda. Special emphasize is given to the role of Big Data Analytics, a key aspect of the corporate digital transformation agenda, valuable for optimized decision-making (section 8.2).

The presentation of the research question in section 8.3 serves as a motivation to explain the need to identify information requirements in an increasingly information and data-driven business environment. In section 8.4 the key focus is on the special role of accurate, up-to-date and meaningful information-provisioning to business functions. Thus, the value of Big Data Analytics for supporting the provisioning of information is outlined in this section, also explaining how a centralized approach to data retrieval yields synergies across business functions. On these grounds a conceptual framework is developed in section 8.5, rooted in extant theory, which provides the structural underpinning for the guided assessment of the information requirements on a business function level.

8.1 The digital transformation of the business landscape

The development of the internet combined with leaps in information technology (Bandyopadhyay *et al.*, 2010; Lee, 2002), such as storage, network and telecommunications capabilities, enables companies to have access to large amount of data almost in real-time, viewing *"information as a strategic asset"* (Mason-Jones and Towill, 1997, p. 140). The emergence of the long proposed "Internet of Things" (IoT) marks a milestone in this development (Ashton, 2009), fuelled by the integration of technologies and communication solutions moving from standalone devices to an intelligent network of objects, in which the physical and virtual worlds interact (Atzori *et al.*, 2010). In this next technology leap, also referred to as the *fourth industrial revolution* ("Industry 4.0"), *cyber-physical systems* (Lee, 2008) are expected to propel the amount of data generated by and available to companies to unforeseen new levels. Accordingly, the amount of data available globally, already doubling every two years, is expected to grow exponentially from 4.4 zettabytes[2] in 2013 to 44 zettabytes by 2020 (Turner *et al.*, 2014).

Portraying an “information explosion”, this development is accompanied by the shift from the current analogue to the digital business world, fuelled by the ubiquitous availability of digital information technologies. A key differentiator between the two paradigms is the disruptive character of digital technologies (Kitchin, 2014), which is expected to have a massive impact on the way businesses are operating (Beath *et al.*, 2012). Being well capable to shake up traditional business models as well as whole industries, this shift from analogue to digital will likely affect the distribution of power among business partners. The emergence of new business models, i.e. online retailers without physical outlets, which leverage the new ecosystem to their advantage, increasingly disrupting the business of traditional brick and mortar businesses, needs to be mentioned here. However, the potential of the technology shift to digital is not limited to purely online-only businesses. If managed correctly, it also provides great opportunities for traditional “brick and mortar” businesses to compete against online-only competitions. The key factor being that traditional business can leverage the insights gained through online channels in order to provide an enhanced customer experience also in the offline world. Thus the digital approach supplements their traditional business approach, transforming it into a hybrid; an opportunity unrivaled by online-only businesses.

From an economics perspective the advantages of digital technology utilization for businesses are plenty: They are likely to materialize in improved and new processes and services, reduced cost as planning and execution time is reduced leading to accelerated time to market, fewer process errors such as faulty shipments, and in essence in an improvement of the corporate financial bottom line. The better access to information through integration of digital technologies, such as RFID, remote monitoring, and autonomous control, ultimately result in overall improvements of operations efficiency.

However, the availability of information should not be restricted to the corporate level but also embrace the supply chain perspective. Thus, it can be expected that recent technological advancements will continue to impact whole supply chains which

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[2] One zettabyte = one billion terabytes (10^{21} bytes)

become increasingly networked as opposed to the traditional linear setup, therefore adapting to the new information-centric production environment where *"information moves independently of product at internet speeds"* (Kuglin and Rosenbaum, 2001, p. 59). This is a major aspect as seamless supply chains (Towill, 1997), not only in the digital business world, are inevitably dependent on the availability of information. Companies that understand the importance of holistic information availability, viewing the supply chain as one end-to-end process, harnessing the technological and organizational potential of the digital transformation, are not only well positioned to disrupt and penetrate further industries, but to define new markets. As such, the adoption of digital technologies is no longer an order winner, to reference Hill (1993), but increasingly a market qualifier in the global economic environment.

8.2 Big Data and Analytics: An overview in a management context

8.2.1 Definition and key aspects

The amount of information and data generated by, available to, and collected through companies is growing with an unforeseen fast pace (McAfee and Brynjolfsson, 2012). This increasingly poses a challenge for companies as it complicates the identification and extraction of the most relevant and valuable information required for managing the business and ultimately the supply chain (Beath *et al.*, 2012). The term Big Data has been coined in this respect, reflecting the volume surge of data generated; also embracing the aspect that data is increasing in variety and generated with rising velocity (Laney, 2001).

A comprehensive definition of Big Data, which will be used in this dissertation, has been proposed by Beyer and Laney (2012): *"Big data is high-volume, -velocity and -variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision-making"* (p. 1). Big Data subsumes all kinds of stored (digital) communication, which may include –but is not limited to– "*messages, updates, and images posted to social networks, readings from sensors, and GPS signals from cell phones"* (McAfee and Brynjolfsson, 2012, p. 5). In short, basically any piece of data generated by humans or machines and made accessible to others adds to Big Data. The growth of more voluminous and unstructured Big Data environments is influenced by a range of factors such as the trend towards real-time readings from sensors and RFID tags which enables the monitoring of assets and business processes. Other factors being the increased need for end-to-end visibility along the supply chain, enhanced automation levels as well as required efficiency gains at the manufacturing level (Davenport *et al.*, 2013; Zelbst *et al.*, 2011).

The characteristics of Big Data, driven along the three dimensions of volume, variety, and velocity, present a challenge for the processing of Big Data through conventional data management tools. The reason being that these systems are not designed to deal with datasets of such size, terabytes to exabytes, and complexity, ranging from sensor to social media data (Waller and Fawcett, 2013). Thus, the concept of Big Data Analytics, combining *"advanced and unique data storage, management, analysis, and visualization technologies"*, was developed in order to manage this intangible growing mass of data (Chen *et al.*, 2012, p. 1166).
However, the accumulation and processing of large amounts of data by the public and private sector is not a novelty of our time. Early examples of the generation of large scale data can be traced back to Roman times, when census data were collected for tax calculation purposes (Parkin, 1992). Nevertheless, despite huge advancements in processing technology since these days, most notably the invention of the punch-card computer, the processing of collected data and the timely extraction of relevant information constituted a main bottleneck. It was not before the widespread availability of low-cost parallel computing power, networked systems, and sophisticated scalable algorithms that a solution to this problem was developed. Long considered a niche playground for data scientists, Analytics essentially describes the application of advanced statistics to Big Data, as it opens new opportunities in the exploration and utilization of large datasets (Gupta *et al.*, 2012; Zikopoulos and Eaton, 2011). Having its base in statistical methods and data mining techniques developed for data management and warehousing since the 1970s (Chen *et al.*, 2012), the concept of Big Data Analytics would not be existent without the advancements in information technology –especially data storage and processing. The aim of Analytics is to automatically identify behavioral patterns within the data, which eventually allow to forecast future behavior to some extend (Shmueli and Koppius, 2010). The process behind Analytics uses data which is isolated against a problem and correlated with contextual information. Thus, the power of Big Data Analytics is to turn "meaningless" data into "meaningful" information, following the definitions of data and information by Boisot and Canals (2004). Paying tribute to the knowledge creation power of Analytics, outlined in the transformational process,

some researchers proposed to use the term “Smart Data” instead of “Big Data”, although the discussion is considered being rather fruitless (Pentland, 2014).
The widespread public popularity increase of Big Data Analytics in recent years is mainly driven by private corporations, recognizing that data generated for example by customers provides a rich source for tailored marketing activities, as well as the development of new services and products (Boyd and Crawford, 2012). Labelled the *“next big thing in innovation”* (Gobble, 2013, p. 64), Big Data Analytics thus seems to provide auspicious possibilities across a range of application areas such as medical practice, public policy, or corporate decision-making (Mayer-Schönberger and Cukier, 2013). It is already used for short term weather forecasting, forecasting outbreak of epidemic diseases, prediction of location and frequency of crimes. A range of supply chain problems such as the optimized re-planning of shipment routes, medicine and health care workforce allocation, as well as police force allocation all have the potential of being solved by Big Data Analytics. With regard to its applicability in a business environment, Big Data Analytics is expected to trigger a “management revolution,” essentially changing management practice and revolutionizing supply chain dynamics (McAfee and Brynjolfsson, 2012; Waller and Fawcett, 2013).

For completeness, it should be noted that Analytics, despite its prime role, is not the only technology available to harness the potential of Big Data. Other technologies exist such as social network, mobile, and cloud technologies (Sridhar and Raja, 2014). They complete the range of Big Data dependent technologies, usually subsumed under the acronym “SMAC” (social, mobile, analytics, and cloud). Nevertheless, the “predictive” nature of Analytics adds to its key role in this set, and may likely represent a game changing competitive advantage from a corporate perspective. As such, companies could potentially achieve cost advantages through application of Analytics as unplanned equipment downtimes can be reduced significantly, allowing the companies to cut buffer inventories, thus enabling the partners to operate a leaner supply chain while eliminating supply risks. Portraying the supply chain perspective, however, it is imperative that information on potential uncontrolled malfunctions is shared with supply chain partners to allow for timely mitigation actions across the chain.

Depending on the industry, some companies, such as *Amazon.com*, are already using Big Data Analytics to increasingly “predict”, i.e. forecast, customer purchase behavior, which helps them to drive sales, leveraging an unrivalled competitive advantage (Davenport, 2006; Ross *et al.*, 2013). Other companies, for example *SAS Analytics*[3] or *Accenture Analytics*[4] are offering predictive analytics “as a service”, which may include constant monitoring of customer equipment’s functionality. By applying sophisticated statistical models to customer’s datasets, potential process failures are “predicted”. This is based on a constant monitoring and matching of real-time data against set metrics, which allows for early detection and mitigation in due course.

The application of predictive analytics on Big Data, however, could pose an information security risk if not managed properly. This holds true for companies and even more for supply chains. As such, security issues have been reported to be a major obstacle for using IT in supply chains (Beath *et al.*, 2012; Jharkharia and Shankar, 2005). Recent reports of governmental surveillance programs also capable of skimming proprietary corporate internet communication, as well as the growing threat by cyber-attacks, have the potential to add to the discussion on supply chain and information security. However, only the consideration of privacy implications regarding the use of information will lead to employee engagement and increased customer loyalty. In addition, as business are increasingly digital, they are more likely to be affected by disruptions. Accordingly, resilience of the data infrastructure is key as the interconnected and automated business operations rely on 24/7 availability. Resilience, the potential to keep the availability of IT systems in an "always on" mode at acceptable levels of operational performance, is thus becoming a commodity, a necessity in a digital environment. From a society standpoint it can be observed that the digital revolution started as a driver of electronic change, which will enable a range of industries / societies to flourish. But this “brave new world” is at the same time under threat to develop into a dystopia of governmental control and marketing of every aspect of human life. Despite these challenges, which clearly require consideration in the future business landscape, the advantages of Big Data Analytics as outlined above prevail.

From an academic standpoint it needs to be considered that Big Data Analytics, being a technique from the information sciences is still in its infancy in regard to application in the management sciences (McAfee and Brynjolfsson, 2012), which also

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[3] www.sas.com/en_us/software/analytics.html, last accessed January 24th, 2015

[4] http://www.accenture.com/us-en/Pages/service-consulting-analytics-overview-summary.aspx, last accessed January 24th, 2015

holds true for its application in SCM. Like any new approach, it is thus subject to initial teething troubles. Nevertheless, as the performance of the supply chain is to a large degree dependent on the availability of vital information for all partners (Hult *et al.*, 2004), the application of Big Data Analytics, which is likely to enhance performance and improve the competitive positioning, seems to be fruitful in a SCM context (Sahay and Ranjan, 2008; Trkman *et al.*, 2010). From a theoretical perspective, it can be argued that this follows New's (1997) supply chain hypothesis, whereas SCM offers competitive advantage by implementing techniques for performance improvement.

8.2.2 Defining the scope of Big Data Analytics

Due to the novelty of the concept of Big Data Analytics, the management research community is struggling to grasp the value of this concept, especially as other similar information management concepts exist, such as Business Intelligence, Business Analytics, or Master Data Management (Chae and Olson, 2013; Horvath, 2001; Otto *et al.*, 2009). Enabling a common understanding of the terms, the following section provides a brief definition of each of the concepts. Business Intelligence, a term coined in the business and IT community in the 1990s, describes a set of theories, methodologies, architectures, and technologies for the analysis and assessment of business data environments (Chen *et al.*, 2012). The goal is to support corporate decision-making by turning raw data into meaningful information. Business Analytics, essentially the analytical engine of Business Intelligence, is used to scrutinize corporate data for data patterns (Saxena and Srinivasan, 2013). However, the main difference to Business Intelligence is its additional focus on the provision of potential future developments (Davenport, 2006). Aiming to overcome information management and integration challenges, the concept of Master Data Management (MDM) was designed to prevent the existence of multiple variants of the same data at different points within the company (Dreibelbis *et al.*, 2008). The key is to maintain consistency within the corporate data required for the handling of business processes, in order to prepare the grounds for an assessment of reference data, transactional data, or analytical data.

Nevertheless, from the author's point of view, the concept of Big Data Analytics – despite having undisputed similarities to other concepts such as the analysis and assessment of data or its predictive touch – is different. Portraying a holistic approach, Big Data Analytics rather supplements the existing concepts, offering an extension to the scope of these information management concepts, aiming to provide insights which the other concepts do not support. The supplementing, evolutionary character of Big Data Analytics is best described based on two dimensions, which the author decided to label the "origin of information" dimension and the "type of information" dimension. The interaction of these two dimensions is displayed in Figure 8.1 (p. 216).

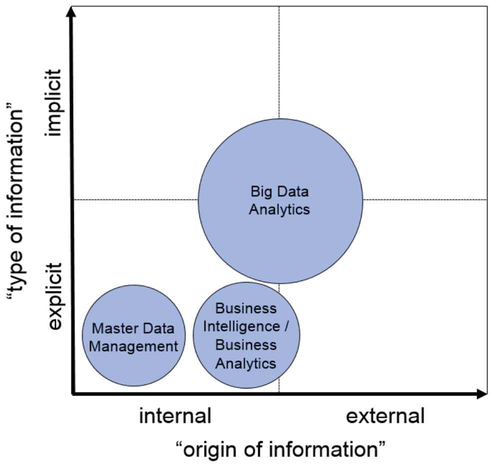

Figure 8.1: Application of information management concepts based on the "origin of information" and "type of information" dimensions
(Source: Author)

The "origin of information" dimensions can be classified into internal and external sections, describing if information stems from within or outside the company. Many information management systems like Master Data Management systems operate solely on internal company related business information, such as internal transactional data on material movements, but are usually prone to a lack of transparency (Otto *et al.*, 2009). Business Intelligence and Business Analytics systems could extend towards the utilization of external information like supplier inventory information, but these systems are often suffering from complexity issues and low degrees of cross-boundary standardization (Chae and Olson, 2013). The emergence of Big Data Analytics represents a paradigm shift in this regard, paying tribute to better exploitation of the growing amount of data, as these systems are designed with a focus to include all information sources available, regardless if the information originates within or outside the focal business environment.

The "type of information" dimension can be differentiated into explicit and implicit information. Explicit or manifest information is clearly structured, such as inventory forecasts or transaction data, where the value of information is apparent from the beginning. In contrast, implicit information, such as equipment sensor readings, GPS tags, or social media content is rather intangible and latent. Thus, it may not occur at first glance what the value and purpose of collecting the information is. The real value can be hidden and may only be operationalized through the application of statistical and mathematical models, which enable the identification of patterns, such as machinery malfunction indicators. The large-scale utilization of all information types (explicit and implicit) regardless if the information was generated by internal (the company) or external sources (clients and customers) marks the novelty of the concept of Big Data Analytics.

Accordingly, it can be argued that Big Data Analytics may represent the next evolutionary stage of information management concepts, motivated by the idea that every bit of information may eventually be turned into a competitive advantage. This needs to be considered in decision-making, as the focused exploitation of information is likely to be the next driver of corporate value creation (Zhou and Benton, 2007).

8.3 Research question development (RQ5)

The unrivalled potential of Big Data Analytics drives more sophisticated data driven decision-making as well as new ways to innovate, organize, and learn (Yiu, 2012; Kiron, 2013), having direct implications for businesses as *"almost no sphere of business activity will remain untouched by this movement"* (McAfee and Brynjolfsson, 2012, p. 7). The rationale being that information availability is the driver of corporate decision-making on strategic, tactical, and operational levels, as fact-based decision-making requires a sound foundation (Rai *et al.*, 2006). This was showcased in an extensive research study on Big Data Analytics, comprising 3,000 business executives, where LaValle *et al.* (2011) found that it is crucial for companies to analyze and manage the growing amount of data in order to extract the relevant pieces and to feed that information into their decision-making process. However, not being able to mine the data available and thus not having access to up-to-date, accurate and meaningful information represents a risk for companies and subsequently for the supply chain, as decisions need to be made on a reliable, evidence-driven basis (Ross *et al.*, 2013).

This holds especially true in regard to supply chain management, which heavily depends on the availability of accurate and up-to-date information for business execution (Cooper and Tracey, 2005; Gunasekaran and Ngai, 2004). Accordingly, the importance and value of information for effective SCM has been highlighted extensively in SCM research, most notably in regard to the sharing of information (Lee *et al.*, 1997; Li and Lin, 2006; Mentzer *et al.*, 2001). In the same direction Tang (2006) suggested that the coordination between supply chain partners could improve, if *"they can access various types of private information that is available to individual supply chain partners"* (p. 453). Christopher and Peck (2004) advocated for an exchange of upstream and downstream risk profile information among supply chain members to reduce associated risks.

However, given the steady growth of potentially relevant information and the corresponding challenges to identify the most valuable items, it is surprising that research on risks tied to and stemming from the use of information in supply chains is scarce (Kache and Seuring, 2014b). Especially the issue that the lack of accurate and "right" information, although being an essential ingredient for the application of Big Data Analytics as outlined above, may pose a risk to the supply chain has gained little attention in the academic supply chain landscape. Thus it constitutes a research gap, as identified in the literature review (section 6.8.4, p. 186) of the previously presented part of this dissertation. From a scholarly standpoint this research void clearly justifies the relevance of further research in this area. In addition, the importance of research on the topic is underlined by the growing number of SCM-focused papers and conferences calling for research on aspects of Big Data Analytics.

Further validating the existence of the research gap, a quick scan of the available literature was conducted using Google Scholar and applying the search terms "big data analytics" combined with "supply chain". The scan revealed that only three scholarly articles consider Big Data Analytics from a SCM perspective (Davenport, 2006; LaValle *et al.*, 2011; Waller and Fawcett, 2013). However, these authors do not facilitate a discussion on the role and value of accurate information at the corporate and supply chain level. They rather focus on the general applicability of data science, predictive analytics, and Big Data in regard to SCM (Davenport, 2006; Waller and Fawcett, 2013), or provide case examples underlining the importance of data analysis for decision-making (LaValle *et al.*, 2011).

Accordingly, the research presented in this dissertation aims to close this gap, focussing on the use of information at corporate and supply chains level, considering the opportunities and challenges imposed through the emergence of Big Data Analytics. Special attention is given to the aspect of how companies and supply chains identify valuable information required for decision-making as a means to reduce information risks. The subject will be approached through the following corresponding research question (RQ 5):

What are the implications of Big Data Analytics on information usage at corporate and supply chain level, especially with regard to information identification required for decision-making?

In order to address the last research question in this thesis, insights into the aspects of information usage are vital, where a focus should be on the assessment of information requirements for decision-making. Given the increasing growth of available information, a clear understanding of information requirements for decision-making is a strategic requirement and a source for competitive excellence through streamlined execution as information has a *"catalytic impact on real-time decision-making"* (George *et al.*, 2014, p. 324). The research extends previous researchers' work (Ross *et al.*, 2013) who found in a study that decision-making based on information is the key for effective data exploitation at the corporate level. However, Ross and his co-authors did not provide insights on the underlying aspect of how a company determines what the "right information" is they require for decision-making. Nevertheless, this seems to be the prerequisite for a focused application of Big Data Analytics motivated by the idea that you can only search for something if you know what you are looking for. However, the extraction of relevant information is subject to the availability of information which specifies the to-be-searched information. The dilemma can best be portrayed by the "needle in the haystack" analogy: The ever growing amount of information, represented through Big Data, represents the "haystack". The relevant information is the "needle" hidden in the haystack. However, basically all information may seem relevant at first glance for decision-making; the haystack thus seems to consist only of needles. An assessment of all potential information in regard to suitability for decision-making does not seem feasible from a resource point of view. Therefore it is paramount to specify the characteristics of the relevant needle which needs to be extracted from the haystack in order to enable a focused analysis of relevant information. In other words, the “right” information which is perceived most useful for decision-making needs to be defined. The collection of information requirements at business function level provides a suitable approach for this endeavor.

8.4 The value of Big Data Analytics for supporting the provisioning of information on a business function level

As indicated above, the research aims to provide insights into how companies and supply chains can leverage Big Data Analytics to manage the growing amount of data at the business function interface.

From a research point of view this makes good sense as, despite data management efforts, the scouting of individual departments for relevant information, which could be leveraged in decision-making, is still a wide-spread industry practice (Frey *et al.*, 2013; Hertzum and Pejtersen, 2000). Following the time consuming and highly inefficient but common practice, basically every department, sometimes even various entities within the same department, is utilizing corporate data bases such as SAP R/3, to search and retrieve relevant business data. Once extracted, the business function then analyzes the data, turning it into information which aids departmental decision-making. The just outlined current state of corporate information sourcing is depicted in Figure 8.2 (p. 221). This practice results in a lot of waste in terms of unnecessary resource utilization, both from the technology as well as human capacity perspective. In addition, the surge in data volume, variety, and complexity increasingly poses a challenge for business functions to extract the most relevant information. The current modus operandi is thus not only restricted in terms of efficiency, but also limited in regard to its applicability in a digital businesses environment.

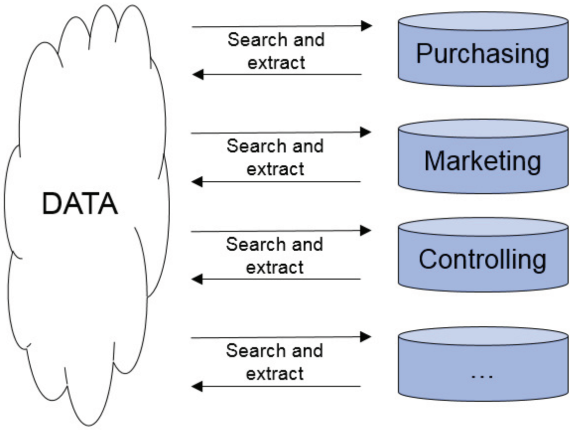

Figure 8.2: Current state of corporate information sourcing
(Source: Author)

Aiming to optimize the information sourcing process, the implementation of a centralized data service function seems suitable in this context in order to support the information provisioning to the business functions. Such focused provisioning of information, made available through a centralized data service function – dedicated to tailored data extraction and processing –, may well be a feasible solution to manage the steadily growing amount of information and release business functions from the time consuming effort to scout for relevant information. In such a concept, the data service function is positioned as a governing entity between the business functions, which enables a "smart" sharing of extracted data between business functions. Thus, the holistic perspective taken is expected to yield synergies derived from centralization, which allows for the extraction of conclusions from data and information that would remain hidden if viewed sorely through the eyes of an individual business function. In this regard, the business value of Big Data Analytics manifests in the fact that it represents an excellent tool which can be leveraged by the data service function to support the provisioning of relevant information on a business function level. The exemplary integration of such a (Big) Data service function into the existing business landscape is portrayed in Figure 8.3 (p. 222).

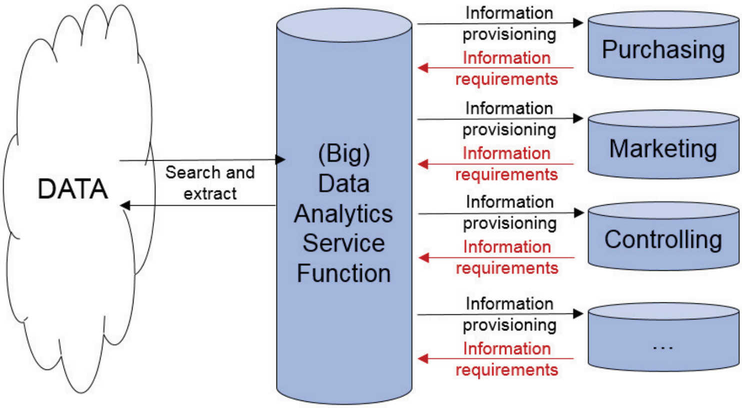

Figure 8.3: Proposed optimized scenario of corporate information sourcing
(Source: Author)

Being the major improvement of the proposed future scenario of corporate information sourcing, compared to the current setup, the business functions operationalize the (Big) data service function to get access to tailored information based on their needs. However, as outlined previously, it is a paramount prerequisite for the data service function concept that the business functions provide their information requirements, meaning the information they require for decision-making, to the data service function. In Figure 8.3 this is represented by the “information requirements” arrows, highlighted in red color. Based on these parameters, the data service function then searches and extracts the required data from the sources available. It is important to note that the sources are not necessarily limited to corporate sources only, but should include the data made available by supply chain partners. In addition, the sources explicitly embrace the full depth of Big Data as defined earlier in this dissertation. The extracted data is processed by the data service function in order to extract meaningful information, using the techniques of Big Data Analytics. In the final step, the relevant information, extracted as per the business function’s definition, is then provided to the requesting business function for further use. In essence, the main advantage of the future scenario over the current setup (Figure 8.2) is a reduction of waste as processes become leaner, freeing up resources which could be leveraged to drive growth.

The installation of the above described data service functions, also known as *hyperscale data centers*, which can not only process large amounts of data but also scale computational tasks to achieve superior performance, are a key element of becoming a digital business (Jeon, 2012). In addition, these centers provide opportunities to reduce operational cost through scalability of operations. Portraying the relevance of such an information provisioning entity, a range of companies already make use of hyperscale data centers, enjoying dramatic reductions of the time required to run analytic jobs, thereby overcoming the bottleneck of storage and retrieval of large data volumes. For instance these centers process analyses across distributed databases using specialized tools such as SAP HANA up to 10.000 faster than conventional data centers, putting these companies at the forefront of their industries as decisions can be made on almost real-time basis (Accenture, 2014). However, for a streamlined operation of these data service functions the definition of standards regarding data quality is required in order to ensure a delivery of information to business functions with constant quality. Thus, the definition of quality standards on the normative level is essential as it provides the grounds for the autonomous execution of tasks on the operational business level (ten Hompel, 2010).

Further leveraging cost improvement opportunities, it may be beneficial for companies to consider outsourcing the data service function. The application of external cloud computing solutions, known as “platform as a service” (PaaS), would allow for a maximum of flexibility combined with low investments in IT assets (Malfara, 2013). Nevertheless, such procedure seems only applicable in a business environment with mature processes.

The key aspect for the use of data service centers, either internal of outsourced, portrays the fact that the data service function requires the business functions to provide exact input on the information required. In order to ensure a smooth operation of the data service function the information requirements should be available in a standardized way. However, it is expected that the business functions are not aware of this quality requirement. In addition, it is questionable that the business functions are readily able to articulate their information requirements.

As already indicated above, the timely identification of valuable information is essential for informed decision-making and a means to reduce information risks in the supply chain. Aiding to the standardized collection of information requirements, the development of a framework for the structured assessment of information requirements at the individual business function level seems beneficial. Thus, in the next section of this dissertation a conceptual framework for the assessments of information requirements at business functions will be developed. The information requirements framework serves as a necessary building block for streamlined and centralized information provisioning, enabling business functions to deal with the growing amount of data, making use of Big Data Analytics in order to drive informed decision-making at corporate and supply chain level.

8.5 A conceptual framework for the assessment of information requirements

In a first step the theoretical underpinning governing the proposed conceptual framework is identified. These aspects provide the basis for the subsequent exploratory development of a conceptual framework for the assessment of business functions' information requirements, necessary to drive informed decision-making at the corporate and supply chain level.

8.5.1 Identifying a theoretical foundation for the conceptual framework

As outlined previously, digital-savvy companies do not just gather market or customer insights and make "smart" decisions, but they are able to turn these decisions into actions. As decision-making processes and the required corresponding "right information" vary across corporations and business functions, it seems reasonable to assess information requirements of corporations on a micro rather than on the macro level. Accordingly, the author decided to develop a conceptual framework with a clear focus on applicability in a business environment, taking a multi-dimensional perspective. However, making "right" decisions requires companies to know what "right" is. Thus, underlining the importance of having the right information, corporate decision-making requires the provisioning of information on which to base decisions.
In the next section, the theoretical foundation for the subsequent development of the conceptual framework for the assessment of information requirements is outlined.

As the availability of information has both strategic as well as operational business implications, the research approach applied was designed to cater for optimal coverage of the two areas. Following Meredith (1998), who recommended to basing one's own research on other researcher's findings, a theory-based framework needed to be identified from the extant literature. This framework serves as a baseline from which to develop the conceptual framework, which allows for a structured empirical assessment of information requirements. After scrutinizing a range of frameworks in regard to their applicability to this research, the author decided that the work by Seuring (2009) provided a sound starting point as it combines strategic management theory with aspects of operations theory. Relating to the focused factory concept (Skinner, 1974), Seuring utilizes operations theory as comprised of the Theory of swift and even flow and the Theory of performance frontiers (Schmenner and Swink, 1998) and transfers the concept to SCM. The resulting "product-relationship-matrix" framework arranges the "five Ps" for supply chain strategy, namely Products and Services, Partners and Partnerships, Plants and Stocks, Processes, Planning and Control, along configurational (or strategic) and operational decisions to be taken in the formation of a supply chain (Figure 8.4, p. 225).

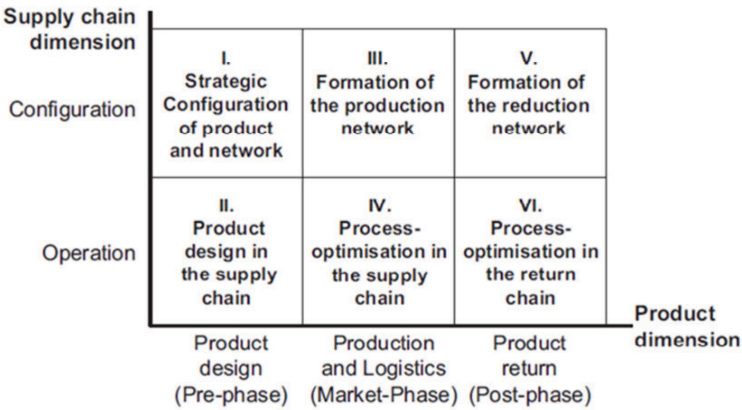

Figure 8.4: The product-relationship-matrix in supply chain management
(Source: Seuring, 2009, p. 225)

Employing a process approach, the matrix follows the life-cycle process along three phases, namely product design (pre-phase), production and logistics (market-phase) and product return (post-phase). Following Seuring's (2009) framework, the application of the "supply chain dimension" (Y-axis) allows for a structured analysis of the business functions' information requirements along configurational (or strategic) and operational decisions, covering all stages of the life-cycle process (the frameworks "product dimension" on the X-axis). The configurational decisions subsume the strategy and planning level, while the operational decisions relate to executional tasks.

8.5.2 Development of the conceptual framework

In this section the conceptual framework is developed, based on the outlined theoretical grounding, which provides a structure for the guided assessment of the information requirements on a business function level. This is the prerequisite for a focused application of Big Data Analytics, which subsequently could be leveraged to provide the information upon which business functions can then base their evidence-based decision-making.

Building on the previously highlighted information dependency of business functions, the author advanced Seuring's two-dimensional product-relationship model (Figure 8.4) by adding a third dimension. The third dimension is represented by the newly added Z-axis, which extends the model's applicability from a two-dimensional to a three-dimensional approach. The Z-axis contains the "information dimension," which allows for an assessment of the individual business functions' information requirements. The resultant conceptual three-dimensional information requirement framework (Figure 8.5, p. 227), allows for a structured assessment of selected business functions' information requirements for configurational (strategic) and operational decision-making in every step of the life-cycle process.

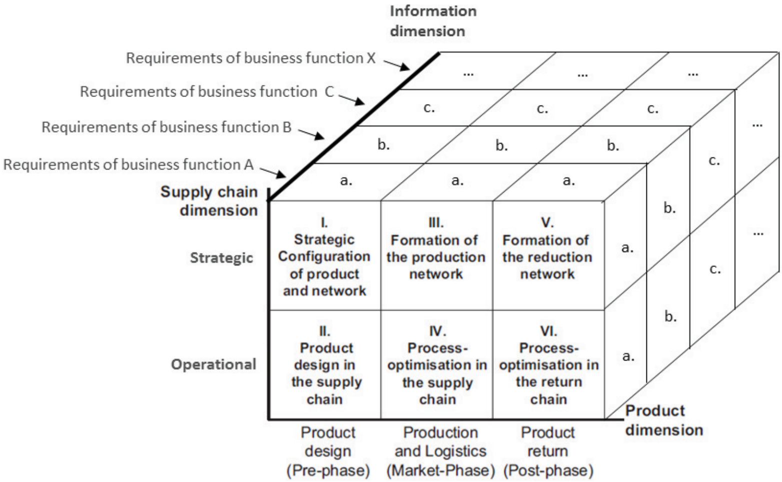

Figure 8.5: The information requirements framework
(Source: Author)

Although the systematic collection of information requirements is a new approach from a discipline of management perspective, similar procedures can be considered standard in other disciplines. For example, the information systems sciences utilize an approach known as *information requirements engineering*, or *requirements analysis*, which is commonly used in the design phase of computer-based systems engineering (Pandey *et al.*, 2011; Byrd *et al.*, 1992). Following a structured, systematic procedure, this multi-step approach covers the elicitation, understanding, documentation, and analysis of the capabilities and features the planned system needs to possess. For an in-depth study of the processual steps the interested reader is referred to the classical work by Sommerville and Kotonya (1998). Their seminal work provides a detailed overview of the constituents governing each step the requirements engineering approach.

Borrowing from the approach in the information systems sciences, the author of this dissertation assessed if the process of *information requirements engineering* yields some insights suitable to guide the assessment of business functions information requirements. As a result, it seems applicable to facilitate the elicitation of information requirements by following through the below presented process, which the author labels the "five stage information requirements collection process":

1. **Information requirements inception:** As-is assessment of the current landscape of information requirements on which decisions are being based. The collected current state needs to be formalized for the assessment in the subsequent stage.
2. **Information requirements analysis:** The gathered existing information requirements are assessed in terms of applicability to functional, corporate, and supply chain requirements in order to define the needs for missing or more accurate requirements.
3. **Information requirements formalization:** New information needs, in terms of more accurate or previously missing requirements, are defined and collected along the configurational and operational level. This process should include the formalization of the explicit need for the information. Thus, a case for the relevance of the required information needs to be established.
4. **Information requirements validation:** The full list of information requirements is validated through key stakeholders. This step also covers an assessment of requirements quality as well as structural consistency. Although the process can be terminated upon completion of this stage (stage 4) as the relevant requirements have been collected, it is strongly advised to commence the process (stage 5). This is considered paramount in order to ensure long-term relevance of the requirements and reduce risks tied to use of irrelevant information needs.
5. **Information requirements monitoring:** The validated list of information requirements should be monitored on a continuous basis, latest when structural or functional changes in the company / supply chain occur, to ensure the information requirements meet actual demand. The iterative monitoring process is best operationalized by following through stages 1 to 4 as outlined above.

Ground on the information requirements engineering approach of the information systems sciences (Neill and Laplante, 2003; Nguyen and Swatman, 2003), the author of this dissertation is certain that the process enables a structured and standardized collection of the business functions' information requirements based on a tested approach.

The information requirements framework is operationalized by following a chronological process approach along six "sub-processes" which follows the structure proposed by Seuring (2009), shown in Figure 8.5 (p. 227). Each of the sub-processes is assessed through the five stage process with a focus on the individual information requirements of a certain business function, whereas in the framework the business functions represents an “area” of that sub-process. In the following the chronological process is exemplified for better clarity of how the sub-processes and the areas are operationalized:

Starting in “sub-process I.” the “strategic configuration of product and network” is determined, which includes decisions on specific future product and service offerings and possible co-operations.

Within “area a.” on the “information dimension” of “sub-process I.” the information requirements of “business function A” are assessed along the five stage process. Accordingly, the information required is gathered, analyzed, formalized, validated, and prepared for continuous monitoring. Next, the information requirements for “business function B” are collected and assessed in “area b.” of “sub-process I.”, following the five stage process. The same procedure is continued for “business function C” in “area c.” of “sub-process I.” Upon completion of “area c.” of “sub-process I.” the strategic information requirements of the product design phase have been collected.

Moving to “sub-process II.” the operational information requirements of product design are identified for each business function, starting with “area a.” of “sub-process II” and following through to “area c.” Next, the strategic information requirements for the formation of the production network (“sub-process III.”) are collected from a business function perspective, starting with “area a.” of “sub-process III.” and following through to “area c.” This processual approach is continued until the last area of “sub-process VI.” has been assessed. By working through all areas of the six sub-processes in this chorological process order, all information relevant aspects in the life-cycle process for the business functions included in the assessment are systematically identified.

It should be noted that the order of the business functions, exemplified by business function A to C, represented through areas in the framework, does not constitute a structure in the sense that a certain function is more important than others are, or that the functions are dependent on each other. The order of the business functions is only used for explanatory purposes in order to outline the execution of the framework. In addition, due to the flexible design of the framework, the order of information collection can be altered if required in the sense that all sub-processes can be completed for a single business function first before moving on to the next area, collecting information from other functions.

A key benefit of the proposed framework is its seamless scalability as business functions can easily be added – exemplified through the inclusion of "business function X" – and removed as required, therefore providing maximum flexibility to map corporate information requirement needs with the resources available. Nevertheless, the best results are expected to be achieved when the framework is applied to as many business functions as possible as synergies can be derived from the detection of similar information requirements at cross-functional level. As a rule of thumb, at least the vital core business processes should be included in an information requirements assessment exercise. However, the identification of these relevant core processes is subject to managements' judgment taking into account business and industry characteristics at corporate and supply chain level.

The framework collects vital insights on the use of specific information requirements on a business function level ("information dimension"), as a clear understanding of information requirements is paramount to reap the benefits and operationalize Big Data Analytics (Ross *et al.*, 2013). However, as the volume and variety of data grows with increasing velocity (Laney, 2001), so does the scale and complexity of data in the supply chain. Accordingly, the usability of the framework is by no means limited to the corporate level, as the framework was explicitly developed to allow for an assessment of the supply chain information requirements. Due to the modular and systematic structure of the framework, the information requirements – assuming they were collected at the same business function level but at different companies along the chain – can be exchanged and compared between supply chain partners. This procedure requires a certain level of trust and collaboration between supply chain partners, which may be an obstacle (Moberg *et al.*, 2002). Nevertheless, as indicated by Myhr and Spekman (2005) the supply chain partners benefit from such practices through a streamlined provision of information from the partners, which they can leverage to support their decision-making processes.

The proposed framework contributes to managerial theory building and adds value as it allows for a standardized structured assessment of business functions' information requirements, required to leverage the potential of Big Data Analytics. As according to Manuj and Mentzer (2008), *"the challenge is the ability to filter data for the most important information"* (p. 148), and given that business functions spend a substantial amount of time retrieving the information required for decision-making, knowledge about the functions information requirements is paramount from an overarching perspective to improve the functions' information provisioning. In this light, the framework can be seen as a practical tool to support centralized information provisioning to aide decision-making of business functions. Such focused provisioning of information, made available through a (Big) data service function – dedicated to tailored data extraction and processing –, may well be a suitable solution to manage the steadily growing amount of information and release business functions from the time consuming effort to scout for relevant information on their own. In addition, the holistic perspective taken is expected to yield synergies derived from centralization, allowing to extract conclusions from information and data that would remain hidden if viewed sorely through the eyes of an individual business function. The corresponding aspect of collaboration, being a key consideration to operationalize Big Data Analytics and extensively discussed by Beath *et al.* (2011), is taken care of in the framework as it allows for inclusion of a scalable amount of business functions.

Time is the critical element and timely data availability is paramount to turn information into a competitive advantage as the value of information deteriorates over time (Constantiou and Kallinikos, 2014; Stalk and Hout, 1990). Thus, it needs to be mentioned that the process of assessing a function's information requirements is not a one-time exercise. As the market environment and other parameters constantly change, companies should bear in mind that the "right information" is only a snapshot at a given moment in time, and that the information is only "right" with regard to the environmental parameters at that point in time. Subsequently, a regular review of the information requirements is essential, which must include possible alterations of the information requirements to adhere to changing conditions. The implementation of a rigorous review procedure, as covered in step 5 of the information requirements collection process (*information requirements continuous monitoring*), ensures high quality levels as well as the provisioning of accurate, up-to-date, and meaningful information to the business functions.

Not just having the data, but also knowing how to mine the data, using Analytics, and being agile in the process of making the right decisions, ultimately driving the market and continuously monitoring the environment is increasingly important. The company that does it right not just enjoys a distinct competitive advantage, but increases its chances of staying in the market. The proposed framework provides a practical guidance to assess how companies handle to "know" what the right information is. In this regard, the value of information should be scrutinized from two directions: First, evaluating what kind of information is important for companies to operate their own business and second, assessing the information in accordance to its marketing potential, considering new business opportunities through the sale of information to either supply chain partners or third parties. The corresponding assessment can be done with the help of the framework, which allows the researcher to systematically collect the required information for his own use at the business functions, but also for marketing purposes.

This chapter motivated and justified the selection of the exemplary under-represented area. Focussing on the role and value of information in supply chains, outlined along the nexus of SCM and the digital transformation agenda, special emphasize was given to the role of Big Data Analytics, which is a key aspect of the corporate digital transformation agenda, valuable for optimized decision-making. The presentation of the research question explained the need to identify information requirements in an increasingly information and data-driven business environment. A discussion of the role of information from a business function perspective led to the presentation of a centralized approach to data retrieval expected to yield synergies. On this basis a conceptual framework was developed for the guided assessment of the information requirements on a business function level.

The information requirement framework is largely of exploratory nature, although being theoretically ground on extant literature. However, the framework has yet to withstand the test for practical usability. This results in a certain lack of validity although the framework's practical relevance is unquestioned from the author's point of view, given the lack of research in this fundamental area. Enhancing the validity of the framework and reducing potential weaknesses, further research steps will be conducted in the course of this dissertation in order to operationalize and fine-tune the framework.

Due to the novelty of the Big Data Analytics concept, which materializes in a lack of comparable studies, the author thus applies a rather broad, exploratory Delphi study approach as will be presented in the next chapter (chapter 9). Utilizing experts' insights, the aim is to develop a first conceptualization of the challenges and opportunities of Big Data Analytics at corporate and supply chain level. In a next step, these insights and findings will then be integrated into the information requirement framework in order to enhance the structure and validity of the framework.

9 Assessing the impact of Big Data Analytics on corporate and supply chain level – A Delphi study approach

The Delphi methodology (Linstone and Turoff, 2002) is a suitable research approach for research into a new field of study, *“assessing present trends for which suitable data may be lacking”* (Rowe *et al.*, 1991, p. 241) by obtaining *“the most reliable consensus of opinion of a group of experts”* (Dalkey and Helmer, 1963, p. 458). In regard to the research at hand, the key benefit is to gain a deeper expert understanding of the implications of Big Data Analytics on information usage with a special focus on information requirements and decision-making at corporate and supply chain level.

The following chapter presents the Delphi study methodology used, outlining definitions and characteristics (sections 9.1 and 9.2), also providing a justification for the applicability and selection of the Delphi study methodology for the proposed research (section 9.3). In addition, the design of the study, including the selection of the expert panel as well as the presentation of the data collection process is outlined (section 9.4). Further increasing the transparency of the research process, the analysis and assessment phases are explained in detail, which includes a presentation of the findings of the Delphi study (section 9.5).

9.1 Definition of the Delphi methodology

The Delphi methodology, named after the ancient oracle at the Greek temple of Delphi, who offered visions of the future to those who sought advice, is a popular research instrument employed in technical and scientific investigations across a range of disciplines, such as business, education, and health research (Keeney *et al.*, 2006; Landeta and Barrutia, 2011). Although first performed in 1948, it was not until 1963 that the methodology was described in an academic publication, based on research conducted in the 1950s within the defense industry by Dalkey and Helmer of the RAND cooperation (Dalkey and Helmer, 1963; Dalkey *et al.*, 1969). Employing the new research methodology they ran various Delphi experiments in order to extract *“expert opinion to the selection –from the point of view of a Soviet strategic planner– of an optimal U.S. industrial target system, with a corresponding estimation of the number of atomic bombs required to reduce munitions output by a prescribed amount”* (Rowe and Wright, 1999, p. 354). Despite its overall defense-driven objective, the underlying scientific aim was to find practical ways how the negative impact of group interactions in decision-making could be limited (Rowe *et al.*, 1991). After having assessed the wealth of extant literature on Delphi research, it appears that two main aims can be distilled, which the Delphi methodology is designed to fulfill. As such, some researchers proclaim that the prime focus of the Delphi methodology is to reach a group consensus in order to support decision-making (e.g. Dalkey and Helmer, 1963; Keeney *et al.*, 2006; Lamb, 1975):

- The Delphi methodology supports to *"obtain the most reliable consensus of opinion of a group of experts"* (Dalkey and Helmer, 1963, p. 458).
- *The Delphi technique is a structured process that uses a series of questionnaires or 'rounds' to gather information which are continued until 'group' consensus is reached"* (Keeney *et al.*, 2006, p. 206).
- The Delphi methodology is *"conducted with the aim of achieving consensus or agreement among experts"* (Meijering *et al.*, 2013, p. 1607).

Other researchers (e.g. Förster and von der Gracht, 2014; Rowe and Wright, 1999; Moeller *et al.*, 1983), adhering to the initial visionary forecasting idea of the Greek oracle, see the major value of the Delphi study in its problem-solving strength, underlining its use in increasing forecast accuracy. This is evident in the following statements:

- The Delphi method *"is intended for use in judgment and forecasting situations in which pure model-based statistical methods are not practical or possible because of the lack of appropriate historical / economic / technical data, and thus where some form of human judgmental input is necessary"* (Rowe and Wright, 1999, p. 354).
- *"The Delphi technique has become one of the most commonly used and accepted methods to forecast future events"* (Moeller *et al.*, 1983, p. 96).
- The Delphi method is *"particularly applied in judgmental forecasting and corporate foresight where companies strive to generate forecasts about relevant issues in order to establish a more profound basis for strategic decisions"* (Förster and von der Gracht, 2014, p. 215).

Given the multitude of Delphi method definitions, as found by Bolger *et al.* (2011), a vivid discussion has evolved in the sciences on which of the two elements, consensus or forecast accuracy, is more relevant to the Delphi process. However, it seems that these two elements are not mutually exclusive as a Delphi study aims to achieve both objectives (Rowe and Wright, 1999), principally being a tool *for "prediction and consensus in contexts of uncertainty"* (Landeta and Barrutia, 2011, p. 135). In the same direction Gutpa and Clarke (1996) add that the Delphi methodology is *"a qualitative, long-range forecasting technique, that elicits, refines, and draws upon the collective opinion and expertise of a panel of experts"* (p. 185). In essence, the strength of the Delphi methodology lies in its function as a tool to enhance group judgment (Rowe *et al.*, 1991). This is evident in its design so as to *"obtain as many high-quality responses and opinions as possible on a given issue(s) from a panel of experts to enhance decision-making"* (Gutpa and Clarke, 1996, p. 186). The use of expert panels in the group communication process is fuelled by small group dynamics (Goodman, 1987), driven by the underlying assumption of the Delphi methodology that *"two heads are better than one, or...n heads are better than one"* (Dalkey, 1972, p. 15). This assumption is motivated by the "theory of errors", proposed by Dalkey (1975), which basically outlines that an aggregate of a group is superior to the majority of the groups individuals and that an increase in the number of respondents results in a reduced risk of reaching an erroneous group consensus (Rowe *et al.*, 1991).

A comprehensive and detailed definition of the conventional Delphi methodology, covering both elements as mentioned above, was presented by Linstone and Turoff (2002, p. 3): *"Delphi may be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem. To accomplish this 'structured communication' there is provided: some feedback of individual contributions of information and knowledge; some assessment of the group judgment or view; some opportunity for individuals to revise views; and some degree of anonymity for the individual responses."* As this definition is followed by the majority of researchers employing the Delphi study methodology across disciplines (for example Klenk and Hickey, 2011; McKenna, 1994; Mullen, 2003; Okoli and Pawlowski, 2004; Seuring and Müller, 2008b), it is found suitable to serve as the guiding Delphi definition in this dissertation.

9.2 Characteristics of the Delphi methodology

The Delphi methodology, originally developed as a conventional pen-and-paper Delphi method, has been steadily modified and extended. As a result, a range of different variations of the Delphi methodology have evolved, for example the computer-based real-time Delphi method (Linstone and Turoff, 2011; Rowe and Wright, 2011). Given the sum of Delphi variations, Gupta and Clarke (1996) conclude that *the "versatility of Delphi is both its power and its fallibility"* (p. 190). This is based on their finding that the multitude of modifications to the Delphi methodology over the years have in some cases lead to a better understanding of the technique, but in other cases been rather random which undermined its quality and credibility. In general, researchers differentiate between three categories of the Delphi methodology, namely the Policy Delphi, the Decision Delphi, and the Classical Delphi (Crisp *et al.*, 1997; Van Zolingen and Klaassen, 2003; Woudenberg, 1991).

The *Policy Delphi* (Turoff, 1970) aims to develop policy alternatives through the use of a structured dialogue where it is not required to reach a group consensus, but to extract as many different opinions as possible from the expert panel. A key feature of this Delphi version, among others such as iteration, controlled feedback, polarized group response or selective anonymity, where participants may answer questions individually, but may also revert to group interaction, is the facilitation of structured conflict to increase the quality of answers (Rayens and Hahn, 2000).

In a *Decision Delphi* (Rauch, 1979), used for example in decision-making on social development, the expert panel is composed of real decision makers, involved in the problem of the study under investigation, rather than distant, uninvolved experts. Being the key differentiator, it is the main goal of a Decision Delphi to structure thinking in order to reach a group consensus (Tichy, 2001).

Being the most commonly used and researched Delphi methodology, the *Classical Delphi* (Kendall, 1977) is characterized by anonymity, iteration, controlled feedback, statistical group response and stability in responses among a range of experts on the subject under research (Linstone und Turoff, 2002).

In essence, based on the three categorizations as outlined above, the following aspects can be distilled as being fundamental to a Delphi research approach (Gupta and Clarke, 1996; Hasson *et al.*, 2000; Häder and Häder, 2000; Linstone and Turoff, 2002; Rowe *et al.*, 1991):

- anonymity of respondents,
- inclusion of experts (which in the case of the Decision Delphi need to be involved in the subject under research),
- repeated iterations,
- controlled feedback to the participants, and
- statistical aggregation of group response.

The role and function of these aspects within the Delphi methodology will be presented in the following section as they portray key advantages of the Delphi research methodology:

The **anonymity** of participants in a Delphi experiment, where the participants' identity is not disclosed to the other participating parties, allows for the participants to answer in private. This increases each participant's ability to express his own opinion without having to face group pressure consequences (Grisham, 2009). Reducing process loss within the experiment (Bolger and Wright, 2011), the participants are able to answer freely and even change their opinion. Thus, as the social interaction is technically limited between participants any kind of "*socially motivated hindrances which usually trigger process loss are removed from the experiment"* (Rowe *et al.*, 1991, p. 236). This results in participants' answers being more ad-hoc and "natural," which eliminates interference from factors tied to stressful situations, such as having to give the response in an atmosphere which the participant is not used to (for example in a research lab setting). Increasing response quality, great degrees of freedom can be given to the participants regarding their individual choice of answer location and answer pace. In essence, a key benefit of the anonymity is the removal of negative aspects linked to the social difficulties within freely interacting groups. This specifically aims to avoid situations where a specific expert develops into an opinion leader and dominates the consensus (Keeney *et al.*, 2006). According to Jairath and Weinstein (1994), the aspect of anonymity can be seen as a major reason for the popularity of the Delphi methodology as it enables the inclusion of a large number of individuals across a multitude of locations and covering a range of expertise. This allows for a maximum of freedom for the researcher in the research design. Nevertheless, especially the aspect of anonymity is also seen as a shortcoming of the methodology by some researchers such as Goodman (1987), as the participants' anonymity may reduce their accountability for proposed opinions.

The **inclusion of experts** is operationalized through "*a series of intensive questionnaires interspersed with controlled opinion feedback*", with the aim to extract the experts views towards a given subject, as outlined in the original work by Dalkey and Helmer (1963, p. 458). Expert participation is fundamental for the Delphi study as the to-be-researched topics are usually very specific in scope and require a high degree of knowledge on the individual subject (Okoli and Pawlowski, 2004). In addition, the inclusion of experts has been reported as being the key driver of accurate results (Riggs, 1983).

The **controlled feedback to the participants** ensures that each participant has access to the answer of all the others, provided through the research monitor team. This is a prerequisite for individual opinion adjustment in preparation to the next iterative round. Similar to the aspect of anonymity, the controlled feedback is a lever to reduce hierarchy-driven behavior as the participants can freely express their thoughts (Crisp *et al.*, 1997).

Repeated iterations allow the members of the expert panel to rethink and potentially change their opinion over the course of multiple rounds (Lamb, 1975). In contrast to a "one-round Delphi" (de Meyrick, 2003), a multiple round Delphi requires higher research efforts in terms of having to assess and aggregate the answers more than once which generates higher cost (Bolger and Wright, 2011). However, the results of a multi-round Delphi with continuous expert assessment are generally more robust, accurate and add to construct validity. They also yield higher quality as the participants' answers are more "thought through" (Parente *et al.*, 1984).

The **statistical aggregation of group response** at the end of each iterative round offers insights into the process of group consensus building, thereby providing essential details on the number of further rounds required to reach a stable consensus. Additional insights can be derived through a comparison of the final aggregated responses of the group to the individual's answers, where the deviation spread between the two items is assessed (Dalkey *et al.*, 1969; Rowe and Wright, 1999).

In the following the process of the Delphi methodology approach will be outlined, exemplified through the Classical Delphi approach, as being the most commonly used Delphi version. Although a variety of processes have been proposed, which differ in terms of granularity (e.g. Grisham, 2009), the four-step approach as proposed by Linstone and Turoff (2002) is the most widely accepted approach for the Classical Delphi and will therefore be presented.

1. In a first step, the research problem or the research question is operationalized through the development of related assessment criteria, which are suitable for quantitative judgment through the panel of experts. Rowe and Wright (2011) outline that these criteria can be either prepared by the research monitor team, which steers and conducts the Delphi study with the experts, or the criteria are developed by the panel of experts, using open qualitative questions. This constitutes *round one* in a Delphi study.
2. Step two comprises the creation of a standardized questionnaire which will be sent (*round two*) to the panel of anonymous informed individuals ("experts") in a specific field of application in order to seek their opinion or judgment on a particular issue (McKenna, 1994). Woudenberg (1991) proposes the execution of a "pretest" study where the questionnaire is being tested with a small sample of experts before being circulated to the full group. This allows for early detection and removal of potential flaws within the questionnaire, ultimately reducing the risk of participants' non-response.
3. In the third step, the questionnaires have been filled in and returned by the participants. The data is summarized by the research monitor team and a new, more refined questionnaire is designed based on the solicited responses. In this *third round*, the new questionnaire is then circulated to each participant. It shows the overall group response to a certain question of round two, as well as the contrasting participant's own response. The aim of round three is to give participants the opportunity to revise their initial response under consideration of the presented anonymized group results (Keeney *et al.*, 2006).
4. In step four, the final step, the monitor team checks if the returned questionnaires from round three have altered the overall results, or if a stable consensus has been reached. In case no stable consensus could be reached, the process of questionnaire refinement, results collection, aggregation, and feedback to the respondents continues, until a stable consensus is achieved. In addition, the Delphi study can be terminated based on any predetermined end-criteria, such as a maximum number of rounds (Linstone and Turoff, 2002).

The Delphi methodology has been described to be best applied to research contexts where other traditional research methods, such as surveys or case studies, do not provide suitable outcomes as initial input information is not at hand (Rowe *et al.*, 1991).

Application areas where the Delphi methodology was successfully applied in a range of context in the past include the evaluation of possible budget allocations (Ang *et al.*, 1979), the exploration of urban and regional planning options (Yousuf, 2007), the gathering of data not accurately known before (Hsu and Sandford, 2007), or the development of causal relationships in complex economic or social phenomena (Bradley and Stewart, 2002), among others.

Adding to the ongoing discussion of the value of the Delphi methodology, which has long been debated in academia, most notably in regard to the applicability of the methodology to a range of research contexts, Linstone and Turoff (2002, p. 4) distill the following scenarios which indicate the applicability of the Delphi methodology to a research problem:

- "*The problem does not lend itself to precise analytical techniques but can benefit from subjective judgments on a collective basis.*
- *The individuals needed to contribute to the examination of a broad or complex problem have no history of adequate communication and may represent diverse backgrounds with respect to experience or expertise.*
- *More individuals are needed than can effectively interact in a face-to-face exchange.*
- *Time and cost make frequent group meetings infeasible.*
- *The efficiency of face-to-face meetings can be increased by a supplemental group communication process.*
- *Disagreements among individuals are so severe or politically unpalatable that the communication process must be refereed and / or anonymity assured.*
- *The heterogeneity of the participants must be preserved to assure validity of the results, i.e. avoidance of domination by quantity or by strength of personality ('bandwagon effect').*"

Nevertheless, the appropriateness of the application of the Delphi methodology is dependent on the alternative research methods available (Reid, 1988). Grisham (2009) adds to the above scenarios proposed by Linstone and Turoff (2002), stating that a Delphi study is fruitful if this *“technique has not been utilized in the past”,* also offering an *“opportunity to check the validity of the cross-disciplinary (social, psychological, ethical, managerial, cultural, anthropological, etc.) nature of the issue”* (p. 117).

However, despite the advantages of the Delphi methodology, as outlined in this chapter, the applicability of the methodology is also subject to criticism (Cantrill *et al.*, 1996). Three major reasons for critique can be distilled, which are linked to the often inaccurate execution of the Delphi methodology, as found in a study on Delphi methodology usage by Rowe and co-authors (1991):

Firstly, authors making use of the Delphi methodology tend to tailor the Delphi methodology to their research needs and rarely stick to the pure application of one Delphi version. Often they apply a variety of methodological deviations where, for instance, the first round is structured. Although this limits the opinion building process right from the start, adding bias as the answers of the participants are guided instead of giving them the freedom to freely express their opinion to a given topic, this is often necessary in order to provide a common starting point which frames the data collection (McMurray, 1994).

The second critique is linked to the composition of the expert panel. Exceptional ideas and new thinking requires the input from knowledgeable experts with long experience in the area of question. However, as from a research design perspective, the identification and recruiting of experts willing to participate in a Delphi study is a major obstacle, a great range of Delphi studies revert to the easier approach and rather employ “inexperts”, such as for instance homogeneous groups of students (Baker *et al.*, 2006). This short-cut approach, however, is inadvertently threatened by a standardization of participants’ knowledge, a phenomena inherent to groups with similar backgrounds (Okoli and Pawlowski, 2004). As the aim of the Delphi methodology is to gather a range of different views towards a topic, to aggregate the views, and to generate consensus among participants’ views, the *“benefit of any group-like aggregation”* is in question *“if varied information is not available to be shared”* (Rowe *et al.*, 1991, p. 241). Accordingly, the heterogeneity of the panel is paramount to generate value-adding results.

Nevertheless, the required heterogeneity leads to the third major critique of the Delphi methodology: The aggregated opinions from a group of diverse experts on a usually narrowly scoped topic are difficult to generalize (Rowe and Wright, 2011).

However, although impacting on the methods external validity and reliability, this is seen as a rather maintainable aspect as the Delphi methodology is predominantly applied in exploratory qualitative research contexts, where few if any other research methods are suitable (Lin *et al.*, 2008; Williams and Webb, 1994). Nevertheless, as proposed by Loo (2002), this shortcoming of the Delphi methodology can be overcome through the use of “across method” research triangulation. This enhances the generalizability of results while adding to external validity and reliability as proven by van Dijk (1990).

9.3 Justification for selected research method

The Delphi methodology, in particular the Classical Delphi, was selected for this research, as it is superior to a range of other research methods, such as focus groups or interviews, for exploring a new field of research under consideration of time and financial restrictions.

Given the novelty of Big Data Analytics in a management context, which also holds true in regard to supply chain management, a great depth of special knowledge is required in order for being able to answer the research question. The consultation of knowledagble subject matter experts was seen as the only feasible way to collect the required insights, also adding to the validity as well as relibaility of the study. Individual expert interviews would have potentially yielded more in-depth insights but the participants would not have been able to embrace other respondents’ feedback. This was expected to result in less fruitful results and also negatively affect the quality and depth of the study. In addition, this approach limits the generation of an agreed upon valid group consensus, which was regarded as being important for this study so as to increase the validity of the Delphi study results.

The application of the focus or panel group methodology, which is known as an acknowledged tool to reach a group consensus, was not feasible due to the international composition of the group of experts, being located in five countries across three continents. Having the participants gather in one location to run the study was not possible due to financial restrictions. Another disadvantage of the focus / panel group methodology is linked to the risk of opinion ownership where a few participants dominate the discussion, thus preventing a balanced opinion provisioning by all participants (Dalkey and Helmer, 1963). Accordingly, the Delphi method was repeatedly found to outperform this type of nominal group technique in terms of forecast accuracy and consensus building (Bolger and Wright, 2011; Kauko and Palmroos, 2014). The anonymous collection of expert insights using a structured questionnaire overcomes this risk of opinion leadership, as it allows for all participants to provide their undisputed views free of social pressure towards the research topic, while also enabling a controlled feedback of participants' answers to all members of the group. The transparency of this research process, where each expert answer was archived by the research monitor team (the author of this dissertation), ensured that the study results are reliable and valid from a methodology point of view. As the iterative approach allows for multiple data collection points throughout the study, the Delphi method ultimately represents an excellent tool to maximize the amount of high quality responses and opinions extracted from the study's panel (Gupta and Clarke, 1996). The distributed, flexible approach of the Delphi study, where the participants control location and answer pace, was considered the key advantage of the Delphi study in order to reach an acceptable answer response rate required to obtain valid research results. In lieu thereof, the Classical Delphi (Kendall, 1977; Linstone and Turoff, 2002) approach has been chosen in this work as a suitable research technique for the collection of empirical data in order to gain a deeper understanding of the implications of Big Data Analytics on information usage, especially information requirements and decision-making at corporate and supply chain level.

9.4 Application of the Delphi methodology

As the effectiveness of the Delphi methodology is dependent upon the way it is being conducted (Bolger and Wright, 2011), utmost care was taken in preparing for a smooth collection of empirical data. This comprised the identification of suitable experts as well as gaining a clear understanding on design parameters of the Delphi study.

9.4.1 Design of the Delphi study

The design of the Delphi study is founded on the structural recommendations outlined by Okoli and Pawlowski (2004), based on Schmidt (1997) and Linestone and Turoff (2002), which provides excellent guidance to describe the research process applied in the subsequent chapters. Following their recommendations, the data collection process starts with the brainstorming phase (*initial collection of factors*). It commences with a consolidation phase where most important factors are chosen (*narrowing down of factors*) and ends with the evaluation phase, where a *ranking of relevant factors* is conducted through multiple rounds if required, until the end-criteria is reached.

Following Rowe and Wright (2011), the data collection is initiated through open qualitative questions, which motivate the development of criteria by the panel of experts. Going forward, the aggregated criteria serve as a platform for the subsequent quantitative rounds.

The definition of a qualifying cut-off or termination point is a major component in the design of the Delphi study (Keeney *et al.*, 2006). The following two approaches are available to determine the best cut-off point:

The mathematical, non-parametrical statistical approach employs the repeated measurement of the degree of concordance within the expert answers. This is operationalized by comparing the group mean ranking in the second and third round to a fictitious "perfect consensus" mean ranking (Couger, 1988). The degree of concordance between the two rankings is assessed using Kendall's coefficient of concordance, known as *Kendall's W* (Kendall, 1955). Kendall's W is a solid measure which allows for a fact-based assessment if any consensus has been reached and whether the consensus is increasing or declining (Abdi, 2007). In addition, it gives insights into the relative strength of consensus. Schmidt (1997) proposes a classification of Kendall's W comprising five steps, ranging from 0 (no concordance) to 1 (highest concordance), where a value of 0.7 represents a valid cut-off value (Table 9.1, p. 245). Although other measurement procedures exists, a quick scan of the extant literature reveals that Kendall's W is the most popular mathematical method applied, mainly due to the method's simplicity.

Kendall's *W*	**Interpretation**	**Confidence in Ranks**
.1	Very weak agreement	None
.3	Weak agreement	Low
.5	Moderate agreement	Fair
.7	Strong agreement	High
.9	Unusually strong agreement	Very high

Table 9.1: Interpretation of Kendall's *W*
(Source: Schmidt, 1997)

The second approach to determine the cut-off criteria for the Delphi study, the qualitative approach, is governed by the fact that no further insights and no improvement in answer quality can be derived from additional Delphi rounds. This is usually the case if two consecutive rounds receive stable feedback with very little variations in results.

9.4.2 Selection of experts

The expert selection process is a major component in the design of a Delphi study as the number and quality of experts has a direct impact on the quality of the answers and thus on the overall value of the research results. The size of the optimal expert panel has been vividly debated among scholars. As such, a range of authors have reviewed research publications containing Delphi studies regarding the used panel size, revealing that anything from ten to many hundreds of experts were considered in the various studies (Mullen, 2003; Powell, 2003; Williams and Webb, 1994). Based on a comparison of studies, Okoli and Pawlowski (2004) have defined a panel size of 10-18 experts as being sufficient to derive meaningful, yet robust results in most cases. It should be noted, however, that the optimal size is also dependent on the number of experts which are potentially available (Förster and von der Gracht, 2014).

Considering that academic research at the crossroad of Big Data Analytics and SCM is scarce as outlined in section 8.3 (p. 217ff), limiting the availability of scholars for the planned research, the author opted for an exploratory practitioner-involved research approach. The practitioners were identified within a leading global company in the management consulting industry. This industry seemed suitable for the selection of practitioners based on two assumptions:

The first assumption was tied to the novelty of the research topic linking the areas of Big Data Analytics and SCM. It was therefore expected that very few companies in rather “traditional” industries, such as automotive, chemicals, or fast moving consumer goods (FMCG), to name a few, have dedicated personnel which is knowledgeable in this area. Getting access to these few forward thinking experts was also deemed a major challenge. However, as it has been reported that management consultants are employed by clients for their holistic forward thinking mindset (Rubenstein-Montano *et al.*, 2001), which in essence is a good description of the required experts’ skills, it seemed reasonable to assume that suitable experts could be found within the management consulting industry. In addition, consultants have a rather broad set of knowledge across a range of clients and industries, a benefit of the project type of work, which was expected beneficial in order to get a holistic perspective on cross-industry aspects of Big Data Analytics in the evaluation phase of the research.

The company utilized for the research in this dissertation is a leading player in providing management consulting, technology, and outsourcing services to a global base of clients. Driving the digital transformation agenda – a key focus of the company's strategy – industry expertise combined with digital technological capabilities are leveraged to support the clients on their digital transformational journey. The company's forward thinking capabilities in this area are evident through a range of publications, mostly "white papers", on Big Data Analytics and related topics. In addition, the company has been repeatedly acknowledged as a prime source for SCM and operations consulting expertise (Canibol *et al.*, 2014). As the panel is expected to provide their opinion on aspects at the intersection of Big Data Analytics and SCM, the opportunity to interview experts from both areas, Big Data Analytics as well as SCM, within the same company constituted a major advantage and thus justifies the selection of the company.

The second assumption was bound to the fact that the author was granted permission to contact the company's experts. As the buy-in and commitment of experts in a Delphi study is sometimes difficult to achieve (Hasson *et al.*, 2000) the direct access to the company was seen as a major aspect aiding the identification of potential experts. The author's strong ties to company executives, although being a source of bias, greatly increases the chance of convincing employees to participate as experts in the research study.

Considering the above mentioned aspects, the respective management consulting company was considered suitable to serve as an excellent source for the identification of experts and has been accordingly been selected by the author.

The following outlines the selection of the experts, which roughly followed the expert selection process for Delphi panels comprising five steps, outlined by Okoli and Pawlowski (2004), and based on Delbecq *et al.* (1975). As a first step, the author assessed factors which would be important to collect from the Delphi panel. It appeared that the initial research question provided a good basis for the collection of input. Step two required the nomination of experts. However, a major challenge at this point in time was the fact that a pre-determined list of experts was not available to the author. Nevertheless, one key contact person had been recommended which upon request provided four additional potential expert contacts, mostly senior partners of the firm. These contacts were asked to nominate at least four additional experts each, which represents the third step of the expert selection approach. For the nomination of the experts it was important that these persons had project experience or insights into current developments involving Big Data Analytics and SCM topics. Commencing with the “snowballing” approach, a total of 30 potential experts could be nominated, knowledgeable in either one or both areas of SCM or Big Data Analytics. As the list of experts was developed through the input of four senior members of the management consultancy’s leadership team responsible for Big Data Analytics as well as SCM activities, it can be assumed that the selection of experts is balanced and representative in terms of expertise. Thus, the results are expected to comply with aspects of external validity.

Aiming for increased analysis possibilities the expert panel was segmented into groups, which in this case was conducted along the aspects of qualification and seniority (step 4 of the expert selection process). However, to create groups of experts committed to participate, it was considered reasonable to first collect the experts’ consent to participate in multiple rounds of questions. Accordingly, each of the 30 potential sample candidates was contacted using personalized emails and asked for their willingness to participate in the study. This represents step five, the last step of the expert selection process. Along with the email a copy of the research proposal was sent to each expert, outlining in detail the purpose of the research, pinpointing the importance to participate. It was also explained what was required of the experts, what will be done with the information, also providing a rough schedule of the study’s duration (3 phases) as well as estimates of the time the participants will have to allow for each phase of the study. In addition and being the only incentive for their participation, the experts were promised a copy of the study’s results upon request. In case of non-response to the initial invitation, follow up reminder emails were sent to the experts. Some experts were in addition contacted via telephone and through instant messenger chats. In the end, a total of 20 experts consented to participate in the Delphi study, which is a suitable sample size following the recommendations by Okoli and Pawlowski (2004). Of the remaining ten experts which did not provide their consent, nine did not respond to multiple follow-up emails and one expert explicitly asked to be removed from the panel.

Following the recommendations by Rowe *et al.* (1991, p. 241) and as outlined previously (section 9.2), heterogeneity of the groups was a guiding principle when selecting the group of experts. Aiming for a balanced grouping approach, the sample of 20 experts was split into two groups according to their key qualifications: One group of eleven experts had a strong technical background, focussing on digital business transformational issues, especially Big Data and / or Analytics. Accordingly, this group will be labelled “Big Data / Analytics”. The other group of nine experts had more of a managerial background, where the focus of expertise was on SCM or similar areas such as operations. This group will thus be subsumed under the label “SCM”. The rationale for the grouping of experts, besides enhanced assessment possibilities of study outcomes, is based on the idea that the study may eventually provide an answer to overcome the often described gap of understanding between technical and managerial employees which is a common problem in companies as outlined by Waller and Fawcett (2013). As the dissertation employs a mixed group approach the work may therefore be seen as a further initiative driving to overcome the differences between technical and managerial point of views, essentially aiming to derive a common, multi-perspective view towards research along the aspects of Big Data Analytics and SCM.

The initially planned grouping of the experts according to seniority was not considered any further as it soon was observed that the composition of the panel did only yield unbalanced group sizes. Thus, it appeared that the majority of experts (14) was of a senior level with usually more than 8 years expertise (Level 4 and 5). In contrast, the group of experts with less than 8 years of experience in either SCM or Big Data and / or Analytics (Level 1 to 3) was considered too small to constitute an own sub-sample (6 experts). Table 9.2 details the composition of the final expert panel considering panel qualification levels as well as expert seniority per level. It is assumed that seniority and the respective experience in a certain area of subject directly impact on an expert’s expertise.

Level of expertise	Number of panel experts with …		Σ
	… a main focus on Big Data / Analytics	… a main focus on SCM	
Level 5 (Highest level)	3	2	**5**
Level 4	4	5	**9**
Level 3	2	1	**3**
Level 2	1	1	**2**
Level 1 (Entry level)	1	0	**1**
Σ	**11**	**9**	**20**

Table 9.2: Expert panel composition statistics
(Source: Author)

The total expert selection process, from establishing first contacts to collecting final written consent of the 20 participants, covered a period of almost 3 months, starting in October 2013. Investigations into the reasons for the slow response outlined that this was largely due to the high workload of the experts, which resulted in a low prioritization of the research study in their daily work. This is yet another reason for the application of the Delphi study in the research context as it allows for a self-paced autonomous answer procedure.

9.4.3 Data collection process and response rate

As the first contact with the expert panel had already been established through a detailed introductory email asking for the panel member's consent to participate as outlined above, the panel had been provided with the rationale and overall motivation for the Delphi study.

Given the author's experience in the expert selection process, which included the lengthy and time-consuming task of "chasing" the panel member for their written consent to participate, it was likely that such issues would also continue well into the consecutive rounds of the Delphi study. As such, it was expected by the author that a small number of participants would not respond to the invitation to provide their feedback in all rounds, even though the experts had given their written consent to participate throughout all rounds of the Delphi study.

As the number of Delphi rounds depends on a range of factors, for example the amount of time available for the study or if an initial starting question has been provided to the participants and thus does not need to be developed by the panel (Hasson *et al.*, 2000), the author planned to cover three rounds of expert feedback. Although the limit to three rounds seems contradictory considering that the research was designed according to the four-step Classical Delphi approach as proposed by Linstone and Turoff (2002), outlined in section 9.2, it should be noted, following recommendations by Rowe and Wright (2011), that the initial starting question will be provided by the author and does not need to be developed by the panel. Thus, the presented approach deviates from Linstone and Turoff's (2002) approach in the way that the research process involving the panel will start with round two of Linstone and Turoff's model, being the first touch point for the collection of expert insights. For reasons of clarity the starting round will be referred to as "round one" as it is the first data collection step involving experts in the below presented Delphi study. In addition, the limitation to three rounds of expert feedback follows other researchers' recommendations whereby three rounds will be sufficient in a Delphi study to provide stable feedback (Green *et al*., 1999; Okoli and Pawlowski, 2004). Thus, the scoping to three rounds was expected to increase the experts' willingness to participate, as a more lengthy Delphi process might have impacted in a negative way on the participation rate.

Furthermore, a range of other measures were considered in order to increase experts' response rate. This included the design of the questionnaires used in the Delphi study which were built so as to ensure that every single round would not require more than 8-15 minutes to complete. The true participation of the experts was held anonymous thereby removing opinion leader bias. Accordingly, the names of the experts were not disclosed at any point during the Delphi study.

Throughout the three data collection rounds the experts were asked to provide their written feedback via email within two weeks of questionnaire receipt. In the case where no answer was received by the author within the given timeframe, the experts were sent up to six reminders via email and in some cases were also contacted via instant messenger, text message, and phone. In rare cases this resulted in an extension of the timeline by up to 6 weeks compared to the initial due date two weeks from questionnaire receipt.

Before the questionnaires were sent to the expert sample, each round's questionnaire was checked for consistency and comprehensiveness through a pre-test with one senior expert of the panel. If found applicable, the questionnaire was adjusted and fine-tuned to fit pre-test recommendations. Even though the employee had already taken part in the pre-test, the inclusion of the same employee in the Delphi rounds was not considered to be a limitation to the research as the answer possibilities in the rounds were close to infinite. The inclusion is also justified by the negative impact on the panel size caused by the removal of the expert. The pre-tests were found suitable to ensure reliability of the research, an approach also found applicable by a range of other researchers (Von der Gracht and Darkow, 2010). Nevertheless, despite these measures to strengthen the panel's response rate, the number of participating experts was subject to deterioration during the data collection phase, as will be outlined in this chapter.

The first qualitative Delphi round was initiated in mid February 2014. Following the scope of the fifth research question (RQ 5), outlined in section 8.3, the 20 participants were asked to brainstorm on the following two questions:

1) What are the potential implications of Big Data Analytics on information usage and decision-making on corporate level?

2) What are the potential implications of Big Data Analytics on information usage and decision-making on supply chain level?

The design of the first round needed to balance high levels of freedom for participants to answer, thereby not limiting the scope of participants' potential ideas, with the requirement of establishing a certain degree of comparability between the experts' responses. Thus, further splitting the questions to increase granularity, the participants were required to provide three to five opportunities and challenges associated with to each of the two open questions. This numeric range was set for orientation purposes only; although it was considered useful to ensure that participants would not revert to the easier and less time-consuming option of providing a single answer only. Nevertheless, due to the novelty of the research at the intersection of Big Data Analytics and SCM and the issues associated, as presented throughout chapter 8, it was still expected by the author of this dissertation that the experts would provide more than five opportunities and challenges. In essence, round one of the Delphi study required the experts to provide input to four sub-questions which were comprised of the two questions as outlined above, each broken down into two perspectives, namely the opportunity as well as the challenge perspective linked to that very question. Table 9.3 (p. 253) visualizes the build-up and codification of the two experimental questions and the corresponding four sub-questions provided to the experts in round one of the Delphi study. In addition, the table outlines the acronym codification for each sub-question (CO = corporate level opportunities; CC = corporate level challenges; SO = supply chain level opportunities; SC = supply chain level challenges) as used throughout the later part of the dissertation.

Question	Sub-question	Code
What are the potential implications of Big Data Analytics on information usage and decision-making on ***corporate level***?	What are potential ***opportunities***?	CO
	What are potential ***challenges***?	CC
What are the potential implications of Big Data Analytics on information usage and decision-making on ***supply chain level***?	What are potential ***opportunities***?	SO
	What are potential ***challenges***?	SC

Table 9.3: Codification of questions and sub-questions
(Source: Author)

In order to ease the response process, the sub-questions were sent via email. These emails contained a bullet-point section which the experts could use to structure their response. 15 of the 20 experts provided their brainstorming responses to the four sub-questions, which equals a response rate of 75% for the first round. The remaining 5 experts were contacted again vie email, instant messenger, and phone up to three times, although not resulting in an increase of the return rate.

Upon receipt of the answers, each response was scrutinized for completeness and consistency. If a response was missing or found inconsistent, the respondents were approached by the author and asked to submit the missing input. Following a recommendation by Hasson *et al.* (2000), the responses were entered into a tracking sheet using Microsoft Excel software, which was found suitable to monitor the responses. This step was also expected to ease the subsequent analysis of the individual answers.

As a response to the four sub-questions 343 individual answer items were provided by the 15 experts. As each expert was asked to provide three to five answer items to each sub-question, leading to a total range of twelve to 20 expected answer items per individual, the average amount of 22 to 23 answers effectively provided can be interpreted as demonstrating the panel's great level of interest, also proving the overall applicability of the research question RQ5. Due to the diversity of answers, it was necessary to aggregate the individual responses into group constructs in order to extract overarching similarities between the response items as well as underlying topics. As outlined by Saunders (1980), objects can be sorted into groups according to similarity using hierarchical clustering. The qualitative cluster analysis approach utilized in the work by Carter *et al.* (2007), based on Revelle (1979), was found suitable to guide the aggregation process. As the Delphi study participants provided feedback on four separate sub-questions, every sub-question was assessed individually.

The clustering process will be described in the following: As a first step it was assumed that every answer item constitutes an individual cluster. In the case of the sub-question asking for the experts' view on opportunities at corporate level, which will be used as an example to describe the process for clarity, this resulted in 101 initial clusters (or single answer items). These clusters were then mapped on individual columns along with their definition. Instead of the traditional approach, which is based on index cards, the author used Microsoft Excel software to map the clusters, which was found suitable to streamline and speed up the mapping process. Following recommendations (Carter *et al.*, 2007), *"the two clusters that were viewed as most alike were then combined to form a new composite cluster"* (p. 643), resulting in 100 (101 less 1) clusters for corporate level opportunities. One cluster contained two answer items, the other 99 clusters contained only one answer item each. In the next step, the remaining 100 corporate level opportunity clusters were all compared to each other to identify the most likely pair, which then formed a new cluster. This "pattern matching" process was repeated until all individual items were sorted according to their overarching cluster fit, resulting in 11 corporate level opportunity clusters. These final clusters will be labelled "constructs". This process was followed through for all four groups of answer items until the 343 initial answer items across four groups were aggregated into 26 unique constructs across corporate and supply chain level, covering opportunities as well as challenges.

Although the initial answers were structured into 26 constructs, which equals a compression by more than 90% compared to the initial number of 343 answer items, the number of final constructs exceeded the recommended guideline number of 20 constructs as proposed in extant literature (Schmidt, 1997, p. 769). Nevertheless, despite the potential negative impact on the return rate in the next phases of the Delphi study, as more constructs take more expert time to evaluate, the author decided to keep the higher number of constructs, as this reflected the complexity and diversity of expert views and also provided more in-depth assessment opportunities. In addition, it was expected that the experts would be more inclined to continue their participation if they recognized the influence of their initial answers in the final constructs.

It needs to be mentioned that the 26 constructs could be applicable on either corporate or supply chain level but also on both levels. This led to a range of cases where multiples of constructs were used across the four groups, resulting in a total of 43 constructs being applied. This is subject to the nature of providing opportunities and challenges on both corporate and supply chain level which bear some similarities as the supply chain perspective builds on corporate aspects. Table 9.4 details the breakdown of answer items and constructs per sub-question.

Question	Sub-question	Code	Number of answer items per sub-question	Number of final constructs per sub-question
What are the potential implications of Big Data Analytics on information usage and decision-making on corporate level?	What are potential opportunities?	CO	101	11
	What are potential challenges?	CC	56	9
What are the potential implications of Big Data Analytics on information usage and decision-making on supply chain level?	What are potential opportunities?	SO	124	12
	What are potential challenges?	SC	62	11
Σ			**343**	**43**

Table 9.4: Breakdown of answer items and constructs per sub-question
(Source: Author)

As a preparation to round two, the list of constructs was cross-checked by a senior panel expert in order to ensure construct validity and accuracy.

In the second round of the Delphi study, being of quantitative nature and starting in mid-May 2014, the 43 constructs across the sub-questions were prioritized and ranked by the expert panel. Okoli and Pawlowski (2004) describe the procedure of having the experts prioritize the perceived effects of factors as a suitable approach aiding the researcher's selection of *"the factors with the strongest effects"* (p. 15). In a preparatory step a standardized questionnaire using Microsoft Excel software was developed which contained the 43 constructs split into four sub-sections according to sub-questions (see Table 9.4). Starting round two of the Delphi study, the Excel sheet was then sent to the experts via email, asking the experts to prioritize every construct on a 5-point Likert scale, ranging from “very high” (rating 5), “high” (rating 4), “medium” (rating 3), “low” (rating 2), to “very low” (rating 1). In addition, the “not applicable” (rating 0) option was included.

The order of the constructs within the sub-sections was permutated in order to ensure that the order of constructs between the sub-sections did not yield a similar structure (i.e. the same construct was never at the same position across sub-sections). This was necessary to avoid the expert panel potentially short-cutting a detailed review of the constructs and simply provide the same ranking if they recognized a similar structure across the sub-sections.

Similar to the first round, the experts were sent up to four reminder emails in the case of non-response within the two week answer timeframe, resulting in a five-week deadline extension. As all experts returned their responses, a 100% return rate was achieved in round two. The prioritizations were checked for consistency and one expert had to be contacted to provide missing input to three constructs.

The author conducted a statistical assessment of the individual prioritizations using Microsoft Excel software. Accordingly, the arithmetic mean average prioritization score for each of the 43 constructs was calculated and added as a new column into the Excel sheet returned by the experts. This served as a preparation for round three.

The third round was conducted from mid July 2014 onwards over a period of 6 weeks. Following the recommendations of Grisham (2009), the experts were provided with their initial prioritization for each construct which was contrasted with the calculated arithmetic group mean average score for the same construct. Upon provision of this quantitative summary feedback outlining central tendencies at construct level, the experts were able to review their initial score, compare it to the group mean average, and provide adjustments if necessary. Any adjustment needed to be justified in writing in the provided comment section in order to understand the rationale for any adjustment. All of the 15 experts returned their questionnaire in this round, which equals a return rate of 100%. Ensuring high quality levels, the questionnaires were checked for consistency, and rework requested from the expert where applicable.

Assessing the responses, it became apparent that of the 645 construct ratings (15 experts * 43 constructs) only 26 ratings were subject to expert adjustments, which equals an adjustment rate of 3.7%. The revisited values were used to calculate and update the new group mean average score for the respective construct.

Upon completion of round three, the previously outlined qualitative end-criterion was reached as the study was initially designed to include three rounds. Therefore, following Kauko and Palmroos (2014), who support the rationale that the end-criterion can well be pre-determined in the design phase of a Delphi study, no further rounds were required. In addition, as only minor adjustments were submitted by the Delphi panel in the progress from round two to round three, one can assume, following Crisp *et al.* (1997), that, through the group opinion building process, consensus as well as stability of the data has been reached. This is most apparent as 96.3% of the 645 constructs rated by the panel in round two remained unchanged in round three. As further progression of the Delphi study through additional rounds was not expected to yield significantly higher levels of stability the Delphi data collection was completed. A summary of the data collection process outlining key milestones is provided in Figure 9.1 (p. 258).

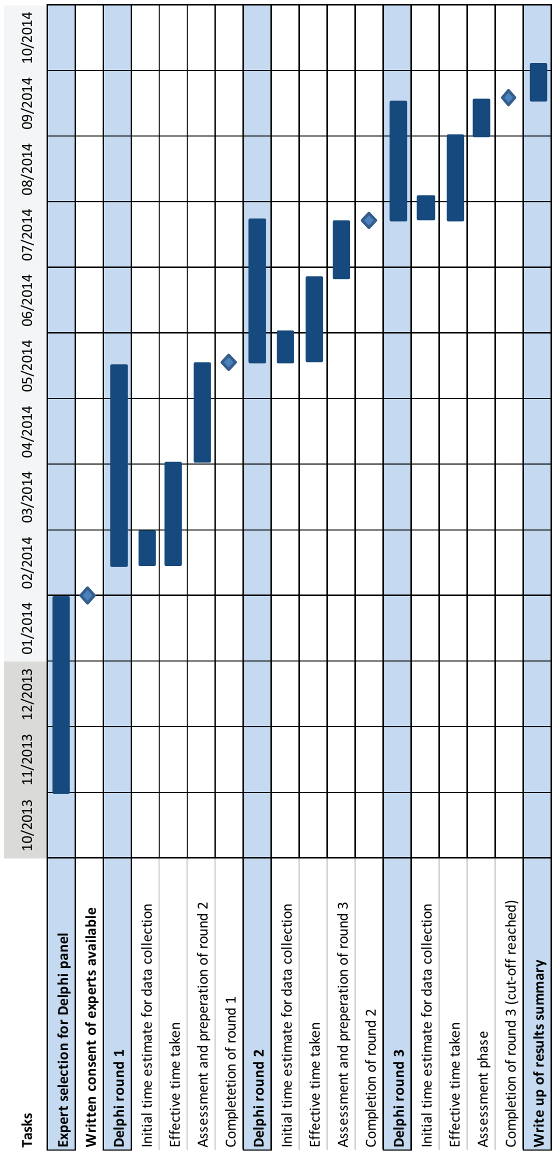

Figure 9.1: Timeline and key milestones of the Delphi study data collection process
(Source: Author)

9.5 Presentation of Delphi study results

The next section presents and assesses the results of the Delphi study where each round will be showcased individually. This includes the presentation of the motivating overall aim of the respective round as well as outlining the instructions and exact questions as received by the panel.

9.5.1 Round 1 (Initial questions)

The initial qualitative data collection round aimed at operationalizing the research question so as to provide a basis for the quantitative data collection in the subsequent rounds. Twenty experts were asked to brainstorm and submit their written input on the following two experimental open questions:

1. *"What are the potential implications of Big Data Analytics on information usage and decision-making on corporate level?"*
2. *"What are the potential implications of Big Data Analytics on information usage and decision-making on supply chain level?"*

The following additional information was also provided by the author:

> *"To ensure a range of different aspects are provided, I would kindly ask you to answer each of the questions by naming 3 to 5 opportunities / chances and 3 to 5 challenges from your personal perspective."*

A total of 15 experts responded to the two questions. As the experts were required to provide their view to the two questions along the "opportunities" and "challenges" dimensions as outlined above, the presentation of results will also be structured accordingly.

Opportunities on corporate and supply chain level

The assessment of the expert responses revealed that while some opportunities and challenges were only valid from a corporate or supply chain view, some aspects were mentioned by the panel as being applicable to both areas. Accordingly, 15 unique opportunities could be identified, with three opportunities on corporate level, four on supply chain level, as well as eight opportunities linked to both levels. The analysis will first focus on the level-overarching opportunities, followed by a presentation of the corporate and supply chain specific opportunities. For enhanced comprehension and aiding structural presentation, the areas of positive impact and identified opportunities imposed by Big Data Analytics adoption on corporate and supply chain level as extracted from the expert answers are summarized in Table 9.5 (p. 261). It needs to be mentioned that the presentation of the opportunities does not follow a specific order in the sense that the opportunity at the top of the list is prime to the others. This will be part of the prioritization in round two of the Delphi study (section 9.5.2). Furthermore, it should be noted that the following sections of this chapter are based purely on the experts' inputs as collected through the first Delphi phase. In order to avoid a mix-up between expert views and author interpretation, it must be stated that the presented material does not reflect the view of the author of this dissertation.

Areas with identified opportunities	Level of applicability	
	corporate	supply chain
Information management: enhanced discovery, access, availability, exploitation, and provisioning of information / data within company and supply chain	X	X
Operations efficiency and maintenance: more precise modeling allows for more accurate decisions; continuous optimization and productivity improvements through automation, machine learning and machine-to-machine based processes; leaner operations and optimized servicing through predictive analytics	X	X
Supply chain visibility and transparency: real-time control, multi-tier (process, decision, financial) visibility irrespective of data location	X	X
Responsiveness: increased robustness of supply chain; increased (real-time) responsiveness to customer needs and changing market conditions; reduced time-to-market	X	X
Product and market strategy: enhanced customer segmentation allows for better scalability and mass personalization; improved customer service levels; better customer acquisition strategies / sales channel strategies (web, social); customization of delivery	X	X
Demand management and production planning: product launch and release planning; increased granularity of planning levels allows for optimized, shorter planning cycles	X	X
Innovation and product design: utilization of product usage data, POS data, field data from devices, customer data, and supplier suggestions to drive product and process innovation	X	X
Financial implications: reduced long-term cost; increased ability to invest; improved understanding of cost drivers and impacts	X	X
New business model development: increased competitive advantage through new (innovative) business models / strategies and new ways of addressing the market place	X	
Customer behavior: better perception of customer behavior (customer intimacy, visibility)	X	
Talent management and HR: employee life cycle management through optimized employee utilization, enhanced education, enhanced safety, optimized retention	X	
Integration and collaboration: integrated (supply network) optimization and collaboration with entire supply chain ecosystem; use of integrated data platforms during design phase		X
Logistics: product traceability leads to lead-time reduction (e.g. by in-transit processing of goods); real-time rescheduling, route planning, re-routing and road side service planning		X
Inventory: SC inventory optimization / real-time inventory control		X
Risk management: enhanced risk evaluation; continuity management at industry / SC level to reduce impact of disruptions		X

Table 9.5: Identified opportunities linked to Big Data Analytics adoption on corporate and supply chain level (Source: Author)

Information management

As identified by the experts, the application of Big Data Analytics is likely to promote a range of opportunities linked to the management of information such as enhanced discovery, access, availability, and exploitation of data and information on company and supply chain level. This also includes the detection of trends extracted from the datasets which can be leveraged in forecasting activities. In addition, the provisioning of information within company and supply chain offers great potential for process optimization and fact-based decision-making. From a supply chain perspective, Big Data Analytics offers the opportunity to explore existing datasets in the supply chain through use of data visualization, helping to detect which data sources are not yet being harnessed to drive value. These capabilities are enabled by advances in new storage and mining capabilities, being the technical foundation of information management, which facilitate the detection and analysis of new valuable insights. On this basis, information management enables companies and supply chains to anticipate business behavior and to prepare for optimized leverage of this information. In essence, the information management opportunity of Big Data Analytics is driven by its use as an early warning system which provides the company with the knowledge that a disruption, for instance in processes or markets, is about to materialize. Following the experts, companies must understand that this disruption could be leveraged as an advantage by the company that has the best timing in terms of actions and financial investments. The required assessment will have to be done at industry level or even company level as supply chain processes may not be as critical to company survival or success in all industries. Accordingly, it is fundamental to get a clear picture of what kind of potential threats and opportunities may be impacting on the company and on the supply chain. Efforts should then be directed to develop mitigation plans tailored to specific scenarios. For optimized preparation, depending on the industry, companies and supply chains need to understand if the disruption is already having an impact or if there is time to build mitigation capabilities, for example through collaborative learning.

Operations efficiency and maintenance

The opportunities of Big Data Analytics in regard to operations efficiency and maintenance are related to potentially changing the entire way a company acquires, processes, gains insight and uses this knowledge to become more precise in their decisions as well as defining products that generated revenues from data.

Having access to a bigger amount of data and information allows for the compilation of more precise models, such as for modeling customer behavior, which would receive less bias from unknown information. This could significantly reduce the risk of taking decisions in cases where not enough information is present. Thus, more precise modeling allows for more accurate decisions.

As outlined by the panel, many leading companies have started collecting factory floor data to improve manufacturing processes as well as the quality of products, thereby making the products and processes more consistent. Likewise, companies are planning to use medical sensors to monitor safe work practices and use analysis of such datasets to improve safety as well as productivity. The enhanced access to data enables continuous optimization and control through analytics-driven real-time insights. Therefore, an opportunity is tied to improving productivity by using data-driven insights, e.g. being more productive with less resource input, while at the same time supporting continuous optimization efforts. Evolving into a leaner company, based on and driven by automation, companies are able to apply complex optimization algorithms to Big Data volumes in order to improve different business processes like stock distribution or consumption forecast. The integrated use of machine learning and machine-to-machine (M2M) based processes for non-critical decision-making is considered paramount in this regard by the experts.

The proper utilization of Big Data Analytics could result in a significant increase in profitability of companies. However, as demonstrated by the 2008 financial crisis, data analysis alone is not sufficient. Business managers must exercise their own judgment on top of data analytics to gain meaningful competitive advantage. Nevertheless, processed data will help executives to take more decisions based on facts and real behaviors as productivity improvements can be achieved through replacing, or at least supplementing, gut-based decisions with more standardized, scientific data approaches and fact-driven decisions.

Big Data Analytics creates significant competitive advantage for data intensive sectors such as retail, insurance, financial services, travel and many others that are connected through millions of transactions, customers, or data points. However, in terms of operations strategy it needs to be considered that competitive information is also more easily accessible for competitors, creating challenges for companies to protect their proprietary information. In addition, the widespread use of Big Data Analytics results in increased visibility of cost and pricing data, insights which are already becoming more accessible across a spectrum of industries. Some companies even collect and analyze satellite imagery to help understand competitor's physical facilities network, expansion plans, and business constraints as revealed for example by facility capacity or shipping movements.

Furthermore, the application of Big Data Analytics holds a range of benefits in regard to optimized maintenance and servicing capabilities. In asset-intensive industries, Big Data Analytics focuses on sensor data used to monitor assets in close-to-real-time and real-time, allowing for higher availability and greater productivity of the asset base. The automated data collection combined with pattern matching of stored information can help companies to predict when a machine will stop working, also being the foundation for anticipating maintenance and spare part needs. If a machine starts to deviate slightly from the preset norm, potential problems can be solved before materializing into machine malfunctions. Such a predictive parts maintenance capability, allowing for an optimized, cost effective lean spare parts allocation management, significantly reduces equipment downtime and enables a higher utilization of the cost intensive asset base. This applies to machines in the field as well as to factories. Accordingly, fleet operators use telematics to track behavior of vehicles and thus know exactly when to change oil, replace battery or tires. As reported by the experts, such practices not only help to reduce the down time of the vehicle or enable better planning for the deployment of servicing equipment but – depending on factors such as driving behavior or vehicle conditions– result in an extended equipment usage period.

Supply chain visibility and transparency

Big Data Analytics changes the way information is being used as it enables end-to-end supply chain visibility with real-time access to corporate and supply chain insights, irrespective of data source location. Information becomes more transparent and available at a much higher frequency, allowing the shortening of planning cycles as well as increased granularity of planning levels, leading to a reduction in inventory stocks. In addition, replenishment plans can be based on near real-time demand leading to a better service level.

As the Big Data Analytics capabilities to gather and process real-time information improve, ultimately driving down costs, more companies are expected to increase the granularity of their forecasting. In contrast to compiling a weekly forecast for sales territories this may result in a constant evaluation of store level stock-keeping units

(SKU) against the predicted level of sales numbers. Such an “always-on” Analytics capability bears the potential to base forecasting decisions on latest data and adjust the forecast on a minute-to-minute basis.

The increased data transparency gained through Big Data Analytics, potentially covering all historical trends and performance indicators, enables improved customer service and is the foundation for web-enabled customer self-service. This is driven by real-time monitoring possibilities, which equip companies with the means to generate alerts and take decisions real-time.

Visibility across supply chains, such as cash-to-cash or order-to-cash cycle process visibility, makes supply chains more agile and efficient as each stakeholder in the value chain benefits from visibility into not only the immediate preceding and succeeding value creators but beyond them. Such multi-tier visibility makes supply chain decisions more dynamic, flexible, and also participatory. This is especially important for supply chains spread across country borders, which therefore pursue transparency initiatives to get better control of their supply chains. The application of geographic location and data mapping, data visualization, as well as supply-sensing transmission through sensors on items, totes, trucks, and rail cars, provides the tools to transform supply chain visibility from near real-time to real-time. Accordingly, companies use RFID readers, motion sensors, and conveyors to monitor processes, materials, and asset movements in real-time. The scope extends across suppliers, manufacturing sites, customers, and in-service partners and –through the use of more granular, multi-dimensional information– results in reduced inventory, improved productivity, and overall lower costs.

From a corporate and supply chain perspective it is, according to the experts, important to achieve “one version of the truth”, as datasets derived from a range of entities may even contain contradictory information. However, the effective and successful consolidation of these datasets as well as the technology investments necessary call for a well-balanced approach for the sharing of risks and investments between parties involved.

The traceability of products represents another opportunity driven by Big Data Analytics. Traceability solutions are already embraced by a range of industry, for example across leading food, pharmaceuticals, electronics, and automobile companies. Tracing ingredients of products to origins and tracking the product throughout its life-cycle not only reduces product loss and increases the efficiency of supply chains, but also ensures product integrity while improving the overall sustainability of the business model. The data made available from sensors, pallets, products, users, and the entire supply chain infrastructure all play their part in tracing and tracking products or personnel throughout the supply chain. For instance, the increased transparency gained through Big Data Analytics, supported by mobile solutions, can be utilized in route planning, enabling logistics companies to track and analyze vehicle movements in order, for instance, to minimize the number of left turns on the route. The rationale being that left turns at crossroads (under right-hand traffic conditions) potentially incur a longer waiting period compared to right turns as the oncoming traffic needs to pass first. This has a small but direct impact on each truck's fuel consumption. However, added up across the whole fleet of many hundred trucks this may provide a suitable opportunity to improve the companies' overall bottom line. Thus, the experts state that through analysis of the vast amount of data real value is realized in taking business decisions that will make products safer, processes more robust and overall supply chains more sustainable.

Responsiveness

Big Data Analytics, as highlighted by the panel experts, enables businesses to react quicker to changing market conditions by understanding and detecting what in their ecosystem is working well and what is not. The responsiveness is thereby driven by the scalability of information technology. This is a key aspect of Big Data Analytics, designed to process and run jobs that are executed in parallel, having the potential to scale the amount of servers or nodes required to increase computational capacity when required.

The resultant achieved reduction in time required to gain vital insights enables a more rapid dissemination of information to decision makers which may also be accompanied by automated real-time recommendations. The advantages of this reduced time-to-market approach are not only applicable to digital marketing and sales channels, such as mobile or web, but also offer leverage for traditional sales channels such as the branch or the call center.

On the supply chain level, Big Data Analytics enables a faster reaction to customer needs and changing market conditions. The responsiveness is fuelled by the predictive capability of Big Data Analytics, which enables the supply chain to take into account potential impacting factors as well as changes, and prepare accordingly. In addition, the supply chain is likely to become more robust to change. For instance, a clearly identified demand combined with high levels of supply chain visibility may – dependent on product specifications– offer the opportunity for in-transit processing for goods. The supply chain becomes more agile as amendments and product configurations could be finished close to the final point of consumption, maximizing sales and reducing waste, whilst circumventing the long lead-times usually generated by offshore manufacturing.

Product and market strategy

Following the experts' input to the Delphi study, a range of factors in regard to product and market strategy bear optimization potential based on Big Data Analytics. As such, companies can test the acceptance of planned product launches in new markets by analyzing social media responses and planning launch strategies accordingly. Big Data Analytics will allow for narrower segmentation of customers, which facilitates better scalability and leads to proliferation of precisely tailored product and service offerings. The improved segmentation is likely to enhance the performance of a range of business activities such as marketing, delivery options, advertising, and capital investment, to name but a few. Some companies, especially in the consumer electronics industry, study the social media responses for new products (such as a new smart phone model) and accordingly craft their launch strategy including sequence of rollout in various countries as well as inventory positioning. In the retail sector, Big Data Analytics expedites the analysis of in-store purchasing behaviors in real-time. With such quick insight into demand shifts, stores can adjust merchandise activities, stock levels, and also pricing to maximize sales.

The enhanced customer segmentation may also act as a driver of mass personalization: Big Data Analytics applies computing power to the vast amounts of data being generated by each person each day to continuously and uniquely modify products and services to fit specific customer needs. E-commerce companies extensively leverage this information as they study and track their customer's online browsing behavior and accordingly push customized offers just tailored for the individual customer. The combination of satellite positioning technology (such as GPS) and social network information further enhances the possibilities allowing to offer customers the right product in the most sales-effective moment. Big Data Analytics is the driver behind such sophisticated targeted promotion campaigns and it can be expected, according to the expert panel, that Big Data will form the cornerstone of strategy for many industries, particularly those with high customer contact through web sites and social media. As such, Big Data Analytics will help companies to better understand what certain customer groups, the ones using social media at least, really want as well as identify and attract new potential customers. In particular, companies can tailor customer acquisition strategies through analyzing client's social media activities and thus listening to their customer's real needs. This enables proactive contact and presentation of new products and product bundles through social and web sales channel strategies and is expected to greatly improve customer service levels.

Besides its impact on product strategy, the experts mention that Big Data Analytics is increasingly playing a substantial role in the definition of the corporate sustainability strategy, especially for larger companies. In the automotive industry, for example, where fuel economy is a major challenge and a key sales argument, companies have started to develop science-based models that project CO2 emissions generated by fleets of vehicles on roads worldwide for a certain period of years. Data scientists employed by these companied have used Big Data Analytics to develop and feed mathematical models that optimize millions of possible vehicle combinations to help construct a technology road map that results in greener products.

Demand management and production planning

According to the experts, demand management and production planning benefits from Big Data Analytics as the increased granularity of planning levels allows for optimized, shorter planning cycles including product launch and release planning. The higher levels of granularity also enable near real-time forecasting at micro level, down to the single customer, which really puts the customer at the center of corporate strategy. The effective dissemination of data has the potential to be self-perpetuating as the frame of reference for opportunities and trends can be adjusted organically as data granularity improves. Already, companies are experimenting with technology that combines advanced forecasting techniques and order optimization to generate orders which get adjusted to real-time demand signals on a daily basis and incorporate supply side constraints feeds. Thus, the actionable use of wider demand variables such as point-of-sales (POS) and customer data is a suitable vehicle to improve planning levels (forecast accuracy) and enable real-time demand sensing.

Business-to-consumer (B2C) companies can hugely benefit from Big Data Analytics as companies can leverage the information gain to create customer-centric assortments. As in the past the data points like sell-through rates, out-of-stocks, or price promotions within the merchandising hierarchy were analyzed to make production-related decisions, these data points can now be linked and analyzed at a more granular level, for example on SKU, time, and place dimensions. This enables companies to have a clearer picture of the probability of selling a particular product at a certain time and place, ultimately giving them the opportunity to optimize their range by location, time, and profitability. In addition, the ubiquitous use of digital discount coupons and promotion codes has shaken the traditional ways of running promotions: Promotions are becoming more dynamic and change quickly depending upon insights gained by real-time data analytics. In this environment Big Data Analytics assists in advertisement placement, also helping to determine which promotion channel will deliver the biggest impact for a certain customer segment.

On the retail side, the coordination of promotions and other targeted marketing efforts needs to be closely linked to supply chain capabilities as it is a risk for companies to make offers and then not be able to fulfill the orders. In this scenario, Big Data Analytics helps to make forecasting and therefore demand and production planning more transparent, resulting for instance in reduced inventory obsolescence as well as increased fill rates.

As Big Data Analytics solutions materialize in the supply chain, more integrated, overarching optimization may become possible. This may include a more frequent, up to real-time running of production planning sequences on bill-of-material (BOM) and inventory level as supported for instance through real-time database applications such as SAP HANA. In addition, effective integrated optimization needs to include promotion planning as well as procurement planning and should be based on the objective of total business benefit maximization.

Innovation and product design

Big Data Analytics can create significant advantage in terms of product innovation. As such, companies can make use of a range of data sources such as product usage data, POS data, field data from devices, customer data, and supplier suggestions to drive product and process innovation. Thus, Big Data Analytics enables companies to create newer and better portfolios of products and services by incorporating new insights drawn from data to inform corporate portfolio decisions. In terms of product design, the data extracted may itself be turned into an innovative product which generates revenues as non-proprietary information and insights can be sold.

Facilitating research and development (R&D) activities, the expert panel outlines how Big Data Analytics enables innovation as it speeds up the time at which data is accessible to marketers, product developers, researchers, and strategic planners. It also enables data scientists and business analysts to accelerate the speed at which they test-and-learn and iterate through new hypotheses. Big Data Analytics actually revolutionizes R&D in industries such as pharmaceuticals, petro-chemicals, biotechnology, and healthcare as the predictive modeling of biological processes and drugs becomes significantly more sophisticated and wide-spread. Likewise, molecular and clinical data can be quickly analyzed to efficiently find molecules with a high probability of successfully converting into drugs.

The full innovative potential of Big Data Analytics, however, is best leveraged in a supply chain context. Accordingly, the panel states that companies need to collaborate with customers, suppliers and even other functions that were off limits till recently to co-create products through use of Big Data Analytics. In advanced manufacturing sectors such as the automotive industry, the increased use of integrated data platforms will allow companies and their partners to collaborate during the design phase – a crucial determinant of final manufacturing costs.

Financial implications

The experts link the financial implications of Big Data Analytics predominantly to the large investments necessary to set up the required technological infrastructure. It should be considered that investments in Big Data Analytics technology may result in less investment in other areas which are presumably seen as more important. Adding to the complication, the benefits of Big Data Analytics may not be visible right after the often long implementation timeframe of such systems. The reason being that the insights from these systems only materialize into value over a longer period of time, as datasets need to be collected to derive trends and make predictions. Nevertheless, despite the often high upfront investments, Big Data Analytics generates higher availability and greater productivity fostered by an improved understanding of cost drivers and impacts as derived from the data, which reduces the need for capital expenditure and thus provides a long-term competitive advantage. In addition, the usage of open source software technologies for Big Data Analytics systems is a viable option to help organizations reduce their software licensing cost. After all, Big Data Analytics equips companies and supply chains with the ability to make data-driven targeted investments to enhance operational efficiency, thus increasing overall profitability and reducing cost on the long run.

Whereas the above outlined opportunities were identified by the experts on both corporate as well as supply chain level, the next section presents the opportunities which are expected to materialize predominantly on corporate level, before the sole supply chain opportunities are outlined in the last step.

New business model development

The access to new data sources and new insights gained by Big Data Analytics enables companies to pursue new business opportunities. This is driven by the availability of previously unavailable knowledge which can be leveraged to develop and pursue new business opportunities, ultimately leading to an enhanced competitive positioning of the firm.

However, as the impact of Big Data Analytics varies significantly from industry to industry, business models will invariable undergo incremental or radical changes depending on industry characteristics. For example, the emergence of real-time location data has created an entirely new set of location based services. Ubiquitous navigation services till recently were unheard of in developing countries. Such services are directly impacting travel, transport, and tourism sectors. Companies such as *Airbnb* are using Big Data Analytics to recommend accommodation to guests, considering a multitude of factors to create recommendations such as guest's own preferences, social media connections, rental history, and reviews, to name a few. In the financial services industry, Big Data Analytics has spurred entirely new business models which use algorithmic trading to analyze massive amounts of market data in real-time, identifying opportunities to capture value instantly. These new Big Data Analytics-enabled business models all represent new ways of addressing the marketplace.

On the other hand, the potential of available information can be leveraged to fine-tune existing business models. As such, companies in the car insurance sector go a step beyond traditional analysis of annual claims, trying to add more granular data on peoples' driving behavior. Thus, they work towards the use of public data gained through social media in order to design custom-tailored casualty insurance products where the customer is actively involved through incentives. It can be expected that in the near future some companies will develop products where the customer, depending on the degree of customer cooperation, granting the company access to sensitive customer data suitable for individual driving behavior assessment, can directly influence their individual insurance premium or the degree of their incentivation.

Customer behavior

Customer intimacy is an area where Big Data Analytics can create a significant advantage, especially in terms of improving the quality of perceived customer behavior. Pieces of information that in the past were not available or required time-consuming, expensive diagnosis projects and thorough surveys, now can be collected from analyzing vast amounts of available data generated by the customer. Increasingly, the customer does not even need to be asked to provide the data as he voluntarily provides visibility into his preferences. As such, customers add to the data stream by feeding data sources through memberships in loyalty programs or social media activity including posts (“likes”), reviews, and comments on corporate product sites. The extracted behavioral patterns of customers are a vital aspect for companies scince they provide great opportunities to be leveraged in tailored marketing campaigns and customer retention analytics, eventually becoming the foundation for decision-making as they govern promotion and product launch plans. In essence, based on expert feedback it can be concluded that companies which manage social media activities by using Big Data Analytics are likely to create huge competitive advantages for themselves.

Talent management and HR

The management of the employee life cycle was identified by the experts as being an area of opportunity for the application of Big Data Analytics. This includes the whole human resource (HR) process, covering the screening of candidates, the selection, offer making, induction, training and coaching, performance assessment, as well as overall career progression monitoring. The intelligence gathered from the range of corporate data sources offers a plethora of possibilities in managing human resources and is expected to influence future HR practices. As such, companies can determine the best fit between employee and task based on the availability of data on employee aspirations and opinions, improving the overall productivity of the firm. These instruments also increase the employee satisfaction levels; the company benefits from increased visibility into employee preferences as the management of retention levels is optimized. Greater visibility into datasets also enables enhanced and tailored employee education and up-skilling possibilities while positively impacting on workforce safety.

A range of supply chain-focused opportunities linked to the adoption of Big Data Analytics were identified by the panel and will be outlined below.

Integration and collaboration

Cross-functional integration and collaboration with partners is key to fully unlocking the potential of Big Data Analytics across the supply chain. This is driven by the fact that in supply chains, the decisions on a range of aspects such as order quantities, due dates, sources, make or buy, are often based on an optimization of local steps within the chain. Thus, the integrated supply chain approach to collaboration through data sharing, combined with the high levels of visibility across the supply chain, represents an opportunity to optimize all steps in the extended supply chain, even outside the focal organization. It can be expected that all facets of the traditional supply chain, including product design, procurement, manufacturing, delivery, and service delivery will see the use of data-driven decisions made available through integrated data exchange platforms. Big Data Analytics is the enabler of this development, equipping companies with the ability to connect and collaborate with the entire supply chain ecosystem, driving the delivery of products at lower cost to the supply chain at a whole.

In terms of supply chain and facilities design, Big Data Analytics has the potential to take traditional operations research techniques for planning to the next level. Supply chain design traditionally optimizes a company's own inbound and outbound supply chains in an end-to-end approach. As companies are looking at optimizing supply networks with multiple entities, Big Data Analytics provides the solution to integrating across the range of corporate touch points. Taking an industry perspective, in asset intensive industries, for example, the supply chain benefits are expected to be primarily focused on the maintenance, repair, and operations (MRO) side as well as procurement activities, allowing better control and management of spare parts inventories, as well as providing opportunities for procuring energy and other consumables used to operate the assets.

Logistics

Big Data Analytics provides a range of opportunities from a supply chain logistics point of view, driven by the fact that traffic information as well as product location can be used to predict possible delays in deliveries across the supply chain. Based on such information appropriate mitigation actions can be initiated. The real-time visibility and traceability of the transport network across the supply chain, combined with the monitoring of external conditions, provides unmatched possibilities to re-schedule and optimize delivery modes in real-time, resulting in a reduction of lead time. Other application benefits of Big Data Analytics range from the sensing of transportation hub congestion and re-routing of vehicles, road-side service planning, to even shipping the right goods to the right locations a few days in advance sensing bad weather forecasts. The experts also see the value of Big Data Analytics in opening up new supply chain relationships. For example, a shipper can utilize the collective purchasing power of a supply chain network of carriers which bids the best rates, offering the shipper access to previously unknown shipping partners who help to lower the shipper's transportation spend. Consumer feedback on carriers and deliveries can also be used to improve outbound execution service and safety. In addition, companies use Big Data Analytics to predict which drivers might be at risk of accidents because of fatigue or other factors.

Inventory

The enhanced visibility of inventory stock across the supply chain, enabled by Big Data Analytics, allows for the holistic optimization of inventories, as the amount in inventory shrink can be reduced through the perpetual real-time monitoring of stock information based on key metrics. In addition, fuelled by the integrated optimization with upstream and downstream partners an overall reduction of system inventory in the supply chain can be achieved. Furthermore, the information on inventory location at a given point in time along with its condition can reduce labor tied to monitoring and tracking down inventory in retail environments. However, supply chains will have to consider unstructured data inputs beyond traditional demand and supply side variables to come up with inventory management guidelines.

On a larger scale, Big Data Analytics has the potential to solve the "inventory vs. customer service" issue, which is based on the understanding that the higher the customer service levels, the higher the inventory levels to be held at stock to fulfill these service levels. The availability of granular inventory information across the supply chain, derived from Big Data Analytics, enables companies to operate very responsive supply chains to meet real demand while keeping inventories in check. In addition, supply chain and marketing functions can work closely at a warehouse area level to push promotion offers through social media, thereby shaping demand and liquidating non-moving stocks. Such granular level of coordination between brand managers, supply chain and trade partner calls for close collaboration, speedy execution, and real-time Big Data Analytics at micro-customer segment level.

Risk management

As Big Data Analytics allows the scrutining of vast amounts of data in a short period of time, it will be easier to understand and evaluate the risks of certain decisions that until now did not have enough data to quantify their expected outcome.

Although companies have long used complex datasets to plan supply chains to meet customer demand, firms are now looking to combine data from external sources to better predict future risks and improve the evaluation possibilities of the risks associated to the current supply chain. As such, the real-time information gained from integrated data sources may provide suitable input for continuity management practices at company, supply chain, and industry level and reduces the impact of disruptions. This may promote the development of real-time or near real-time response and mitigation capabilities to real or perceived supply chain interruptions.

Challenges on corporate and supply chain level

Besides the many opportunities as outlined above, a range of challenges linked to Big Data Analytics adoption were found applicable to both corporate and supply chain perspectives. Thus, nine unique challenges could be identified as fitting both the corporate and the supply chain perspectives. In addition, although no specific corporate-level challenges were identified, two challenges were mentioned by the panel experts as being explicitly tied to the supply chain level. The presentation of challenges will follow the same structure as utilized for the previous presentation of opportunities, starting with overarching challenges before assessing level-specific aspects. Table 9.6 (p. 276) summarizes the respective challenges in regard to Big Data Analytics on information usage and decision-making as identified by the experts.

Areas with identified challenges	**Level of applicability**	
	corporate	**supply chain**
Ethical and managerial implications: balance human vs. analytics management style avoiding a "cold" data-driven over-reliance on information; challenge to distill actionable right decisions from sophisticated reports (descriptive reporting vs. predictive analysis) to and avoid misuse	X	X
Transformational change: need to evolve current organizational structures (dynamic processes, structures, reporting, skills) to leverage the potential of Big Data	X	X
Cultural change: building a data-driven mindset in decision-making and challenging "new truth" from information, establishing openness to trust data (not only for test but also in production)	X	X
Business strategy and objective: establish a clear need / internal justification for Big Data through business cases; clear objective to implement Big Data required (purpose such as threat of new competitor entry or a unique business offering); challenge to "sell" Big Data to customers and clients	X	X
IT capabilities and infrastructure: lack of powerful infrastructure (technology, processes & people) to process real time information; fragmented system landscape due to lack of technical standardization a challenge for end-to-end visibility	X	X
Financial implications: high investments required (technology, processes & people) combined with shortened investment cycles in IT infrastructure; investments are prioritized according to business case, not need	X	X
Information management: management of information complexity (integrity, quality, volume); identification and knowledge of relevant information avoiding inaccurate information	X	X
Information and cyber security: threat of information leakage; respecting customer's individual data privacy; differentiation between private and public data increasingly challenging	X	X
Talent management and HR: lack of skilled resources (analytical, data-driven, technical understanding); unfocused talent management (unclear role description for Big Data employees)	X	X
Integration and collaboration: cross-functional collaboration, integration across company boundaries also with customers required for Big Data; reluctance to cooperate		X
Governance and compliance: need for control tower (CXO, Chief Data Officer) to orchestrate and control Big Data efforts across supply networks efficiently and install required collaboration rules (common consensus about goals, different maturity levels, standardization, incentive structure)		X

Table 9.6: Identified challenges linked to Big Data Analytics adoption on corporate and supply chain level
(Source: Author)

Ethical and managerial implications

A range of challenges linked to ethical and managerial implications of Big Data Analytics were identified by the expert panel. As such, Big Data Analytics-enabled companies may be at risk of evolving towards a "cold" management style where the value of analysis and facts is weighted higher than human intuition. The risk is that these companies lose the right proportion of human components such as sense of purpose, value, and inspiration in decision-making, which may well result in the demise of aspects of humanity in these organizations. Therefore, the panel advises that companies need to be cautious and avoid an over-reliance on data-driven techniques in decision-making. The key is to balance the human and the data-driven analytics management style.

As data is a decision enabler, Big Data Analytics improves the articulation of trends and helps to shape the conclusions that should be drawn. However, the fundamental business principles still need to be understood by those using the information in order to avoid mistakes and misinterpretations – similar to truck drivers purely relying on route guidance via satellite navigation systems without applying common sense or questioning routing recommendations. In general, the information extracted through Big Data Analytics can be misunderstood and the complexity of the data model made trivial, with its meaning being lost, if the executive who is getting the report output is not prepared to understand it. Thus, as decisions are taken based on reports, the way those are made is critical. Accordingly, a challenge is to distill actionable "right" conclusions from sophisticated reports while at the same time limiting the misuse of reports. If the analysis is not accurate, this may well result in contradictory reports and thus wrong decisions, eventually contravening the principles of Big Data Analytics and the reasons for its adoption. Therefore, it is not sufficient to only have proper Big Data Analytics tools and processes, but it is paramount to have experts who draw the right conclusions from the models and reports, using human intuition and interpretation skills. An issue in this regard is that in order to understand certain kind of models, reporting is becoming increasingly more complicated. Nevertheless, despite the benefits of automated decision-making for non-critical routine tasks, critical tasks should always involve a human mind as the last instance to cross-check the recommendations, as the over-reliance on data can be fatal in consequence. Thus, Big Data Analytics should not be seen as a panacea to solving every business problem but as a driver to make more informed, reliable decisions. In some cases, Big Data Analytics may not even be necessary to process certain amounts of data, but it can be misused as such to derive "right" decisions, promoting the results as being the "undisputable truth". As these aspects are critical on a corporate level, they are well valid from a supply chain perspective although the magnitude of challenges intensifies with the number of parties involved.

Transformational change

A challenge linked to the effective adoption of Big Data Analytics materializes in the fact that most companies must fundamentally change their processes, structures, skills, and modus operandi in order to operate in a digital data environment. The issue is that the significant amount of information provided by Big Data Analytics and the necessity to process the information in general overwhelms the capabilities of processes and structures on corporate and supply chain level, which were not developed for such purposes. On the supply chain side, supply chain processes designed for the challenges of the previous decade are suddenly under stress due to ever-growing information and process requirements from various functions.

Thus, a transformational change is required, driven by the need to evolve the current corporate and supply chain organizational structure in regard to setup and reporting capabilities, enabling the company to take advantage of opportunities while being able to adequately respond to challenges. Companies will have to define dynamic processes with a lot of scenario-based cases built into the processes to provide the required process agility to match the real-time intelligence generated by Big Data Analytics.

Nevertheless, as the business environment is constantly changing, companies need to find solutions in order to develop their organizational structures at the same pace as technology changes, being agile in terms of reacting and adapting to the requirement of the new business ecosystem.

Cultural change

In addition to transformational changes, companies in the supply chain may have to consider a range of cultural changes required to fully leverage the advantages of Big Data Analytics. The expert panel reports that companies struggle with the task of opening up the ingrained business processes where employees rely on gut feelings and intuition and install supplementing analytics-driven reasoning. Intuition can well be a part of such a solution, however, it should not be the prime source of inspiration.

Despite building a corporate level culture and mind-set of being data-driven in corporate decision-making, it is equally important to engage in an open dialogue and to challenge the “new truth” as distilled from data sources. In essence, the solution is not to either reject or trust data and Big Data Analytics recommendations, but to establish a culture where employees get a feeling for the right interpretation of data sources in general and the value of information in particular. A challenge in this regard is the fact that Big Data Analytics is often more considered as being useful for data exploration in test environments, in comparison to its application in a production environment. However, it is also in the production environment where the potential of Big Data Analytics in terms of predictive maintenance can be harnessed. In addition, as cultural changes are only effective on the long haul, the value of Big Data Analytics may also be suffering from the perception that root causes for a potentially experienced ineffective use of Big Data Analytics in a production environment, such as low quality or inconsistency of master data, do not need to be fixed as it is easier to put the blame on the Big Data Analytics system. Despite the possible open refusal of employees to accept computer-generated work instructions, this may well be due to a lack of employees’ process knowledge. Cultural change programs thus need to educate employees on corporate and supply chain level, outlining changes while providing them with the overarching picture required for the adoption of a Big Data Analytics, data-driven mindset.

Business strategy and objective

The expert panel found that although Big Data Analytics is on the agenda of corporate executives, the subject is perceived to be technology heavy and is often not talked about in business language that is easily understood by shareholders. While some advantages are visible, many stakeholders are still not very clear about the business case for embracing Big Data Analytics. This is largely due to the fact that companies either do not have an idea about the subject or do not communicate the need for Big Data Analytics.

The business cases for Big Data Analytics are not as obvious for top management as for example the implementation of a hands-on customer relationship management (CRM) system. As a result, process owners are faced with ongoing struggles to get the right investment levels approved by the board. In addition, due to the business-driven nature of investments, Big Data Analytics implementations are required to quickly show results in term of corporate performance improvements. However, as the full potential of Big Data Analytics unfolds over a longer period of time, as compared for example to ubiquitous savings programs, funding may cease due to the seeming non-performance of the system before the full benefits can materialize. Accordingly, businesses adopting Big Data Analytics need either a clear starting objective, a unique offering or at least a precise understanding of the purpose of such systems within their organization. This is required to ensure the company stays focused through the implementation journey, harnessing the benefits while avoiding a situation where the investments only prove what is already known. Even though the purposes for Big Data Analytics are plenty, companies need to consider that the emerging Big Data Analytics environment, despite its current infancy in the business ecosystem, will be a commodity in the future for many industries. This change may well result in a potential increase in competitive threats from existing players or new disruptive players that are more nimble at leveraging analytics.

Eventually, the decision to adopt Big Data Analytics may not only be a corporate one but could also be driven by outside requirements such as supply chain obligations. The company may not be able to react to what the models based on Big Data Analytics ask it to do – but their supply chain partners and competitors may. In other words, adding more information may add new valuable opportunities that the company cannot target due to its own internal resource constraints. A collaborative supply chain approach where information as well as orders are swapped across parties to balance capacity utilization could be the solution to bypass such bottlenecks. However, for a Big Data Analytics program involving multiple stakeholders across the supply chain, the development of a business model which allows for a fair distribution of cost and benefits amongst the participants might be a challenging issue.

IT capabilities and infrastructure

The lack of a powerful infrastructure in terms of technology, processes, and people required to process information can pose a challenge for the adoption of Big Data Analytics. While many executives understand the potential behind the availability of vast amounts of data and the need for required storage capabilities, most executives do not know what kind of insights they really want to draw from the data collected. In addition, companies are still trying to figure out how to best fit Big Data Analytics into their IT landscape, while also suffering from a lack of understanding of technology solutions to make sense of the available data.

Furthermore, at the time of writing of this dissertation the experts stated that the systems supporting Big Data Analytics available on the market suffer from a lack of technical standardization, especially in terms of standardized interfaces. As a consequence, the integration of internal systems with third party systems, purchased from a range of specialized vendors each offering a very specific asset, is a fundamental integration challenge. This may well pose a threat for the adoption of Big Data Analytics, resulting in the inability to achieve corporate and supply end-to-end visibility.

While many IT companies have taken up pilot programs to demonstrate the usability of Big Data Analytics, companies across supply chains will not only have to invest in technology for the adoption of Big Data Analytics. They are also obligated to finance the supporting infrastructure, such as Control Towers, required to efficiently orchestrate the information exchange across global multi-tier supply networks.

Financial implications

According to the experts' opinion Big Data Analytics today is cost-prohibitive for many medium size companies and even the large companies are cautious about investments. Many companies have taken up pilot studies but only some companies have started to implement Big Data Analytics in a systematic pattern. Although the cost of data storage and processing is coming down at a rapid pace, the financial aspect still remains a big roadblock for the adoption of Big Data Analytics. As such, not only the initial significant investments into infrastructure (technology, processes, and people) need to be considered. From a business case perspective, continuous financial obligations derived from Big Data Analytics such as software licensing fees or cost related to IT operations, for instance energy cost for data centers, are key factors which require attention.

The procedure of calculating returns based on investment cycles can be seen as another major challenge from a financial point of view: Companies invest in fleets, plants, and machinery often with a five to ten year amortization time horizon in mind. As technology is becoming all pervasive and the lify cycles of information technology equipment are shrinking, companies might fear that they are being left behind by the competition if they do not constantly invest in system upgrades. However, many of the assets may not have been fully amortized by the time of upgrade. The constant challenge in such situation for companies is to find a way to justify and prioritize the investments in technology required for Big Data Analytics.

Information management

A common pitfall in regard to the management of information is the extraction of conclusions from data without applying the right level of data cleansing. In addition, results derived from Big Data Analytics may not be challenged by decision makers, who in addition often do not know what they expect to do with the data received. This lack of knowledge, combined with the risk of operating based on inaccurate data, can lead organizations towards making wrong decisions. As such, companies need to be able to draw actionable insights from the data, which includes establishing a clearly documented connection between an insight and the appropriate action. However, the effort required to ensure data quality and manage the level of uncertainty or unreliability across the process should not be underestimated. On a different level, the question remains as how to manage information coming from employees, for example from the field force, while ensuring a high level of ethical compliance in regard to data usage.

It is thus paramount to manage the complexity of information across business processes in terms of integrity, quality, and also volume. A challenge is not to be overwhelmed by the data flow, and remain focused, following the main objective of the analysis. However, it might not be possible for the company to join all its information sources and link all its business intelligence-related departments in order to use and extend the usage of Big Data. The ability to effectively separate the valuable signals from the noise represents an important element in this endeavor. This should embrace the installation of a continuous process governing decisions on the amount of data being stored – too often companies resort to a maverick data collection style, collecting every piece of data available because it might be transformed into valuable information. However, the significantly increased amount of insights needs to be interpreted, which requires additional intelligence capacity. Companies are better off if they first categorize data into important and non-important data and then prioritize their Big Data Analytics activities, focussing on storing the kind of data which seems promising in terms of performance impact and really constitutes a competitive advantage. Thus, one challenge besides the quality of stored information concerns the quantity of a particular kind of data that should be stored, also considering the storage guidelines such as the intervals of time between recordings or the time horizon applied to stored data.

In the future a potential solution to data growth and issues with handling excessive amounts of data and extracting information may be found in “cognitive computing”. This is a technique where machines learn from past experiences and base their decisions on these self-generated “memories”. The present issues linked to growing streams of data would then become obsolete as data is handled automatically.

The above outlined challenges are also applicable from a supply chain perspective, although the complexity multiplies when going across suppliers and customers to make sure that the valuable data is being collected and the non-valuable data is being refused. Data quality, volume of data, and data integrity especially in terms of master data is also a huge issue on the supply chain level. Companies will have to invest in strengthening the ability of their extended supply chain to collect, manage, and process large amounts of data and effectively collaborate with each other. However, in many cases a company will depend on getting information from customers or vendors that do not see the benefit of or even feel threatened by sharing information.

Information and cyber security

More and more data gets mined and reported, which puts the boundary between private and public data increasingly under pressure. As even the differentiation between confidential and public information is increasingly under threat, data and cyber security is seen by the experts as a big challenge for the adoption of Big Data Analytics. Thus a growing amount of customers, companies, and governments is concerned about the security of their data. For the overall success of a Big Data Analytics program, organizations need to address these issues upfront, implementing the corresponding mitigation systems into their environment. This includes an assessment of the implications of a potential data leakage on vital day-to-day business capabilities.

From a supply chain view, issues of data security require special consideration as companies are increasingly dependent on information provided by supply chain peers. Challenges rooted in data security may represent a blocking point for Big Data Analytics adoption as participants are cautious about sharing data in a supply network, driven for instance by fear of losing the control over proprietary information. The challenge is linked to ensuring that data is not being shared without the owner’s consent. On the customer level, the acceptance of Big Data Analytics is dependent on the right and responsible use of customer information such as social networks information or location information, not surpassing the customers' privacy limits, which may be different in each single case. The development of guidelines governing the ethical use of data seems a suitable vehicle in order to address these crucial issues.

Talent management and HR

The experts outlined how companies need qualified Big Data analysts and data scientists who understand statistical modeling, operate Big Data systems, and interpret the data streams while also being able to educate management in the appropriate use of reports. In order to create a solution in a Big Data Analytics environment that has a significant impact on performance, it is estimated by the panel that a group of ten to twenty data scientists is required to manage the complexities. However, they argue that putting such a team together may represent a true challenge as a shortage of skilled talent is one of the most frequently cited problems in regard to Big Data Analytics. Accordingly, they add that the identification and recruitment of well-trained and skilled candidates in the market is a critical bottleneck. In addition to these challenges, companies are struggling to clearly specify roles, responsibilities, benefits, reporting structures, and career paths of the required new type of employees. This is not only limited to the entry-level type of employees but also includes the C-level (CEO, CFO, etc.), which is especially concerning as the rise of data-driven analytics is expected by panel members to result in the emergence of the new Chief Data Officer (CDO) figure, responsible for representing Big Data Analytics activities. Unfocused talent management represents a major issue for companies in the journey to become attractive for relevant but scarce talent without having to pay significantly over-price.

Big Data Analytics not only has implications for new employees, but also impacts on the daily routine of current employees. Developing towards an analytical and data-driven workforce, employees will have to go through a steep learning curve as well as change management journey in order to adapt to the requirements of Big Data Analytics. Companies need to offer support and ensure that all employees understand what is required of them to fully support the corporate digital agenda.

Some supply chain focused challenges linked to Big Data Analytics were identified by the panel, which will be outlined below.

Integration and collaboration

Collaboration between functions and across stakeholders, including the customer, is critical for building digital supply networks in general, and the adoption of Big Data Analytics in particular, the reason being that new insights can be derived from information which may be only available from the partners in the supply chain. Furthermore, the reach of vertical supply chain integration and optimization could be deepened and extended through insights gained from Big Data Analytics, thereby overcoming the current approach where supply chains are often optimized on a layer by layer basis. However, despite the known benefits, participants are cautious about sharing data and information with their partners in the supply network as they fear disclosing proprietary information. Likewise, the cooperation benefits are often not equally shared as the incentive structures are just starting to evolve beyond tier one suppliers and customers.

From a technology point of view, the flow of goods and transactions across organization requires a certain level of standardization. Even if new solutions allow complex mapping, translation, and integration of data, this is still a bottleneck in the majority of instances. On a more overarching level it should be considered that various industries and companies are at different stages of technological maturity. Thus, these entities need to carefully choose and set their supply chain collaboration priorities. Enabling all partners to operate at the necessary level of technology requires large investments in IT at a granular level which may however not be financially supportable by smaller companies. Depending on the criticality and importance of these entities for the supply chain structure, it can therefore be attractive for partners to provide the required funds in order to strengthen the overall capabilities of the supply chain. Nevertheless, besides the benefit of such financial partnerships, the balancing of the incentive structure applied needs to be taken into account.

Governance and compliance

As supply chains grow in size and complexity with multiple companies coming together to address industry-wide issues, achieving consensus on a common goal is often difficult due to partners' potentially different interests as well as the differences in partners' technological maturity levels. The installation of a supply chain governance structure, such as a control tower, ensures that all participants' business interests are considered while orchestrating and controlling Big Data Analytics efforts across the supply chain partners. To be effective on a supply chain level, Big Data Analytics requires the collaboration between supply chain partners. Thus, it will be critical –besides the definition of business rules necessary to turn low quality data into insights– to define rules of engagement, agree on technology interfaces between systems, and shape the overall framework in which all interested parties will work together. As rules are only effective if they are binding for all partners the neutral governance entity may also ensure rule enforcement among participating parties.

9.5.2 Round 2 (Prioritizing of developed constructs)

Round two, the first quantitative round of the Delphi study, was designed to prioritize the previously collected opportunities and challenges of Big Data Analytics in regard to information usage and decision-making on corporate and supply chain level. As a preparatory step to round 2 and as outlined in section 9.4.3, the experts' answers as provided in round 1 were aggregated into group constructs. The overall aim of the prioritization is to identify the key opportunity and challenge constructs which should preferably be considered in adopting Big Data Analytics.

The experts were provided with the following instructions:

> *"Phase 2 requires the participants to rate the relevance of the consolidated constructs on a 5-point Likert scale. Please rate each construct's relevance in the Excel sheet provided on a scale of 5 (very high relevance) to 1 (very low relevance). Please use the default option 0 (not relevant) if you are unable to rate the construct's relevance."*

In total 43 constructs, split into four sections according to sub-questions (see Table 9.4, p. 255), were prioritized and ranked for relevance by the expert panel on a 5-point Likert scale, ranging from "very high" (5), "high" (4), "medium" (3), "low" (2) to "very low" (1). In addition the default value "not applicable" (0) was a selectable option in order to ensure each expert could provide a relevance rating to each construct. The individual prioritizations returned by the 15 experts were consolidated and statistically assessed using Microsoft Excel software.

For every construct the individual frequency distribution was evaluated in order to get a clear picture of the experts' view to the construct's relevance. In addition, the arithmetic group mean value, which in the following will be represented by the mathematical symbol $\overline{x}$, was calculated for each construct which seemed most suitable to serve as the key metric for comparing the constructs. The mean, in contrast to the median, for example, allows for a more detailed comparison of the ratings with higher levels of granularity. The selection in favor of the mean is supported by the finding that the prioritization scores were found to be rather clustered in the upper scoring range, overall showing little tendency towards variability and thus not covering the full spectrum of the rating scale.

In order to identify the highest ranking constructs in each sub-section it was required to sort the constructs in descending order based on their mean group value. In the case where the mean group value of two or more constructs was identical, the respective constructs were in addition compared and sorted based on a descriptive level according to the number of “very high” or “high” expert ratings. In total 11 opportunity and challenge constructs were rated by the panel experts as being of at least “high” relevance, thus yielding a $\overline{x}$ equal to or above 4.0. The next section briefly presents the results of the ranking procedure in round 2, with a focus on the opportunities and challenges with a high relevance for Big Data Analytics adoption on corporate and supply chain level.

The highest ranking opportunity construct on corporate level in round 2 was “customer behavior” ($\overline{x}$ = 4.4). This construct also received the highest mean rating given by the expert panel across all opportunities as well as across all sub-sections. “Information management” was the second highest opportunity on corporate level ($\overline{x}$ = 4.0), outlining the relevance of enhanced discovery, assessment, availability, exploitation, and provisioning of data and information.

On the supply chain level, the expert panel valued five opportunities as being of “high” relevance, namely “logistics,” “supply chain visibility and transparency,” “operations efficiency and maintenance,” “inventory,” and “integration and collaboration”. The highest ranked opportunity of Big Data Analytics was found in regard to the “logistics” construct ($\overline{x}$ = 4.2). The second highest supply chain opportunity was “supply chain visibility and transparency” ($\overline{x}$ = 4.07). The third to fifth place was distributed across the opportunities of “operations efficiency and maintenance” (third), “inventory” (fourth) and “integration and collaboration” (fifth), respectively, which all showed a $\overline{x}$ value of 4.0.

Four challenges were rated by the expert panel as being of high relevance. On the corporate level, two challenges are considered of prime relevance, both yielding a $\overline{x}$ value of 4.07: “IT capabilities and infrastructure” and “business strategy and objective”.

From the supply chain side, “Governance and compliance” was the major challenge as identified by the experts. With a $\overline{x}$ value of 4.27 this challenge received the highest mean rating given by the expert panel across all challenge constructs. The second highest valued challenge ($\overline{x}$ = 4.2) was linked to “Integration and collaboration”.

A full list of all constructs on corporate and supply chain level ranked according to their prioritization is provided in Table 9.7 (p. 289) for all corporate level opportunities, Table 9.8 (p. 290) for all supply chain level opportunities, Table 9.9 (p. 291) for all corporate level challenges, and Table 9.10 (p. 292) for all supply chain level challenges. This prioritization ranking is the result of the statistical evaluation of the 43 constructs along the four sub-sections (Table 9.3, p. 253) in the second round of the Delphi study.

Item code	Description of construct (opportunities on corporate level)	Number of experts with respective rating (round 2)						$\overline{x}$	Std. dev.
		5 (very high)	4 (high)	3 (medium)	2 (low)	1 (very low)	0 (not relevant)		
CO-7	**Customer behavior:** better perception of customer behavior (customer intimacy, visibility)	8	5	2	0	0	0	4.4	0.736
CO-1	**Information management:** enhanced discovery, access, availability, exploitation, and provisioning of information/data within company and supply chain	4	7	4	0	0	0	4.0	0.755
CO-4	**Supply chain visibility and transparency:** real-time control, multi-tier (process, decision, financial) visibility irrespective of data location	7	3	4	0	0	1	3.93	1.387
CO-5	**Responsiveness:** increased robustness of supply chain; increased (real-time) responsiveness to customer needs and changing market conditions; reduced time-to-market	5	4	6	0	0	0	3.93	0.883
CO-3	**Operations efficiency and maintenance:** more precise modeling allows for more accurate decisions; continuous optimization and productivity improvements through automation, machine learning and machine-to-machine based processes; leaner operations and optimized servicing through predictive analytics	4	7	3	1	0	0	3.93	1.187
CO-8	**Product and market strategy:** enhanced customer segmentation allows for better scalability and mass personalization; improved customer service levels; better customer acquisition strategies/ sales channel strategies (web, social); customization of delivery	3	8	4	0	0	0	3.93	0.883
CO-2	**New business models:** increased competitive advantage through new (innovative) business models/strategies and new ways of addressing the market place	6	4	2	3	0	0	3.87	0.703
CO-10	**Innovation and product design:** utilization of product usage data, POS data, field data from devices, customer data, and supplier suggestions to drive product and process innovation	3	7	4	1	0	0	3.8	0.861
CO-9	**Demand management and production planning:** product launch and release planning; increased granularity of planning levels allows for optimized, shorter planning cycles	0	9	4	1	0	1	3.33	1.112
CO-6	**Financial implications:** reduced long-term cost; increased ability to invest; improved understanding of cost drivers and impacts	1	4	8	2	0	0	3.27	0.798
CO-11	**Talent management and HR:** employee life cycle management through optimized employee utilization, enhanced education, enhanced safety, optimized retention	0	5	6	3	1	0	3.0	0.925

Table 9.7: Ranked opportunity constructs on corporate level according to relevance (round 2) (Source: Author)

Item code	Description of construct (opportunities on supply chain level)	Number of experts with respective rating (round 2)						$\overline{x}$	Std. dev.
		5 (very high)	4 (high)	3 (medium)	2 (low)	1 (very low)	0 (not relevant)		
SO-3	**Logistics:** product traceability leads to lead-time reduction (e.g. by in-transit processing of goods); real-time rescheduling, route planning, re-routing and road side service planning service planning	7	4	4	0	0	0	4.2	0.861
SO-2	**Supply chain visibility and transparency:** real-time control, multi-tier (process, decision, financial) visibility irrespective of data location	5	6	4	0	0	0	4.07	0.798
SO-8	**Operations efficiency and maintenance:** more precise modeling allows for more accurate decisions; continuous optimization and productivity improvements through automation, machine learning and machine-to-machine based processes; leaner operations and optimized servicing through predictive analytics	6	3	6	0	0	0	4.0	0.925
SO-5	**Inventory:** SC inventory optimization / real-time inventory control	4	7	4	0	0	0	4.0	0.755
SO-1	**Integration and collaboration:** integrated (supply network) optimization and collaboration with entire supply chain ecosystem; use of integrated data platforms during design phase	3	9	3	0	0	0	4.0	0.798
SO-10	**Responsiveness:** increased robustness of supply chain; increased (real-time) responsiveness to customer needs and changing market conditions; reduced time-to-market	4	6	5	0	0	0	3.93	0.654
SO-7	**Innovation and product design:** utilization of product usage data, POS data, field data from devices, customer data, and supplier suggestions to drive product and process innovation	5	4	5	1	0	0	3.87	0.990
SO-6	**Product and market strategy:** enhanced customer segmentation allows for better scalability and mass personalization; improved customer service levels; better customer acquisition strategies/ sales channel strategies (web, social); customization of delivery	4	6	4	1	0	0	3.87	0.915
SO-4	**Demand management and production planning:** product launch and release planning; increased granularity of planning levels allows for optimized, shorter planning cycles	2	7	6	0	0	0	3.73	0.703
SO-9	**Risk management:** enhanced risk evaluation; continuity management at industry / SC level to reduce impact of disruptions	1	9	5	0	0	0	3.73	0.593
SO-12	**Financial implications:** reduced long-term cost; increased ability to invest; improved understanding of cost drivers and impacts	3	2	9	1	0	0	3.47	0.915
SO-11	**Information management:** enhanced discovery, access, availability, exploitation, and provisioning of information/data within company and supply chain	1	4	8	2	0	0	3.27	0.798

Table 9.8: Ranked opportunity constructs on supply chain level according to relevance (round 2) (Source: Author)

Item code	Description of construct (challenges on corporate level)	Number of experts with respective rating (round 2)						$\overline{x}$	Std. dev.
		5 (very high)	4 (high)	3 (medium)	2 (low)	1 (very low)	0 (not relevant)		
CC-3	**IT capabilities and infrastructure** lack of powerful infrastructure (technology, processes & people) to process information; fragmented system landscape due to lack of technical standardization a challenge for end-to-end visibility	7	3	4	1	0	0	4.07	1.032
CC-9	**Business strategy and objective:** establish a clear need/internal justification for Big Data through business cases; clear objective to implement Big Data required (purpose such as threat of new competitor entry or a unique business offering); challenge to "sell" Big Data to customers and clients	7	3	4	1	0	0	4.07	1.032
CC-7	**Information management** management of information complexity (integrity, quality, volume); identification and knowledge of relevant information avoiding inaccurate information	3	8	4	0	0	0	3.93	0.703
CC-4	**Talent management and HR:** lack of skilled resources; unfocused talent management (unclear role description for Big Data employees)	5	3	7	0	0	0	3.87	0.915
CC-1	**Transformational change:** need to evolve current organizational structures (dynamic processes, structures, reporting, skills) to leverage the potential of Big Data	3	6	5	1	0	0	3.73	0.883
CC-2	**Cultural change:** building a data-driven mindset in decision-making and challenging "new truth" from information, establishing openness to trust data (not only for test but also in production)	2	8	4	1	0	0	3.73	0.798
CC-8	**Information and cyber security:** threat of information leakage; respecting customer's individual data privacy; differentiation between private and public data increasingly challenging	7	2	2	2	1	1	3.6	1.681
CC-5	**Financial implications:** high investments required (technology, processes & people) combined with shortened investment cycles in IT infrastructure; investments are prioritized according to business case not necessarily need	1	5	4	5	0	0	3.13	0.990
CC-6	**Ethical and managerial implications:** balance human vs. analytics management style avoiding a "cold" data driven over-reliance on information; challenge to distill actionable right decisions from sophisticated reports (descriptive reporting vs. predictive analysis) and avoid misuse	1	3	7	3	0	1	2.93	1.162

Table 9.9: Ranked challenge constructs on corporate level according to relevance (round 2) (Source: Author)

Item code	Description of construct (challenges on supply chain level)	Number of experts with respective rating (round 2)						$\overline{x}$	Std. dev.
		5 (very high)	4 (high)	3 (medium)	2 (low)	1 (very low)	0 (not relevant)		
SC-1	**Governance and compliance:** need for control tower to orchestrate and control Big Data efforts across supply networks efficiently and install required collaboration rules (common consensus about goals, different maturity levels, standardization, incentive structure)	6	7	2	0	0	0	4.27	0.703
SC-4	**Integration and collaboration:** cross-functional collaboration, integration across company boundaries also with customers required for Big Data; reluctance to cooperate	7	4	4	0	0	0	4.2	0.861
SC-3	**Business strategy and objective:** establish a clear need/internal justification for Big Data through business cases; clear objective to implement Big Data required; challenge to "sell" Big Data to customers and clients	4	6	4	1	0	0	3.87	0.915
SC-5	**IT capabilities and infrastructure** lack of powerful infrastructure (technology, processes & people) to process information; fragmented system landscape due to lack of technical standardization a challenge for end-to-end visibility	5	4	3	3	0	0	3.73	1.162
SC-11	**Talent management and HR:** lack of skilled resources; unfocused talent management (unclear role description for Big Data employees)	4	3	8	0	0	0	3.73	0.883
SC-6	**Financial implications:** high investments required combined with shortened investment cycles in IT infrastructure; investments are prioritized according to business case not necessarily need	3	8	1	3	0	0	3.73	1.032
SC-10	**Transformational change:** need to evolve current organizational structures (dynamic processes, structures, reporting, skills) to leverage the potential of Big Data	1	8	6	0	0	0	3.67	0.617
SC-7	**Information and cyber security:** threat of information leakage; respecting customer's individual data privacy; differentiation between private and public data increasingly challenging	5	2	6	0	2	0	3.53	0.961
SC-8	**Cultural change:** building a data-driven mindset in decision-making and challenging "new truth" from information, establishing openness to trust data (not only for test but also in production)	3	6	3	2	0	1	3.47	1.355
SC-9	**Information management** management of information complexity (integrity, quality, volume); identification and knowledge of relevant information avoiding inaccurate information	2	7	3	2	1	0	3.47	1.125
SC-2	**Ethical and managerial implications:** balance human vs. analytics management style avoiding a "cold" data driven over-reliance on information; challenge to distill actionable right decisions from sophisticated reports (descriptive reporting vs. predictive analysis) and avoid misuse	0	3	8	3	0	1	2.8	1.014

Table 9.10: Ranked challenge constructs on supply chain level according to relevance (round 2) (Source: Author)

9.5.3 Round 3 (Validation of group response against individual response)

Round 3, the second quantitative round of the Delphi study, enabled the experts to validate their initial prioritization given in round 2 against the average mean group response. The aim of this approach was to improve the individual expert's response quality but also to impact on overall group response quality in terms of a more balanced rating distribution.

The experts were provided with the following instructions:

> *„Please open the attached Excel file which contains your individual responses to each construct as well as the group mean rating. Carefully review your individual response and contrast it to the group mean rating. If you think that your initial rating should be changed, please provide the new rating [rating scale 0 (not relevant) to 5 (very high)]. If you changed your rating, please provide the justification for the change, or any additional comment."*

Overall, it was observed by the author that the third round of the Delphi study was subject to process gain as the experts were now familiar with the research approach and applied procedure, an observation usually described in Delphi study research (Bolger and Wright, 2011). A total of 15 experts returned their reviewed prioritizations to round 3, which equals a 100% return rate. The fact that all experts from round 2 also continued their participation in round 3 underlines the experts' high levels of commitment to the study's success. Furthermore, this can be seen as a supportive argument for the relevance of the research topic from a practitioner point of view.

The prioritization ratings to round 3 were consolidated by the author and statistically assessed using Microsoft Excel software. In addition and taking the same approach as applied in round 2, the highest ranking constructs in each sub-section were identified. This was done by sorting the constructs in descending order according to their now adjusted mean group value. Contrasting the reviewed prioritization in round 3 to the previous values as assessed in round 2 of the Delphi study, the magnitude of the rating adjustment on corporate and supply chain level became apparent. This is visualized in Table 9.11 (p. 294) for opportunity constructs and Table 9.12 (p. 295) for challenge constructs, as the arrows in the last row of the tables indicate the rating change of the respective construct from round 2 to round 3.

Item code	Level	Construct (corporate level)	Number of experts with respective rating (round 3) 5 (very high)	4 (high)	3 (medium)	2 (low)	1 (very low)	0 (not relevant)	$\overline{x}_{R3}$	Std. dev.	$\overline{x}_{R2}$	Std. dev.	$\Delta\,(\overline{x}_{R3}, \overline{x}_{R2})$	Increase ↑ No change ● Decrease ↓
CO-7	corporate	Customer behavior	8	5	2	0	0	0	4.4	0.736	4.4	0.736	0.00	●
CO-1	corporate	Information management	4	7	4	0	0	0	4.2	0.783	4.0	0.755	0.20	↑
CO-4	corporate	Supply chain visibility and transparency	7	4	4	0	0	0	4.0	0.886	3.93	1.387	0.07	↑
CO-5	corporate	Responsiveness	5	4	6	0	0	0	4.0	0.886	3.93	0.883	0.07	↑
CO-2	corporate	New business models	6	4	2	3	0	0	3.93	1.189	3.87	1.187	0.06	↑
CO-3	corporate	Operations efficiency and maintenance	4	8	2	1	0	0	3.93	1.023	3.93	0.883	0.00	●
CO-8	corporate	Product and market strategy	3	8	4	0	0	0	3.93	0.703	3.93	0.703	0.00	●
CO-10	corporate	Innovation and product design	4	7	3	1	0	0	3.87	0.886	3.8	0.861	0.07	↑
CO-9	corporate	Demand management & production planning	0	9	5	0	0	1	3.4	1.055	3.33	1.112	0.07	↑
CO-6	corporate	Financial implications	1	4	9	1	0	0	3.33	0.723	3.26	0.798	0.06	↑
CO-11	corporate	Talent management and HR	0	5	6	3	1	0	3.0	0.925	3.0	0.925	0.00	●

Item code	Level	Construct (supply chain level)	Number of experts with respective rating (round 3) 5 (very high)	4 (high)	3 (medium)	2 (low)	1 (very low)	0 (not relevant)	$\overline{x}_{R3}$	Std. dev.	$\overline{x}_{R2}$	Std. dev.	$\Delta\,(\overline{x}_{R3}, \overline{x}_{R2})$	Increase ↑ No change ● Decrease ↓
SO-3	supply chain	Logistics	7	5	3	0	0	0	4.27	0.798	4.2	0.861	0.07	↑
SO-2	supply chain	Supply chain visibility and transparency	5	7	3	0	0	0	4.13	0.743	4.07	0.798	0.06	↑
SO-8	supply chain	Operations efficiency and maintenance	6	4	5	0	0	0	4.07	0.883	4.0	0.925	0.07	↑
SO-5	supply chain	Inventory	4	7	4	0	0	0	4.07	0.759	4.0	0.755	0.07	↑
SO-10	supply chain	Responsiveness	4	6	5	0	0	0	4.0	0.801	3.93	0.798	0.07	↑
SO-1	supply chain	Integration and collaboration	3	10	2	0	0	0	4.0	0.597	4.0	0.654	0.00	●
SO-7	supply chain	Innovation and product design	4	7	4	0	0	0	3.93	0.759	3.87	0.990	0.06	↑
SO-6	supply chain	Product and market strategy	4	6	4	1	0	0	3.87	0.915	3.87	0.915	0.00	●
SO-4	supply chain	Demand management & production planning	2	7	6	0	0	0	3.8	0.707	3.73	0.703	0.07	↑
SO-9	supply chain	Risk management	1	10	4	0	0	0	3.73	0.565	3.73	0.593	0.00	●
SO-12	supply chain	Financial implications	3	2	9	1	0	0	3.47	0.915	3.47	0.915	0.00	●
SO-11	supply chain	Information management	1	4	9	1	0	0	3.33	0.723	3.27	0.798	0.06	↑

Table 9.11: Comparison of round 3 opportunity construct relevance ranking on corporate and supply chain level against round 2 ranking (Source: Author)

Item code	Level	Construct (corporate level)	Number of experts with respective rating (round 3) 5 (very high)	4 (high)	3 (medium)	2 (low)	1 (very low)	0 (not relevant)	$\bar{x}_{R3}$	Std. dev.	$\bar{x}_{R2}$	Std. dev.	$\Delta\ (\bar{x}_{R3}, \bar{x}_{R2})$	Increase / No change / Decrease
CC-3	corporate	IT capabilities and infrastructure	7	3	4	1	0	0	4.07	1.032	4.07	1.032	0.00	●
CC-9	corporate	Business strategy and objective	7	3	4	1	0	0	4.07	1.032	4.07	1.032	0.00	●
CC-7	corporate	Information management	3	8	4	0	0	0	3.93	0.703	3.93	0.703	0.00	●
CC-4	corporate	Talent management and HR	5	3	7	0	0	0	3.87	0.915	3.87	0.915	0.00	●
CC-1	corporate	Transformational change	3	6	5	1	0	0	3.8	0.886	3.73	0.883	0.07	↑
CC-2	corporate	Cultural change	2	9	3	1	0	0	3.73	0.777	3.73	0.798	0.00	●
CC-8	corporate	Information and cyber security	6	3	2	2	1	1	3.53	1.641	3.6	1.681	-0.07	↓
CC-5	corporate	Financial implications	1	5	4	5	0	0	3.13	0.990	3.13	0.990	0.00	●
CC-6	corporate	Ethical and managerial implications	1	3	7	3	0	1	2.93	1.162	2.93	1.162	0.00	●

Item code	Level	Construct (supply chain level)	Number of experts with respective rating (round 3) 5 (very high)	4 (high)	3 (medium)	2 (low)	1 (very low)	0 (not relevant)	$\bar{x}_{R3}$	Std. dev.	$\bar{x}_{R2}$	Std. dev.	$\Delta\ (\bar{x}_{R3}, \bar{x}_{R2})$	Increase / No change / Decrease
SC-1	supply chain	Governance and compliance	6	8	1	0	0	0	4.33	0.617	4.27	0.703	0.06	↑
SC-4	supply chain	Integration and collaboration	7	4	4	0	0	0	4.2	0.861	4.2	0.861	0.00	●
SC-3	supply chain	Business strategy and objective	3	7	4	1	0	0	3.8	0.861	3.87	0.915	-0.07	↓
SC-5	supply chain	IT capabilities and infrastructure	5	4	3	3	0	0	3.73	1.162	3.73	1.162	0.00	●
SC-11	supply chain	Talent management and HR	4	3	8	0	0	0	3.73	1.192	3.73	0.883	0.00	●
SC-6	supply chain	Financial implications	3	8	1	3	0	0	3.73	1.032	3.73	1.032	0.00	●
SC-10	supply chain	Transformational change	1	8	6	0	0	0	3.67	0.617	3.67	0.617	0.00	●
SC-7	supply chain	Information and cyber security	5	3	5	0	2	0	3.6	1.352	3.53	0.961	0.07	↑
SC-8	supply chain	Cultural change	3	7	2	2	0	1	3.6	1.357	3.47	1.355	0.13	↑
SC-9	supply chain	Information management	2	7	4	2	0	0	3.53	0.913	3.47	1.125	0.06	↑
SC-2	supply chain	Ethical and managerial implications	0	2	8	4	0	1	2.67	0.975	2.8	1.014	-0.13	↓

Table 9.12: Comparison of round 3 challenge construct relevance ranking on corporate and supply chain level against round 2 ranking (Source: Author)

For reasons of clarity and easing the differentiation between the $\overline{x}$ values derived from round 2 and round 3 of the Delphi study, the remainder of this dissertation uses the symbol $\overline{x}_{R2}$ for the round 2 $\overline{x}$ values and $\overline{x}_{R3}$ for the round 3 $\overline{x}$ values.
It can be claimed that a consensus among participants has been reached in round 3 of the Delphi study, evident in the fact that variations in answers between round 2 and 3 are minuscule, as 96.3% of the constructs rated by the panel in round 2 remained unchanged in round 3. Thus, the updated prioritization results of round 3, resembled by the respective construct's $\overline{x}_{R3}$ value as presented in Table 9.11 and Table 9.12, can be considered as being stable. Accordingly, the Delphi study will terminate upon completion of round 3 following the definitions governing the cut of criteria as outlined in section 9.4.1. The results of round 3 therefore constitute the final results of the Delhi study.

The following section briefly reflects on the round 3 results as a detailed interpretation of the Delphi study results will be presented in chapter 10 (p. 298ff).
Although all experts reviewed their initial rating score from round 2, seven out of the 15 participating experts took the chance to adjust at least parts of their initial rating values, while the rough majority of experts reconfirmed their initial rating scores. As the experts were asked to provide the reason for any rating adjustments, further insights into the experts' rationale could be extracted. As such, the experts commonly reported that they gained a more accurate understanding of the constructs relevance in the timespan between the round 2 to round 3 data collection points. This understanding was mainly driven by experts' discussions with client executives, exposure to client applications as well as latest market insights.
It can be observed from a comparison of the results of the second and third Delphi round that the subsequent rating adjustments conducted by the seven experts on average yielded an increase of the overall expert ratings. As indicated in Table 9.11 (p. 294) and Table 9.12 (p. 295), this was mainly driven by 20 constructs with $\overline{x}_{R3}$ value increases ranging from 0.06 to 0.2 points. In contrast, the majority of constructs did not show a change of the $\overline{x}_{R3}$ value (20 constructs) or even constituted a lower $\overline{x}_{R3}$ value compared to round two (3 constructs).
The increase of the mean value was also not distributed evenly across the sub-sections as the majority of higher rated constructs was found in the opportunity dimensions (15 increased adjustments), with seven constructs on corporate level and eight on supply chain level. Only five challenge constructs were positively adjusted,

one on corporate and four on supply chain level. In addition, the challenge constructs also accounted for all reductive adjustments of the $\overline{x}_{R3}$ values (one on corporate and two on supply chain level). Based on the above outlined distribution it can be stated that the third round of the Delphi study fostered higher levels of relevance ratings of the opportunities and challenges linked to Big Data Analytics-enabled information availability. Thus, the aim of round 3 was achieved as the group response quality was improved in terms of a more stable, balanced prioritization among participants.
This is also reflected in the number of opportunity and challenge constructs which were rated by the panel experts as being of at least "high" relevance, yielding a $\overline{x}_{R3}$ equal or above 4.0. This number has grown from 11 constructs identified in round 2 to 14 constructs as found in round 3. Whereas the "high" relevance rating of the 11 opportunity and challenge constructs from round 2, previously presented in section 9.5.2, could be confirmed in round 3, three additional opportunity constructs were elevated from medium to high relevance by the experts. Accordingly, the opportunities "supply chain visibility and transparency" ($\overline{x}_{R3}$ = 4.0) as well as "responsiveness" ($\overline{x}_{R3}$ = 4.0) were added as third and fourth highest ranked corporate level opportunities. Furthermore, the opportunities of Big Data Analytics in regard to increased "responsiveness" were also considered as being of high relevance from a supply chain perspective, ranking fifth place on that level ($\overline{x}_{R3}$ = 4.0).

The above chapter presented the Delphi study methodology used, outlining definitions and characteristics, also providing a justification for the applicability and selection of the Delphi study methodology in the applied research. This is supplemented by a presentation of the design of the study, including the selection of the expert panel as well as the data collection process. The outcomes of the Delphi study's three round data collection process were presented, thus preparing the grounds for a detailed assessment and interpretation of the Delphi study results in the upcoming chapter 10.

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10 Assessing the findings from the Delphi study

In this chapter the results of the Delphi study, as presented throughout chapter 9, will be discussed. This involves a reflection on the opportunities and challenges derived from the expert prioritization in order to further systematize the constructs. The aim of this chapter is to distill the key opportunities and challenges linked to Big Data Analytics-infused information usage from the Delphi study results (section 10.1, p. 298ff), thereby providing an answer to research question RQ 5. Paving the way for a more granular assessment of key opportunities and challenges, section 10.3 (p. 328ff) provides a theoretical underpinning of the major overarching Delphi study constructs identified in section 10.1. Thus, following an exploratory approach, the overarching constructs find their basis ex-post in the respective literature, making use of the findings from the literature review study as presented in the desk research part of the dissertation. In addition, the Delphi study findings will be put into use in the context of the information requirements framework, initially proposed in section 8.5.2 (p. 226). This is operationalized in section 10.2 (p. 317ff) as the identified opportunities and challenges are mapped to the framework's respective configurational (strategic) and operational structure along the life-cycle process.

10.1 Opportunities and challenges of Big Data Analytics on corporate and supply chain level

Enabling a more differentiated assessment and discussion of the Delphi study findings it seems reasonable to cluster the prioritized constructs. Following a systematic approach, this will be done based on the constructs' group mean value ranges $\overline{x}_{R3}$ for the opportunity and challenge as well as corporate and supply chain level sub-sections.

As outlined in the previous chapter the constructs with a $\overline{x}_{R3}$ value of equal or above 4.0 were rated as being of "high" relevance. This classification concept will be kept and applied in the following, although being extended to cover the full scale of value ranges as presented in Table 10.1 (p. 299). Accordingly, the constructs with a $\overline{x}_{R3}$ value below 4.0 but equal or above 3.5 will be considered being of "high to medium" relevance, while the constructs with a $\overline{x}_{R3}$ value below 3.5 but equal or above 3.0 are of "medium" relevance. Any construct with a $\overline{x}_{R3}$ value below 3.0 is valued as having "medium to low" relevance. For the remainder of this thesis, the four before mentioned $\overline{x}_{R3}$ value ranges will be referred to as clusters A, B, C, and D, with cluster A representing the high relevance $\overline{x}_{R3}$ values while cluster D portrays other end of the scale, the medium to low relevance $\overline{x}_{R3}$ values.

Cluster dimension	Relevance grading	Associated ranges for $\overline{x}_{R3}$
A	High	$4.0 \leq \overline{x}_{R3} \leq 5.0$
B	Medium to high	$3.5 \leq \overline{x}_{R3} < 4.0$
C	Medium	$3.0 \leq \overline{x}_{R3} < 3.5$
D	Low to medium	$\overline{x}_{R3} < 3.0$

Table 10.1: Relevance grading scale used to cluster constructs
(Source: Author)

The rationale for the clustering being that a focus of the discussion on the elements prioritized with high relevance only bears the risk to neglect the impact of the constructs which received a lower rating but may nonetheless be of importance to understand the implications of Big Data Analytics from a corporate and supply chain perspective. Thus, the clustering approach allows for a more granular prioritization of the constructs on individual cluster dimension level, thereby providing extended assessment possibilities within the clusters of each sub-section. The author is aware that the selection of the value ranges may be a source of bias. However, the scale of the value ranges was justified as the definition of the applied value ranges was related to the overall relevance scale.

Nevertheless, although it can be claimed that all constructs across the clusters, as identified by the experts, are of importance and need to be considered in regard to the adoption of Big Data Analytics, the subsequent discussion of the findings still needs to be scaled to the most relevant constructs in order to enable a fruitful debate along the value of the constructs. The scoping approach to selected key constructs is also motivated by the planned mapping of the Delphi study findings to the information requirements framework, which will be discussed in detail in section 10.2.

Accordingly, the author of this dissertation decided to focus on all opportunity and challenge constructs in the A cluster as these are viewed by the experts as being most relevant. In addition, considering the above discussion, it seems reasonable from an assessment perspective to also cover all constructs in the B, C, and D clusters. The rationale being that these clusters contained opportunities and challenges which were rated by a substantial number of experts as being of significant relevance. Significant relevance in this case, being the threshold for the potential inclusion of constructs from the B, C, and D clusters, is defined as a “very high” relevance rating by a minimum of five experts. Aiding to a better comprehension of the approach, the clustering structure is operationalized in Table 10.2 (p. 301) for the corporate level opportunities, Table 10.3 (p. 302) for supply chain level opportunities, Table 10.4 (p. 303) for corporate level challenges, and Table 10.5 (p. 304) for challenges on supply chain levels. The highlighted key constructs comply with the above outlined scoping conditions, namely cluster A affiliation plus any construct with a “very high” relevance rating by a minimum of five experts.

In essence, as these identified key opportunities and challenges were distilled from the expert prioritizations, it can be claimed that they reflect the major implications of Big Data Analytics-driven information availability at corporate and supply chain level.

The following sections of this chapter outline the identified key opportunities and challenges, building on the description of the opportunities and challenges as already presented in detail in round one of the Delphi study data collection phase (section 9.5.1).

Item code	Level	Construct (corporate level)	Number of experts with respective rating (round 3)						$\overline{x}_{R3}$	Cluster
			5 (very high)	4 (high)	3 (medium)	2 (low)	1 (very low)	0 (not relevant)		
CO-7	corporate	Customer behavior	8	5	2	0	0	0	4.4	A
CO-1	corporate	Information management	4	7	4	0	0	0	4.2	A
CO-4	corporate	Supply chain visibility and transparency	7	4	4	0	0	0	4.0	A
CO-5	corporate	Responsiveness	5	4	6	0	0	0	4.0	A
CO-2	corporate	New business models	6	4	2	3	0	0	3.93	B
CO-3	corporate	Operations efficiency and maintenance	4	8	2	1	0	0	3.93	B
CO-8	corporate	Product and market strategy	3	8	4	0	0	0	3.93	B
CO-10	corporate	Innovation and product design	4	7	3	1	0	0	3.87	B
CO-9	corporate	Demand management and production planning	0	9	5	0	0	1	3.4	C
CO-6	corporate	Financial implications	1	4	9	1	0	0	3.33	C
CO-11	corporate	Talent management and HR	0	5	6	3	1	0	3.0	C

Table 10.2: Final relevance ranking and cluster structure of opportunity constructs on corporate level
(Source: Author)

Item code	Level	Construct (supply chain level)	Number of experts with respective rating (round 3)						$\overline{x}_{R3}$	Cluster
			5 (very high)	4 (high)	3 (medium)	2 (low)	1 (very low)	0 (not relevant)		
SO-3	supply chain	Logistics	7	5	3	0	0	0	4.27	A
SO-2	supply chain	Supply chain visibility and transparency	5	7	3	0	0	0	4.13	A
SO-8	supply chain	Operations efficiency and maintenance	6	4	5	0	0	0	4.07	A
SO-5	supply chain	Inventory	4	7	4	0	0	0	4.07	A
SO-10	supply chain	Responsiveness	4	6	5	0	0	0	4.0	A
SO-1	supply chain	Integration and collaboration	3	10	2	0	0	0	4.0	A
SO-7	supply chain	Innovation and product design	4	7	4	0	0	0	3.93	B
SO-6	supply chain	Product and market strategy	4	6	4	1	0	0	3.87	B
SO-4	supply chain	Demand management and production planning	2	7	6	0	0	0	3.8	B
SO-9	supply chain	Risk management	1	10	4	0	0	0	3.73	B
SO-12	supply chain	Financial implications	3	2	9	1	0	0	3.47	B
SO-11	supply chain	Information management	1	4	9	1	0	0	3.33	C

Table 10.3: Final relevance ranking and cluster structure of opportunity constructs on supply chain level
(Source: Author)

Item code	Level	Construct (corporate level)	Number of experts with respective rating (round 3)						$\overline{x}_{R3}$	Cluster
			5 (very high)	4 (high)	3 (medium)	2 (low)	1 (very low)	0 (not relevant)		
CC-3	corporate	IT capabilities and infrastructure	7	3	4	1	0	0	4.07	A
CC-9	corporate	Business strategy and objective	7	3	4	1	0	0	4.07	A
CC-7	corporate	Information management	3	8	4	0	0	0	3.93	B
CC-4	corporate	Talent management and HR	5	3	7	0	0	0	3.87	B
CC-1	corporate	Transformational change	3	6	5	1	0	0	3.8	B
CC-2	corporate	Cultural change	2	9	3	1	0	0	3.73	B
CC-8	corporate	Information and cyber security	6	3	2	2	1	1	3.53	B
CC-5	corporate	Financial implications	1	5	4	5	0	0	3.13	C
CC-6	corporate	Ethical and managerial implications	1	3	7	3	0	1	2.93	D

Table 10.4: Final relevance ranking and cluster structure of challenge constructs on corporate level
(Source: Author)

Item code	Level	Construct (supply chain level)	Number of experts with respective rating (round 3)						$\overline{x}_{R3}$	Cluster
			5 (very high)	4 (high)	3 (medium)	2 (low)	1 (very low)	0 (not relevant)		
SC-1	supply chain	Governance and compliance	6	8	1	0	0	0	4.33	A
SC-4	supply chain	Integration and collaboration	7	4	4	0	0	0	4.2	A
SC-3	supply chain	Business strategy and objective	3	7	4	1	0	0	3.8	B
SC-5	supply chain	IT capabilities and infrastructure	5	4	3	3	0	0	3.73	B
SC-11	supply chain	Talent management and HR	4	3	8	0	0	0	3.73	B
SC-6	supply chain	Financial implications	3	8	1	3	0	0	3.73	B
SC-10	supply chain	Transformational change	1	8	6	0	0	0	3.67	B
SC-7	supply chain	Information and cyber security	5	3	5	0	2	0	3.6	B
SC-8	supply chain	Cultural change	3	7	2	2	0	1	3.6	B
SC-9	supply chain	Information management	2	7	4	2	0	0	3.53	B
SC-2	supply chain	Ethical and managerial implications	0	2	8	4	0	1	2.67	D

Table 10.5: Final relevance ranking and cluster structure of challenge constructs on supply chain level
(Source: Author)

10.1.1 Key opportunities on corporate level

Following the judgment of the experts, the enhanced availability of information, triggered by the adoption of Big Data Analytics, has the highest positive impact on the corporate level in the following five key opportunity areas: “customer behavior,” “information management,” “supply chain visibility and transparency,” “responsiveness,” and “new business models”.

As the customer is the ultimate driver of business activities (Davenport and Short, 1990; Lyons *et al.*, 2012), insights into **customer behavior** are paramount from a business perspective. Although corporate activities have since long been trying to address customers’ needs, it has not been before the enhanced possibilities of large scale information exploitation, enabled through Big Data Analytics, that true customer-centricity was made possible. Accordingly, the biggest corporate benefit of Big Data Analytics-driven information availability lies in a better perception of customer intimacy, especially in regards the quality of perceived customer behavior. Reflecting on the relevance of customer centricity, more than every second expert agrees that Big Data Analytics-driven information availability has a very high impact on a company’s better perception of customer needs. Underlining the potential of Big Data Analytics in supporting customer visibility, the positive impact on customer behavior can be seen as the key selling argument for the adaptation of Big Data Analytics on a corporate level. This is supported by the Delphi study results where this construct received the highest relevance rating given by the expert panel across all opportunities.

Enhanced availability of information, fuelled by Big Data Analytics, was found to be very beneficial for corporate **information management**, allowing for enhanced discovery, assessment, availability, exploitation, and provisioning of data and information. Being the second highest ranked opportunity from a corporate perceptive, the potential of Big Data Analytics bears the opportunity to explore existing datasets on a corporate level through use of data visualization, helping to detect data sources which are not yet being utilized to drive value. This also includes the detection of trends extracted from the datasets which can be leveraged for example in forecasting activities.

Based on the above it can be argued that better insights into customer data as well as improved information management possibilities drive the visibility of information.

This may well be extended to include other parties in the manufacturing network, thereby leading to enhanced **supply chain visibility and transparency**. Following the experts opinion, the impact of enhanced corporate information availability on the visibility and transparency of the supply chain represents the third most relevant opportunity on corporate level.

The higher levels of visibility achieved through Big Data Analytics act as drivers for time compression, essentially being the prerequisite for the required **responsiveness** of a company in order to react to environmental influences. Accordingly, companies are enabled to react quicker to changing market conditions, made possible through visibility and a deeper understanding of their information-enriched ecosystem. The connection between the elements visibility and responsiveness was recognized by the panel experts as they judge the impact of the two opportunities as being similar in magnitude.

The depth as well as breadth of available information, which the company can operate on, increases through the use of Big Data Analytics. New insights gained can be further utilized to help improve the competitive position of the firm. Thus, existing business models can be fine-tuned through the availability of more granular datasets. In addition, the insights gained through increased availability of information could be used to assess existing and pursue new business opportunities. For instance, the proposed use of bundling strategies for the sale of “excess” information goods with little value to the selling company (Bakos and Brynjolfsson, 2001; Geng *et al.*, 2005) to parties for which the information holds high value may be an example for the exploitation of information through a new corporate business model. The vital role on and impact of Big Data Analytics for the development of **new business models** is reflected in the experts ranking of this key corporate opportunity (rank five).

Figure 10.1 (p. 307) summarizes the expert rating results which were the basis for the selection of the above presented key opportunities on corporate level.

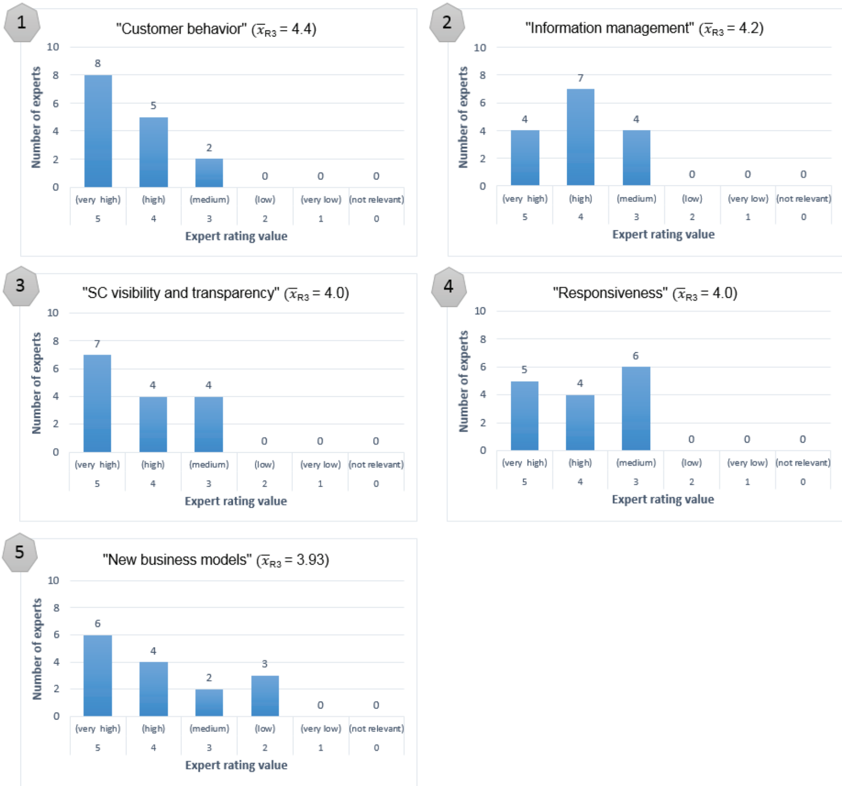


Figure 10.1: Expert rating frequency distribution of key corporate opportunities
(Source: Author)

10.1.2 Key opportunities on supply chain level

Six key opportunities were identified by the experts on the supply chain level as being directly influenced by Big Data Analytics adoption, namely “logistics,” “supply chain visibility and transparency,” “operations efficiency and maintenance,” “inventory,” “responsiveness,” as well as “integration and collaboration”.

The main opportunity of increased information availability through Big Data Analytics on the supply chain lies in the optimization potential of inter-company **logistics**. This view was supported by almost every second expert. In addition, the prime role of Big Data Analytics in logistics application is underlined as the logistics construct received the second highest relevance rating given by the expert panel across all opportunities. The benefits include that the value of information enriched Big Data

Analytics adoption in logistics offers the potential to track and trace products across the entities of the supply chain. Accordingly, real-time traffic information as well as current product location data shared among parties can be utilized to predict possible delays in deliveries across the supply chain. These insights provide great value for logistics decision-making.

As outlined above, a prerequisite for logistics optimization is the availability of end-to-end real-time information access and control. These required high levels of **supply chain visibility and transparency**, which were already outlined as being key on the corporate level, are valued by the experts as being the second most promising opportunity from a supply chain perspective. As Big Data Analytics enables end-to-end supply chain visibility with real-time access to corporate and supply chain insights the higher levels of visibility lead to improved supply chain agility and efficiency. Thus, each stakeholder in the value chain benefits from visibility into not only the immediate preceding and succeeding value creators but also beyond. Such multi-tier visibility makes supply chain decisions more dynamic, flexible, and also participatory.

The very high impact of greater information availability on **operations efficiency and maintenance** capabilities was outlined by six of the 15 experts. Ranked as the third key opportunity by the experts, the benefits from Big Data Analytics materialize in continuous optimization, automated control as well as monitoring possibilities through analytics driven real-time insights along the supply chain. The application of complex optimization algorithms to Big Data volumes is a key enabler in this regard to make products and processes more consistent, enabling the operation of a leaner supply chain. As the benefits also include an optimization of the maintenance and servicing capabilities through automation and predictive analytics, Big Data Analytics adoption across the supply chain is a suitable tool to improve asset base utilization. From a financial perspective this would drive the profitability of the supply chain.

Vital information becomes more transparent and available at much higher frequency, as parties cooperate and share insights across the supply chain. This allows to shorten planning cycles and to operate planning with higher levels of granularity, leading to more efficient **inventory** management practices, ultimately resulting in optimized inventory stocks. This key opportunity is ranked by the experts at fourth place, yielding the same relevance level as the above described “operations efficiency and maintenance” opportunity.

Following the expert judgment, the above described reduction of planning lead time, fuelled by improved supply chain visibility, is a great example for the time benefits of increased data availability on the supply chain level, especially in regard to cycle time compression. Accordingly, the impact of Big Data Analytics in regard to increased **responsiveness**, a key aspect also on the corporate level, marks the fifth key opportunity from a supply chain perspective.

In order to fully unlock the time compression potential of Big Data Analytics-enabled information availability across the supply chain, companies are required to adopt cross-functional **integration and collaboration** approaches with key partners. The intensified integration and collaboration efforts along the supply chain foster a trustful culture of relationship building in supply chains, leading to higher levels of information-sharing across parties. The idea that any type of information required for corporate decision-making is available at some entity within the chain can be seen as the key driver of collaboration. As such, the integrated supply chain approach to collaboration through data and information-sharing, made possible through integrated data exchange platforms, is valued by the experts as being the sixth key opportunity on supply chain level. In combination with higher levels of visibility across the supply chain, this will enable true collaboration along entire supply chain ecosystem, eventually resulting in the delivery of better products at lower cost to the supply chain as a whole.

The importance of the above presented key supply chain benefits of information availability is supported by the descriptive assessment of experts’ ratings as summarized in Figure 10.2 (p. 310) showcasing that a great range of experts agree on the potential of the six presented constructs.

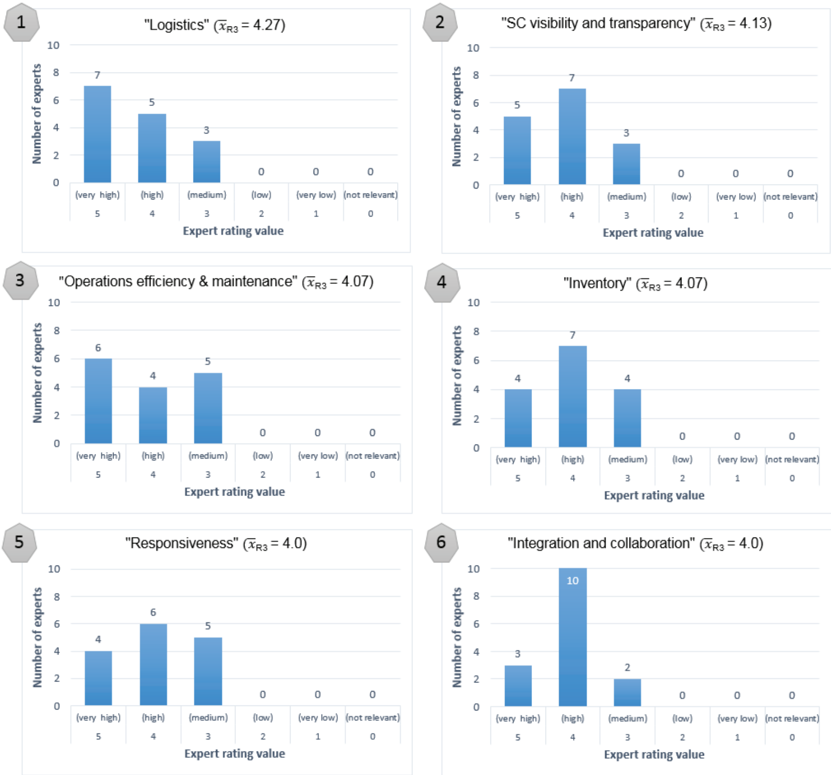


Figure 10.2: Expert rating frequency distribution of key supply chain opportunities
(Source: Author)

10.1.3 Key challenges on corporate level

Based on the Delphi study's expert recommendations four key challenges, all linked to the increased availability of information driven by Big Data Analytics, can be extracted on the corporate level: "IT capabilities and infrastructure," "business strategy and objective," "talent management," as well as "information and cyber security".

The lack of relevant **IT capabilities** as well as a powerful **IT infrastructure**, required to process data and make sense of large amounts of information, was rated by the experts as being the most prominent challenge for the adoption of Big Data Analytics on the corporate level. Seven of 15 experts outlined the very high relevance of this issue, distinguishing between two levels of abstraction: IT capabilities and IT infrastructure. On the IT capabilities side, a major issue is linked to the recruitment of the required IT workforce. Taking the infrastructure perspective, a key reason for the lack of capable IT infrastructure is often tied to the applied financial investment cycles. Thus, a replacement or upgrade of the existent IT infrastructure is often hindered as the assets many not have fully amortized by the time of upgrade. The constant challenge in such situations for companies is to find a way how to justify and prioritize the ongoing investments in technology required for Big Data Analytics.

The development of a starting objective, a unique offering or at least a clear corporate understanding of the purpose of Big Data Analytics adoption can be seen as a solution to the challenge. However, almost every second expert agrees that the definition of a clear **objective** for Big Data Analytics as well as the required integration of Big Data Analytics into the corporate **business strategy** is in itself a key challenge for companies. Ranked second most relevant corporate challenge, the lack of a clear corporate understanding of how Big Data Analytics initiatives can be "sold" to stakeholders, under consideration of its value for reaching business objectives, eventually results in Big Data Analytics initiatives facing continuous funding difficulties.

As outlined above, the lack of IT experts poses a challenge to corporations. Underlining the magnitude of this challenge, issues tied to **talent management and HR** were rated as being the third most challenging aspect to Big Data Analytics adoption on a corporate level. Following Davenport and Patil's (2012) argumentation that the assessment and discovery of data patterns requires "data scientist", companies need qualified and specialized Big Data employees who understand statistical modeling, operate Big Data systems, and interpret the data streams. However, due to the novelty of the "data scientist" concept, companies struggle to come up with explicit skill descriptions required for the recruitment of the new type of employee. According to the experts, the reason for this may be found in a lack of knowledge on what may be required from such employees. One major aspect in this regard is the discussion if Big Data Analytics really requires a new type of employees or if the – yet unspecific – tasks constitute an extension to existing skill sets. However, as similar questions have not yet been entirely solved in other even more mature research areas, such as for example in SCM where companies still struggle to delineate the skillset of a supply chain manager against the skillset of a logistics manager (Zinn and Goldsby, 2014), companies should not wait for the silver bullet approach to emerge. As unfocused talent management represents a major issue for companies in the journey to attract relevant talent, taking into account the shortage of talent, a first conceptualization in regard to what type of skills are required from a corporate perceptive **seems a suitable** starting point to address talent management issues.

As companies increasingly have access to sensitive customer data, questions around **information and cyber security** arise. While access to confidential information is heavily regulated on an intra-company level, data security may be a concern from a customer perspective. Being the forth key challenge on corporate level, data security challenges can thus constitute a blocking point for corporate data collection efforts as customers may be cautious or even reluctant to share information. The installation and adherence of a customer data guideline is key to overcome these concerns and develop a trustful relationship.

Figure 10.3 (p. 312) displays a summary of the expert rating results which were the basis for the selection of the above presented key challenges from a corporate perspective.

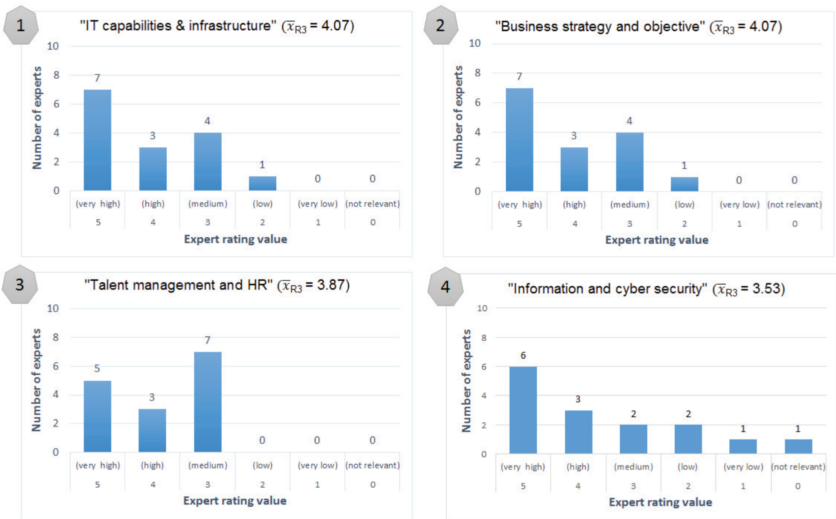


Figure 10.3: Expert rating frequency distribution of key corporate challenges
(Source: Author)

10.1.4 Key challenges on supply chain level

Four challenges can be considered being of prime relevance from a supply chain perspective, namely “governance and compliance,” “integration and collaboration,” “IT capabilities and infrastructure,” and “information and cyber security”.

To fully leverage the potential of information exploitation across the chain, every party in the chain should participate and make its share of information available to the partners. However, for the effective exploitation of data and the shared use of information sources across the supply chain a well-managed approach to coordination is essential in order to align the multitude of Big Data Analytics initiatives across all participating entities. This is reflected by the expert recommendations as the most challenging aspect linked to Big Data Analytics adoption from a supply chain perspective is based on aspects of Big Data Analytics **governance and compliance**. The development and installation of a supply chain governance structure is seen as paramount to steer and orchestrate Big Data Analytics efforts across the supply chain partners. Being the most critical aspect to Big Data Analytics adoption across the chain, such function is essential to achieve group consensus on common goals, setting the overall direction for future developments. Further benefits of this overarching neutral function are linked to its potential in mediating and resolving disputes among members as well as ensuring compliance to collaboration rules. Taking a financial perspective, the expected high acceptance levels of such a control tower function among supply chain parties underlines its value to drive the development of a balanced incentive structure promoting the participants provision of information to the group.

The installation of an effective and successful governance function which steers the Big Data Analytics initiatives of supply chain entities is inevitably bound to the parties’ willingness to **collaborate and integrate** with partners. Thus, the critical understanding that collaboration between functions and across stakeholders, extending well towards the customer, is a major aspect when building digital supply networks. Being the second key challenge from a supply chain perspective this view was shared by almost every second expert. A key issue in this regard stems from the problem that parties may be reluctant to cooperate as the immediate benefits of collaborative efforts are not instantly visible. Nevertheless, it is important for all parties to understand that true benefits can be extracted from viewing not only the physical supply chain but also the data and information supply chain as one entity, one end-to-end outcome-driven process. Underlining the criticality of collaborative approaches for Big Data Analytics adoption, the assessment of experts' judgment found that enhanced levels of integration and collaboration do not only reduce supply chain risks but be turned into key opportunities for the Big Data Analytics-driven exploitation of information (section 10.1.2).

Aspects of **IT infrastructure** landscape and **IT-related capability** planning can be considered vital business elements subject to corporate control. Challenges experienced within these areas on the corporate level, briefly discussed in section 10.1.3, are at risk to being carried over to the chain and thus multiply when companies aim for an extension of these systems towards the chain. As identified by the experts, the operation of fragmented corporate IT systems with varying maturity levels poses a real threat to IT effectiveness, hindering end-to-end supply chain visibility. The complexity tied to IT capabilities and infrastructure was recognized by the experts as this challenge was rated as the third major challenge on the supply chain level. Due to the corporate influence on the supply chain, IT infrastructure and capabilities need to be aligned in terms of functionality throughout the chain, ensuring a smooth exchange of information. A common shared understanding on the definition of standards and interface is paramount in this regard.

The definition of standards also seems to be fruitful in regard to the handling of sensitive information in a supply chain context. Similar to the corporate level, issues of data security also require special consideration from the supply chain perspective as companies are increasingly dependent on information which may well originate beyond the single company. Accordingly, **information and cyber security** was valued as the forth key challenge on supply chain level. Data security challenges can constitute a blocking point for Big Data Analytics adoption as participating companies are reluctant to share information with members of the chain as the inevitably lose control over proprietary information. The challenge is linked to ensure that data is not being shared without the owner's consent. It is therefore of utmost importance to develop a trustful relationship with partners and discuss the usage of shared data as well as privacy concerns upfront, aiming to balance individual data privacy requirements and concerns with supply chain needs.

Figure 10.4 (p. 315) presents the expert rating results which served as the basis for the selection of the above outlined key challenges on supply chain level.

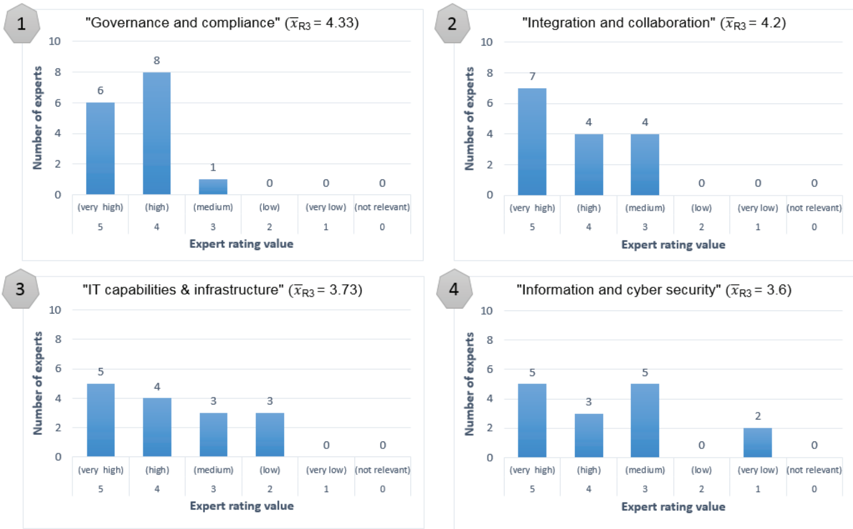


Figure 10.4: Expert rating frequency distribution of key supply chain challenges
(Source: Author)

10.2 Applying the Delphi study findings to the information requirements framework

Utilizing experts' insights, the Delphi study allowed for the development of a first conceptualization of the opportunities as well as challenges linked to the adoption of Big Data Analytics at corporate and supply chain level. This has been achieved as 43 major constructs across the four sub-sections could be identified and ranked according to their relevance. Based on the ranking 18 key constructs could be distilled which are of prime relevance.

Making use of these insights, the Delphi study findings provide excellent leverage for being integrated into the information requirements framework, presented in detail in section 8.5.2 (p. 226ff), following the life-cycle structure represented by the six sub-processes of the framework. The rationale being that the identified opportunity and challenge constructs seem to be suitable to serve as incubators for the generation of ideas in regard to what kind of information could be considered by companies in their digital transformation journey. The constructs thus represent a great starting point for the structured identification, mapping, and assessment of digital business transformation-driven, Big Data Analytics-related information requirements useful for decision-making at corporate business function as well as supply chain level.

Linking to the five stage information requirements collection process, previously outlined in section 8.5.2., the constructs are likely to be beneficial for the collection of information requirements in the analysis stage (stage two) while also supporting the formalization of requirements (stage three). In stage two in particular, the constructs could be utilized to benchmark the current landscape of corporate information requirements on which decisions are being based. They thus serve to assess if new information requirements with a digital impact, drawn from the constructs, need to be added to the existing requirements to fully support the application of Big Data Analytics. In case of the indication that new digital-rooted information requirements need to be added, the constructs may be suitable to support the definition of new information needs, in terms of more accurate or previously missing requirements, which could be collected along the configurational and operational level (stage three).

In a wider sense, the identified proposed constructs enable businesses to assess if their processes are equipped and robust enough to make use of the opportunities and deal with the challenges of the digital business transformation in general and the adoption of Big Data Analytics in particular.

From a methodology perspective, each construct was mapped in regard to its logical fit to the six sub-processes of the information requirements framework. Following the life-cycle structure, a construct could fit multiple (or even all) sub-processes, underlining its relevance and overall value in the life-cycle process. Nevertheless, although all identified constructs may provide valuable input and thus should be generally considered for the identification of information requirements, it may from a managerial point of view not always be possible – due to business and time restrictions – to scrutinize all opportunity and challenge constructs in sufficient depth. The grouping of the constructs based on their relevance, as outlined earlier in section 10.1 (p. 298ff), offers a feasible solution. It allows to scale the assessment focus on the constructs which were rated by the experts as being most relevant, thereby streamlining the identification of information requirements framed to the respective situation. However, in order to provide a holistic picture, the following mapping does not only build on the 18 key opportunities and challenges as presented in sections 10.1.1 to 10.1.4, but comprises all 43 opportunities and challenges identified.

In order to determine a construct's fit to a sub-process (sub-processes I to VI), the author scrutinized each construct from the following perspective: *"Has the opportunity / challenge construct the potential to yield insights which can be formalized into information requirements and used in decision-making in the respective sub-process?"* In case the construct was found by the author to potentially provide insights, it was tagged accordingly with the rationale for the tagging being noted. The results of the construct mapping to the respective sub-processes of the information requirements framework are displayed in Table 10.7 (p. 321) and Table 10.8 (p. 322) for the corporate and supply chain level opportunity constructs and Table 10.9 (p. 323) as well as Table 10.10 (p. 324) for the challenge constructs on both levels. The 18 key constructs as identified in the Delphi study are highlighted for easier orientation. Enhancing the transparency of the mapping process, it should be noted that for each construct one selected exemplified information requirement was identified by the author for explanatory purposes (Table 10.7 to Table 10.10) as it was not attempted to formalize all potential information requirements. Thus, as the aim of the mapping was to sorely provide a general indicative overview of information requirements which could be drawn from the constructs, the tables do not include a complete list of potential information requirements useful for decision-making. Accordingly, a complete assessment of the potential information requirements, which would be subject to industry, company, and even product specificities, is not part of the dissertation.

As the constructs were discussed in detail in section 9.5.1 as well as section 10.1.1 to 10.1.4, a further discussion of the constructs will be omitted. However, to support the overall understanding of the mapping process, the process will be exemplified following the mapping of the construct "customer behavior" to the framework's respective configurational (strategic) and operational structure along the life-cycle process: The construct "customer behavior" is relevant on a corporate level, as the selection of the right partners in the strategic configuration of product and network (sub-process I) determines the subsequent processes' ability to derive insights which could be turned to satisfy information needs. Thus, it seems beneficial to select partners who share their insights and perception of customer needs as these insights may fulfill information needs relevant for own decision-making. In addition, the gained insights are beneficial when collaborately designing the product (sub-process II) as the product can be developed right away with a focus on latest marketplace and customer needs. Ultimately governing the selection of appropriate partners in the market-phase and thus the formation of the production network (sub-process III), the insights to customer buying behavior are useful to optimize sales and operations planning processes, including launch planning as well as production forecasting (sub-process IV). With regard to the return phase, customer visibility is paramount on a corporate level in order to decide early on how the return of products should be handled considering the customers' preferences. As such, insights on (potential) customer behavior ultimately fulfill corporate information needs which impact on decision-making in regard to the formation and design of the reduction network (sub-process V) as well as the optimization of the return-process (sub-process IV). Although this step is the final step in the life-cycle process, the post-phase is as important as the pre-phase and market-phase as the lack of an adequate return or even repair procedure may negatively impact on customer's initial purchase behavior.

Throughout the mapping process it was found that not every construct could be addressed with the above outlined question. Thus, some constructs were not "information requirements-focused", they did not yield insights which could be turned into formalized information requirements as their value was more of a "process-focused" nature. The process value fit of a construct in this regard was determined by asking the question: *"Is the opportunity / challenge construct a direct result of Big Data Analytics adoption?"* As the mapping process for the "information requirements-focused" construct had been previously showcased by use of the "customer behavior" construct, the following briefly explains the mapping process for the "process-focused" constructs, exemplified along the "responsiveness" construct. The "responsiveness" construct is of processual value as the adoption of Big Data Analytics, according to the expert answers from the Delphi study, impacts on the whole business process as it enables businesses to react quicker to changing market conditions. The construct is thus a direct result of increased information availability. No insights, however, can be drawn from the "responsiveness" construct which could be turned into specific information requirements useful for decision-making. The only insight is the conclusion that faster exchange of information increases corporate and supply chain responsiveness, which, being of general nature, cannot be drilled down to a specific formalized information need. The "process-focused" constructs, although not yielding insights which can be formalized into information requirements, still supplement the "information requirements-focused" constructs. These constructs are, for instance, expected to be of great use as key sales arguments for the implementation of digital business transformation programs in general and the adoption of Big Data Analytics in particular. They thus provide the foundation for defining a clear rationale for a Big Data Analytics need, underlining the required integration of Big Data Analytics into the corporate business strategy.

The characteristics of the “process-focused” constructs and the “information requirements-focused” constructs, governing the categorization used in the mapping process are summarized and compared in Table 10.6 (p. 319).

Construct focus	information requirements-focused	process-focused
Categorization question applied to constructs	“Has the opportunity / challenge construct the potential to yield insights which can be formalized into information requirements and used in decision-making in the respective sub-process?”	“Is the opportunity / challenge construct a direct result of Big Data Analytics adoption?”

Table 10.6: Characteristics of constructs governing the categorization mapping
(Source: Author)

For interpretive purposes it needs to be stated that although the construct mapping as outlined in Table 10.7 to Table 10.10 covers the „long list“ of 43 constructs, the mapping does not give insights in regard to whether a certain opportunity or challenge construct yields insights to formalize information requirements relevant on an individual business function level. The mapping is rather to be seen as an indication, aiming to outline what kind of opportunity and challenge constructs a company in general should look at a certain point in the life-cycle process in order to identify respective information requirements which support the digital transformation journey. Going forward, it is advisable in order to further develop the framework to tailor the “long list” under consideration of business function’s needs, thus determining the relevance of constructs to individual business functions. Nevertheless, as the aim of the dissertation was to present a first collection of opportunities and challenges linked to the emergence of Big Data Analytics the extension of the research scope to map the exact fit between opportunity / challenge constructs and individual business functions will be left to future research to come.

After having mapped all constructs to the six sub-processes along the life-cycle process, the following context was commonly observed: If a construct is yielding insights which can be formalized into information requirements and used for decision-making on the operational level, the construct is also relevant on the configuration level as the configurational selection of partners influences the respective operational capabilities in that phase of the life-cycle process. This is evident in regard to all constructs and is thus claimed to be a common rule of the mapping process.

Furthermore, in contrast to the “information requirements-focused” constructs, it was apparent that each of the “process-focused” constructs was applicable to every one of the six sub-sections of the integrated information requirements framework. This may serve as an ex-post justification of the overarching relevance of the “process-focused” constructs which, as assumed before, are likely to be of great value for being utilized as key sales arguments for Big Data Analytics implementation.

A closer examination of the mapped constructs to the information requirements framework (Table 10.7 to Table 10.10) leads to the observation that a great part of the constructs on corporate and supply chain level seem to be relevant for all sub-processes. Especially concerning the challenge constructs, this observation holds true irrespective of the constructs’ “information requirements-focused” or “process-focused” orientation. This, however, is just another argument underlining the value of these challenges as being key considerations, vital in all aspects along the product life-cycle. When adopting Big Data Analytics in an industry context it is thus paramount from a managerial perspective to ensure that these challenges are considered before potential issues materialize. Adding to this, the author would like to point out that the presented tables (Table 10.7 to Table 10.10) are intended for being used as checklists, which guide the collection of information requirements on corporate and supply chain level. However, the current mapping is to some degree biased by the author’s opinion and should be seen as a first conceptualization. Adding to validity, the current mapping of the constructs to the information requirements framework yet needs to be validated via real-life industry cases.

Dimension	Level	Construct with detailed description	Identified construct focus	Rationale for construct focus decision - examplified information requirements	Life-cycle stages: Product phase (Pre-phase) Sub-process I: Strategic configuration of product and network	Product phase (Pre-phase) Sub-process II: Product design in supply chain	Production and Logistics (Market-phase) Sub-process III: Formation of the production network	Production and Logistics (Market-phase) Sub-process IV: Process-optimisation in the supply chain	Product return (Post-phase) Sub-process V: Formation of the reduction network	Product return (Post-phase) Sub-process VI: Process-optimisation in the return chain
opportunity	corporate	**Customer behavior:** better perception of customer behavior (customer intimacy, visibility)	information requirements-focused	- Info on (future) buying behavior (who buys what kind of product in what quality, quantity at what time in what	x	x	x	x	x	x
opportunity	corporate	**Operations efficiency and maintenance:** continuous optimization and productivity improvements through automation, machine learning and machine-to-machine based processes; leaner operations and optimized servicing through predictive analytics	information requirements-focused	- Info on machine utilization - Info on machine tear and wear status (predictive maintenance)			x	x		x
opportunity	corporate	**Product and market strategy:** enhanced customer segmentation allows for better scalability and mass personalization; improved customer service levels; better customer acquisition strategies/ sales channel strategies (web, social); customization of delivery	information requirements-focused	- Info on segmentation of customers	x	x	x	x	x	x
opportunity	corporate	**Innovation and product design:** utilization of product usage data, POS data, field data from devices, customer data, and supplier suggestions to drive product and process innovation	information requirements-focused	- Info on product usage, trends, customers feedback on potential new products before	x	x				
opportunity	corporate	**Demand management and production planning:** product launch and release planning; increased granularity of planning levels allows for optimized, shorter planning cycles	information requirements-focused	- Info on optimal lauch time under consideration of external factors			x	x		x
opportunity	corporate	**Talent management and HR:** employee life cycle management through optimized employee utilization, enhanced education, enhanced safety, optimized retention	information requirements-focused	- Info on utilization of individual employee, time spent on tasks, etc	x	x	x	x	x	x
opportunity	corporate	**Supply chain visibility and transparency:** real-time control, multi-tier (process, decision, financial) visibility irrespective of data	process-focused	Construct is a result of better customer perception	x	x	x	x	x	x
opportunity	corporate	**Information management:** enhanced discovery, access, availability, exploitation, and provisioning of information/data within company and supply chain	process-focused	Construct is a result of increased information availability	x	x	x	x	x	x
opportunity	corporate	**Responsiveness:** increased robustness of supply chain; increased (real-time) responsiveness to customer needs and changing market conditions; reduced time-to-market	process-focused	Construct is a result of increased information availability	x	x	x	x	x	x
opportunity	corporate	**New business models:** increased competitive advantage through new (innovative) business models/strategies and new ways of addressing the market place	process-focused	Construct is a result of increased information availability	x	x	x	x	x	x
opportunity	corporate	**Financial implications:** reduced long-term cost; increased ability to invest; improved understanding of cost drivers and impacts	process-focused	Construct is a result of increased information	x	x	x	x	x	x

Table 10.7: Delphi study constructs (opportunities, corporate level) mapped to the six sub-processes of the information requirements framework (Source: Author)

Dimension	Level	Construct with detailed description	Identified construct focus	Rationale for construct focus decision - examplified information requirements	Life-cycle stages: Product phase (Pre-phase)		Production and Logistics (Market-phase)		Product return (Post-phase)	
					Sub-process I: Strategic configuration of product and network	**Sub-process II:** Product design in supply chain	**Sub-process III:** Formation of the production network	**Sub-process IV:** Process-optimisation in the supply chain	**Sub-process V:** Formation of the reduction network	**Sub-process VI:** Process-optimisation in the return chain
opportunity	supply chain	**Logistics:** product traceability leads to lead-time reduction (e.g. by in- transit processing of goods); real-time rescheduling, route planning, re-routing and road side service planning service	information requirements-focused	- Info on exact location of product (in transit)			x	x	x	x
opportunity	supply chain	**Operations efficiency and maintenance:** continuous optimization and productivity improvements through automation, machine learning and machine-to-machine based processes; leaner operations and optimized servicing through predictive analytics	information requirements-focused	- Info on machine utilization, machine tear and wear status (predictive maintenance)			x	x		
opportunity	supply chain	**Inventory:** SC inventory optimization / real-time inventory control	information requirements-focused	- Info on location of product in warehouse, quantity, qualiyt and upcoming orders +			x	x		
opportunity	supply chain	**Integration and collaboration:** integrated (supply network) optimization and collaboration with entire supply chain ecosystem; use of integrated data platforms during design phase	information requirements-focused	- Info on current status of BDA implementation at partners	x	x	x	x	x	x
opportunity	supply chain	**Innovation and product design:** utilization of product usage data, POS data, field data from devices, customer data, and supplier suggestions to drive product and process innovation	information requirements-focused	- Info on product usage, trends, customers feedback on potential new products before	x	x				
opportunity	supply chain	**Product and market strategy:** enhanced customer segmentation allows for better scalability and mass personalization; improved customer service levels; better customer acquisition strategies/ sales channel strategies (web, social); customization of delivery	information requirements-focused	- Info on suitable segmentation of customers	x	x	x	x		
opportunity	supply chain	**Demand management and production planning:** product launch and release planning; increased granularity of planning levels allows for optimized, shorter planning cycles	information requirements-focused	- Info on optimal lauch time under consideration of external factors			x	x		
opportunity	supply chain	**Supply chain visibility and transparency:** real-time control, multi-tier (process, decision, financial) visibility irrespective of data	process-focused	Construct is a result of better customer perception	x	x	x	x	x	x
opportunity	supply chain	**Responsiveness:** increased robustness of supply chain; increased (real-time) responsiveness to customer needs and changing market conditions; reduced time-to-market	process-focused	Construct is a result of increased information availability	x	x	x	x	x	x
opportunity	supply chain	**Risk management:** enhanced risk evaluation; continuity management at industry / SC level to reduce impact of disruptions	process-focused	Construct is a result of increased information	x	x	x	x	x	x
opportunity	supply chain	**Financial implications:** reduced long-term cost; increased ability to invest; improved understanding of cost drivers and impacts	process-focused	Construct is a result of increased information	x	x	x	x	x	x
opportunity	supply chain	**Information management:** enhanced discovery, access, availability, exploitation, and provisioning of information/data within company and supply chain	process-focused	Construct is a result of increased information availability	x	x	x	x	x	x

Table 10.8: Delphi study constructs (opportunities, supply chain level) mapped to the six sub-processes of the information requirements framework (Source: Author)

Dimension	Level	Construct with detailed description	Identified construct focus	Rationale for construct focus decision - examplified information requirements	Life-cycle stages: Product phase (Pre-phase)		Life-cycle stages: Production and Logistics (Market-phase)		Life-cycle stages: Product return (Post-phase)	
					Sub-process I: Strategic configuration of product and network	**Sub-process II:** Product design in supply chain	**Sub-process III:** Formation of the production network	**Sub-process IV:** Process-optimisation in the supply chain	**Sub-process V:** Formation of the reduction network	**Sub-process VI:** Process-optimisation in the return chain
challenge	corporate	**IT capabilities and infrastructure:** lack of powerful infrastructure (technology, processes & people) to process information; fragmented system landscape due to lack of technical standardization a challenge for end-to-end visibility	information requirements-focused	- Info on IT capabilities of partners in the network (also determines future capabilities)	x	x	x	x	x	x
challenge	corporate	**Talent management and HR:** lack of skilled resources; unfocused talent management (unclear role description for Big Data employees)	information requirements-focused	- Info on required skill sets, role description of data scientists	x	x	x	x	x	x
challenge	corporate	**Information and cyber security:** threat of information leakage; respecting customer's individual data privacy; differentiation between private and public data increasingly challenging	information requirements-focused	- Info on data leakages to develop counter actions - Info on privacy levels to ensure compliance with private/public levels	x	x	x	x	x	x
challenge	corporate	**Business strategy and objective:** establish a clear need/internal justification for Big Data through business cases; clear objective to implement Big Data required (purpose such as threat of new competitor entry or a unique business offering); challenge to "sell" Big Data to customers and clients	information requirements-focused	- Info on benefits of Big Data Analytics adoption, financial impact, etc	x	x	x	x	x	x
challenge	corporate	**Transformational change:** need to evolve current organizational structures (dynamic processes, structures, reporting, skills) to leverage the potential of Big Data	information requirements-focused	- Info on future organizational requirements needed to develop organizational blueprinting	x	x	x	x	x	x
challenge	corporate	**Cultural change:** building a data-driven mindset in decision-making and challenging "new truth" from information, establishing openness to trust data (not only for test but also in production)	information requirements-focused	- Infos on levers to enable cultural change, development of rules	x	x	x	x	x	x
challenge	corporate	**Financial implications:** high investments required (technology, processes & people) combined with shortened investment cycles in IT infrastructure; investments are prioritized according to business case not necessarily need	information requirements-focused	- Info on required financial investment levels, scope, etc	x	x	x	x	x	x
challenge	corporate	**Ethical and managerial implications:** balance human vs. analytics management style avoiding a "cold" data driven over-reliance on information; challenge to distill actionable right decisions from sophisticated reports (descriptive reporting vs. predictive analysis) and avoid misuse	information requirements-focused	- Infos on current management approach, development of rules to ensure actionable right descisions are made	x	x	x	x	x	x
challenge	corporate	**Information management:** management of information complexity (integrity, quality, volume); identification and knowledge of relevant information avoiding inaccurate information	process-focused	Construct is a result of increased information availability	x	x	x	x	x	x

Table 10.9: Delphi study constructs (challenges, corporate level) mapped to the six sub-processes of the information requirements framework (Source: Author)

Dimension	Level	Construct with detailed description	Identified construct focus	Rationale for construct focus decision - examplified information requirements	Life-cycle stages: Product phase (Pre-phase)		Production and Logistics (Market-phase)		Product return (Post-phase)	
					Sub-process I: Strategic configuration of product and network	**Sub-process II:** Product design in supply chain	**Sub-process III:** Formation of the production network	**Sub-process IV:** Process-optimisation in the supply chain	**Sub-process V:** Formation of the reduction network	**Sub-process VI:** Process-optimisation in the return chain
challenge	supply chain	**Integration and collaboration:** cross-functional collaboration, integration across company boundaries also with customers required for Big Data; reluctance to cooperate	information requirements-focused	- Info on current status of BDA implementation at peers - Info on potential levers to ensure partner buy-in	x	x	x	x	x	x
challenge	supply chain	**IT capabilities and infrastructure** lack of powerful infrastructure (technology, processes & people) to process information; fragmented system landscape due to lack of technical standardization a challenge for end-to-end visibility	information requirements-focused	- Info on IT capabilities of partners in the network (also determines future capabilities) to develop holistic supply	x	x	x	x	x	x
challenge	supply chain	**Talent management and HR:** lack of skilled resources; unfocused talent management (unclear role description for Big Data employees)	information requirements-focused	- Info on required skill sets, role description of data scientists across supply chain	x	x	x	x	x	x
challenge	supply chain	**Information and cyber security:** threat of information leakage; respecting customer's individual data privacy; differentiation between private and public data increasingly challenging	information requirements-focused	- Info on privacy levels to ensure compliance with private/public levels in the supply chain	x	x	x	x	x	x
challenge	supply chain	**Business strategy and objective:** establish a clear need/internal justification for Big Data through business cases; clear objective to implement Big Data required; challenge to "sell" Big Data to customers and clients	information requirements-focused	- Info on benefits of Big Data Analytics adoption, financial impact for supply chain partners, etc	x	x	x	x	x	x
challenge	supply chain	**Financial implications:** high investments required combined with shortened investment cycles in IT infrastructure; investments are prioritized according to business case not necessarily need	information requirements-focused	- Info on required financial investment levels, scope, etc	x	x	x	x	x	x
challenge	supply chain	**Transformational change:** need to evolve current organizational structures (dynamic processes, structures, reporting, skills) to leverage the potential of Big Data	information requirements-focused	- Info on future organizational requirements considering supply chain needs	x	x	x	x	x	x
challenge	supply chain	**Cultural change:** building a data-driven mindset in decision-making and challenging "new truth" from information, establishing openness to trust data (not only for test but also in	information requirements-focused	- Infos on levers to enable cultural change, development of rules, exchange of best	x	x	x	x	x	x
challenge	supply chain	**Ethical and managerial implications:** balance human vs. analytics management style avoiding a "cold" data driven over-reliance on information; challenge to distill actionable right decisions from sophisticated reports (descriptive reporting vs. predictive analysis) and avoid misuse	information requirements-focused	- Infos on current management approaches in the chain, development of rules to support descision-making under consideration of supply chain aspects	x	x	x	x	x	x
challenge	supply chain	**Governance and compliance:** need for control tower to orchestrate and control Big Data efforts across supply networks (common consensus about goals, incentive structure)	process-focused	Construct is a result of increased information availability	x	x	x	x	x	x
challenge	supply chain	**Information management** management of information complexity (integrity, quality, volume); identification and knowledge of relevant information avoiding inaccurate information	process-focused	Construct is a result of increased information availability	x	x	x	x	x	x

Table 10.10: Delphi study constructs (challenges, supply chain level) mapped to the six sub-processes of the information requirements framework (Source: Author)

Having outlined the key opportunities and challenges on corporate as well as on supply chain level, it can be argued that some of the above presented constructs are relevant not only on a single dimension (for example on the supply chain and challenge level only). Five constructs were found which are seemingly overarching as presented in Figure 10.5 (p. 325).

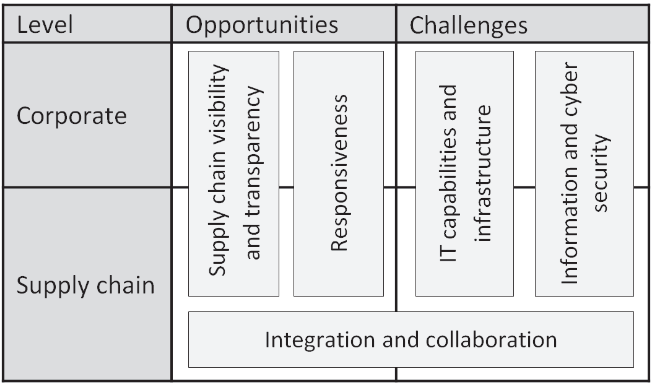


Figure 10.5: Overarching opportunities / challenges constructs on corporate / supply chain level (Source: Author)

Providing structure to the presentation of findings, the “vertical links” between constructs, e.g. corporate and supply chain level overarching, will be outlined first before commencing with the presentation of “horizontal links” (opportunities and challenges overarching). On the opportunities level especially the constructs “supply chain visibility and transparency” as well as “responsiveness” can be regarded as being bridging elements, relevant across both corporate and supply chain levels. From a challenges perspective the constructs “IT capabilities and infrastructure” and “Information and cyber security” can be seen as the major overarching elements covering the corporate as well as supply chain level.
Furthermore, extending the assessment towards a two-dimensional view, the author has assessed if certain constructs are not only overarching on corporate and supply chain level as described above, but may instead be bridging the opportunity and challenge level (“horizontal links”). Thus, it can be argued, based on the Delphi study findings, that the “Integration and collaboration” construct on the supply chain level

can be regarded as being a source of opportunities while at the same time holding a range of challenges. No overarching key opportunities and challenges constructs could be identified on the corporate level.

The above outlined five major links, namely “supply chain visibility and transparency,” “responsiveness,” “IT capabilities and infrastructure,” “integration and collaboration,” as well as “information and cyber security”, will be discussed in the next section (section 10.3, p. 326). Section 10.3 thus provides the theoretical underpinning for the overarching Delphi study constructs based on insights drawn from the literature review study which was outlined in chapter 6 (p. 85ff).

10.3 Interlinking overarching Delphi study constructs with literature review insights

As outlined in section 7.6 (p. 207ff), a key aim of the desk research part of this dissertation was to put theory into practice thereby contributing *to “bridge the gap between theoretical rigor and practical relevance”* (Prockl, 2005) in SCM. Accordingly, an under-represented area of research previously identified in the literature study, concerning the value and role of information in a business context, was investigated through application of the Delphi study methodology. As outlined in section 10.1, this led to the identification of five major overarching challenge and opportunity constructs, namely “supply chain visibility and transparency,” “responsiveness,” “IT capabilities and infrastructure,” “integration and collaboration,” as well as “information and cyber security”. These constructs, however, were drawn from the analysis of expert insights only which may be seen as a source of bias, potentially impacting on the validity of the findings. Aiming to overcome this limitation, also opening up possibilities to further explore these constructs, this current section thus provides a theoretical underpinning to the five constructs. Adding theoretical rigor to the practical findings of the Delphi study, this is achieved as these overarching challenge and opportunity constructs on corporate and supply chain level are matched and linked to respective categories derived from the previously outlined literature review study. Thus, making use of the respective findings from the literature review study, the five overarching constructs are rooted ex-post in the respective literature base. In essence, the theoretical founding of the Delphi study constructs allows for a more granular level of abstraction of practical research findings.

Aiming for a transparent research process, the applied matching procedure will be outlined in the following. Making use of the holistic “framework map” of major aspects of SCM (Table 4.3, p. 37), initially utilized in the literature review part of the dissertation (especially chapter 6, p. 85ff), each of the five constructs was assessed by the author in regard to its fit to the 26 categories. This was done by scrutinizing the literature review findings in chapter 6 for any aspects that would justify a link between the construct and a given category. The matching procedure involved that the literature reviews in a certain category were checked if they contained further references to other categories. This will be exemplified along the “integration and collaboration” construct’s link to the “collaboration” category: Chan and Chan (2010) outline in their review on collaboration that “*coordination is an important ingredient to improve the performance”* (p. 2793). Thus, it is assumed that links do not only exist from the “integration and collaboration” construct to the “coordination” category, but that the “performance” category should be considered as being linked to the “integration and collaboration” construct as well. Snowballing through the categories in the above described procedure ensured that all linking categories as outlined in the literature review were considered as bearing links. However, although it can be argued that some constructs are of importance for basically all categories, the scope of the assessment needed to be focused on the key categories. The rationale being that the inclusion of all relevant categories may have obstructed the detection of relevant insights and in essence may have yielded less valuable insights. Thus, allowing for a thorough discussion of the literature links of the categories in the latter part of this section, the author decided to limit the number of to-be-discussed links to a maximum of five categories per construct. Nevertheless, the challenge was to extract these categories for which the construct is most paramount. This step was supported through the use of the contingency analysis results, visualized in the “map of supply chain management” (Figure 6.2, p. 169) and presented in chapter 6.7.3 (p. 168ff), which provided a statistically sound justification for the relevance of category links.

Having assessed all constructs based on the above presented procedure, it can be claimed that the following matches between constructs and categories, as outlined in Table 10.11 (p. 328), are reasonable.

The overarching construct…	…can be linked to the following categories in the "framework map" of major aspects of SCM (Table 4.3, p. 37)
Supply chain visibility and transparency	Collaboration Integration Information-sharing Customer focus Supply chain planning
Responsiveness	Lean and agile supply strategies Collaboration Information-sharing Customer focus
Integration and collaboration	Integration Collaboration Supply chain performance Information technology
IT capabilities and infrastructure	Information technology Information-sharing Competitive advantage Integration
Information and cyber security	Information technology Competitive advantage Integration Collaboration

Table 10.11: Linking overarching Delphi study constructs to categories of the "framework map" of major aspects of SCM (Source: Author)

In the following, using insights from the literature review as presented throughout chapter 6 (p. 85ff), the links between the above outlined constructs and the respective categories will be discussed and justified.

10.3.1 Overarching construct "Supply chain visibility and transparency"

As portrayed in Table 10.11, and following literature review insights, the "supply chain visibility and transparency" construct may be directly linked to the categories "collaboration," "integration," "information-sharing," "customer focus," and "supply chain planning". This is justified as follows:

Collaboration: The importance of collaboration, especially external collaboration, is described in the review by Chan and Chan (2010) as being an *"important ingredient"* (Chan and Chan, 2010, p. 2793) in SCM, which has a significant impact on providing visibility across the chain. In other words, a lack of collaboration across the supply chain has a negative impact on process transparency, ultimately limiting the visibility of real demand. As this is a major problem in supply chains, following the review by Jain *et al.* (2009), collaboration is a key ingredient for achieving supply chain visibility and transparency.

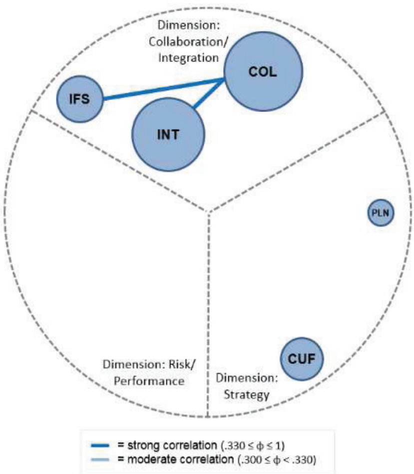
Integration: Collaboration is closely linked to integration in order to better align parties across the supply chain, also achieving higher levels of performance (Gunasekaran and Ngai, 2007). Following Giunipero *et al.* (2008) supply chain integration is a key factor for competitive success as it focusses on linking processes and extending the single company view of the logistics framework to the overall alignment of the chain of companies. Integrated processes across partners in return foster visibility and transparency across the chain (Barrat, 2004).

Information-sharing: A fundamental element to achieve visibility and transparency across the supply chain is the collaborative sharing of information between partners (Barrat and Oke, 2007; van Hoek *et al.,* 2008). Thus, being the prerequisite for end-to-end real-time information visibility across all entities, information-sharing between parties has been identified in the literature review as being paramount for a streamlined execution of SCM, leading to improved performance, responsiveness, and flexibility, while reducing uncertainties among supply chain partners (Zhang *et al.*, 2011; Stevenson and Spring, 2007).

Customer focus: According to literature review findings, SCM needs to be customer-centric as the availability of accurate information of market trends and customer preferences is paramount for business success (Jain *et al.*, 2009; Stevenson and Spring, 2007). As better insights into customer data drive the visibility of information, the customer's behavior is a major focus. Driven by the *"dynamics and the constantly changing rules of the marketing environment of the 21st century"* (Constantinides, 2006, p. 431) customer behavior is subject to significant changes, showing trends towards individualisation, reduced brand preference, and increased customer sophistication. The ubiquitous availability of digital technology, such as smart phones, combined with the possibilities for customers to express their opinion online, e.g. through social networks, put the traditional marketing approach – one-way communication from the company to the customer –, initially designed for mass markets, under pressure (Mangold and Faulds, 2009). As companies are pushed to re-think their marketing efforts to listen and truly engage with the customer, the visibility and transparency into customer information becomes the key driver of marketing decision-making, ultimately determining the success of the company in the market place.

Supply chain planning: As outlined by Slone *et al.* (2007), an orchestrated approach is required in SCM to ensure that the resources of every entity are utilized as effectively as possible towards the overall supply chain goal. In order to facilitate planning on the functional as well as on the cross-company level, visibility and transparency into orders at every step within the chain is mandatory and in essence a key success factor for supply chain planning as outlined in the reviews by Giunipero *et al.* (2008) and Selviaridis and Spring (2005).

Based on the above outlined statements it can be argued that the construct „supply chain visibility and transparency“ is from a literature review perspective linked in theory of the categories “collaboration,” “integration,” “information-sharing,” “customer focus,” and “supply chain planning”. Utilizing the “map of supply chain management” (Figure 6.2, p. 169), presented in chapter 6.7.3 (p. 168ff), the links between categories are visualized in Figure 10.6 (p. 330). Pointing to the previously outlined approach of snowballing through the categories in order to identify the categories which are linked to the constructs, Figure 10.6 supports the justification for the inclusion of categories in the respective construct.



Category acronym codes:

COL	Collaboration	CUF	Customer focus	IFS	Information-sharing
INT	Integration	PLN	Supply chain planning		

Figure 10.6: Categories linking to the “supply chain visibility and transparency” construct (Source: Author)

10.3.2 Overarching construct "Responsiveness"

Following Table 10.11 (p. 328) a literature review connection exists from the "responsiveness" construct to the "lean and agile supply strategies," "information-sharing," and "customer focus" categories. This is justified as follows:

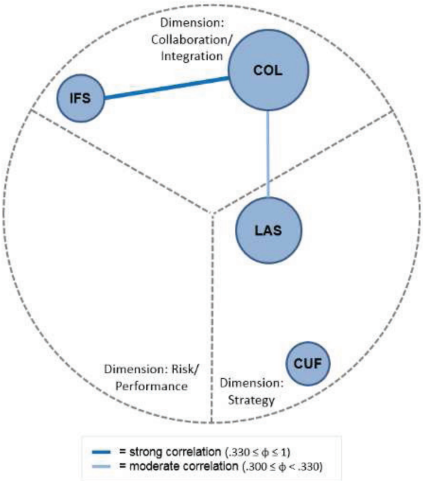
Lean and agile supply strategies: As an environment of constantly changing market demand is a challenge for every supply chain, the application of lean and agile supply strategies provides a suitable approach to achieve superior responsiveness within the supply chain (Anderson *et al.*, 1989). But as stated in the review by van Hoek *et al.* (2008) the alignment of business functions, such as logistics and R&D, is a prerequisite for the application of these approaches. Towill and Christopher (2002) outlined that responsiveness is the main goal when applying lean and agile supply strategies, making use of *"automation to enable rapid changeovers (i.e. reduced set-up times) and thus enable a greater responsiveness"* (p. 301) to cope with unforeseen circumstances such as shifts in demand. Accordingly, following the above statements, it can be claimed that the construct "responsiveness" shows linked into the literature review category "lean and agile supply strategies".

Collaboration: The application especially of the agile supply strategy requires a collaborative approach across supply chain members for being most effective (Naim and Gosling, 2011). Highlighted by Babbar and Prasad (1998a) and Ghadge *et al.* (2012), the collaborative approach ensures that the supply chain is flexible to respond to changes or disturbances. Based on these insights it can be argued that "collaboration" is a key aspect of the "responsiveness" construct.

Information-sharing: The review findings by Delbufalo (2012) conclude that an implementation of lean and agile supply strategies requires trust between partners, as information needs to be shared across company borders to enable synchronization of production schedules. This in return will result in increased levels of responsiveness across the chain, as outlined in the reviews by Stevenson and Spring (2007) and Zhang *et al.* (2011), which justifies the link between the construct "responsiveness" and the category "information-sharing" on the grounds of literature review evidence.

Customer focus: A connection between the "responsiveness" construct and the "customer focus" category is evident in Reichhart and Holweg's (2007) literature review. They state that companies are required to *“increase their responsiveness to customer needs by offering high product variety with short lead-times”* (Reichhart and Holweg, 2007, p. 1144) as customers expect timely service. The increased (real-time) responsiveness to customer needs and changing market conditions, driven by the increased availability of information, is ultimately linked to a better perception of customer intimacy (Li and Lin, 2006). Following the review by Harrison and van Hoek (2008) this allows to better fulfill customer’s needs in areas such as functionality, quality, and service (Labro, 2006; Tavares Thomé *et al.*, 2012). Thus, the development of customer relationships is seen as a key driver *“to proactively seek information on customer preferences and needs, and then become more responsive”* (Vickery *et al.*, 2003, p. 526). Harrison and van Hoek’s (2008) work outlined that value creation in the supply chain is tied to fulfilling customer’s needs, which guides aspects such as functionality, quality, and service (Labro, 2006; Tavares Thomé *et al.*, 2012).

As outlined in the above literature statements the author argues that the construct “responsiveness” is from a literature perspective linked in theory of the categories “lean and agile supply strategies,” “collaboration,” “information-sharing,” and “customer focus”. The links between the categories are visualized in Figure 10.7 (p. 333).



Category acronym codes:

COL	Collaboration	CUF	Customer focus	IFS	Information-sharing
LAS	Lean and agile supply				

Figure 10.7: Categories linking to the "responsiveness" construct
(Source: Author)

10.3.3 Overarching construct "Integration and collaboration"

Based on Table 10.11 (p. 328) and as outlined in the literature, it can be claimed that the construct "integration and collaboration" is primarily linked to the literature review categories "integration," "collaboration," "supply chain performance," as well as "information technology". This is justified as follows:

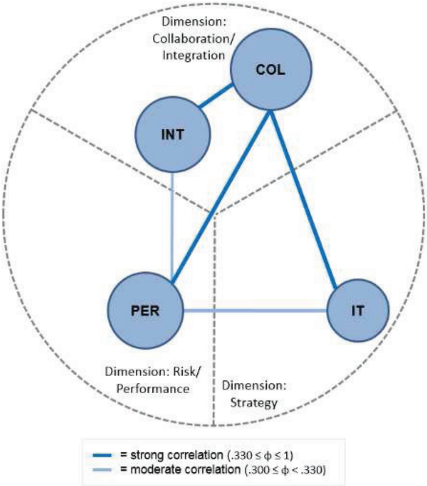
Integration: Following Caridi *et al.* (2005) and Gunasekaran and Ngai (2007) the whole supply chain should be synchronized and integrated in order to enable a seamless flow of material and information across all entities, driving integrated (supply network) optimization and collaboration with the entire supply chain ecosystem. However, such sophisticated integration approaches require a leading party for being fully operational. Accordingly, a "channel leader" was found to be a vital enabler of integration and collaboration along the chain (Cooper *et al.*, 1997). These statements support the existence of a link between the "integration and collaboration" construct and the "integration" category.

Collaboration: The review by Chan and Chan (2010) highlights the importance of collaboration, stating that *"coordination is an important ingredient to improve the performance of supply chains subject to the presence of system dynamics"* (p. 2793). However, as outlined by Hassini *et al.* (2012), potential *"incompatibilities between the known principles of performance measures and supply chain dynamics"* (p. 69) could restrict the potential of collaboration efforts. Nevertheless, following the review by Burgess *et al.* (2006), collaboration is a key ingredient for supply chain management, which is essentially driven by relationships.

Supply chain performance: An integrated supply chain setup requires companies not to only optimize their own processes but to adopt a systems thinking approach, viewing optimization as a means to improve the performance of the whole supply chain (Chen and Paulraj, 2004). This was confirmed in the review study by van der Vaart and van Donk (2008), outlining that the integration with suppliers has a measurable direct impact on the focal company's performance. Accordingly, it can be argued that a link does not only exist from the "integration and collaboration" construct to the "integration" category, but that the "performance" category should be considered as being linked to the "integration and collaboration" construct as well.

Information technology: As outlined by the panel experts, a high degree of collaboration is the foundation for the effective use of integrated data platforms, for example during the product design phase. This is supported in the literature reviews by Akyuz and Erkan (2010) and Jain *et al.* (2009), stating that the use of information systems and technology, such as agent technology, would allow for web-enabled collaboration among supply chain partners. This may foster the virtual integration of the supply chain, ultimately resulting in performance improvements as all members of the supply chain work towards a common goal (Glock, 2012).

Based on the above outlined literature review statements it can be argued that the construct „integration and collaboration" can be linked to the categories "integration," "collaboration," "supply chain performance," and "information technology". The links between the categories are visualized in Figure 10.8 (p. 335).



Category acronym codes:

COL	Collaboration	INT	Integration	IT	Information technology
PER	Supply chain performance				

Figure 10.8: Categories linking to the "integration and collaboration" construct
(Source: Author)

10.3.4 Overarching construct "IT capabilities and infrastructure"

As depicted in Table 10.11 (p. 328) it is argued that the construct „IT capabilities and infrastructure" shows links to the categories „information technology," "information-sharing," "competitive advantage," and "integration". This is justified as follows:

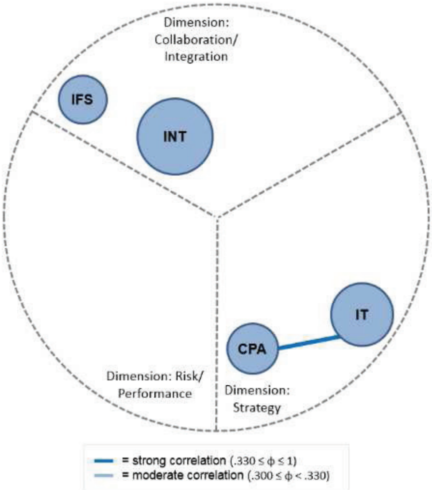
Information technology: The Delphi study expert base argued that a lack of powerful infrastructure, subsuming technology, processes, and people, is a key challenge for the processing of real time information in a digital business environment. This is reflected in the literature reviews and thus justifies the link between the construct "IT capabilities and infrastructure" and the category "information technology". Accordingly, Hazen *et al.* (2012) highlighted the importance of a functioning IT landscape and the right IT infrastructure for effective supply chain collaboration. This is supported in the review by Gunasekaran and Ngai (2004) who state that especially the IT infrastructure is a key factor governing the development of IT for effective SCM. In consequence, the design of the IT infrastructure is a key question to be considered in the IT landscape planning phase as it provides the framework for future business practices.

Information-sharing: The literature study by Cheng and Grimm (2006) highlighted the applicability of information technology for the electronic sharing of information along the chain at low cost. Thus, based on their argument it can be reasoned that a link between the "information-sharing" category and the "IT capabilities and infrastructure" construct exists.

Competitive advantage: Displaying the overall value of IT in a supply chain context the review by Keller and Ozment (2009) links IT to the category of competitive advantage, highlighting that IT has *"advanced to become a competitive advantage for many industries"* (p. 388). This view is supported in the reviews by Tavares Thomé *et al.* (2012) and van Hoek (2008), stating that companies need to be aware of the role of IT as being an enabler of business processes and a driver of organizational change. Adding to the view of the Delphi study experts which claimed that a lack of skilled people is a key issue for the processing of real time information, the review by Gravier and Farris (2008) found that a fundamental aspect of IT planning and implementation in the supply chain is the availability of IT related skills in the workforce, which needs to be considered in IT planning to avoid operational risks.

Integration: The review by Fabbe-Costes and Jahre (2008) found that *"the IT / systems layer is not included as part of supply chain integration in many papers, whereas others point to this as a major aspect of such integration"* (p. 143). This underlines the role and value of IT for supply chain integration, thereby linking the "IT capabilities and infrastructure" construct to the "integration" category.

Following arguments extracted from the literature reviews as outlined above, the grounding of the "IT capabilities and infrastructure" construct in the "information technology," "information-sharing," "competitive advantage," and "integration" categories can be justified. The links between the categories are visualized in Figure 10.9 (p. 337).



Category acronym codes:

CPA	Competitive advantage	IFS	Information-sharing	INT	Integration
IT	Information technology				

Figure 10.9: Categories linking to the "IT capabilities and infrastructure" construct
(Source: Author)

Making use of the respective findings from the literature review study, the five overarching constructs were validated by establishing their basis ex-post in the respective literature. Going forward it may further be argued that, apart from the above discussed constructs basically all 43 constructs, as extracted in the Delphi study, can be validated ex-post through the use of literature review insights following the above presented approach.

10.3.5 Overarching construct "Information and cyber security"

As portrayed in Table 10.11 (p. 328), and following literature review insights, the "information and cyber security" construct may be rooted in the categories "information technology," "competitive advantage," "integration," and "collaboration". This is justified as follows:

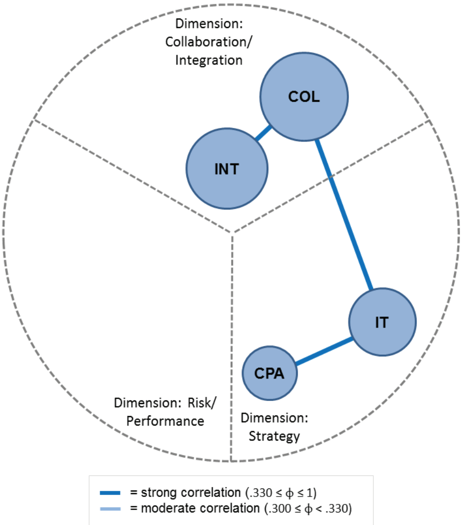
Information technology: The management of information and cyber security represents a major challenge in a digital business world and needs to be considered from a corporate and supply chain perspective as to limit and mitigate associated risks. However, following the literature review by Williams *et al.* (2008), companies often only have a *“fragmented understanding of supply chain security issues”* (p. 276), driven by a lack of technological and systems understanding. This supports the existence of a link between the “information and cyber security” construct and the “information technology” category.

Competitive advantage: The complexity linked to the management of information and cyber security is fueled by aspects of perceived security and general reluctance to financial investments. However, as a functioning IT landscape and access to information is increasingly valued as a key source of competitive advantage, as identified in the reviews by Hazen and Byrd (2012) and Keller and Ozment (2009), the protection of these assets in a networked environment should not be valued simply as “nice to have”, as it increasingly represents a competitive necessity.

Integration: The review by Glock (2012) outlines the virtual integration of the supply chain as a key driver for sustained supply chain performance. However, potential issues and risks stemming from integrating multiple partners’ systems should not be underestimated. The installation of an effective cyber security strategy is a feasible way of identifying potential risks, mitigating potential threats before they materialize. Ideally, such a mitigation strategy needs to consider aspects of IT architectures not only on a company level but should embrace every potential entry point for unauthorized access across the supply chain (Smith *et al.*, 2007).

Collaboration: Collaboration is an *“important ingredient”* of SCM, as outlined in the review by Chan and Chan (2010, p. 2793), which has a significant impact on providing visibility across the chain. Being a key aspect, supply chain peers need to collaborate as to get full visibility on supply chain security issues. This is a prerequisite to avoid or limit the impact of security breaches. The development of a joint information and cyber security strategy should also be seen as a collaborative approach which could, however build upon the individual companies’ security policies.

Based on the above outlined literature review statements it can be argued that the construct „information and cyber security” can be linked to the categories information technology,” “competitive advantage,” “integration,” and “collaboration”. The links between the categories are visualized in Figure 10.10 (p. 339).



Category acronym codes:

COL	Collaboration	CPA	Competitive advantage	INT	Integration
IT	Information technology				

Figure 10.10: Categories linking to the "Information and cyber security" construct
(Source: Author)

Summing up, chapter 10 presented a detailed analysis of the key opportunities and challenges of Big Data Analytics adoption identified through the Delphi study. Furthermore, the Delphi study findings were operationalized in the context of the information requirements framework as the identified opportunity and challenge constructs were mapped to the framework's respective configurational (strategic) and operational structure along the life-cycle process. Following the five stage information requirements collection process, the resultant mapping of constructs enables the structured identification, mapping and assessment of digital transformation-driven, Big Data Analytics-related information requirements useful for decision-making at corporate business function as well as supply chain level.

Looping the key Delphi study findings back into the literature review part of the dissertation, thereby providing a transitory bridge between the field research and desk research part of this dissertation, a solid grounding of the constructs was developed by interlinking the overarching Delphi study constructs with literature review insights.

The next chapter, chapter 11, discusses the contribution of the empirical field research part of this dissertation which is operationalized along the lines of the conceptual framework for the assessment of information requirements, as well as the Delphi study. In addition, the academic and managerial implications are presented and the strength and limitation debated. The chapter concludes with recommendations to future research.

11 Discussion of the dissertation's field research part

The main aim of this chapter is to discuss and thus make sense of the academic implications of the empirical field study presented, showing its overall contribution to the existing body of knowledge (section 11.1). Special consideration is given to address the research questions RQ 4 and RQ 5 as presented in sections 1.2 and 8.3, respectively. The academic and managerial implications of the empirical field research (section 11.2) are addressed which includes the strength (section 11.3), as well as a critical assessment of the limitations (section 11.4). The discussion chapter concludes with a reflection on the recommendations for further research, discussing logical next steps while giving an outlook on potential future findings (section 11.5).

11.1 Contribution

Portraying the emerging transition trend from an analog to a digital business ecosystem, the field research part of this work contributes to the body of knowledge in two ways.

Linking to the identified under-represented areas of research outlined in the empirical desk research part of the dissertation (section 6.7.3, p. 168), the first aim of the empirical field research was to investigate the value and role of information in a business context, driven by the fact that a lack of understating of this important element increasingly poses to be a risk for corporations and ultimately to the supply chain. This is motivated by the fact that the growing amount of information poses a challenge for the identification, extraction, and leverage of relevant information. In consequence this development may have an impact on the role and value of information. Due to the lack of comparable material on the value and role of information, especially at the intersection of SCM and the digital business transformation agenda in general and Big Data Analytics in particular, the author approached the topic in an experimental fashion. Adding to theory building through conceptual research (Meredith, 1993; Weick, 1995), the first aim was achieved through application of an experimental research approach comprising three research phases, namely the development of the information requirements framework, a Delphi study, as well as the integration of the before mentioned into a combined framework. Being a key contribution of the empirical field research part, the research approach applied well serves as an answer to RQ 4 (*"How can exploratory research help to address under-represented areas of SCM research?"*).

As it can be claimed that the value of Big Data Analytics lies in the provisioning of tailored information to business functions, as outlined in section 8.4, the second aim of the research was to examine how the identification of relevant information required for decision-making at business function level can be operationalized.

Accordingly, a conceptual framework was developed based on strategic as well as operations theory, as the author of this dissertation extended Seuring's (2009) "product-relationship-matrix" framework by inclusion of a third dimension, the "information" dimension. Given the complexity linked to the surge of available information, the resultant framework allows for a rigorous and systematic assessment of information requirements at business function level. This is the prerequisite for a focused provisioning of information for decision-making across all stages of the life-cycle process. On an operational level, the framework employs the proposed "five stage information requirements collection process", being based on a tested approach, which supports the structured and standardized collection of the business functions' information requirements.

Supplementing the presented framework with starting points for the identification of potential information requirements, a Delphi study was conducted with a panel of 15 Big Data Analytics experts from industry. The Delphi study findings contribute to extant knowledge by presenting 43 opportunities and challenges linked to the emergence of Big Data Analytics from a corporate and supply chain perspective. The constructs equip the research community with a first collection of aspects, which could provide the basis to tailor further research at the nexus of Big Data Analytics and SCM. This constitutes the answer to research question RQ 5 ("*What are the implications of Big Data Analytics on information usage at corporate and supply chain level, especially with regard to information identification required for decision-making?*").

In order to operationalize the systematic identification of relevant information required for decision-making at business function level, thereby addressing the second aim of the empirical field research part of the dissertation, the constructs as developed through the Delphi study were integrated into and mapped to the conceptual framework. Resembling the novelty of the research, the outlined integrated information requirements framework closes a gap in existing management research by presenting a first comprehensive, expert opinion-enhanced framework to formalize the identification, mapping and assessment of information requirements in a standardized manner along the life-cycle process. In line with the thinking of Fawcett and Waller (2011), where *„theory creates understanding, which is the foundation of good decision-making"* (p. 2) the theory-based framework thus supports the centralized provisioning of information as the basis for decision-making, ultimately providing a practical starting point for streamlined information provisioning throughout the supply chain.

Reflecting on the outlined rigor-relevance gap (Prockl, 2005), section 10.3 adds theoretical rigor to the Delphi study's practical findings as the identified key challenge and opportunity constructs on corporate and supply chain level are linked into the previously outlined literature review study. Looping the findings of the field research part of this dissertation back into the desk research part, the theoretical foundation of overarching constructs allows for an ex-post justification of the findings, eventually building a case for more balanced research in SCM.

11.2 Academic and managerial implications

Taking a scholarly perspective, research at the intersection of SCM and the digital transformational agenda, especially concerning Big Data Analytics, may yield a multitude of aspects relevant for the progression of managerial research. Thus, bringing together the best from two worlds, the implications of Big Data Analytics are likely to revolutionize businesses and change management practice (Fawcett and Waller, 2014). Furthermore, it has been stated that the emergence of these rather data-driven scientific approaches, as opposed to knowledge-driven research methods, may result in the formation of a new *"situated, reflexive and contextually nuanced epistemology"* (Kitchin, 2014, p. 1). Eventually supplementing the existing positivist and interpretivist approaches, this may impact on the way research is conducted in the future. In this light, the empirical field research part of this dissertation could well contribute to the development of the management sciences as it provides the academic research community with a deeper understanding of the implications of the digital data revolution. The contribution from a management research perspective focus on outlining new possibilities to establish "consilience", to speak with the words of Wilson (1998), which is the generation of conclusions based on previously unrelated sources of data. The rationale for this is rooted in the trinity of *"unprecedented volume, microlevel detail, and multifaceted richness"* (George *et al.*, 2014, p. 324) of large datasets which are increasingly accessible to management scientists. However, management research is likely to require an overhaul to embrace the analysis potential linked to the digital ecosystem in general and Big Data in particular. Researchers may need to rethink the value of applying analytical methods as the commonly used statistical tools may not be sufficient to extract the full depth of significant information. An example is given by George *et al.* (2014) who state that *"the typical statistical approach of relying on p-values to establish the significance of a finding is unlikely to be effective because the immense volume of data means that almost everything is significant."* (p. 323). Thus, the use of these statistical tools is likely to result in false correlations when applied to Big Data, ultimately leading to wrong conclusions.

To overcome this issue, management researchers are advised to look beyond their cup's rims and test a variety of research approaches such as *"cluster analysis, data fusion and integration, data mining, genetic algorithms, machine learning, natural language processing, neural networks, network analysis, signal processing, spatial analysis, simulation, time series analysis, and visualization"* (George *et al.*, 2014, p. 323) from a range of disciplines such as statistics, or computer sciences. An enhanced application of data analysis, moving beyond the common focus on averages and outliers would enable researchers to explore the causality of patterns in order to gain actionable insights and aid decision-making. These new insights are fuelled by the increased granularity level of Big Data, yet academics have to understand and grasp the potential of these changes.

The use of content analysis with contingency analysis to analyze Big Data may also seem suitable in this context for the identification of robust patterns in the data. This may provide insights to critical innovations, trends, disruptions, or revolutions which the management discipline could act upon.

From a methodology perspective, the empirical field research part builds a case for a stronger utilization of experimental research techniques, exemplified through the developed conceptual framework combined with the Delphi study methodology. Based on the author's experience, the applied mixed research approach is recommended to the research community as a suitable research technique for the exploration of a newly emerging area where the collection and assessment of empirical data would otherwise not be feasible.

From a theory development viewpoint, especially the Delphi study methodology provided useful insights in terms of outlining the key opportunities and challenges linked to Big Data Analytics in a business, especially SCM context. This opens opportunities to leverage this knowledge as a platform for further scholarly in-depth investigations at the nexus of Big Data Analytics and SCM but also include other managerial fields of research.

The longitudinal implications from an academic perspective can be seen in the benchmarking and audit capability of the integrated information requirements framework. As such, the information requirements of a range of business functions across a multitude of companies could be collected and compared over time. On these basis it may well be possible to identify the most commonly used information requirements, eventually deriving "best in class" information requirements in terms of applicability in a digital ecosystem, considering opportunities and challenges of Big Data Analytics.

The managerial implications are driven by the common understanding that the shift from an analog to a digital ecosystem, based on Big Data Analytics, combined with the disruptive character of digital technologies (Kitchin, 2014), bears great potential from a business perspective (see section 8.1). Nevertheless, it has been reported that the adoption of Big Data Analytics is far from being simple, highlighted through research by Buytendijk and Laney (2013) who found that 85% of the *Fortune 500* companies are unable to exploit the potential of Big Data Analytics for strategic competitive advantage. A key aspect being, as outlined in the above field research part of the dissertation, that the journey to adoption of Big Data Analytics holds not only opportunities but also a range of challenges. The presented framework helps to address these challenges by providing managers with a structured, systematic approach to identify information requirements on a business function level. This knowledge is paramount for the informed provisioning of information to business functions through a centralized Big Data Analytics function, which is the essence of fact-based decision-making.

Further managerial implications are derived from the SCM perspective towards digital transformation in general and Big Data Analytics in particular. As such, the applicability of Big Data Analytics in SCM is driven by the interconnectedness of companies where relevant information is a key raw material which may well originate beyond a company's realm. For instance, inventory information and sales information can be seen as suitable for sharing across partners, which increases the visibility and transparency of the supply chain. However, a company needs to know what kind of information it must focus on to support fact-based decision-making, as this ultimately represents a strategic necessity in a digital ecosystem and a unique source of operational excellence. This is the rationale for a detailed assessment of information requirements at corporate and supply chain level and hence the motivation of this research.

Accordingly, the managerial value-add of this dissertation is based on the provisioning of a framework which enables practitioners to identify the information relevant for decision-making at business function level across all stages of the life-cycle process. This marks the divide between the work presented and the rare previous publications, for example the work by Ross *et al.* (2013) or Westhaus and Seuring (2005): Although the before-mentioned publications also discuss the provisioning of information, making references to the important value of information for corporate and supply chain activities, they collectively miss out on outlining how businesses go about identifying the relevant information needed. The integrated information requirements framework developed in this dissertation can be seen as a first step in providing an answer to this question as the framework supports a structured and systematic, yet scalable assessment of information requirements under consideration of the digital transformation implications on business processes.

From an operations point of view, the proposed approach fosters the elimination of excess resource waste, especially linked to the common practice where individual departments, or even multiple entities within the same department, individually scout for the most relevant information. From a quantitative, financial perspective, the value of the framework is difficult to assess due to its transformational character which however is expected to result in overall, long-term performance improvements.

11.3 Strengths of the field research part

The main strength of the empirical field study stems from its unique character and contribution to the academic and managerial knowledge body.

Despite the variety of research on SCM, limited research has been conducted at the intersection of SCM and Big Data Analytics, considering the role and value of information. As it is imperative for companies in the supply chain to have access to up-to-date, accurate and meaningful information for decision-making, the growing amount of data and information poses a real business challenge as it makes an identification of relevant and meaningful information increasingly difficult. Following the "needle in the haystack" analogy, the integrated information requirements framework developed in the empirical field research part of this dissertation enables companies to determine their individual information requirements, which in turn will ease the identification of meaningful information upon which Big Data Analytics could be operationalized. Taking into account the relevance of this concept, it can be claimed that the research breaks ground in management research as the existence of a comparable empirical study at the intersection of SCM and Big Data Analytics with a focus on the implications imposed through Big Data Analytics is not known to the author. The proposed integrated framework is thus the first of its kind which in essence closes a gap in the methodological landscape of managerial research.

A further strength unfolds when the empirical desk research part and the empirical field research part of this dissertation are viewed as one combined piece of research: As such, the balanced view of the research and the chosen qualitative investigation approach – often neglected among scholars –, including the Delphi study with 15 participants, covering various levels of hierarchy and backgrounds, represents another major strength. This is especially important as the study built a case for the applicability of the qualitative research approach in the context of SCM, adding to both academics' and practitioners' knowledge.

The empirical field research was designed with a strong adherence to quality criteria, such as validity and reliability. Following the typology for research quality criteria proposed by Krippendorff (2012), showcased in Figure 3.1 (p. 32), the next section discusses how these elements were taken care of in the empirical field research part of the thesis.

The adherence of the empirical field research part to *sampling validity* is driven by the design of the Delphi study and was already touched upon in section 9.4.2. However, given the challenges described, linked to the identification and participation buy-in of the 15 experts; and considering the quality of the responses throughout all rounds of the Delphi study, it can be claimed that the sample population is representative and thus valid from a sampling perspective.

The *semantic validity* of the field research part is fulfilled as the conceptual framework was developed based on extant theory, extending Seuring's (2009) "product-relationship-matrix" framework by inclusion of the "information" dimension.

The author employed a structured, systematic approach to process respondents' answers throughout all three rounds of the Delphi study. Aiming to limit interferences tied to the individual assessment of respondents' input, an Excel-based monitoring tool was developed in order to guide the analysis. As each answer was processed by the author of this dissertation through this tool in a standardized manner, it could be guaranteed that each answer was treated in the same, objective way without giving preference to certain answers. Thus, through the application of this rigorous approach, it was ensured that the empirical field research part yields *structural validity*.

Functional validity of the field research part was ensured as the author employed a clustering approach, using the pattern matching technique as described in section 9.4.3, to develop unique constructs from the experts' answers to the first round of the Delphi study. This ensured that the constructs used in the subsequent second and third round of the Delphi study were each mutually exclusive as well as collaboratively exhaustive.

Internal validity of the research, conveyed through structural as well as functional validity, was achieved through discussions with other researchers, for example at two international conferences and two doctoral seminars, where the current state of the Delphi study research as well as preliminary findings were presented to an academic as well as practitioner audience (Kache and Seuring, 2014a; Kache and Seuring, 2014b).

The use of two sources of evidence, namely Seuring's (2009) "product-relationship-matrix" framework as well as the multi-round Delphi study with continuous expert assessment across two levels of abstraction (corporate and supply chain) ensured *construct validity*, especially *correlative validity*, of the empirical field research. In addition, draft framework designs of the information requirements framework as well as the corresponding constructs were extensively discussed in detail with research colleagues and repeatedly presented to expert audiences. Further adding to construct validity, the author conducted pre-tests of the questionnaires at the beginning of each Delphi round before commencing the data collection phase with the full group of experts. Furthermore, utmost care was taken by the author to outline the red line of arguments throughout the research, thereby strengthening the overall comprehension of research results.

The *predictive validity* of the empirical field research is mainly driven by the research question RQ 5 (“What are the implications of Big Data Analytics on information usage at corporate and supply chain level, especially with regard to information identification required for decision-making”) which was explicitly designed with a forecasting intent in mind. Furthermore, the predictability can be derived from the selection of the Delphi study methodology which is known to be an excellent forecasting technique. However, the predictive nature of the empirical field research is best showcased along the Delphi study result-enhanced information requirements framework. As the framework serves as a point of reference for the collection and assessment of information requirement needs, it provides the necessary baseline against which future information needs can be quantified. At the time of writing and as a stand-alone piece of research, however, the research is of limited value from a predictive perspective.

The empirical field research was conducted with a focus on aspects of reliability, namely stability, replicability, and accuracy. However, the Delphi study methodology itself, being a qualitative research technique, is rather unstable in terms of results in the sense that a second Delphi study assessment with the same expert panel, following the same approach and using the same questions, is likely to yield at least slightly different results. The reason being that, following the findings of other Delphi studies such as the research by Edwards and co-authors (2010), the chance for variations in experts’ responses over time is expected to be substantial. Accordingly, the *stability* of the research was at least to some extent hampered by the choice of research method. Nevertheless, as the Delphi study includes multiple rounds of assessment which are iterated until a stable conclusion has been research across the panel, at least the results of the Delphi study can be considered being stable.

The challenges linked to methodological stability are also impacting on the *replicability* of the results. The author managed these aspects by ensuring that all research steps as well as the results gained were as outlined as transparent as possible. This was achieved by documenting the conceptual framework development process as well as Delphi study research process, including the design, selection of experts and data collection process comprising all three rounds.

The *accuracy* of the empirical field research results was facilitated through iterative rounds of accuracy checks in the development of the conceptual framework as well as the Delphi study methodology. Thus, the pre-test of the three rounds ensured that only a fault-free version of the respective questionnaire would be sent to the expert panel. In addition, the identified 26 unique constructs were discussed with a range of other researchers as the thoughtful composition of these vital elements was a cornerstone for the success of the research and directly impacted on the relevance of the research. Further adding to enhance accuracy of the research, the researchers were given the opportunity in round three to adjust their initial rating of the constructs provided in round two. The critical self-assessment of the initial results yielded high degrees of stability of the results in round three.

Lastly, a great deal of strength of the empirical field research is derived from the selection of the research objective itself: the company’s and experts’ faith in the research process and the author of this dissertation which facilitated the author’s unusual position as being able to collect rich insights on a relevant theme. This was the prerequisite for an independent investigation of the opportunities and challenges of Big Data Analytics adoption through means of the Delphi study approach. In essence, the granted degrees of freedom can be valued as being the key enablers for the execution of the empirical field research project, driven by the fact that companies are usually reluctant to having researchers assess issues without major restrictions or close management supervision.

11.4 Limitations of the field research part

Although the presented empirical field research yields a range of strengths it is not free from limitations which will accordingly be discussed.

Like the empirical desk research part of this dissertation, the empirical field research part was subject to resource constraints, most notably linked to time and finance resources. It can be claimed that more of each resource would have elevated the results to higher levels of granularity.

A potential limitation is linked to the development process of the conceptional information requirements framework. Although being based on Seuring’s (2009) foundational “product-relationship-matrix” framework only, it provided a sound basis

for the theoretical grounding of the developed information requirements framework. The author of this dissertation is aware that other potentially relevant models exist. However, these did not provide full coverage of the whole life-cycle process including the product return (post-phase), and hence where not considered for this research.
Limitations also stem from the Delphi study research approach as being the main data collection technique in the field research part of the dissertation.
For instance, the selection of the key constructs in section 10.1 may be regarded as a limitation, most notably driven by the definition of the threshold governing the inclusion of constructs as being “key construct”. The pragmatic mixed approach of including all constructs with the highest value as well as the constructs which received at least 5 “very high” ratings, ensures a balanced inclusion of key expert opportunities and challenges and was accordingly chosen to offset this limitation.

The composition of the Delphi study’s expert panel is also subject to limitations. Like all qualitative interview techniques, the expert opinions gathered reflect only the individual expert’s view, the interpretation of which is thus highly subjective. The external validity of the empirical field research results may thus be subject to limitation as the collected opportunities and challenges are representing the very personal views of 15 experts on Big Data Analytics. This may invoke a certain amount of bias towards the generalizability of the findings. However, it was deemed acceptable in the sense that the innovative results are still of great value to the research community, providing empirical evidence of the potential opportunities and challenges linked to the adoption of Big Data Analytics in a corporate and supply chain setting.

Another limitation is linked to the focus of the Delphi study on a single company in a single industry. However, given the difficulties encountered by academic researchers in regard to accessing knowledgeable industry experts on a niche topic, the author considers it a fortunate situation having had access to the panel of experts. Nevertheless, considering the high dependency of research validation on up-to-date industry data, the inclusion of a greater number of experts, following the same Delphi study approach as utilized throughout this dissertation, would further increase the sampling validity. Thus, more data would allow for a better validation of the findings, as the impact of sample participants giving false information – either accidentally or on purpose – diminishes exponentially to the size of the panel. This limitation is not only prone to the sample size but on the broader scale also applies to the number of companies included in the research. Enabling an unbiased, balanced research view, not only focussing on one company but beyond, it would thus be advisable to extend the sample population. The inclusion of experts from a range of companies across industries in a supply chain would be a suitable approach in order to gain a true understanding of the information requirements at cross-company level. However, given the research constraints, derived from the short time frame, the funding and the personal capacity limits of a single researcher, it was not possible to employ a tested corporate or even supply chain view of the subject. Nevertheless, despite these limitations important knowledge at the intersection of SCM and Big Data Analytics could be obtained.

A further limitation stems from linking the overarching constructs, identified in the Delphi study, to the categories from the holistic "framework map" of major aspects of SCM (Table 10.11, p. 328). Thus, the links between constructs and categories were identified based on literature review insights. However, the use of the literature review base was regarded as being a suitable starting point for the theoretical grounding of constructs. In addition, in order to strengthen the linking arguments between constructs and categories, further references were included as appropriate which were not previously covered in the 103 literature review sample. In addition, the reduction to a selected number of categories for which the construct is paramount represents a limitation. Nevertheless, this was required from a comprehensive scoping perspective, driven by the likely event that the inclusion of all relevant categories may have obstructed the detection of relevant insights. The author admits that the selection of a few categories only is subject to researcher bias. This, however, was accepted in order to develop a first conceptual grounding of overarching constructs in literature review finding's theory.

Limitations are also evident in regard to the proposed integrated information requirements framework. As such, the mapping of the Delphi study constructs to the framework is a source of bias as the mapping was conducted by a single researcher only (the author of this dissertation). However, the author aimed to mitigate the limitation through the application of a transparent research approach where the author outlined the mapping process of the constructs, exemplified along the "customer behavior" as well as "responsiveness" constructs.

In addition, the exemplary information requirements outlined in Table 10.7 to Table 10.10 are highly subjective as they were added by the author based on his own business experience. Nevertheless, this was accepted by the author as these requirements should only be seen as an indication in terms of what kind of requirements can be potentially collected with the integrated framework. Thus, the identification of real-life information requirements was not part of this dissertation’s scope. Furthermore, the proposed integrated information requirements framework has yet to withstand its applicability under real-life conditions. However, considering the restrictions on the research timeframe, this shortcoming was at least partly mitigated through the continuous presentation of the framework at conferences and other venues where the applicability of the framework and overall relevance of the presented field research was repeatedly confirmed by scholars and industry experts. In addition, the successful integration of the Delphi study results into the information requirements framework allows for a certain degree of validation of the framework as the opportunities and challenges identified by the expert panel yielded an exact match to the framework’s life-cycle structure.

11.5 Recommendations for further research

It has been argued that knowledge generation is a continuous process (Spiegler, 2003). In line with this statement, the results of the empirical field research part of this dissertation as presented are yet another piece in the research process at the intersection of Big Data Analytics and SCM. Nevertheless, further in-depth investigations and validations of the findings are recommended. Based on the limitations as outlined in the previous section, future research endeavors are seen most valuable if directed onto the following issues:

A major potential for future research stems from the recognition that the proposed integrated framework may not be applicable to all industries in a “one-size-fits-all” solution. Thus, as the framework is highly dependent on individual business functions’ input, which may vary greatly between different industries, a practical application of the framework is likely to require tailored versions of the framework to cater for individual industry-specific needs. Nevertheless, it needs to be considered that despite potential differences in application, it is likely that some information requirements between industries may be similar. This will briefly be showcased in the following by the author, exemplified along the wealth of information used for weather forecasts as this information is fundamental and versatility leveraged across industries. In the agricultural industry, for instance, meteorological information is required, being paramount for day-to-day farm management decision-making such as determining the necessity and exact timing for fertilizer application on crops. In public life supply chains, too, meteorological information is required for decision-making, although not always on such granular levels and short intervals as in the farming industry. Thus, in this industry weather information is commonly considered, but only relevant and acted upon in a few circumstances such as meteorological perturbations where it is vital for decision-making in regard to the effective allocation of health care, rescue and police personnel. The methodological recommendations on future research outlined in the remainder of this section offer a suitable setting to establish the knowledge on industry specific information requirements, serving as the basis for adapting the framework accordingly.

Going forward, it is advisable in order to further develop the integrated framework to tailor the “long list” of 43 constructs under consideration of business function’s needs, thus determining the relevance of constructs to individual business functions. Nevertheless, as the aim of the dissertation was to present a first collection of opportunities and challenges linked to the emergence of Big Data Analytics the extension of the research scope to map the exact fit between opportunity / challenge constructs and individual business functions will be left to future research.

Although the framework supports the identification of information requirements, only a selected few information requirements as provided in Table 10.7 to Table 10.10 were outlined in order to exemplify the research process presented. The research did not, however, provide a full overview of the potential information requirements. Accordingly, further research should thus focus on identifying these requirements. From the author’s point of view, such future research is inevitably linked to overcome the framework’s validity shortcomings, driven by the fact that the proposed information requirements framework yet has to be validated in a real-life scenario. Although the applied Delphi study can be seen as a first step towards validating the relevance of the framework, the framework should thus be operationalized through more empirical research. Following Ellram (1996), the case study method proves an excellent method for use in extended empirical research. The adaptation of the critical case study approach, being widely recommended for use in exploratory studies (Yin, 2013) could be suitable for such future research. This roots in researchers’ valuation that the case based approach is a good, “*if not the best*” (Eisenhardt and Graebner, 2007, p. 25) starting point for research to confront and bridge theory and practice (Giménez, 2005). Other benefits include basing the case approach on a variety of other complementary methods, such as the applied qualitative Delphi methodology (Mentzer and Flint, 1997; Meredith, 1998; Yin, 2011) As such, the framework could be tested through a staged research approach, where the Delphi study methodology represents the first validation step with subsequent case studies used for extended validation purposes. This follows other researcher's argumentation stating that a multi-method approach to empirical research in SCM should be targeted as the optimum (Giménez, 2005), explicitly underlining the applicability of the Delphi methodology in such a wider research process comprising qualitative and quantitative components (Rowe and Wright, 2011).

A viable reason for these recommendations stems from validity, as every research method lacks at least one aspect of it, i.e. case studies lack external validity (Mentzer and Flint, 1997). Thus, through triangulation (McGrath, 1982), applying a variety of methods helps to overcome a single method's shortcomings and maximize validity as the validity of the research findings increments proportional to the number of methods applied (Creswell, 2013). The findings by Boone *et al.* (2007), based on Jick (1979) add to this, highlighting the value of triangulation in SCM research *"as it leads to robust results and provides opportunities for cross-method synergies"* (p. 601), which provide more perspectives on the subject under investigation. The recommended approach follows recommendations as outlined above, advising a balanced research approach through methodological triangulation of the findings obtained through the Delphi study (Creswell and Clark, 2007). Thus, the expert insights gained, especially the provided construct relevance rating, could be verified in the subsequent case study phase (Yin, 2013; Eisenhardt, 1989). This could be operationalized through the application of semi-structured interviews on various industry samples, also aiming to collect input on information requirements by various business functions across the life cycle. These interviews should be conducted following the sub-processes of the conceptual framework along the life-cycle. From an operational perspective, the interviews are expected to be of highest impact if conducted with executive managers of a range of business functions which are affected by aspects of the digital business transformation, in particular Big Data Analytics. By linking the findings from the two research methods, the Delphi methodology and the case study approach, future research could provide guidance on real-world information requirements at corporate and supply chain level across selected business functions, which are necessary to leverage the potential of Big Data Analytics.

Accordingly, through the application of the framework to real-life cases as proposed above, a list of core information requirements for each business function across the integrated information requirements framework's six sub-processes could be distilled. This would supplement the framework and may provide a sound foundation for the benchmarking of information requirements on a larger scale, aiming to derive "best-in-class" information requirements. However, the author would like to point out that such activities may require a differentiated view towards information requirements in the sense that the requirements may vary in regard to their use in a business-to-business (B2B) or final customer environment.

From an academic perspective, the case study extension to the existing integrated information requirements framework could be leveraged in longitudinal research on the development of information requirements over time. Such longitudinal benchmarking may also be beneficial as it enables an objective assessment of the qualitative and quantitative value of the proposed information requirements framework in general and an application of Big Data Analytics in particular. For instance, an assessment of the longitudinal datasets may produce insights into information effectiveness, especially towards the causalities between the availability of a certain required information and the immediate risk mitigation potential derived from the availability of that information. After all, such insights may provide a true selling point for the integrated information requirements framework presented from a practitioner's perspective.

Big Data Analytics is gaining increasing attention in the management sciences but empirical research on the topic is scarce. Due to the lack of comparable material on the usage of information in the light of Big Data Analytics in SCM, the presented empirical field research was of exploratory nature. This also holds true for the recommended case study approach. As it is the nature of exploratory research, the outcomes of such a case based approach are difficult to predict. Nevertheless, there are a couple of insights, which are expected to be obtained through the application of case study research. According to Manuj and Mentzer (2008) "*the challenge is the ability to filter data for the most important information"* (p. 148). Therefore, it will be particularly interesting to obtain insights on how companies manage the provisioning of information for decision-making to business functions, given the possibilities of Big

Data Analytics. Big Data Analytics is a “hot topic” and it is likely that case companies are aware of the shifts in regard to the use of information, information requirements, and corresponding opportunities and challenges for their business. However, it is expected that the cases portray the understanding that companies are at best starting to think about how to approach the required transformational shift to a digital ecosystem in their business environment. Thus, it would be surprising to find well-established processes of organized Big Data Analytics management as the institutionalization of Big Data Analytics within organizations has been reported to be in its infancy (Beath *et al.,* 2012). This, however, depends largely on the type of industry the companies are operating in, with companies with a strong affiliation in the information technology sector expected to lead the way. In addition, given the investments in IT and headcount required to set up digital storage and mining capabilities, a key issue as identified in the Delphi study, it is questionable if Big Data Analytics may be affordable only for large corporations. Research into this direction is thus required. Within the leading companies that already have experience in Big Data Analytics, it would be particularly interesting to gain insights into the major obstacles the companies were faced with, including coverage of the mitigation actions taken.

This chapter presented a thorough discussion of the empirical field research part of the dissertation, providing the answers to the final two outstanding research questions RQ 4 and RQ 5. Showing the empirical field research’s overall contribution to the existing body of knowledge from a managerial as well as practitioner perspective, the strength and limitations were critically outlined. Chapter 11 concludes with the detailed provisioning of relevant future research opportunities.

Chapter 12, the final chapter, combines the contributions of the empirical desk research and the empirical field research parts of this dissertation, recaps on the overall essence of the research, thereby concluding this dissertation report.

12 Conclusion

This final chapter recaps the dissertation research process, providing a final summary of the chapters as presented in the desk research and the field research parts of this dissertation (section 12.1). Closing the research loop between the two parts, a brief reflection will be given on the overall value-add of the dissertation (section 12.2), the contributions of the empirical desk as well as field research having been extensively discussed in chapters 7 and 11, respectively.

12.1 Summarization

In the introductory chapter, chapter 1 (p. 1ff), the need to conduct research on the two topics discussed in this dissertation was presented, namely literature review usage in a SCM context as well as the role and value of information in a digital business context. Based on the aim of the research, five research questions were presented, followed by an overview of the dissertation's overall research agenda.

The theoretical foundations for the dissertation were developed in chapter 2 (p. 9ff). This chapter outlined key definitions of SCM, reflected on the development of SCM over time, and discussed the conceptualization of SCM in regard to its recognition as a management discipline of its own. Furthermore, considering ontological and epistemological perspectives, the chapter contained a broad section on research strategies and methodologies in SCM. This served as the basis for the methodological grounding of the dissertation.

Linking to the research methodologies presented, the third chapter (p. 21ff) embodied the methodological framing for the research methods applied in the desk research part of the dissertation. The selected research methods, namely systematic literature review, content analysis, and contingency analysis, were presented and justified in the context of the research aim. In addition, the chapter provided the rationale for the integration and systematic leverage of the three research methods in order to conduct transparent, replicable research.

Taking the broad perspective on SCM, chapter 4 (p. 33ff) showcased a range of essential highly cited frameworks extracted from the extant literature which can be considered paramount to the understanding of SCM. The key aspects of the frameworks were condensed so as to yield a unifying conceptual "framework map" of

SCM, comprising six distinctive dimensions and 26 categories. The resultant framework map was used in subsequent steps of the dissertation, also serving as the guiding foundation of the content analysis approach applied to the literature review sample. Enhancing the validity of the framework map, this chapter gave a detailed presentation of each of the six dimensions and their respective 26 categories, thoroughly grounding the categories in extant SCM theory.

Applying the conceptual framework map, the execution of the systematic literature review process through application of the four-step content analysis approach (Mayring, 2010) was formalized in chapter 5 (p. 64ff). This also included the presentation of first descriptive content analysis results.

Chapter 6 (p. 85ff) presented the findings from the review methodology, following the content analysis approach. The identification of current shortfalls in the literature provided the foundation for a precise definition of the presumed under-represented areas of research in SCM. To enhance the validity of the findings and as a means to assess possible interrelations between the dimensions and categories identified, a contingency analysis was applied. As a result the contingency analysis strengthened the content analysis findings, showing that a range of dimensions of SCM are interrelated.

The key insights from the dissertation's desk research part, comprising the literature review, the content as well as contingency analysis, were outlined and reflected upon in chapter 7 (p. 168ff). Accordingly, the contribution, the academic and managerial implications as well as the strengths and limitations of the empirical desk research part were discussed. Bridging the desk research part of the dissertation to the exploratory field research part the chapter provided the transition link from the literature review part (chapters 3-7) to the exemplary assessment of an under-represented area of research in SCM (chapters 8-11).

The rationale for the selection of the under-represented area, focussing on the role and value of information in a digital business function context, was presented in chapter 8 (p. 209ff). This was done with a key focus on the intersection of SCM and the implications of the digital business transformation agenda, exemplified by Big Data Analytics. Enabling a focused application of Analytics capabilities to Big Data, the chapter was dedicated to the development of a theory-based conceptual framework for the guided assessment of business functions' information requirements on the corporate and supply chain level.

The subsequent Delphi study research, outlined in chapter 9 (p. 234ff), enhanced the validity of the framework. Utilizing experts' insights, the Delphi study identified 43 opportunities and challenges linked to the adoption of Big Data Analytics in a corporate and supply chain environment. Special consideration was given in this chapter to the design of the study, the selection of the expert panel, as well as the overall data collection process.

Putting the findings of the previous chapter into perspective, chapter 10 (p. 298ff) distilled 18 key opportunities and challenges from the Delphi study's expert prioritizations which reflect the major implications of Big Data Analytics-driven information availability at corporate and supply chain level. The value of the constructs was thoroughly discussed. Presenting a main contribution of the field research part of the dissertation, the chapter outlines how the Delphi study findings were integrated into and mapped to the proposed conceptual information requirements framework (section 8.5.2, p. 226ff) previously presented in section 8.5.2.

The resultant Delphi-enhanced, integrated information requirements framework closed a gap in existing management research by presenting a first comprehensive framework for the formalized, standardized identification, mapping and assessment of information requirements along the life-cycle process. The resultant integrated information requirements framework (Table 10.7 to Table 10.10) can be used by businesses to assess if their processes are equipped and robust enough to make use of the opportunities and deal with the challenges of the digital business transformation in general and the adoption of Big Data Analytics in particular.

In addition, this chapter provided the transitory bridge between the field research and desk research part of this dissertation, looping the key Delphi study findings back into the literature review part of the dissertation, as a solid foundation of the constructs was developed by interlinking the overarching Delphi study constructs with literature review insights. In a nutshell, this chapter gives guidance to academics and practitioners alike with regard to the opportunities and challenges linked to the digital transformation of business, exemplified through the application of Big Data Analytics.

The contribution of the dissertation's empirical field research part as well as the academic and managerial implications were discussed in chapter 11 (p. 341ff). This chapter also highlighted the strengths as well as limitations of the empirical field research part of the dissertation. Uncovering possible future research possibilities, the chapter provided guidance on potential next research steps in order to further validate the proposed integrated information requirements framework.

Finally, chapter 12 (p. 358ff) summarized the process of the desk research as well as field research parts of this dissertation.

12.2 Reflection

In the concluding section below, the author reflects on the overall value-add of the dissertation, thereby closing the research loop between the two parts.

This dissertation contributed original knowledge to the subject of SCM in the way that the author of this dissertation assessed the current landscape of SCM research represented in literature reviews and pinpointed under-represented areas of research as well as potential future research directions in the field of SCM.

The resultant list of research gaps and the mapping of the SCM landscape provided enables researchers to better scale and modularize their own area of research, following the framework's theory-based, multi-dimensional, and comprehensive structure. The author would welcome it if the mapping serves as the foundation for more in depth research at the gaps identified.

As the empirical field research part of the dissertation was based on one identified exemplary under-researched area, portraying the value and role of digital information in a business function context, it can be concluded that the dissertation builds a case for more balanced research in SCM with the aim to *"bridge the gap between theoretical rigor and practical relevance*" (Prockl, 2005) in SCM. Furthermore, the above outlined research at the nexus of SCM and Big Data Analytics, balancing distance and involvement between academics and practitioners in the research process, may foster trans-disciplinary learning between research areas.

In general, the proposed integrated information requirements framework contributes to theory building through conceptual research (Meredith, 1993; Weick, 1995) along the lines of the digital business transformation agenda in general and Big Data Analytics in particular. It adds value as it allows for a standardized structured assessment of business functions' information requirements, needed to leverage the potential of Big Data Analytics.

Underlining the value of the presented research, a digital agenda which subsumes Big Data Analytics as well as other SMAC technologies should not be valued simply as "nice to have" from a business perspective, as it increasingly represents a competitive necessity. Companies that understand the importance of holistic information availability, viewing the supply chain as one end-to-end process, and harnessing the potential of the digital transformation, are not only well positioned to disrupt and penetrate further industries, but to define new markets. As such, the adoption of digital technologies is no longer an order winner, to reference Hill (1993), but increasingly a market qualifier in the globally dispersed economic environment. Accordingly, the companies that do not transform their processes as indicated throughout this dissertation are likely to face a strong future headwind.

Furthermore, the successful adaptation of Big Data Analytics within a company is first and foremost tied to a successful integration of Big Data and SCM, as the integrative and collaborative philosophy of SCM is key to all business activities (Horvath, 2001). From a discipline development point of view, the emergence of Big Data Analytics thus provides excellent opportunities to sharpen and redefine the role of SCM. The SCM research community should grasp this opportunity to rejuvenate the multi-disciplinary role of SCM, as debated in section 2.1 (p. 9ff), and strengthen its positioning within the orchestra of business functions. Combined with an enhanced utilization of more "scientific" research methods, such as the structured systematic literature review approach, this could present a powerful countermeasure against a proclaimed demise of SCM (Fawcett and Waller, 2014). After all, this may likely add to accelerating the overall relevance and recognition of SCM as being a discipline of its own.

As it is the case for most emerging concepts, the use of Big Data Analytics is vividly debated among scholars and the discussion is not limited to the field of SCM. The author of this dissertation is certain that the research presented contributes to a better comprehension of the value of Big Data Analytics in a corporate and supply chain context. Based on the research presented, other researchers and practitioners alike are encouraged to investigate corporate and supply chain problems considering the potential of Big Data Analytics, making use of the proposed integrated information requirement frameworks under consideration of the recommendations for further research. This will be beneficial from a scientific as well as managerial perspective, as a thorough understanding of the constituents of a digital ecosystem is a key ingredient for the competitiveness and overall productivity of the company and ultimately of the supply chain as a whole.

References

Accenture (2014), Accenture Technology Vision 2014 "Every Business Is a Digital Business - From Digitally Disrupted to Digital Disrupter".

Abbasi, M. and Nilsson, F. (2012), "Themes and challenges in making supply chains environmentally sustainable", *Supply Chain Management: An International Journal*, Vol. 17 No. 5, pp. 517-530.

Abdi, H. (2007), "The Kendall rank correlation coefficient", in Salkind, N.J. and Rasmussen, K. (Eds.), *Encyclopedia of Measurement and Statistics,* Sage Publications, Thousand Oaks, CA, pp. 508-510.

Afshin Mansouri, S., Gallear, D. and Askariazad, M.H. (2012), "Decision support for build-to-order supply chain management through multiobjective optimization", *International Journal of Production Economics*, Vol. 135 No. 1, pp. 24-36.

Agarwal, A. and Shankar, R. (2003), "On-line trust building in e-enabled supplies chain", *Supply Chain Management: An International Journal*, Vol. 8 No. 4, pp. 324-334.

Agresti, A. (1992), "A Survey of Exact Inference for Contingency Tables", *Statistical Science*, Vol. 7 No. 1, pp. 131-153.

Akyuz, G.A. and Erkan, T.E. (2010), "Supply chain performance measurement: a literature review", *International Journal of Production Research*, Vol. 48 No. 17, pp. 5137-5155.

Alexander, M. and Young, D. (1996), "Strategic outsourcing", *Long Range Planning*, Vol. 29 No. 1, pp. 116-119.

Altham, P.M. (1969), "Exact Bayesian analysis of a 2×2 contingency table, and Fisher's 'exact' significance test", *Journal of the Royal Statistical Society. Series B (Methodological)*, pp. 261-269.

Amundson, S.D. (1998), "Relationships between theory-driven empirical research in operations management and other disciplines", *Journal of Operations Management*, Vol. 16, pp. 341-59.

Anderson, D.L., Britt, F.F. and Favre, D.J. (2007), "The 7 principles of supply chain management", *Supply Chain Management Review*, Vol. 11 No. 3, pp. 41-46.

Anderson, J.C., Cleveland, G. and Schroeder, R.G. (1989), "Operations strategy: a literature review", *Journal of Operations Management*, Vol. 8 No. 2, pp. 133-158.

Andraski, J.C. (1998), "Leadership and the realization of supply chain collaboration", *Journal of Business Logistics*, Vol. 19 No. 2, pp. 9-11.

Andrews, D.W. (1988), "Chi-square diagnostic tests for econometric models: Introduction and applications", *Journal of Econometrics*, Vol. 37 No. 1, pp. 135-156.

Ang, J.S., Chua, J.H. and Sellers, R. (1979), "Generating cash flow estimates: an actual study using the Delphi Technique", *Financial Management*, pp. 64-67.

Aronsson, H. and Brodin, M.H. (2006), "The environmental impact of changing logistics structures", *International Journal of Logistics Management*, Vol. 17 No. 3, pp. 394-415.

Ashby, A., Leat, M. and Hudson-Smith, M. (2012), "Making connections: a review of supply chain management and sustainability literature", *Supply Chain Management: An International Journal*, Vol. 17 No. 5, pp. 497-516.

Ashton, K. (2009), "That 'Internet of Things' Thing", *RFiD Journal*, Vol. 22, pp. 97-114.

Atasu, A., Guide, V.D.R. and Wassenhove, L.N. (2008), "Product Reuse Economics in Closed-Loop Supply Chain Research", *Production and Operations Management*, Vol. 17 No. 5, pp. 483-496.

Atzori, L., Iera, A. and Morabito, G. (2010), "The internet of things: A survey", *Computer Networks*, Vol. 54 No. 15, pp. 2787-2805.

Babbar, S. and Prasad, S. (1998a), "International purchasing, inventory management and logistics research: an assessment and agenda", *International Journal of Operations & Production Management,* Vol. 18 No. 1, pp. 6-36.

Babbar, S. and Prasad, S. (1998b), "International purchasing, inventory management and logistics research: an assessment and agenda", *International Journal of Physical Distribution & Logistics Management,* Vol. 28 No. 6, pp. 403-433.

Backhaus, K., Erichson, B., Plinke, W. and Weiber, R. (2008), *Multivariate Analysemethoden: Eine anwendungsorientierte Einführung (Multivariate methods of data analysis: A use-oriented introduction)*, Springer, Berlin, Germany.

Bai, C. and Sarkis, J. (2010), "Integrating sustainability into supplier selection with grey system and rough set methodologies", *International Journal of Production Economics*, Vol. 124 No. 1, pp. 252-264.

Baker, J., Lovell, K. and Harris, N. (2006), "How expert are the experts? An exploration of the concept of 'expert' within Delphi panel techniques", *Nurse Researcher*, Vol. 14 No. 1, pp. 59-70.

Bakos, Y. and Brynjolfsson, E. (1999), "Bundling information goods: Pricing, profits, and efficiency", *Management Science*, Vol. 45 No. 12, pp. 1613-1630.

Ballou, R.H., Gilbert, S.M. and Mukherjee, A. (2000), "New managerial challenges from supply chain opportunities", *Industrial Marketing Management*, Vol. 29 No. 1, pp. 7-18.

Barney, J.B. (1991), "Firm resources and sustained competitive advantage", *Journal of Management*, Vol. 17 No. 1, pp. 99-120.

Barratt, M. (2004), "Understanding the meaning of collaboration in the supply chain", *Supply Chain Management: An International Journal*, Vol. 9 No. 1, pp. 30-42.

Barratt, M. and Oke, A. (2007), "Antecedents of supply chain visibility in retail supply chains: a resource-based theory perspective", *Journal of Operations Management*, Vol. 25 No. 6, pp. 1217-1233.

Bartels, R. (1962), *The Development of Marketing Thought*, Irwin, Homewood, IL, pp. 195-197.

Bandyopadhyay, T., Jacob, V. and Raghunathan, S. (2010), "Information security in networked supply chains: impact of network vulnerability and supply chain integration on incentives to invest", *Information Technology and Management*, Vol. 11 No. 1, pp. 7-23.

Beamon, B.M. (1998), "Supply chain design and analysis: Models and methods", *International Journal of Production Economics,* Vol. 55 No. 3, pp. 281-294.

Beamon, B.M. (1999), "Measuring supply chain Performance", *International Journal of Operations & Production Management,* Vol. 19 No. 3, pp. 275-292.

Beath, C., Becerra-Fernandez, I., Ross, J. and Short, J. (2012), "Finding value in the information explosion", *MIT Sloan Management Review*, Vol. 53 No. 4, pp. 18-20.

Bechtel, C. and Jayaram, J. (1997), "Supply chain management: a strategic perspective", *International Journal of Logistics Management,* Vol. 8 No. 1,pp. 15-34.

Berelson, B. (1952), *Content Analysis in Communications Research*, The Free Press, Glencoe, IL.

Beske, P. and Seuring, S. (2014), "Putting Sustainability into Supply Chain Management", *Supply Chain Management: An International Journal*, Vol. 19 No. 3, pp. 322-331.

Bessant, J., Kaplinsky, R. and Lamming, R. (2003), “Putting supply chain learning into practice”, *International Journal of Operations & Production Management*, Vol. 23 No. 2, pp. 167-184.

Beyer, M.A. and Laney, D. (2012), *The importance of 'big data': a definition*, Gartner, Stamford, CT.

Bhaskar, R. (2013), *A realist theory of science,* Routledge, London.

Bitran, G.R., Gurumurthi, S. and Sam, S.L. (2007), “The need for third-party coordination in supply chain governance”, *MIT Sloan Management Review*, Vol. 48 No. 3, pp. 30-37.

Blankley, A. (2008), “A conceptual model for evaluating the financial impact of supply chain management technology investments”, I*nternational Journal of Logistics Management,* Vol. 19 No. 2, pp. 155-182.

Boisot, M. and Canals, A. (2004), “Data, information and knowledge: have we got it right?”, *Journal of Evolutionary Economics*, Vol. 14 No. 1, pp. 43-67.

Bolger, F., Stranieri, A., Wright, G. and Yearwood, J. (2011), “Does the Delphi process lead to increased accuracy in group-based judgmental forecasts or does it simply induce consensus amongst judgmental forecasters?”, *Technological Forecasting and Social Change*, Vol. 78 No. 9, pp. 1671-1680.

Bolger, F. and Wright, G. (2011), “Improving the Delphi process: lessons from social psychological research”, *Technological Forecasting and Social Change*, Vol. 78 No. 9, pp. 1500-1513.

Bonoma, T.V. (1985), “Case Research in Marketing: Opportunities, Problems, and a Process”, *Journal of Marketing Research*, Vol. 22 No. 2, pp. 201-212.

Boone, C.A., Craighead, C.W. and Hanna, J.B. (2007), “Postponement: an evolving supply chain concept”, *International Journal of Physical Distribution & Logistics Management*, Vol. 37 No. 8, pp. 594-611.

Boote, D.N. and Beile, P. (2005), “Scholars before researchers: On the centrality of the dissertation literature review in research preparation”, *Educational Researcher*, Vol. 34 No. 6, pp. 3-15.

Boyd, D. and Crawford, K. (2012), “Critical questions for big data: Provocations for a cultural, technological, and scholarly phenomenon”, *Information, Communication & Society*, Vol. 15 No. 5, pp. 662-679.

Bradley, L. and Stewart, K. (2002), “A Delphi study of the drivers and inhibitors of Internet banking”, *International Journal of Bank Marketing*, Vol. 20 No. 6, pp. 250-260.

Brass, D.J., Butterfield, K.D. and Skaggs, B.C. (1998), “Relationships and unethical behavior: A social network perspective”, *Academy of Management Review*, Vol. 23 No. 1, pp. 14-31.

Briner, R. and Denyer, D. (2012), “Systematic Review and Evidence Synthesis As A Practice And Scholarship Tool”, in Rousseau, D. (Ed.), *Handbook of Evidence-Based Management: Companies, Classrooms, and Research*, Oxford University Press, Oxford, England, pp. 328-374.

Bruce, M., Daly, L. and Towers, N. (2004), “Lean or agile: a solution for supply chain management in the textiles and clothing industry?”, *International Journal of Operations & Production Management*, Vol. 24 No. 2, pp. 151-170.

Bryman, A. (2012), *Social research methods,* Oxford University Press, Oxford, England.

Bryman, A. and Bell, E. (2003), *Business Research Methods*, Oxford University Press, Oxford, England.

Bryman, A. and Bell, E. (2011), *Business Research Methods*, Oxford University Press, Oxford, England.

Brynjolfsson, E. and Hitt, L.M. (2000), “Beyond computation: Information technology, organizational transformation and business performance”, *The Journal of Economic Perspectives*, pp. 23-48.

Burgess, R. (1998), “Avoiding supply chain management failure: lessons from business process re-engineering”, *International Journal of Logistics Management,* Vol. 9 No. 1, pp. 15-23.

Burgess, K., Singh, P.J. and Koroglu, R. (2006), “Supply chain management: a structured literature review and implications for future research”, *International Journal of Operations & Production Management*, Vol. 26 No. 7, pp. 703-729.

Buytendijk F. and Laney, D. (2013), “Big Data Business Benefits Are Hampered by ‘Culture Clash’”, Gartner Research Publishing, Stamford, CT, September 12, 2013.

Byrd, T.A., Cossick, K.L. and Zmud, R.W. (1992), “A synthesis of research on requirements analysis and knowledge acquisition techniques”, *MIS Quarterly*, pp. 117-138.

Cachon, G.P. and Fisher, M. (2000), “Supply chain inventory management and the value of shared information”, *Management Science*, Vol. 46 No. 8, pp. 1032-1048.

Cagliano, R., Caniato, F. and Spina, G. (2004), “Lean, agile and traditional supply: how do they impact manufacturing performance?”, *Journal of Purchasing and Supply Management*, Vol. 10 No. 4, pp. 151-164.

Canibol, H.P., Hossenfelder, J. and Lünendonk, T. (Eds.) (2014), *Lünendonk®-Handbuch 2014 „Consulting" - 50 führende Partner für Ihr Unternehmen (Lünendonk®-Guidebook 2014 „Consulting“ - 50 leading partners for your company)*, Fakten & Köpfe Verlagsgesellschaft, Kelsterbach, Germany.

Cantor, D.E. (2008), “Workplace safety in the supply chain: a review of the literature and call for research”, *International Journal of Logistics Management,* Vol. 19 No. 1, pp. 65-83.

Cantrill, J.A., Sibbald, B. and Buetow, S. (1996), “The Delphi and nominal group techniques in health services research”, *International Journal of Pharmacy Practice*, Vol. 4 No. 2, pp. 67-74.

Cassivi, L. (2006), “Collaboration planning in a supply chain”, *Supply Chain Management: An International Journal*, Vol. 11 No. 3, pp. 249-258.

Cao, M. and Zhang, Q. (2011), “Supply chain collaboration: impact on collaborative advantage and firm performance”, *Journal of Operations Management*, Vol. 29 No. 3, pp. 163-180.

Caridi, M., Cigolini, R. and De Marco, D. (2005), “Improving supply-chain collaboration by linking intelligent agents to CPFR”, *International Journal of Production Research*, Vol. 43 No. 20, pp. 4191-4218.

Carson, D., Gilmore, A. and Maclaran, P. (1998), “Customer or profit focus: an alternative perspective”, *Journal of Marketing Practice: Applied Marketing Science*, Vol. 4 No. 1, pp. 26–39.

Carter, C.R. and Easton, P.L. (2011), “Sustainable supply chain management: evolution and future directions”, *International Journal of Physical Distribution & Logistics Management*, Vol. 41 No. 1, pp. 46-62.

Carter, C.R. and Ellram, L.M. (2003), “Thirty-Five Years of The Journal of Supply Chain Management: Where Have We Been and Where are We Going?”, *Journal of Supply Chain Management*, Vol. 39 No. 2, pp. 27-39.

Carter, C.R., Kaufmann, L. and Michel, A. (2007), "Behavioral supply management: a taxonomy of judgment and decision-making biases", *International Journal of Physical Distribution & Logistics Management,* Vol. 37 No. 8, pp. 631-669.

Carter, C.R. and Rogers, D.S. (2008), "A framework of sustainable supply chain management: moving toward new theory", *International Journal of Physical Distribution & Logistics Management,* Vol. 38 No. 5, pp. 360-387.

Chae, B. and Olson, D.L. (2013), "Business analytics for supply chain: A dynamic-capabilities framework", *International Journal of Information Technology & Decision Making*, Vol. 12 No. 1, pp. 9-26.

Chae, B., Yen, H.R. and Sheu, C. (2005), "Information technology and supply chain collaboration: moderating effects of existing relationships between partners", *Engineering Management, IEEE Transactions on*, Vol. 52 No. 4, pp. 440-448.

Chan, H.K. and Chan, F.T. (2010), "A review of coordination studies in the context of supply chain dynamics", *International Journal of Production Research*, Vol. 48 No. 10, pp. 2793-2819.

Chandler Jr., A.D. (1962), *Strategy and structure: Chapters in the history of the American industrial enterprise*, MIT Press, Cambridge, MA.

Charvet, F.F., Cooper, M.C. and Gardner, J.T. (2008), "The intellectual structure of supply chain management: a bibliometric approach", *Journal of Business Logistics,* Vol. 29 No. 1, pp. 47-73.

Chase, R.B. and Zhang, A. (1998), "Operations management: internationalization and interdisciplinary integration", *International Journal of Operations & Production Management*, Vol. 18 No. 7, pp. 663-667.

Checkland, P. (1993), *Systems Thinking, Systems Practice*, John Wiley & Sons, New York.

Chen, H., Chiang, R.H. and Storey, V.C. (2012), "Business Intelligence and Analytics: From Big Data to Big Impact", *MIS quarterly*, Vol. 36 No. 4, pp. 1165-1188.

Chen, I.J. and Paulraj, A. (2004), "Towards a theory of supply chain management: the constructs and measurements", *Journal of Operations Management*, Vol. 22 No. 2, pp.119-150.

Cheng, L.C.V. and Grimm, C. M. (2006), "The application of empirical strategic management research to supply chain management", *Journal of Business Logistics*, Vol. 27 No. 1, pp. 1-55.

Chesbrough, H.W., Vanhaverbeke, W. and West, J. (Eds.) (2007), *Open Innovation. Researching a New Paradigm*, University Press, Oxford.

Chicksand, D., Watson, G., Walker, H., Radnor, Z. and Johnston, R. (2012),"Theoretical perspectives in purchasing and supply chain management: an analysis of the literature", *Supply Chain Management: An International Journal*, Vol. 17 Iss: 4 pp. 454-472.

Childerhouse, P., Aitken, J. and Towill, D.R. (2002), "Analysis and design of focused demand chains", *Journal of Operations Management*, Vol. 20 No. 6, pp. 675-689.

Childerhouse, P. and Towill, D.R. (2000), "Engineering supply chains to match customer requirements", *Logistics Information Management*, Vol. 13 No. 6, pp. 337-346.

Childerhouse, P. and Towill, D.R. (2011), "Effective supply chain research via the quick scan audit methodology", *Supply Chain Management: An International Journal*, Vol. 16 No. 1, pp. 5-10.

Choi, T.Y. and Wacker, J.G. (2011), "Theory building in the OM/SCM field: pointing to the future by looking at the past", *Journal of Supply Chain Management,* Vol. 47 No. 2, pp. 8-11.

Christensen, J.F., Olesen M.H. and Kjær J.S. (2005), "The industrial dynamics of open innovation – evidence from the transformation of consumer electronics", *Research Policy,* Vol. 34 No. 10, pp. 1533–1549.

Christopher, M. (2000), "The agile supply chain: competing in volatile markets", *Industrial Marketing Management*, Vol. 29 No. 1, pp. 37-44.

Christopher, M. (2010), *Logistics and supply chain management*, Financial Times/Prentice Hall, London.

Christopher, M. and Lee, H. (2004), "Mitigating supply chain risk through improved confidence", *International Journal of Physical Distribution & Logistics Management*, Vol. 34 No. 5, pp. 388-396.

Christopher, M. and Peck, H. (1997), "Managing Logistics in Fashion Markets", *International Journal of Logistics Management*, Vol. 8 No. 2, pp. 63-74.

Christopher, M. and Peck, H. (2004), "Building the resilient supply chain", *The International Journal of Logistics Management*, Vol. 15 No. 2, pp. 1-14.

Christopher, M. and Towill, D.R. (2000), "Supply chain migration from lean and functional to agile and customized", *Supply Chain Management: An International Journal*, Vol. 5 No. 4, pp. 206-213.

Christopher, M. and Towill, D.R. (2002), "Developing market specific supply chain strategies", *International Journal of Logistics Management,* Vol. 13 No. 1, pp. 1-14.

Christopher, M. and Towill, D.R. (2003), "Supply chain migration from lean and functional to agile and customised", *Supply Chain Management: An International Journal*, Vol. 5 No. 4, pp. 206-213.

Claycomb, C. and Frankwick, G.L. (2004), "A contingency perspective of communication conflict resolution and buyer search effort in buyer-supplier relationships", *Journal of Supply Chain Management: A Global Review of Purchasing & Supply*, Vol. 40 No. 1, pp. 18-34.

Cochran, W.G. (1952), "The $\chi 2$ test of goodness of fit", *The Annals of Mathematical Statistics*, pp. 315-345.

Colicchia, C., Strozzi, F. (2012), "Supply chain risk management: a new methodology for a systematic literature review", *Supply Chain Management: An International Journal*, Vol. 17 No. 4, pp. 403-418.

Cooper, D.P. and Tracey, M. (2005). "Supply chain integration via information technology: strategic implications and future trends", *International Journal of Integrated Supply Management*, Vol. 1 No. 3, pp. 237-257.

Cooper, H. and Hedges, L.V. (Eds.) (1994), *The handbook of research synthesis*, Russell Sage Foundation, New York, NY.

Cooper, M.C. and Ellram, L.M. (1993), "Characteristics of supply chain management and the implications for purchasing and logistics strategy", *International Journal of Logistics Management,* Vol. 4 No. 2, pp. 13-24.

Cooper, M.C., Lambert, D.M. and Pagh, J.D. (1997), "Supply chain management: more than a new name for logistics", *International Journal of Logistics Management,* Vol. 8 No. 1, pp. 1-14.

Couger, D.J. (1988), "Key human resource issues in IS in the 1990s: Views of IS executives versus human resource executives", *Information & Management,* Vol. 14 No. 4, pp. 161-174.

Cousins, P.D., Lawson, B. and Squire, B. (2006), "Supply chain management: theory and practice–the emergence of an academic discipline?", *International Journal of Operations & Production Management*, Vol. 26 No. 7, pp. 697-702.

Constantiou, I.D. and Kallinikos, J. (2014), "New games, new rules: big data and the changing context of strategy", *Journal of Information Technology*.

Constantinides, E. (2006). "The marketing mix revisited: towards the 21st century marketing", *Journal of Marketing Management*, Vol. 22 No. 3-4, pp. 407-438.

Cox, A. (1999), "Power, value and supply chain management", *Supply Chain Management: An International Journal*, Vol. 4 No. 4, pp. 167-175.

Creswell, J.W. (2013), *Research design: Qualitative, quantitative, and mixed methods approaches*, Sage Publications, Thousand Oaks, CA.

Creswell, J.W. and Clark, V.L.P. (2007), *Designing and conducting mixed methods research*, Sage Publications, Thousand Oaks, CA.

Crisp, J., Pelletier, D., Duffield, C., Adams, A. and Nagy, S. (1997), "The Delphi method?", *Nursing Research*, Vol. 46 No. 22, pp. 116-118.

Croom, S.R., Romano, P. and Giannakis, M. (2000), "Supply chain management: an analytical framework for critical literature review", *European Journal of Purchasing & Supply Management*, Vol. 6 No. 1, pp. 67-83.

Crowther, M.A. and Cook, D.J. (2007), "Trials and tribulations of systematic reviews and meta-analysis", *ASH Education Program Book*, Vol. 1, pp. 493-497.

Dalkey, N.C. (1972), "The Delphi method: An experimental study of group opinion", in Dalkey, N.C, Rourke, D.L., Lewis, R. and Snyder D. (Eds.), *Studies in the quality of life: Delphi and decision-making*, Lexington Books, Lexington, MA, pp. 13-54.

Dalkey, N.C. (1975), "Toward a theory of group estimation", in Linstone, H.A. and Turoff, M. (Eds.), *The Delphi Method: Techniques and Applications*, Addison-Wesley, London, pp. 236-261.

Dalkey, N.C., Brown, B.B. and Cochran, S. (1969), *The Delphi method: An experimental study of group opinion (Vol. 3)*, Rand Corporation, Santa Monica, CA.

Dalkey, N. and Helmer, O. (1963), "An experimental application of the Delphi method to the use of experts, *Management Science*, Vol. 9 No. 3, pp. 458-467.

Das, A., Pagell, M., Behm, M. and Veltri, A. (2008), "Toward a theory of the linkages between safety and quality", *Journal of Operations Management*, Vol. 26 No.4, pp. 521-535.

Dasaklis, T.K., Pappis, C.P. and Rachaniotis, N.P. (2012), "Epidemics control and logistics operations: A review", *International Journal of Production Economics*, Vol. 139 No. 2, pp. 393-410.

Davenport, T.H. (2006), "Competing on analytics", *Harvard Business Review*, Vol. 84 No. 1, pp. 98-107.

Davenport, T.H., Barth, P. and Bean, R. (2013), "How 'big data'is different", *MIT Sloan Management Review*, Vol. 54 No. 1, pp. 43-46.

Davenport, T.H. and Patil, D.J. (2012), "Data Scientist", *Harvard Business Review,* Vol. 90, pp. 70-76.

Davenport, T.H. and Short, J.E. (1990), "The new industrial engineering: information technology and business process redesign", *Sloan management review,* Vol. 31 No. 4.

de Meyrick, J. (2003), "The Delphi method and health research", *Health Education*, Vol. 103 No. 1, pp. 7-16.

Defee, C.C., Williams, B., Randall, W.S. and Thomas, R. (2010), "An inventory of theory in logistics and SCM research", *International Journal of Logistics Management,* Vol. 21 No. 3, pp. 404-489.

Delbecq, A.L., Van de Ven, A.H. and Gustafson, D.H. (1975), *Group techniques for program planning: A guide to nominal group and Delphi processes,* Scott, Foresman and Company, Glenview, Illinois.

Delbufalo, E. (2012), "Outcomes of inter-organizational trust in supply chain relationships: a systematic literature review and a meta-analysis of the empirical evidence", *Supply Chain Management: An International Journal*, Vol. 17 No. 4, pp. 377-402.

Denk, N., Kaufmann, L. and Carter, C.R. (2012), "Increasing the rigor of grounded theory research–a review of the SCM literature", *International Journal of Physical Distribution & Logistics Management*, Vol. 42 Iss. 8/9, pp. 742-763.

Denyer, D. and Tranfield, D. (2006), "Using qualitative research synthesis to build an actionable knowledge base", *Management Decision*, Vol. 44 No. 2, pp. 313-227.

Deshpande, R. (1983), "Paradigms lost: on theory and method in Research in Marketing", *Journal of Marketing*, Vol. 47, No. 3, pp. 101-110.

Dreibelbis, A., Hechler, E., Milman, I., Oberhofer, M., van Run, P. and Wolfson, D. (2008), *Enterprise master data management: an SOA approach to managing core information,* Pearson, Boston, MA.

Drucker, P.F. (1962), "The economy's dark continent", *Fortune*, Vol. 65 No. 103, pp. 265-270.

Drucker, P.F. (1990), "The emerging theory of manufacturing", *Harvard Business Review*, Vol. 68 No. 3, pp. 94-102.

Dubin, R. (1976), "Theory building in applied areas", *Handbook of industrial and organizational psychology*, Vol. 17, p. 39.

Duriau, V.J., Reger, R.K. and Pfarrer, M.D. (2007), "A content analysis of the content analysis literature in organization studies: research themes, data sources, and methodological refinements", *Organizational Research Methods*, Vol. 10 No. 1, pp. 5-34.

Easterby-Smith, M., Thorpe, R. and Lowe, A. (2002), *Management Research – An Introduction*, Sage Publications, London.

Edwards, D., Burnard, P., Bennett, K. and Hebden, U. (2010), "A longitudinal study of stress and self-esteem in student nurses", *Nurse Education Today*, Vol. 30 No. 1, pp. 78-84.

Eisenhardt, K.M. (1989), "Building Theories From Case Study Research", *The Academy of Management Review*, Vol. 14 No. 4, pp. 532-550.

Eisenhardt, K.M. and Graebner, M.E. (2007), "Theory building from cases: opportunities and challenges", *Academy of Management Journal*, Vol. 50 No. 1, pp. 25–32.

Eisenhardt, K.M. and Schoonhoven, C.B. (1996), "Resource-based view of strategic alliance formation: strategic and social effects in entrepreneurial firms", *Organization Science*, Vol. 7, pp. 136-150.

Elkington, J., (1997), *Cannibals with Forks: The Triple Bottom Line of 21st Century Business*, Capstone Publishing, Oxford.

Ellis, S.C., Shockley, J. and Henry, R.M. (2011), "Making sense of supply disruption risk research: A conceptual framework grounded in enactment theory", *Journal of Supply Chain Management*, Vol. 47 No. 2, pp. 65-96.

Ellinger, A.E., Ellinger, A.D. and Fitzer, S.J. (2013), Agenda for creating HRD-SCM Advantage. In: Arnäs, P.O., Johansson, M., Arvidsson, N., Pahlén, P., Bergqvist, R., and Stefansson, G. (Eds.): *Proceedings to NOFOMA 2013 - 25th Annual Nordic Logistics Research Network Conference*, 3-5 June 2013, Gothenburg, Sweden.

Ellinger, A.E. (2000), “Improving marketing/logistics cross-functional collaboration in the supply chain”, *Industrial Marketing Management*, Vol. 29 No. 1, pp. 85-96.

Ellinger, A.E., Daugherty, P.J. and Plair, Q.J. (1999), “Customer satisfaction and loyalty in supply chain: the role of communication”, *Transportation Research Part E: Logistics and Transportation Review*, Vol. 35 No. 2, pp. 121-134.

Ellram, L.M. (1996), “The use of the case study method in logistics research”, *Journal of Business Logistics*, Vol. 17 No. 2, pp. 93-138.

Ellram, L.M. and Cooper, M.C. (1990), “Supply Chain Management, Partnerships, and the Shipper’s Third Party Relationship”, *International Journal of Logistics Management*, Vol. 1 No. 2, pp. 1-10.

Ellram, L.M. and Cooper, M.C. (2014), “Supply Chain Management: It’s all about the journey, not the destination”, *Journal of Supply Chain Management*, Vol. 50 No. 1, pp. 8-20.

Ellram, L.M., Tate, W.L. and Billington, C. (2004), “Understanding and managing the services supply chain”, *Journal of Supply Chain Management*, Vol. 40 No. 4, pp. 17-32.

Emerson, R.M. (1976), “Social exchange theory”, *Annual review of sociology*, Vol. 2, pp. 335-362.

Enkel, E., Gassmann, O. and Chesbrough, H.W. (2009), “Open R&D and open innovation: exploring the phenomenon”, *R&D Management,* Vol. 39 No. 4, pp. 311-316.

Everitt, B.S. (1992), *The analysis of contingency tables (Vol. 45),* CRC Press, Boca Raton, FL.

Fabbe-Costes, N. and Jahre, M. (2007), “Supply chain integration improves performance: the Emperor's new suit?”, *International Journal of Physical Distribution & Logistics Management,* Vol. 37 No. 10, pp. 835-855.

Fabbe-Costes, N. and Jahre, M. (2008), “Supply chain integration and performance: a review of the evidence”, *International Journal of Logistics Management,* Vol. 19 No. 2, pp. 130-154.

Fabian, F.H. (2000), “Keeping the tension: pressures to keep the controversy in the management discipline”, *Academy of Management Review,* Vol. 25 No. 2, pp. 350-72.

Faisal, M.N., Banwet, D.K. and Shankar, R. (2006), “Supply chain risk mitigation: modeling the enablers”, *Business Process Management Journal*, Vol. 12 No. 4, pp. 535-552.

Farmer, D.H. and Ploos van Amstel, R. (1991), *Effective Pipeline Management: How to Manage Integrated Logistics*, Gower, Aldershot.

Fawcett, S.E., Osterhaus, P., Magnan, G.M., Brau, J.C. and McCarter, M.W. (2007), “Information sharing and supply chain performance: the role of connectivity and willingness”, *Supply Chain Management: An International Journal*, Vol. 12 No. 5, pp. 358-368.

Fawcett, S.E. and Waller, M.A. (2011), “Making sense out of chaos: Why theory is relevant to supply chain research”, *Journal of Business Logistics*, Vol. 32 No. 1, pp. 1-5.

Fawcett, S.E. and Waller, M.A. (2014), “Can We Stay Ahead of the Obsolescence Curve? On Inflection Points, Proactive Preemption, and the Future of Supply Chain Management”, *Journal of Business Logistics*, Vol. 35 No. 1, pp. 17-22.

Fawcett, S.E., Wallin, C., Allred, C., Fawcett, A.M. and Magnan, G.M. (2011), “Information technology as an enabler of supply chain collaboration: A dynamics-capabilities perspective”, *Journal of Supply Chain Management*, Vol. 47 No. 1, pp. 38-59.

Fayezi, S., O'Loughlin, A. and Zutshi, A. (2012), “Agency theory and supply chain management: a structured literature review”, *Supply Chain Management: An International Journal*, Vol. 17 No. 5, pp. 556-570.

Felin, T. and Hesterly, W.S. (2007), “The knowledge-based view, nested heterogeneity, and new value creation: Philosophical considerations on the locus of knowledge”, *Academy of Management Review*, Vol. 32 No. 1, p. 195-218.

Fiedler, F.E. (1965), “The contingency model: A theory of leadership effectiveness”, *Key Readings in Social Psychology*, Vol. 2, p. 369.

Fink, A. (1998), *Conducting Research Literature Reviews: From Paper to the Internet*, Sage Publications, London, England.

Fisher, M. (1997), “What is the Right Supply Chain for Your Product”, *Harvard Business Review,* Vol. 75 No. 2, pp. 105-116.

Fisher, R.A. (1922), “On the interpretation of $\chi 2$ from contingency tables, and the calculation of P”, *Journal of the Royal Statistical Society*, Vol. 85 No. 1, pp. 87-94.

Forrester, J.W. (1958), “Industrial Dynamics: A Major Breakthrough for Decision Makers”, *Harvard Business Review*, Vol. 38 July-August, pp. 37-66.

Forrester, J.W. (1959), “Advertising: a problem in industrial dynamics”, *Harvard Business Review*, March-April, pp. 100-110.

Forrester, R. and Drexler, A.B. (1999), “A model for team-based organization performance”, *The Academy of Management Executive*, Vol. 13 No. 3, pp. 36-49.

Förster, B. and von der Gracht, H. (2014), “Assessing Delphi panel composition for strategic foresight—A comparison of panels based on company-internal and external participants”, *Technological Forecasting & Social Change,* Vol. 84, pp. 215-229.

Frankel, R., Näslund, D. and Bolumole, Y. (2005), “The "white space" of logistics research: a look at the role of methods usage”, *Journal of Business Logistics*, Vol. 26 No. 2, pp. 185-209.

Freedman, D.H. (1992), “Is management still a science?”, *Harvard Business Review*, Vol. 70 No. 6, p. 26.

Frey, D., Schulz-Hardt, S. and Stahlberg, D. (2013), „Information seeking among individuals and groups and possible consequences for decision-making in business and politics”, *Understanding Group Behavior,* Vol. 2, pp. 211-225.

Fritz, M. and Hausen, T. (2009), “Electronic supply network coordination in agrifood networks: barriers, potentials, and path dependencies”, *International Journal of Production Economics*, Vol. 121 No. 2, pp. 441-453.

Frohlich, M.T. and Westbrook, R. (2001), “Arcs of integration: an international study of supply chain strategies”, *Journal of Operations Management*, Vol. 19, pp. 185-200.

Fuller, J., O’Conor, J. and Rawlinson, R. (1993), “Tailored Logistics: The Next Advantage”, *Harvard Business Review*, Vol. 71 No. 3, pp. 87-98.

Geng, X., Stinchcombe, M.B. and Whinston, A.B. (2005), “Bundling information goods of decreasing value”, *Management Science,* Vol. 51 No. 4, pp. 662-667.

George, G., Haas, M.R. and Pentland, A. (2014), “Big Data and Management”, *Academy of Management Journal*, Vol. 57 No. 2, pp. 321-326.

Ghadge, A., Dani, S. and Kalawsky, R. (2012), “Supply chain risk management: present and future scope”, *International Journal of Logistics Management*, Vol. 23 No.3, pp. 313-339.

Ghosh, A. and Fedorowicz, J. (2008), “The role of trust in supply chain governance”, *Business Process Management Journal*, Vol. 14 No. 4, pp. 453-470.

Ghoshal, S. (2005), “Bad management theories are destroying good management practices”, *Academy of Management Learning & Education*, Vol. 4 No. 1, pp. 75-91.

Ghoshal, S. and Bartlett, C.A. (1990), “The multinational corporation as an interorganizational network”, *Academy of Management Review*, Vol. 15 No. 4, pp. 603-626.

Ghoshal, S. and Moran, P. (1996), “Bad for practice: a critique of the transaction cost theory”, *Academy of Management Review*, Vol. 21, pp. 13–47.

Giménez, C. (2005), “Case Studies and Surveys in Supply Cain Management Research – Two Complementary Methodologies”, in Kotzab, H., Seuring, S., Müller, M. and Reiner, G. (Eds.), *Research Methodologies in Supply Chain Management,* Physica-Verlag, Heidelberg, pp. 315-330.

Giménez, C. and Lourenço, H.R. (2008), “e-SCM: internet's impact on supply chain processes”, *International Journal of Logistics Management*, Vol. 19 No. 3, pp. 309-343.

Giménez, C. and Tachizawa, E.M. (2012), “Extending sustainability to suppliers: a systematic literature review”, *Supply Chain Management: An International Journal*, Vol. 17 No. 5, pp. 531-543.

Giunipero, L.C., Hooker, R.E., Sacha, J.M., Yoon, T.E. and Brudvig, S. (2008), “A decade of SCM literature: past, present and future implications”, *Journal of Supply Chain Management,* Vol. 44 No. 4, pp. 66-86.

Gligor, D.M. and Holcomb, M.C. (2012), “Understanding the role of logistics capabilities in achieving supply chain agility: a systematic literature review”, *Supply Chain Management: An International Journal*, Vol. 17 No. 4, pp. 438-453.

Glock, C.H. (2012), “The joint economic lot size problem: A review”, *International Journal of Production Economics,* Vol. 135 No. 2, pp. 671-686.

Gobble, M.M. (2013), “Big Data: The Next Big Thing in Innovation”, *Research Technology Management*, Vol. 56 No. 1, pp. 64-66.

Goodman, C.M. (1987), “The Delphi technique: a critique”, *Journal of Advanced Nursing*, Vol. 12 No. 6, pp. 729-734.

Goodman, S.N. (1999), “Toward Evidence-Based Medical Statistics. 1: The P Value Fallacy”, *Annals of Internal Medicine*, Vol. 130, pp. 995-1004.

Gold, S., Seuring, S. and Beske, P. (2010), “Sustainable supply chain management and inter-organizational resources: a literature review”, *Corporate Social Responsibility and Environmental Management*, Vol. 17 No. 4, pp. 230-245.

Goldratt, E.M. (1989), *The General Theory of Constraints,* Abraham Goldratt Institute, New Haven, CT.

Golicic, S., Davis, D. and McCarthy, T. (2005), “A Balanced Approach to Research in Supply Chain Management”, in Kotzab, H., Seuring, S., Müller, M. and Reiner, G. (Eds.), *Research Methodologies in Supply Chain Management,* Physica-Verlag, Heidelberg, pp. 15-29.

Golicic, S.L., Foggin, J.H. and Mentzer, J.T. (2003), “Relationship magnitude and its role in interorganizational relationship structure”, *Journal of Business Logistics*, Vol. 24 No. 1, pp. 57-75.

Gosling, J. and Naim, M.M. (2009), “Engineer-to-order supply chain management: A literature review and research agenda”, *International Journal of Production Economics*, Vol. 122 No. 2, pp. 741-754.

Görtz, M. (2011), *Social Software as a Source of Information in the Workplace*, vwh Verlag, Glückstadt, Germany.

Graham, R. (1996), “Outsourcing - the major legal issues”, *Information Security Technical Report*, Vol. 1 No. 3, pp. 6-7, 51-56.

Graneheim, U. and Lundman, B. (2004), “Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness”, *Nurse Education Today*, Vol. 24, pp. 105-112.

Grant, R.M. (1996), “Toward a knowledge-based theory of the firm (Winter Special Issue)”, *Strategic Management Journal*, Vol. 17, pp. 109-122.

Gravier, M.J. and Farris, M.T. (2008), “An analysis of logistics pedagogical literature: past and future trends in curriculum, content, and pedagogy”, *International Journal of Logistics Management,* Vol. 19 No. 2, pp. 233-253.

Green, P.E., Frank, R.E. and Robinson, P.J. (1967), “Cluster analysis in test market selections”, *Management Science*, Vol. 13 No. 8, pp. 387-400.

Green, B., Jones, M., Hughes, D. and Williams, A. (1999), “Applying the Delphi technique in a study of GP’s information requirements”, *Health and Social Care in the Community,* Vol. 17 No. 3, pp. 198-205.

Greenfield, D. and Braithwaite, J. (2008), “Health sector accreditation research: a systematic review”, *International Journal for Quality in Health Care*, Vol. 20 No. 3, pp. 172-183.

Greening, P. and Rutherford, C. (2011), “Disruptions and supply networks: a multi-level, multi-theoretical relational perspective”, *International Journal of Logistics Management,* Vol. 22 No. 1, pp. 104-126.

Grisham, T. (2009), “The Delphi technique: a method for testing complex and multifaceted topics”, *International Journal of Managing Projects in Business*, Vol. 2 No. 1, pp. 112-130.

Gubi, E., Arlbjørn, J.S., and Johansen, J. (2003), “Doctoral dissertations in logistics and supply chain management: a review of Scandinavian contributions from 1990 to 2001”, *International Journal of Physical Distribution & Logistics Management*, Vol. 33 No. 10, pp. 854-885.

Guide, V.D.R., Harrison, T.P. and van Wassenhove, L.N. (2003), “The challenge of closed-loop supply chains”, *Interfaces*, Vol. 33 No. 6, pp. 3-6.

Gulati, R. (2007), “Tent poles, tribalism, and boundary spanning: The rigor-relevance debate in management research”, *Academy of Management Journal*, Vol. 50 No. 4, pp. 775-782.

Gummesson, E. (2000), *Qualitative Methods in Management Research*, Sage Publications, London.

Gummesson, E. (2006), “Qualitative research in management: addressing complexity, context and persona”, *Management Decision*, Vol. 44 No. 2, pp. 167-179.

Gunasekaran, A. and Kobu, B. (2007), “Performance measures and metrics in logistics and supply chain management: a review of recent literature (1995-2004) for research and applications”, *International Journal of Production Research*, Vol. 45 No. 12, pp. 2819-2840.

Gunasekaran, A. and Ngai, E.W.T. (2004), “Information systems in supply chain integration and management”, *European Journal of Operational Research*, Vol. 159 No. 2, pp. 269-295.

Gunasekaran, A. and Ngai, E.W.T. (2007), “Knowledge management in 21st century manufacturing”, *International Journal of Production Research*, Vol. 45 No. 11, pp. 2391-2418.

Gupta, U.G. and Clarke, R.E. (1996), "Theory and applications of the Delphi technique: A bibliography (1975–1994)", *Technological Forecasting and Social Change*, Vol. 53 No. 2, pp. 185-211.

Gupta, R., Gupta, H. and Mohania, M. (2012), "Cloud Computing and Big Data Analytics: What Is New from Databases Perspective?", in Srinivasa, S. and Bhatnagar, V. (Eds.), *Big Data Analytics – Proceedings of the First International Conference, BDA 2012, New Delhi, India,* Springer, Berlin, Germany, pp. 42-61.

Gupta, A. and Maranas, C.D. (2003), "Managing demand uncertainty in supply chain planning", *Computers & Chemical Engineering*, Vol. 27 No. 8, pp. 1219-1227.

Gupta, A.K. and Rogers, E.M. (1991), "Internal marketing: integrating R&D and marketing within the organization", *Journal of Services Marketing*, Vol. 5 No. 2, pp. 55-68.

Håkansson, H. and Waluszewski, À. (2002), *Managing Technological Development*, Routledge, London.

Haberman, S.J. (1988), "A warning on the use of chi-squared statistics with frequency tables with small expected cell counts", *Journal of the American Statistical Association*, Vol. 83 No. 402, pp. 555-560.

Häder, M. and Häder, S. (2000), "Die Delphi-Methode als Gegenstand methodischer Forschung", in Häder, S. (Ed.), *Die Delphi-Technik in den Sozialwissenschaften – Methodische Forschungen und innovative Anwendungen*, Opladen, Germany, pp. 11-31.

Halldórsson, A. and Arlbjørn, J.S. (2005), "Research methodologies in supply chain management–what do we know?", in Kotzab, H. *et al.* (Ed.), *Research methodologies in supply chain management*, Physica-Verlag, Heidelberg, Germany, pp. 107-122.

Hallgren, M. and Olhager, J. (2009), "Lean and agile manufacturing: external and internal drivers and performance outcomes", *International Journal of Operations & Production Management*, Vol. 29 No. 10, pp. 976-999.

Hammervoll, T. (2011), "Honeymoons in supply chain relationships: The effects of financial capital, social capital and psychological commitment", *International Journal of Logistics Management,* Vol. 22 No. 2, pp. 264-279.

Handfield, R.B. and Bechtel, C. (2002), "The role of trust and relationship structure in improving supply chain responsiveness", *Industrial Marketing Management*, Vol. 31 No. 4, pp. 367-382.

Handfield, R.B. and Nichols, E.L. (2002), *Supply chain redesign: transforming supply chains into integrated value systems*, Financial Times Prentice Hall, Upper Saddle River, NJ.

Handfield, R.B., Walton, S., Sroufe, R. and Melnyk, S. (2002), "Applying environmental criteria to supplier assessment: a study in the application of the analytical hierarchy process", *European Journal of Operational Research*, Vol. 141, pp. 70-87.

Harrison, A. and van Hoek, R.I. (2008), Logistics management and strategy: competing through the supply chain, Financial Times/Prentice Hall, London, England.

Harland, C.M. (1996), "Supply chain management: relationships, chains and networks", *British Journal of management*, Vol. 7 No. s1, pp. S63-S80.

Harland, C.M., Lamming, R.C., Walker, H., Phillips, W.E., Caldwell, N.D., Johnsen, T.E. and Zheng, J. (2006), "Supply management: is it a discipline?", *International Journal of Operations & Production Management*, Vol. 26 No. 7, pp. 730-753.

Hart, C. (1998), *Doing a Literature Review: Releasing the Social Science Research Imagination*, Sage Publications, London, England.

Hassini, E., Surti, C. and Searcy, C. (2012), "A literature review and a case study of sustainable supply chains with a focus on metrics", *International Journal of Production Economics*, Vol. 140 No. 1, pp. 69-82.

Hasson, F., Keeney, S. and McKenna, H. (2000), "Research guidelines for the Delphi survey technique", *Journal of Advanced Nursing*, Vol. 32 No. 4, pp. 1008-1015.

Hayes, R.H and Pisano, G.P. (1994), "Beyond World-Class: The New Manufacturing Strategy", *Harvard Business Review,* Vol. 72 No. 3, pp. 77-86.

Hazen, B.T. and Byrd, T.A. (2012), "Toward creating competitive advantage with logistics information technology", *International Journal of Physical Distribution & Logistics Management*, Vol. 42 No. 1, pp. 8-35.

Hazen, B.T., Hall, D.J. and Hanna, J.B. (2012), "Reverse logistics disposition decision-making: Developing a decision framework via content analysis", *International Journal of Physical Distribution & Logistics Management*, Vol. 42 No. 3, pp. 244-274.

Hertzum, M. and Pejtersen, A.M. (2000), "The information-seeking practices of engineers: searching for documents as well as for people", *Information Processing & Management,* Vol. 36 No. 5, pp. 761-778.

Hervani, A.A., Helms, M.M. and Sarkis, J. (2005), "Performance measurement for green supply chain management", *Benchmarking: An International Journal*, Vol. 12 No. 4, pp. 330-353.

Hewitt, F. (1999), "Supply or demand? Chains or pipelines? Co-ordination or control?", *Proceedings from International Symposium in the* Information Age, Florence, pp. 785-790.

Hiebelar, R., Kelly, T.B. and Katteman, C. (1998), *Best Practices Building with Customer-Focussed Solutions,* Simon and Schuster, New York.

Hill, T. (1993), *Manufacturing Strategy: Text and Cases*, Macmillan Press, London.

Hines, P., Lamming, R., Jones, D., Cousins, P. and Rich, N. (2000), *Value Stream Management. Strategy and Excellence in the Supply Chain,* Prentice Hall, London.

Hines, P., Holweg, M. and Rich, N. (2004), "Learning to evolve: a review of contemporary lean thinking", *International Journal of Operations & Production Management*, Vol. 24 No. 10, pp. 994-1011.

Hitt, M.A., Beamish, P.W., Jackson, S.E. and Mathieu, J.E. (2007), "Building theoretical and empirical bridges across levels: Multilevel research in management", *Academy of Management Journal*, Vol. 50 No. 6, pp. 1385-1399.

Hoekstra, S. and Romme, J. (1992), *Integral Logistics Strictures: Developing Customer-orientated Goods Flow,* Simon and Schuster, New York.

Hofer, C.W. (1975), "Toward a contingency theory of business strategy", *Academy of Management Journal*, Vol. 18 No. 4, pp. 784-810.

Holsti, O.R. (1968), "Content Analysis", in Gardner L. and Aronson, E. (Eds.), *The Handbook of Social Psychology*, Addison-Wesley, Oxford, England, pp. 596-623.

Homans, G.C. (1964), "Contemporary theory in sociology", in Faris, R.E.L. (Ed.), *Handbook of modern sociology*, Rand McNally, Chicago, pp. 951-977.

Horvath, L. (2001), "Collaboration: the key to value creation in supply chain management", *Supply Chain Management: An International Journal*, Vol. 6 No. 5, pp. 205-207.

Houlihan, J.B. (1984), "Supply chain management", in *Proceedings of the 19th International Technical Conference of the British Production and Inventory Control Society*, 1984, pp. 101-110.

Houlihan, J.B. (1985), "International supply chain management", *International Journal of Physical Distribution and Materials Management*, Vol. 15 No. 1, pp. 22-39.

Houlihan, J.B. (1988), "International supply chains: A new approach", *Management Decision*, Vol. 26 No. 3, pp. 13-19.

Hsu, C.C. and Sandford, B.A. (2007), "The Delphi technique: making sense of consensus", *Practical Assessment, Research & Evaluation*, Vol. 12 No. 10, pp. 1-8.

Huan, S.H., Sheoran, S.K. and Wang, G. (2004), "A review and analysis of supply chain operations reference (SCOR) model", *Supply Chain Management: An International Journal*, Vol. 9 No. 1, pp. 23-29.

Hult, G.T.M., Ketchen, D.J. and Slater, S.F. (2004), "Information processing, knowledge development, and strategic supply chain performance", *Academy of Management Journal*, Vol. 47 No. 2, pp. 241-253.

Hunt, S.D. (1971), "The morphology of theory and the general theory of marketing", *The Journal of Marketing*, pp. 65-68.

Hunt, S.D. and Davis, D.F. (2008), "Grounding supply chain management in resource-advantage theory", *Journal of Supply Chain Management: A Global Review of Purchasing & Supply*, Vol. 44 No. 1, pp. 10-21.

Iyer, K.N. (2011), "Demand chain collaboration and operational performance: role of IT analytic capability and environmental uncertainty", *Journal of Business & Industrial Marketing*, Vol. 26 No. 2, pp. 81-91.

Jackson, C. (1997), "Behavioral science theory and principles for practice in health education", *Health Education Research*, Vol. 12 No. 1, pp. 143-150.

Jain, V., Wadhwa, S. and Deshmukh, S.G. (2009), "Select supplier-related issues in modelling a dynamic supply chain: potential, challenges and direction for future research", *International Journal of Production Research*, Vol. 47 No. 11, pp. 3013-3039.

Jairath N. and Weinstein J. (1994), "The Delphi Methodology (Part One): a useful administrative approach", *Canadian Journal of Nursing Administration*, Vol. 7 No. 3, pp. 29-40.

Jalali, S. and Wohlin, C. (2012), "Systematic literature studies: database searches vs. backward snowballing", in *Proceedings of the ACM-IEEE international symposium on Empirical software engineering and measurement*, September 2012, pp. 29-38.

Jayaram, J., Vickery, S.K. and Droge, C. (2000), "The effects of information system infrastructure and process improvements on supply-chain time performance", *International Journal of Physical Distribution & Logistics Management*, Vol. 30 No. 3/4, pp. 314-330.

Jayaraman, V., Guide, V.D.R. and Srivastava, R. (1999), "A closed-loop logistics model for remanufacturing", *Journal of the operational research society*, pp. 497-508.

Jensen, J.K. (2012), "Product carbon footprint developments and gaps", *International Journal of Physical Distribution & Logistics Management*, Vol. 42 No. 4, pp. 338-354.

Jensen, M. and Meckling, W. (1976), "Theory of the firm: Managerial behavior, agency costs, and ownership structure", *Journal of Financial Economics*, Vol. 3, pp. 305-360.

Jeon, Y.H. (2012), "Impact of Big Data: Networking Considerations and Case Study", *International Journal of Computer Science and Network Security,* Vol. 12 No. 12, pp. 30-34.

Jharkharia, S. and Shankar, R. (2005), "IT-enablement of supply chains: understanding the barriers", *Journal of Enterprise Information Management*, Vol. 18 No. 1, pp. 11-27.

Jiang, B., Frazier, G.V. and Heiser, D. (2007), "China-related POM research: a literature review and suggestions for future research", *International Journal of Operations & Production Management*, Vol. 27 No. 7, pp. 662-684.

Jick, J.D. (1979), "Mixing quantitative methods: triangulation in action*", Administrative Science Quarterly*, Vol. 24 No. 4, pp. 602-11.

Jones, T.C. and Riley, D.W. (1985), "Using inventory for competitive advantage through supply chain management", *International Journal of Physical Distribution & Logistics Management*, Vol. 15 No. 5, pp. 16-26.

Jüttner, U., Christopher, M. and Godsell, J. (2010), "A strategic framework for integrating marketing and supply chain strategies", *International Journal of Logistics Management*, Vol. 21 No. 1, pp. 104-126.

Jüttner, U., Peck, H. and Christopher, M. (2003), "Supply chain risk management: outlining an agenda for future research", *International Journal of Logistics: Research and Applications*, Vol. 6 No. 4, pp. 197-210.

Kache, F. and Seuring, S. (2013a), A Review of Literature Reviews in Supply Chain Management. In: Arnäs, P.O., Johansson, M., Arvidsson, N., Pahlén, P., Bergqvist, R., and Stefansson, G. (Eds.): *Proceedings to NOFOMA 2013 - 25th Annual Nordic Logistics Research Network Conference*, 3-5 June 2013, Gothenburg, Sweden.

Kache, F. and Seuring, S. (2013b), A Review of Literature Reviews in Supply Chain Management from an Operations Point of View. In: Dethloff, J., Haasis, H.-D., Kopfer, H., Kotzab, H. and Schönberger, J. (Eds.): *Proceedings to Logistikmanagement 2013 Conference - Konferenz der Wissenschaftlichen Kommission Logistik im Verband der Hochschullehrer für Betriebswirtschaft e.V. (VHB)*, 11-13 September 2013, Bremen, Germany.

Kache, F. and Seuring, S. (2014a), Big Data analytics and the exploitation of information in supply chains – An exploratory study from a multi-dimensional perspective. In: Trautrims, A., Diaz, A., Wallenburg, C.M., Kisperska-Morón, D., Estampe, D., Nilsson, F. de Leeuw, S., (Eds.): *Proceedings to ERS 2014 – 9th Council of Supply Chain Management Professionals European Research Seminar Conference*, 28-29 April 2014, Düsseldorf, Germany.

Kache, F. and Seuring, S. (2014b), Big Data and the value of information in supply chains – A conceptual framework for the assessment of information requirements. In: Gammelgaard, B., Kildemose Nielsen, B., Wieland, A., Prockl, G. and Aastrup, J. (Eds.): *Proceedings to NOFOMA 2014 - 26th Annual Nordic Logistics Research Network Conference*, 11-13 June 2014, Copenhagen, Denmark.

Kache, F. and Seuring, S. (2014c), "Linking collaboration and integration to risk and performance in supply chains via a review of literature reviews", *Supply Chain Management: An International Journal,* Vol. 19 No. 5/6, pp. 664-682.

Kanda, A. and Deshmukh, S.G. (2008), „Supply chain coordination: perspectives, empirical studies and research directions", *International Journal of Production Economics*, Vol. 115 No. 2, pp. 316-335.

Kassarjian, H.H. (1977), "Content Analysis in Consumer Research", *Journal of Consumer Research*, Vol. 4 No. 1, pp. 8-18.

Katz, D. and Kahn, R.L. (1966), "Organizations and the system concept", *The Social Psychology of Organizations*, Vol. 1, pp. 14-29.

Kauko, K. and Palmroos, P. (2014), "The Delphi method in forecasting financial markets— An experimental study", *International Journal of Forecasting*, Vol. 30 No. 2, pp. 313-327.

Keeney, S., Hasson, F. and McKenna, H. (2006), "Consulting the oracle: ten lessons from using the Delphi technique in nursing research", *Journal of Advanced Nursing*, Vol. 53 No. 2, pp. 205-212.

Keller, S.B. and Ozment, J. (2009), “Research on personnel issues published in leading logistics journals: what we know and don't know”, *International Journal of Logistics Management,* Vol. 20 No. 3, pp. 378-407.

Kendall, M.G. (1955), *Rank Correlation Methods,* Hafner Publishing Co., New York.

Kendall, J.W. (1977), “Variations of Delphi”, *Technological Forecasting and Social Change*, Vol. 11 No. 1, pp. 75-85.

Ketchen Jr, D.J. and Giunipero, L.C. (2004), “The intersection of strategic management and supply chain management”, *Industrial Marketing Management*, Vol. 33 No. 1, pp. 51-56.

Ketchen Jr, D.J. and Hult, G.T.M. (2007), “Bridging organization theory and supply chain management: the case of best value supply chains”, *Journal of Operations Management*, Vol. 25 No. 2, pp. 573-580.

Kim, G.H., Trimi, S. and Chung, J.H. (2014), “Big-data applications in the government sector”, *Communications of the ACM*, Vol. 57 No. 3, pp. 78-85.

Kirca, A.H. and Yaprac, A. (2010), “The use of meta-analysis in international business research: its current status and suggestions for better practice”, *International Business Review*, Vol. 19 No. 3, pp. 306-14.

Kiron, D. (2013), “Organizational Alignment is Key to Big Data Success”, *MIT Sloan Management Review*, Vol. 54 No. 3, pp. 1-7.

Kitchin, R. (2014), “Big Data, new epistemologies and paradigm shifts”, *Big Data & Society*, Vol. 1 No. 1, pp. 1-13.

Kleindorfer, P.R. and Saad, G.H. (2005), “Managing disruption risks in supply chains”, *Production and Operations Management*, Vol. 14 No. 1, pp. 53-68.

Kleindorfer, P.R., Singhal, K. and Wassenhove, L.N. (2005), “Sustainable operations management”, *Production and Operations Management,* Vol. 14 No. 4, pp. 482-492.

Kleinsorge, I.K., Schary, P.B. and Tanner, R. (1989), “Evaluating logistics decisions”, *International Journal of Physical Distribution & Logistics Management*, Vol. 19 No. 12, pp. 3-14.

Klenk, N.L. and Hickey, G.M. (2011), “A virtual and anonymous, deliberative and analytic participation process for planning and evaluation: The Concept Mapping Policy Delphi”, *International Journal of Forecasting*, Vol. 27 No. 1, pp. 152-165.

Klopack, T.G. (2000), “Balancing the risks and the benefits”, *Drug Discovery Today*, Vol. 5 No. 4, pp. 157-60.

Kondracki, N.L., Wellman, N.S. and Amundson D.R. (2002), “Content analysis: review of methods and their applications in nutrition education”, *Journal of Nutrition Education and Behavior*, Vol. 34, No. 4, pp. 224-230.

Kouvelis, P., Chambers, C. and Wang, H. (2006), “Supply chain management research and production and operations management: review, trends, and opportunities”, *Production and Operations Management,* Vol. 15 No. 3, pp. 449-469.

Kovács, G. and Spens, K.M. (2005), “Abductive reasoning in logistics research”, *International Journal of Physical Distribution & Logistics Management*, Vol. 35 No. 2, pp. 132-144.

Kraatz, M.S. (1998), “Learning by association? Interorganizational networks and adaptation to environmental change”, *Academy of Management Journal*, Vol. 41 No. 6, pp. 621-643.

Krafcik, J.F. (1988), *Triumph of the Lean Production System,* MIT Press, Cambridge, MA.

Kraljic, P. (1983), “Purchasing must become supply management”, *Harvard Business Review*, Vol. 61 No. 5.

Kremic, T. and Tukel, O.I. (2006), “Assisting public organisations in their outsourcing endeavours: a decision support model”, *International Journal of Integrated Supply Management*, Vol. 2 No. 4, pp. 383-406.

Kremic, T., Tukel, O.I. and Rom, W.O. (2006), “Outsourcing decision support: a survey of benefits, risks, and decision factors”, *Supply Chain Management: An International Journal*, Vol. 11 No. 6, pp. 467-482.

Krippendorff, K. (1989), *Content Analysis: An Introduction to Its Methodology*, Sage Publications, Thousand Oaks, CA.

Krippendorff, K. (2012), *Content Analysis: An Introduction to Its Methodology*, Sage Publications, Thousand Oaks, CA.

Kuglin, F. and Rosenbaum, B. (2001), *The supply chain network@ internet speed*, American Management Association, New York.

Kurt Salmon Associates (1993), *Efficient Consumer Response: Enhancing Consumer Value in the Grocery Industry*, Kurt Salmon Associates, London.

Labro, E. (2006), “Is a focus on collaborative product development warranted from a cost commitment perspective?”, *Supply Chain Management: An International Journal*, Vol. 11 No. 6, pp. 503-509.

Lafferty, G. and Roan, A. (2000), “Public sector outsourcing: implications for training and skills”, *Employee Relations*, Vol. 22 No. 1, pp. 76-85.

Lamb, P. (1975), “Research appraisal in the electricity industry—An interesting application of the Delphi Method”, *Industrial Marketing Management*, Vol. 4 No. 2, pp. 89-98.

Lambdin, C. (2012), “Significance tests as sorcery: Science is empirical—significance tests are not”, *Theory & Psychology*, Vol. 22 No. 1, pp. 67-90.

Lambert, D.M. and Cooper, M.C. (2000), “Issues in supply chain management”, *Industrial Marketing Management*, Vol. 29 No. 1, pp. 65-83.

Lambert, D.M., García-Dastugue, S.J. and Croxton, K.L. (2005), “An evaluation of process-oriented supply chain management frameworks”, *Journal of Business Logistics*, Vol. 26 No. 1, pp. 25-51.

Lambert, D.M., Stock, J.R. and Ellram, L.M. (1998), *Fundamentals of Logistics Management*, McGraw-Hill/Irwin, Boston.

Lamming, R., Johnsen, T., Zheng, J. and Harland, C. (2000), “An initial classification of supply networks”, *International Journal of Operations & Production Management,* Vol. 20, No. 6, pp. 675-691.

Lampel, J. and Mintzberg, H. (1996), “Customising Customization”, *Sloan Management Review*, Vol. 38 No. 1, pp. 21-30.

Landeta, J. and Barrutia, J. (2011), “People consultation to construct the future: a Delphi application”, *International Journal of Forecasting*, Vol. 27 No. 1, pp. 134-151.

Laney, D. (2001), “3D Data Management: Controlling Data Volume, Velocity, and Variety”, available at http://blogs.gartner.com/doug-laney/files/2012/01/ad949-3D-Data-Management-Controlling-Data-Volume-Velocity-and-Variety.pdf (accessed November 18th, 2014).

Larntz, K. (1978), “Small-sample comparisons of exact levels for chi-squared goodness-of-fit statistics”, *Journal of the American Statistical Association*, Vol. 73 No. 362, pp. 253-263.

Larson, P.D. and Halldórsson, Á. (2002), "What is SCM? And, where is it?", *Journal of Supply Chain Management*, Vol. 38 No. 4, pp. 36-44

LaValle, S., Lesser, E., Shockley, R., Hopkins, M.S. and Kruschwitz, N. (2011), "Big Data, analytics and the path from insights to value", *MIT Sloan Management Review*, Vol. 52 No. 2, pp. 21-31.

Layder, D. (1993), *New Strategies in Social Research*, Polity, Cambridge.

Lee, A.S. (1989), "A scientific methodology for MIS case studies", *MIS quarterly*, pp. 33-50.

Lee, E.A. (2008), "Cyber physical systems: Design challenges", paper presented at the *11th IEEE International Symposium on Object Oriented Real-Time Distributed Computing (ISORC)*, May 2008, pp. 363-369.

Lee, H.L. (2002), "Aligning supply chain strategies with product uncertainties", *California Management Review*, Vol. 44 No. 3, pp. 105-119.

Lee, H.L., Padmanabhan, V. and Whang, S. (1997), "The bullwhip effect in supply chains1", *Sloan Management Review*, Vol. 38 No. 3, pp. 93-102.

Lee, H.L., So, K.C. and Tang, C.S. (2000), "The value of information sharing in a two-level supply chain", *Management Science*, Vol. 46 No. 5, pp. 626-643.

Lee, H.L. and Whang, S. (2000), "Information sharing in a supply chain", *International Journal of Manufacturing Technology and Management*, Vol. 1 No. 1, pp. 79-93.

Lee, J.-N. and Kim, Y.-G. (1999), "Effect of partnership quality on IS outsourcing: conceptual framework and empirical validation", *Journal of Management Information Systems*, Vol. 15 No. 4, pp. 29-61.

Lee, W.B. and Lau, H.C.W. (1999), "Factory on demand: the shaping of an agile production network", *International Journal of Agile Management Systems*, Vol. 1 No. 2, pp. 83-87.

Levitt, B. and March, J.G. (1988), "Organizational learning", *Annual review of sociology*, pp. 319-340.

Li, G., Yang, H., Sun, L. and Sohal, A.S. (2009), "The impact of IT implementation on supply chain integration and performance*", International Journal of Production Economics,* Vol. 120 No. 1, pp. 125-138.

Li, S. and Lin, B. (2006), "Accessing information sharing and information quality in supply chain management", *Decision Support Systems*, Vol. 42 No. 3, pp. 1641-1656.

Li, S., Ragu-Nathan, B., Ragu-Nathan, T.S. and Subba Rao, S. (2006), "The impact of supply chain management practices on competitive advantage and organizational performance", *Omega*, Vol. 34 No. 2, pp. 107-124.

Li, X., Chung, C., Goldsby, T.J. and Holsapple, C.W. (2008), "A unified model of supply chain agility: the work-design perspective*", International Journal of Logistics Management,* Vol. 19 No. 3, pp. 408-435.

Liao-Troth, S., Thomas, S. and Fawcett, S.E. (2012), "Twenty years of IJLM: evolution in research, *International Journal of Logistics Management, The*, Vol. 23, No. 1, pp. 4-30.

Lin, C., Tan, B. and Chang, S. (2008), "An exploratory model of knowledge flow barriers within healthcare organizations", *Information & Management*, Vol. 45 No. 5, pp. 331-339.

Linstone, H.A. and Turoff, M. (Eds.) (2002), *The Delphi Method: Techniques and Applications,* Addison-Wesley, Reading, MA.

Linstone, H.A. and Turoff, M. (2011), "Delphi: a brief look backward and forward", *Technological Forecasting and Social Change*, Vol. 78 No. 9, pp. 1712-1719.

Linton, J.D., Klassen, R. and Jayaraman, V. (2007), "Sustainable supply chains: an introduction", *Journal of Operations Management*, Vol. 25 No. 6, pp. 1075-1082.

Lipsey, M.W. and Wilson, D.B. (2001), *Practical meta-analysis*, Sage Publications, Thousand Oaks, CA.

Lonsdale, C. (1999), "Effectively managing vertical supply relationships: a risk management model for outsourcing", *Supply Chain Management: An International Journal*, Vol. 4 No. 4, pp. 176-83.

Loo, R. (2002), "The Delphi method: a powerful tool for strategic management", *Policing: An International Journal of Police Strategies & Management*, Vol. 25 No. 4, pp. 762-769.

Lowson, B., King, R. and Hunter, A. (1999), *Quick Response - Origins, Status and Outlook,* John Wiley & Sons, Chichester.

Lyons, A.C., Mondragon, A.E.C., Piller, F. and Poler, R. (2012), *Customer-Driven Supply Chains - From Glass Pipelines to Open Innovation Networks,* Springer, London.

Malfara, D. (2013), "Platform as a Service", working paper ACC 626, University of Waterloo, Waterloo, Canada, 3 July.

Mangold, W.G. and Faulds, D.J. (2009), "Social media: The new hybrid element of the promotion mix", *Business Horizons*, Vol. 52 No. 4, pp. 357-365.

Manuj, I. and Mentzer, J.T. (2008), "Global supply chain risk management", *Journal of Business Logistics*, Vol. 29 No. 1, pp. 133-155.

Moberg, C.R., Cutler, B.D., Gross, A. and Speh, T.W. (2002), "Identifying antecedents of information exchange within supply chains", *International Journal of Physical Distribution & Logistics Management,* Vol. 32 No. 9, pp. 755-770.

Markley, M.J. and Davis, L. (2007), "Exploring future competitive advantage through sustainable supply chains", Int*ernational Journal of Physical Distribution & Logistics Management*, Vol. 37 No. 9, pp. 763-774.

Mason-Jones, R. and Towill, D.R. (1997), "Information enrichment: designing the supply chain for competitive advantage", *Supply Chain Management: An International Journal*, Vol. 2, No. 4, pp. 137-148.

Mason-Jones, R., Naylor, J.B. and Towill, D.R. (2000), "Lean, agile or leagile? Matching your supply chain to the marketplace", *International Journal of Production Research*, Vol. 38, No. 17, pp. 4061-4070.

Mayer-Schönberger, V. and Cukier, K. (2013), *Big data: A revolution that will transform how we live, work, and think,* Houghton Mifflin Harcourt, Boston, MA.

Mayring, P. (2003), *Qualitative Inhaltsanalyse – Grundlagen und Techniken (Qualitative Content Analysis)*, Beltz Verlag, Weinheim.

Mayring, P. (2010), *Qualitative Inhaltsanalyse – Grundlagen und Techniken (Qualitative Content Analysis)*, Beltz Verlag, Weinheim.

McAfee, A. and Brynjolfsson, E. (2012), "Big Data: the management revolution", *Harvard Business Review*, Vol. 90 No. 10, pp. 60-66.

McCarthy, T.M. and Golicic, S.L. (2002), "Implementing collaborative forecasting to improve supply chain performance“, *International Journal of Physical Distribution & Logistics Management*, Vol. 32 No. 6, pp. 431-454.

McGrath, J.E. (1982), "Dilemmatics: the study of research choices and dilemmas", in McGrath, J.E., Martin, J. and Kulka, R.A. (Eds), *Judgement Calls in Research*, Sage, Beverly Hills, CA, pp. 69-102.

McKenna, H.P. (1994), "The Delphi technique: a worthwhile research approach for nursing?", *Journal of Advanced Nursing*, Vol. 19 No. 6, pp. 1221-1225.

McMurray, A.R. (1994), “Three decision-making aids: brainstorming, nominal group, and Delphi technique”, *Journal for Nurses in Professional Development*, Vol. 10 No. 2, pp. 62-65.

Meijering, J.V., Kampen, J.K. and Tobi, H. (2013), “Quantifying the development of agreement among experts in Delphi studies”, *Technological Forecasting and Social Change*, Vol. 80 No. 8, pp. 1607-1614.

Meixell, M.J. and Norbis, M. (2008), “A review of the transportation mode choice and carrier selection literature”, *International Journal of Logistics Management,* Vol. 19 No. 2, pp. 183-211.

Mentzer, J.T. (2004), *Fundamentals of supply chain management: twelve drivers of competitive advantage,* Sage Publications, Thousand Oaks, CA.

Mentzer, J.T., DeWitt, W., Keebler, J.S., Min, S., Nix, N.W., Smith, C.D. and Xacharia, Z.G. (2001), “Defining supply chain management”, *Journal of Business Logistics*, Vol. 22 No. 2, pp. 1-25.

Mentzer, J.T. and Flint, D.J. (1997), “Validity in logistics research”, *Journal of Business Logistics*, Vol. 18 No. 1, pp. 199-216.

Mentzer, J.T. and Kahn, K.B. (1995), “A framework of logistics research”, *Journal of Business Logistics*, Vol. 16 No. 1, pp. 231-250.

Mentzer, J.T., Min, S. and Bobbitt, L.M. (2004), “Toward a unified theory of logistics”, *International Journal of Physical Distribution & Logistics Management*, Vol. 34 No. 8, pp. 606-627.

Mentzer, J.T., Min, S. and Zacharia, Z.G. (2000), “The nature of interfirm partnering in supply chain management”, *Journal of Retailing*, Vol. 76 No. 4, pp. 549-568.

Mentzer, J.T., Stank, T.P. and Esper, T.L. (2008), “Supply chain management and its relationship to logistics, marketing, production, and operations management”, *Journal of Business Logistics*, Vol. 29 No. 1, pp. 31-46.

Meredith, J.R., Raturi, A., Amoako-Gyampah, K. and Kaplan, B. (1989), “Alternative research paradigms in operations”, *Journal of Operations Management*, Vol. 8 No. 4, pp. 297-326.

Meredith, J.R. (1993). “Theory building through conceptual methods”, *International Journal of Operations & Production Management*, Vol. 13 No. 5, pp. 3-11.

Meredith, J.R. (1998), “Building operations management theory through case and field research”, *Journal of Operations Management*, Vol. 16 No. 4, pp. 441-454.

Mehta, C.R. and Patel, N.R. (1983), “A network algorithm for performing Fisher's exact test in r× c contingency tables”, *Journal of the American Statistical Association*, Vol. 78 No. 382, pp. 427-434.

Metters, R., Zhao, X., Bendoly, E., Jiang, B. and Young, S. (2010), “’The way that can be told of is not an unvarying way’: Cultural impacts on Operations Management in Asia”, *Journal of Operations Management*, Vol. 28 No. 3, pp. 177-185.

Merton, R.K. (1949), “The Role of Applied Social Science in the Formation of Policy: A Research Memorandum”, *Philosophy of Science*, Vol. 16 No. 3, pp. 161-181.

Merton, R.K. (1967), *On theoretical sociology: Five essays, old and new*, Free Press, New York.

Meyr, H. and Günther, H.O. (2009), *Supply Chain Planning,* Springer-Verlag, Berlin, Heidelberg.

Miemczyk, J., Johnsen, T.E. and Macquet, M. (2012), “Sustainable purchasing and supply management: a structured literature review of definitions and measures at the dyad, chain and network levels", *Supply Chain Management: An International Journal*, Vol. 17 No. 5, pp. 478-496.

Mills, J., Schmitz, J. and Frizelle, G. (2004), "A strategic review of 'supply networks'", *International Journal of Operations & Production Management*, Vol. 24 No. 10, pp. 1012-1036.

Minner, S. (2003), "Multiple-supplier inventory models in supply chain management: A review", *International Journal of Production Economics*, Vol. 81, pp. 265-279.

Miragliotta, G. (2006), "Layers and mechanisms: A new taxonomy for the bullwhip effect", *International Journal of Production Economics*, Vol. 104 No. 2, pp. 365-381.

Moeller, G.H., Shafer, E.L., Lieber, S.R. and Fesenmaier, D.R. (1983), "The use and misuse of Delphi forecasting", *Recreation Planning and Management*, pp. 96-104.

Mollenkopf, D., Stolze, H., Tate, W.L. and Ueltschy, M. (2010), "Green, lean, and global supply chains", *International Journal of Physical Distribution & Logistics Management*, Vol. 40 No. 1/2, pp. 14-41.

Monczka, R.M., Trent, R.J. and Callahan, T.J. (1993), "Supply base strategies to maximize supplier performance", *International Journal of Physical Distribution and Logistics Management*, Vol. 23 No. 4, pp. 42–54.

Morse, J.M., Barrett, M., Mayan, M., Olson, K. and Spiers, J. (2008), "Verification strategies for establishing reliability and validity in qualitative research", *International Journal of Qualitative Methods*, Vol. 1 No. 2, pp. 13-22.

Morton, S. (Ed.) (1991), *The Corporation of the 1990s: Information Technology and Organizational Transformation*, Oxford University Press, New York.

Mullen, P.M. (2003), "Delphi: myths and reality", *Journal of Health Organization and Management*, Vol. 17 No. 1, pp. 37-52.

Müller, M. (2005), "Action Research in Supply Chain Management – An Introduction", in Kotzab, H., Seuring, S., Müller, M. and Reiner, G. (Eds.), *Research Methodologies in Supply Chain Management,* Physica-Verlag, Heidelberg, pp. 350-364.

Myhr, N. and Spekman, R.E. (2005), "Collaborative supply-chain partnerships built upon trust and electronically mediated exchange", *Journal of Business & Industrial Marketing,* Vol. 20 Nos. 4/5, pp. 179-186.

Nagel, R. and Dove, R. (1991), *21st century manufacturing,* Iacocca Institute, Lehigh University, Bethlehem, PA.

Naim, M.M. and Gosling, J. (2011), "On leanness, agility and leagile supply chains", *International Journal of Production Economics*, Vol. 131 No. 1, pp. 342-354.

Nairn, A. and Bottomley, P. (2003), "Something approaching science? Cluster analysis procedures in the CRM era", *International Journal of Market Research*, Vol. 45 No. 2, pp. 241-61.

Natarajarathinam, M., Capar, I. and Narayanan, A. (2009), "Managing supply chains in times of crisis: a review of literature and insights", *International Journal of Physical Distribution & Logistics Management*, Vol. 39 No. 7, pp. 535-573.

Naylor, J.B., Naim, M.M. and Berry, D. (1999), "Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain", *International Journal of Production Economics,* Vol. 62, pp. 107-118.

Näslund, D. (2002), "Logistics needs qualitative research - especially action research", *International Journal of Physical Distribution & Logistics Management*, Vol. 32 No. 5, pp. 321-338.

Neill, C.J. and Laplante, P.A. (2003), "Requirements engineering: the state of the practice", *IEEE software,* Vol. 20 No. 6, pp. 40-45.

Neuman, L.W. (2006), *Social Research Methods: Qualitative and Quantitative Approaches*, Pearson, Boston, MA.

New, S.J. (1994), "Supply chains – some doubts", in *Proceedings of the 3rd International IPSERA Conference*, April 1994, University of Glamorgan, Wales, pp. 345-62.

New, S.J. (1996), "A framework for analyzing supply chain improvement", *International Journal of Operations & Production Management*, Vol. 16 No. 4, pp. 19-34.

New, S.J. (1997), "The scope of supply chain management research", *Supply Chain Management: An International Journal*, Vol. 2 Iss. 1, pp. 15-22.

Nguyen, L. and Swatman, P.A. (2003), "Managing the requirements engineering process", *Requirements Engineering,* Vol. 8 No. 1, pp. 55-68.

Norrman, A., Jansson, U. (2004), "Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident", *International Journal of Physical Distribution & Logistics Management*, Vol. 34 No. 4, pp. 434-456.

Ohno, T. (1988), *The Toyota Production System Beyond Large Scale Production,* Productivity Press, Portland, OR.

Okoli, C. and Pawlowski, S.D. (2004), "The Delphi method as a research tool: an example, design considerations and applications", *Information & Management*, Vol. 42 No. 1, pp. 15-29.

Olhager, J. (2003), "Strategic positioning of the order penetration point", *International Journal of Production Economics*, Vol. 85 No. 3, pp. 319-329.

Olhager, J., Rudberg, M. and Wikner, J. (2001), "Long-term capacity management: linking the perspectives from manufacturing strategy and sales and operations planning", *International Journal of Production Economics*, Vol. 69 No. 2, pp. 215-225.

Oliver, R.K. and Webber, M.D. (1982), "Supply-chain management: logistics catches up with strategy." in Christopher, M. (Ed.), *Logistics: The strategic issue*, Chapman & Hall, London, pp. 63-75.

Osgood, C.E., Saporta, S. and Nunnally, J.C. (1956), "Evaluative assertion analysis", *Litera*, Vol. 3, pp. 47-102.

Otley, D.T. (1980), "The contingency theory of management accounting: achievement and prognosis", *Accounting, Organizations and Society*, Vol. 5 No. 4, pp. 413-428.

Otley, D.T. and Berry, A.J. (1994), "Case study research in management accounting and control", *Management Accounting Research*, Vol. 5 No. 1, pp. 45-65.

Otto, B., Hüner, K.M., Back, A., Brenner, W., Jung, R., Österle, H. and Winter, R. (2009), "Functional reference architecture for corporate master data management", working paper, Institute of Information Management, University of St. Gallen, St. Gallen, May 31st 2009.

Pagell, M. (2004), "Understanding the factors that enable and inhibit the integration of operations, purchasing and logistics", *Journal of Operations Management*, Vol. 22 No. 5, pp. 459-87.

Pagh, J.D. and Cooper, M.C. (1998), "Supply chain postponement and speculation strategy How to choose the right strategy", *Journal of Business Logistics*, Vol. 19, No. 2, pp. 13-33.

Pandey, D., Suman, U. and Ramani, A.K. (2011), "An Approach to Information Requirement Engineering", in Kim, K.J. and Furht, B. (Eds.), *Proceedings of the 2011 International*

Conference on Information Science and Applications, ICISA 2011, Jeju Island, Republic of Korea, IEEE, pp. 1-4.

Pannirselvam, G.P., Ferguson, L.A., Ash, R.C., and Siferd, S.P. (1999), "Operations management research, an update for the 1990s", *Journal of Operations Management*, Vol. 18 No. 1, pp. 95-112.

Parente, F.J., Anderson, J.K., Myers, P. and O'brien, T. (1984), "An examination of factors contributing to Delphi accuracy", *Journal of Forecasting*, Vol. 3 No. 2, pp. 173-182.

Parker, D.B., Zsidisin, G.A. and Ragatz, G.L. (2008), "Timing and extent of supplier integration in new product development: a contingency approach", *Journal of Supply Chain Management: A Global Review of Purchasing & Supply*, Vol. 44 No. 1, pp. 71-83.

Parkin, T.G. (1992), *Demography and Roman society,* Johns Hopkins University Press, Baltimore, MD.

Pazirandeh, A. (2011), "Sourcing in global health supply chains for developing countries: Literature review and a decision making framework", *International Journal of Physical Distribution & Logistics Management,* Vol. 41 No. 4, pp. 364-384.

Pearson, K. (1904), *On the theory of contingency and its relation to association and normal correlation,* Cambridge University Press, Cambridge, MA.

Pentland, A. (2014), *Social Physics*, Penguin, New York.

Pettit, S. and Beresford, A. (2009), "Critical success factors in the context of humanitarian aid supply chains", *International Journal of Physical Distribution & Logistics Management,* Vol. 39 No. 6, pp. 450-468.

Pettit, T.J., Fiksel, J. and Croxton, K.L. (2010), "Ensuring supply chain resilience: development of a conceptual framework", *Journal of Business Logistics*, Vol. 31 No. 1, pp. 1-21.

Pfohl, H.C., Köhler, H. and Thomas, D. (2010), "State of the art in supply chain risk management research: empirical and conceptual findings and a roadmap for the implementation in practice", *Logistics Research*, Vol. 2 No. 1, pp 33-44.

Pilbeam, C., Alvarez, G. and Wilson, H. (2012), "The governance of supply networks: a systematic literature review", *Supply Chain Management: An International Journal*, Vol. 17 No. 4, pp. 358-376.

Pilkington, A. and Liston-Heyes, C. (1999), "Is production and operations management a discipline? A citation/co-citation study", *International Journal of Operations & Production Management*, Vol. 19 No. 1, pp. 7-20.

Pittet, D., Monod, M., Suter, P. M., Frenk, E. and Auckenthaler, R. (1994), "Candida colonization and subsequent infections in critically ill surgical patients", *Annals of Surgery*, Vol. 220 No. 6, pp. 751.

Ponomarov, S.Y. and Holcomb, M.C. (2009), "Understanding the concept of supply chain resilience", *International Journal of Logistics Management, The*, Vol. 20 No. 1, pp. 124-143.

Porter, M.E. (1980), *Competitive Strategy. Techniques for Analyzing Industries and Competitors*. Free Press, New York.

Powell, C. (2003), "The Delphi technique: myths and realities", *Journal of Advanced Nursing,* Vol. 41 No. 4, pp. 376-382.

Power, D. (2005), "Supply chain management integration and implementation: a literature review", *Supply Chain Management: An International Journal,* Vol. 10, No. 4, pp. 252-263.

Pramatari, K. (2007), "Collaborative supply chain practices and evolving technological approaches", *Supply Chain Management: An International Journal*, Vol. 12 No. 3, pp. 210-220.

Prencipe, A. (1997), "Technological competencies and product's evolutionary dynamics a case study from the aero-engine industry", *Research Policy*, Vol. 25 No. 8, pp. 1261-76.

Prockl, G. (2005), "Supply Chain Diagnostics to Confront Theory and Practice – Re-questioning the Core of Supply Chain Management", in Kotzab, H., Seuring, S., Müller, M. and Reiner, G. (Eds.), *Research Methodologies in Supply Chain Management,* Physica-Verlag, Heidelberg, pp. 398-412.

Quinn, J.B. (1999), "Strategic outsourcing: leveraging knowledge capabilities", *Sloan management review*, Vol. 40 No. 4, pp. 9-21.

Rai, A., Patnayakuni, R. and Seth, N. (2006), "Firm performance impacts of digitally enabled supply chain integration capabilities", *MIS Quarterly*, Vol. 30 No. 2, pp. 225-246.

Rao, S. and Goldsby, T.J. (2009), "Supply chain risks: a review and typology", *International Journal of Logistics Management,* Vol. 20 No. 1, pp. 97-123.

Rauch, W. (1979), "The decision Delphi", *Technological Forecasting and Social Change*, Vol. 15 No. 3, pp. 159-169.

Rayens, M.K. and Hahn, E.J. (2000), "Building consensus using the policy Delphi method", *Policy, Politics, & Nursing Practice*, Vol. 1 No. 4, pp. 308-315.

Reichhart, A. and Holweg, M. (2007), "Creating the customer-responsive supply chain: a reconciliation of concepts", *International Journal of Operations & Production Management*, Vol. 27 No. 11, pp. 1144-1172.

Reid, N.G. (1988), "The Delphi technique, its contributions to the evaluation of professional practice", in Ellis, R. (Ed.), *Professional Competence and Quality Assurance in the Caring Professions,* Chapman & Hall, London, pp. 230-262.

Revelle, W. (1979), "Hierarchical cluster analysis and the internal structure of tests", *Multivariate Behavioral Research,* Vol. 14 No. 1, pp. 57-75.

Rice, W.R. (1989), "Analyzing tables of statistical tests", *Evolution*, pp. 223-225.

Riggs, W.E. (1983), "The Delphi technique: an experimental evaluation", *Technological Forecasting and Social Change*, Vol. 23, pp. 89-94.

Robins, F. (2006), "The challenge of TBL: a responsibility to whom?", *Business and Society Review*, Vol. 111 No. 1, pp. 1-14.

Rodriguez Cano, C., Carrillat, F.A. and Jaramillo, F. (2004), "A meta-analysis of the relationship between market orientation and business performance: evidence from five continents", *International Journal of Research in Marketing*, Vol. 21 No. 2, pp. 179-200.

Ross, J.W., Beath, C.M. and Quaadgras, A. (2013), "You May Not Need Big Data After All", *Harvard Business Review*, Vol. 91 No. 12, pp. 90-98.

Rousseau, D.M. (2006), "Is there such a thing as "evidence-based management"?", *Academy of Management Review*, Vol. 31 No. 2, pp. 256-269.

Rousseau, D.M., Manning, J. and Denyer, D. (2008), "Evidence in Management and Organizational Science: Assembling the Field's Full Weight of Scientific Knowledge Through Syntheses", *The Academy of Management Annals*, Vol. 2 No. 1, pp. 475-515.

Routledge, R. (1998), "Fisher's exact test", in Armitage P. and Colton T. (Eds.), *Encyclopedia of Biostatistics (Vol. 2)*, John Wiley Publishing, New York, pp. 1519-1523.

Rowe, G., Wright, G. and Bolger, F. (1991), "Delphi: a reevaluation of research and theory", *Technological Forecasting and Social Change*, Vol. 39 No. 3, pp. 235-251.

Rowe, G. and Wright, G. (1999), "The Delphi technique as a forecasting tool: issues and analysis", *International Journal of Forecasting*, Vol. 15 No. 4, pp. 353-375.

Rowe, G. and Wright, G. (2011), "The Delphi technique: Past, present, and future prospects—Introduction to the special issue", *Technological Forecasting and Social Change*, Vol. 78 No. 9, pp. 1487-1490.

Rowley, T.J. (1997), "Moving beyond dyadic ties: A network theory of stakeholder influences", *Academy of Management Review*, Vol. 22 No. 4, pp. 887-910.

Rubenstein-Montano, B., Liebowitz, J., Buchwalter, J., McCaw, D., Newman, B. and Rebeck, K. (2001), "A systems thinking framework for knowledge management", *Decision Support Systems,* Vol. 31 No. 1, pp. 5-16.

Sabath, R.E. and Fontanella, J. (2002), "The unfulfilled promise of supply chain collaboration", *Supply Chain Management Review*, Vol. 6 No. 4 (July/Aug. 2002), pp. 24-29.

Sachan, A. and Datta, S. (2005), "Review of supply chain management and logistics research", *International Journal of Physical Distribution & Logistics Management*, Vol. 35 No. 9, pp. 664-705.

Sahay, B.S. and Ranjan, J. (2008), "Real-time business intelligence in supply chain analytics," *Information Management & Computer Security*, Vol. 16 No. 1, pp. 28-48.

Sanders, N.R. and Premus, R. (2005), "Modeling the relationship between firm IT capability, collaboration, and performance", *Journal of Business Logistics*, Vol. 26 No. 1, pp. 1-23.

Sarac, A., Absi, N. and Dauzère-Pérès, S. (2010), "A literature review on the impact of RFID technologies on supply chain management", *International Journal of Production Economics*, Vol. 128 No. 1, pp. 77-95.

Sarkis, J., Helms, M.M. and Hervani, A.A. (2010), "Reverse logistics and social sustainability", *Corporate Social Responsibility and Environmental Management*, Vol. 17, pp. 337-54.

Sarkis, J., Zhu, Q. and Lai, K.-H. (2011), "An organizational theoretic review of green supply chain management literature", *International Journal of Production Economics*, Vol. 130, pp. 1-15.

Saunders, J.A. (1980), "Cluster analysis for market segmentation", *European Journal of Marketing,* Vol. 14 No. 7, pp. 422-36.

Savaskan, R.C., Bhattacharya, S. and van Wassenhove, L.N. (2004), "Closed-loop supply chain models with product remanufacturing", *Management Science*, Vol. 50 No. 2, pp. 239-252.

Saxena, R. and Srinivasan, A. (2013), "A Framework for Business Analytics", in *Business Analytics,* Springer, New York, NY, pp. 1-7.

Schmenner, R.W. and Swink, M.L. (1998), "On theory in operations management", *Journal of Operations Management*, Vol. 17 No. 1. pp. 97-113.

Schmidt, R.C. (1997), "Managing Delphi surveys using nonparametric statistical techniques", *Decision Sciences*, Vol. 28 No. 3, pp. 763-774.

Schoenherr, T. (2009), "Logistics and supply chain management applications within a global context: an overview", *Journal of Business Logistics*, Vol. 30 No. 2, pp. 1-25.

Seaker, R.F., Waller, M.A. and Dunn, S.C. (1993), "A note on research methodology in business logistics", *Logistics and Transportation Review*, Vol. 29 No. 4, pp. 383-387.

Searcy, D.L. and Mentzer, J.T. (2003), "A framework for conducting and evaluating research", *Journal of Accounting Literature*, Vol. 22, pp. 130-167.

Selviaridis, K. and Spring, M. (2007), “Third party logistics: a literature review and research agenda”, *International Journal of Logistics Management,* Vol. 18 No. 1, pp. 125-150.

Sereetrakul, W., Wongveeravuti, S. and Likitapiwat, T. (2013), “Gender differences in saving and spending behaviours of Thai students”, *Research in Education*, Vol. 90 No. 1, pp. 68-81.

Seuring, S. (2008), “Assessing the rigor of case study research in supply chain management”, *Supply Chain Management: An International Journal*, Vol. 13 No. 2, pp. 128-137.

Seuring, S. (2009), “The product-relationship-matrix as framework for strategic supply chain design based on operations theory”, *International Journal of Production Economics*, Vol. 120 No. 1, pp. 221-232.

Seuring, S. and Gold, S. (2012), “Conducting content-analysis based literature reviews in supply chain management”, *Supply Chain Management: An International Journal*, Vol. 17 No. 5, pp. 544-555.

Seuring, S. and Müller, M. (2008a), “From a literature review to a conceptual framework for sustainable supply chain management”, *Journal of Cleaner Production*, Vol. 16 No. 15, pp. 1699-1710.

Seuring, S. and Müller, M. (2008b), “Core issues in sustainable supply chain management–a Delphi study”, *Business Strategy and the Environment*, Vol. 17 No. 8, pp. 455-466.

Sharif, A.M. and Irani, Z. (2012), “Supply chain leadership”, *International Journal of Production Economics*, Vol. 140 No. 1, pp. 57-68.

Sheffi, Y. (2005), *The resilient enterprise: overcoming vulnerability for competitive advantage*, MIT Press Books, Cambridge, MA.

Shelanski, H.A. and Klein, P.G. (1995), “Empirical research in transaction cost economics: a review and assessment”, *Journal of Law, Economics, & Organization*, pp. 335-361.

Shingo, S. (1989), *A study of the Toyota production system from an industrial engineering viewpoint*, Productivity Press, Cambridge, MA.

Shmueli, G. and Koppius, O. (2010), “Predictive analytics in information systems research”, *Robert H. Smith School Research Paper No. RHS, 06-138.*

Sih, A., Hanser, S.F. and McHugh, K.A. (2009), “Social network theory: new insights and issues for behavioral ecologists”, *Behavioral Ecology and Sociobiology*, Vol. 63 No. 7, pp. 975-988.

Simangunsong, E., Hendry, L.C. and Stevenson, M. (2012), “Supply-chain uncertainty: a review and theoretical foundation for future research”, *International Journal of Production Research*, Vol. 50 No. 16, pp. 4493-4523.

Simmel, G. (1950), *The stranger. The Sociology of Georg Simmel*, Free Press, New York, pp. 402-408.

Simon, H.A. (1959), “Theories of decision-making in economics and behavioral science”, *The American Economic Review*, Vol. 49 No. 3, pp. 253-283.

Skinner, W. (1974), “The focused factory”, *Harvard Business Review*, Vol. 52 No. 3, pp. 113-121.

Skipper, J.B., Craighead, C.W., Byrd, T.A. and Rainer, R.K. (2008), “Towards a theoretical foundation of supply network interdependence and technology-enabled coordination strategies”, *International Journal of Physical Distribution & Logistics Management*, Vol. 38 No. 1, pp. 39-56.

Skjøtt-Larsen, T., Schary, P.B., Mikkola, J.H. and Kotzab, H. (2007), *Managing the global supply chain*, Copenhagen Business School Press, Copenhagen.

Skjøtt-Larsen, T., Thernøe, C. and Andresen, C. (2003), "Supply chain collaboration: theoretical perspectives and empirical evidence", *International Journal of Physical Distribution & Logistics Management*, Vol. 33 No. 6, pp. 531-549.

Slone, R.E., Mentzer, J.T., and Dittmann, J.P. (2007), "Are you the weakest link in your company's supply chain?", *Harvard Business Review*, Vol. 85 No. 9, pp. 116.

Smith, G.E., Watson, K.J., Baker, W.H. and Pokorski Ii, J.A. (2007), "A critical balance: collaboration and security in the IT-enabled supply chain", *International Journal of Production Research*, Vol. 45 No. 11, pp. 2595-2613.

Solem, O. (2003), "Epistemology and logistics. A critical overview", *Systemic Practice and Action Research*, Vol. 16 No. 6, pp. 437-454.

Sommerville, I. and Kotonya, G. (1998), *Requirements engineering: processes and techniques,* John Wiley & Sons, Chichester, UK.

Spekman, R.E., Kamauff Jr, J.W. and Myhr, N. (1998), "An empirical investigation into supply chain management: a perspective on partnerships", *Supply Chain Management: An International Journal*, Vol. 3 No. 2, pp. 53-67.

Spekman, R.E., Spear, J. and Kamauff, J. (2002), "Supply chain competency: learning as a key component", *Supply Chain Management: An International Journal*, Vol. 7 No. 1, pp. 41-55.

Spiegler, I. (2003), "Technology and knowledge: bridging a "generating" gap", *Information & Management*, Vol. 40 No. 6, pp. 533-539.

Sridhar, V. and Raja, S.R. (2014), "SMAC: Social, Mobile, Analytics, and Cloud", paper presented at *Sixth International Conference on Communication Systems and Networks (COMSNETS)*, January 2014, pp. 1-3.

Stadtler, H. (2005), "Supply chain management and advanced planning - basics, overview and challenges", *European Journal of Operational Research*, Vol. 163 No. 3, pp. 575-588.

Stalk, G. and Hout, T. (1990), *"Competing Against Time",* Free Press, New York.

Starkey, K., Hatchuel, A. and Tempest, S. (2009), "Management research and the new logics of discovery and engagement", *Journal of Management Studies*, Vol. 46 No. 3, pp. 547-558.

Starkey, K. and Madan, P. (2001), "Bridging the relevance gap: aligning stakeholders in the future of management research", *British Journal of Management*, Vol. 13 No. 3, pp. 3-26.

Stevens, G.C. (1989), "Integrating the supply chain", *International Journal of Physical Distribution & Logistics Management*, Vol. 19 No. 8, pp. 3-8.

Stevenson, M. and Spring, M. (2007), "Flexibility from a supply chain perspective: definition and review", *International Journal of Operations & Production Management*, Vol. 27 No. 7, pp. 685-713.

Stewart, G. (1997), "Supply-chain operations reference model (SCOR): the first cross-industry framework for integrated supply-chain management", *Logistics Information Management,* Vol. 10 No. 2, pp. 62-67.

Stock, J.R. (1997), "Applying Theories from Other Disciplines to Logistics", *International Journal of Physical Distribution & Logistics Management*, Vol. 27 No. 9/10, pp. 515-539.

Stock, J.R. and Boyer, S.L. (2009), "Developing a consensus definition of supply chain management: a qualitative study", *International Journal of Physical Distribution & Logistics Management*, Vol. 39 No. 8, pp. 690-711.

Stock, J.R., Boyer, S.L. and Harmon, T. (2010), "Research opportunities in supply chain management", *Journal of the Academy of Marketing Science*, Vol. 38 No. 1, pp. 32-41.

Storey, J., Emberson, C., Godsell, J. and Harrison, A. (2006), "Supply chain management: theory, practice and future challenges", *International Journal of Operations & Production Management*, Vol. 26 No. 7, pp. 754-774.

Stuart, I., McCutcheon, R., Handfield, R., McLachlin, R. and Samson, D. (2002), "Effective case research in operations management: a process perspective", *Journal of Operations Management*, Vol. 20 No. 5, pp. 419-433.

Subramani, M. (2004), "How do suppliers benefit from information technology use in supply chain relationships?", *MIS Quarterly*, pp. 45-73.

Sutton, R.I. and Staw, B.M. (1995), "What theory is not", *Administrative Science Quarterly*, pp. 371-384.

Sweeney, E. (2013), "The People Dimension in Logistics and Supply Chain Management – its Role and Importance", in Passaro, R. and Thomas, A. (Eds), *Supply Chain Management: Perspectives, Issues and Cases*, McGraw-Hill, Milan, pp. 73-82.

Swink, M. and Way, M. (1995), "Manufacturing strategy: propositions, current research, renewed directions", *International Journal of Operations & Production Management*, Vol. 15 No. 7, pp. 4-26.

Tan, K.C., Kannan, V.R., Handfield, R.B. and Ghosh, S. (1999), "Supply chain management: an empirical study of its impact on performance", *International Journal of Operations & Production Management*, Vol. 19 No. 10, pp. 1034-1052.

Tang, C.S. (2006), "Perspectives in supply chain risk management," *International Journal of Production Economics*, Vol. 103 No. 2, pp. 451-488.

Tang, O. and Nurmaya Musa, S. (2011), "Identifying risk issues and research advancements in supply chain risk management", *International Journal of Production Economics*, Vol. 133 No. 1, pp. 25-34.

Tausczik, Y.R. and Pennebaker, J.W. (2010), "The Psychological Meaning of Words: LIWC and Computerized Text Analysis Methods", *Journal of Language and Social Psychology*, Vol. 29 No.1, pp. 24-54.

Tavares Thomé, A.M., Scavarda, L.F., Fernandez, N.S. and Scavarda, A.J. (2012), "Sales and operations planning: A research synthesis", *International Journal of Production Economics*, Vol. 138 No. 1, pp. 1-13.

Taylor, F.W. (1911), *The principles of scientific management,* Cosimo, New York, pp. 3-4 (reprint, originally published by Harper & Brothers, London, England).

Taylor, F.W. (1914), "Scientific management", *The Sociological Review*, Vol. 7 No. 3, pp. 266-269.

Teece, D.J. (2007), "Explication Dynamic Capabilities: The Nature and Microfoundations of (Sustainable) Enterprise Performance", *Strategic Management Journal*, Vol. 28, pp. 1379-1350.

ten Hompel, M. (2010), Individualisierung als logistisch-technisches Prinzip, in Günthner, W. and ten Hompel, M. (Eds.), *Internet der Dinge in der Intralogistik (The Internet of Things in an intralogistics setup),* Springer, Berlin, pp. 3-7.

Terpend, R., Tyler, B.B., Krause, D.R. and Handfield, R.B. (2008), "Buyer–supplier relationships: derived value over two decades", *Journal of Supply Chain Management*, Vol. 44, No 2, pp. 28-55.

Thomas, R.M. (2003), *Blending Qualitative and Quantitative Research Methods in Theses and Dissertations*, Corwin Press, Thousand Oaks, CA.

Thompson, J.D. (1967), *Organizations in action,* McGraw Hill, New York.

Thonemann, U.W. (2002), "Improving supply-chain performance by sharing advance demand information", *European Journal of Operational Research*, Vol. 142 No. 1, pp. 81-107.

Thorelli, H.B. (1986), "Networks, between markets and hierarchies", *Strategic Management Journal*, Vol. 7 No. 1, pp. 37-51.

Tichy, G. (2001), "The decision Delphi as a tool of technology policy-the Austrian experience", *International Journal of Technology Management*, Vol. 21 No. 7, pp. 756-766.

Tokman, M. and Beitelspacher, L.S. (2011), "Supply chain networks and service-dominant logic: suggestions for future research", *International Journal of Physical Distribution & Logistics Management,* Vol. 41 No. 7, pp. 717-726.

Towill, D.R. (1996), "Time compression and supply chain management: a guided tour", *Supply Chain Management,* Vol. 1 No. 1, pp. 15-27.

Towill, D.R. (1997), "The seamless supply chain: the predator's strategic advantage", *International Journal of Technology Management*, Vol. 13 No. 1, pp. 37-56.

Towill, D. and Christopher, M. (2002), "The supply chain strategy conundrum: to be lean or agile or to be lean and agile?", *International Journal of Logistics*, Vol. 5 No. 3, pp. 299-309.

Tracey, M., Vonderembse, M.A. and Lim, J.S. (1999), "Manufacturing Technology and strategy formulation: keys to enhancing competitiveness and improving performance", *Journal of Operations Management*, Vol. 17, No. 4, pp. 411-28.

Tranfield, D., Denyer, D. and Smart, P. (2003), "Towards a methodology for developing evidence-informed management knowledge by means of systematic review", *British Journal of Management*, Vol. 14 No. 3, pp. 207-222.

Trent, R.J. (2004), "What everyone needs to know about SCM", *Supply Chain Management Review*, Vol. 8 No. 2 (March 2004), pp. 52-59.

Trkman, P., McCormack, K., De Oliveira, M.P.V. and Ladeira, M.B. (2010), "The impact of business analytics on supply chain performance", *Decision Support Systems*, Vol. 49 No. 3, pp. 318-327.

Turner, V., Reinsel, D., Gantz, J.F. and Minton, S. (2014), "The Digital Universe of Opportunities: Rich Data and the Increasing Value of the Internet of Things", available at: http://idcdocserv.com/1678 (accessed November 18th, 2014).

Turoff, M. (1970), "The design of a policy Delphi", *Technological Forecasting and Social Change*, Vol. 2 No. 2, pp. 149-171.

Upton, G.J. (1992), "Fisher's exact test", *Journal of the Royal Statistical Society. Series A. Statistics in Society*, Vol. 155 No. 3, pp. 395-402.

Vachon, S. and Klassen, R.D. (2008), "Environmental management and manufacturing performance: the role of collaboration in the supply chain", *International Journal of Production Economics*, Vol. 111 No. 2, pp. 299-315.

Van der Vaart, T. and van Donk, D.P. (2008), "A critical review of survey-based research in supply chain integration", *International Journal of Production Economics*, Vol. 111 No. 1, pp. 42-55.

Van Dijk, J.A. (1990), "Delphi questionnaires versus individual and group interviews: A comparison case", *Technological Forecasting and Social Change*, Vol. 37 No. 3, pp. 293-304.

Van Hoek, R.I. (1998), "Reconfiguring the supply chain to implement postponed Manufacturing", *International Journal of Logistics Management,* Vol. 9, No. 1, pp. 95-110.

Van Hoek, R.I. (2001), "The rediscovery of postponement a literature review and directions for research", *Journal of Operations Management*, Vol. 19 No. 2, pp. 161-184.

Van Hoek, R.I., Ellinger, A.E. and Johnson, M. (2008), "Great divides: internal alignment between logistics and peer functions", *International Journal of Logistics Management*, Vol. 19 No. 2, pp. 110-129.

Van Zolingen, S.J. and Klaassen, C.A. (2003), "Selection processes in a Delphi study about key qualifications in Senior Secondary Vocational Education", *Technological Forecasting and Social Change*, Vol.70, pp. 317-340.

Venkatraman, N. (1994), "IT-enabled business transformation: from automation to business scope redefinition", *Sloan Management Review*, Vol. 35, pp. 73-73.

Vickery, S.K., Jayaram, J., Droge, C. and Calantone, R. (2003), "The effects of an integrative supply chain strategy on customer service and financial performance: an analysis of direct versus indirect relationships", *Journal of Operations Management*, Vol. 21 No. 5, pp. 523-539.

Visich, J.K., Li, S., Khumawala, B.M. and Reyes, P.M. (2009), "Empirical evidence of RFID impacts on supply chain performance", *International Journal of Operations & Production Management*, Vol. 29, No. 12, pp. 1290-1315.

Vonderembse, M.A., Uppal, M., Huang, S.H. and Dismukes, J.P. (2006), "Designing supply chains: Towards theory development", *International Journal of Production Economics*, Vol. 100 No. 2, pp. 223-238.

Von der Gracht, H.A. and Darkow, I.L. (2010), "Scenarios for the logistics services industry: a Delphi-based analysis for 2025", *International Journal of Production Economics,* Vol. 127 No. 1, pp. 46-59.

Von Neumann, J. and Morgenstern, O. (1945), "Theory of games and economic behavior", *Bulletin of the American Mathematical Society*, Vol. 51, pp. 498-504.

Wagner, S.M. and Bode, C. (2008), "An empirical examination of supply chain performance along several dimensions of risk", *Journal of Business Logistics*, Vol. 29 No. 1, pp. 307-325.

Waller, D.L. and Waller, D.L. (1999), *Operations management: a supply chain approach*, International Thomson Business Press, London.

Waller, M.A. and Fawcett, S.E. (2013), "Data Science, Predictive Analytics, and Big Data: A Revolution That Will Transform Supply Chain Design and Management", *Journal of Business Logistics*, Vol. 34 No. 2, pp. 77-84.

Walton, S.V., Handfield, R.B. and Melnyk, S.A. (1998), "The green supply chain: integrating suppliers into environmental management processes", *Journal of Supply Chain Management*, Vol. 34 No. 2, pp. 2-11.

Waters-Fuller, N. (1995), "Just-in-time purchasing and supply: a review of the literature", *International Journal of Operations & Production Management*, Vol.15 No. 9, pp. 220-236.

Weick, K.E. (1989), "Theory construction as disciplined imagination", *Academy of Management Review*, Vol. 14 No. 4, pp. 516-531.

Weick, K.E. (1995), "What theory is not, theorizing Is", *Administrative Science Quarterly*, Vol. 40 No. 3, pp. 385–390.

Weick, K.E. (2001), "Gapping the relevance bridge: fashions meet fundamentals in management research", *British Journal of Management*, Vol. 12 No. 3, pp. 71-75.

Weimer, G. and Seuring, S. (2009), "Performance measurement in business process outsourcing decisions: Insights from four case studies", *Strategic Outsourcing: An International Journal*, Vol. 2 No. 3, pp. 275-292.

Westbrook, R. (1995), "Action research: a new paradigm for research in production and operations management", *International Journal of Operations & Production Management*, Vol. 5 No. 12, pp. 6-20.

Westhaus, M. and Seuring, S. (2005), "Zum Begriff des Supply Chain Controlling– Ergebnisse einer Delphi-Studie (The concept of Supply Chain Controlling–A Delphi study), *Logistik Management,* Vol. 7 No. 2, pp. 43-54.

Williams, B.D. and Tokar, T. (2008), "A review of inventory management research in major logistics journals: Themes and future directions"*, The International Journal of Logistics Management*, Vol. 19 No. 2, pp. 212-232.

Williams, Z., Lueg, J.E. and LeMay, S.A. (2008), "Supply chain security: an overview and research agenda", *International Journal of Logistics Management*, Vol. 19 No. 2, pp. 254-281.

Williams, P.L. and Webb, C. (1994), "The Delphi technique: a methodological discussion", *Journal of Advanced Nursing*, Vol. 19 No. 1, pp. 180-186.

Williamson, O.E. (1981), "The economics of organization: The transaction cost approach", *American Journal of Sociology*, pp. 548-577.

Wilson, E.O. (1998), *Consilience: The unity of knowledge,* Random House Publishing, New York.

Womack, J.P., Jones, D.T. and Reos, P. (1990), *The machine that changed the world,* Macmillan, New York.

Womack, J.P. and Jones, D.T. (1996), *Lean Thinking*, Simon and Schuster, New York.

Wong, C., Skipworth, H., Godsell, J. and Achimugu, N. (2012), "Towards a theory of supply chain alignment enablers: a systematic literature review", *Supply Chain Management: An International Journal*, Vol. 17 No. 4, pp. 419-437.

Woudenberg, F. (1991), "An evaluation of Delphi", *Technological Forecasting and Social Change*, Vol. 40 No. 2, pp. 131-150.

Wu, F., Yeniyurt, S., Kim, D. and Cavusgil, S.T. (2006), "The impact of information technology on supply chain capabilities and firm performance: a resource-based view", *Industrial Marketing Management*, Vol. 35 No. 4, pp. 493-504.

Wynstra, F. and Pierick, E.T. (2000), "Managing supplier involvement in new product development: a portfolio approach", *European Journal of Purchasing and Supply Management*, Vol. 6 No. 1, pp. 49-57.

Yang, B., Burns, N.D. and Backhouse, C.J. (2004), "Postponement: a review and an integrated framework", *International Journal of Operations & Production Management*, Vol. 24 No. 5, pp. 468-487.

Yin, R.K. (2013). *Case study research: Design and methods*. 5rd edition, Sage Publications, Thousand Oaks, CA.

Yin, R.K. (2011), *Applications of case study research,* Sage Publications, Thousand Oaks, CA.

Yiu, C. (2012), "The Big Data Opportunity: Making Government faster, smarter and more personal", *Policy Exchange*, pp. 1-36.

Yin, Y., Liu, C. and Kaku, I. (2011), "Cooperation and leadership policies in a serial supply chain", *Journal of Manufacturing Systems,* Vol. 30 No. 1, pp. 1-7.

Yoho, K. and Simons, S. (2013), "The Theory of Entrepreneurial Policy Alignment: A Newer Institutional Economics", *Journal of Operations and Supply Chain Management*, Vol. 5 No. 2.

Youn, S., Yang, M.G. and Hong, P. (2012), "Integrative leadership for effective supply chain implementation: An empirical study of Korean firms", *International Journal of Production Economics*, Vol. 139 No. 1, pp. 237-246.

Yousuf, M.I. (2007), "Using experts' opinions through Delphi technique", *Practical Assessment, Research & Evaluation*, Vol. 12 No. 4, pp. 1-8.

Zacharia, Z.G., Sanders, N.R. and Fugate, B.S. (2014), "Evolving functional perspectives within supply chain management", *Journal of Supply Chain Management*, Vol. 50 No. 1, pp. 73-88.

Zachariassen, F. and Arlbjørn, J.S. (2010), "Doctoral dissertations in logistics and supply chain management: A review of Nordic contributions from 2002 to 2008", *International Journal of Physical Distribution & Logistics Management*, Vol. 40 No. 4, pp. 332-352.

Zelbst, P.J., Green, K.W., Sower, V.E. and Abshire, R.D. (2011), "Radio Frequency Identification Technology Utilization and Organizational Agility", *The Journal of Computer Information Systems*, Vol. 52 No. 1, pp. 24-33.

Zhang, X., van Donk, D.P. and van der Vaart, T. (2011), "Does ICT influence supply chain management and performance?: A review of survey-based research", *International Journal of Operations & Production Management*, Vol. 31 No. 11, pp. 1215-1247.

Zhou, H. and Benton Jr, W.C. (2007), "Supply chain practice and information sharing", *Journal of Operations Management*, Vol. 25 No. 6, pp. 1348-1365.

Zinn, W. and Goldsby, T.J. (2014), "Logistics Professional Identity: Strengthening the Discipline as Galaxies Collide", *Journal of Business Logistics*, Vol. 35 No. 1, pp. 23-28.

Zikopoulos, P. and Eaton, C. (2011), *"Understanding Big Data: Analytics for enterprise class hadoop and streaming data"*, McGraw-Hill Osborne Media, New York.

Zsidisin, G.A. and Ellram, L.M. (2003), "An Agency Theory Investigation of Supply Risk Management", *Journal of Supply Chain Management*, Vol. 39 No. 3, pp. 15-27.

Appendices

Appendix A: List of the 103 reference papers contained in the literature review

[1] Abbasi, M. and Nilsson, F. (2012), “Themes and challenges in making supply chains environmentally sustainable”, *Supply Chain Management: An International Journal*, Vol. 17 No. 5, pp. 517-530.

[2] Afshin Mansouri, S., Gallear, D. and Askariazad, M.H. (2012), “Decision support for build-to-order supply chain management through multiobjective optimization”, *International Journal of Production Economics*, Vol. 135 No. 1, pp. 24-36.

[3] Anderson, J.C., Cleveland, G. and Schroeder, R.G. (1989), “Operations strategy: a literature review”, *Journal of Operations Management*, Vol. 8 No. 2, pp. 133-158.

[4] Aronsson, H. and Brodin, M.H. (2006), “The environmental impact of changing logistics structures”, *International Journal of Logistics Management*, Vol. 17 No. 3, pp. 394-415.

[5] Akyuz, G.A. and Erkan, T.E. (2010), “Supply chain performance measurement: a literature review”, *International Journal of Production Research*, Vol. 48 No. 17, pp. 5137-5155.

[6] Ashby, A., Leat, M. and Hudson-Smith, M. (2012), “Making connections: a review of supply chain management and sustainability literature*”, Supply Chain Management: An International Journal*, Vol. 17 No. 5, pp. 497-516.

[7] Atasu, A., Guide, V.D.R. and Wassenhove, L.N. (2008), “Product Reuse Economics in Closed-Loop Supply Chain Research”, *Production and Operations Management*, Vol. 17 No. 5, pp. 483-496.

[8] Babbar, S. and Prasad, S. (1998a), “International purchasing, inventory management and logistics research: an assessment and agenda”, *International Journal of Operations & Production Management*, Vol. 18 No. 1, pp. 6-36.

[9] Babbar, S. and Prasad, S. (1998b), “International purchasing, inventory management and logistics research: an assessment and agenda”, *International Journal of Physical Distribution & Logistics Management*, Vol. 28 No. 6, pp. 403-433.

[10] Beamon, B.M. (1998), “Supply chain design and analysis: Models and methods”, *International Journal of Production Economics*, Vol. 55 No. 3, pp. 281-294.

[11] Blankley, A. (2008), “A conceptual model for evaluating the financial impact of supply chain management technology investments”, *International Journal of Logistics Management*, Vol. 19 No. 2, pp. 155-182.

[12] Boone, C.A., Craighead, C.W. and Hanna, J.B. (2007), “Postponement: an evolving supply chain concept”, *International Journal of Physical Distribution & Logistics Management*, Vol. 37 No. 8, pp. 594-611.

[13] Burgess, K., Singh, P.J. and Koroglu, R. (2006), “Supply chain management: a structured literature review and implications for future research”, *International Journal of Operations & Production Management*, Vol. 26 No. 7, pp. 703-729.

[14] Cantor, D.E. (2008), “Workplace safety in the supply chain: a review of the literature and call for research”, *International Journal of Logistics Management,* Vol. 19 No. 1, pp. 65-83.

[15] Caridi, M., Cigolini, R. and De Marco, D. (2005), "Improving supply-chain collaboration by linking intelligent agents to CPFR", *International Journal of Production Research*, Vol. 43 No. 20, pp. 4191-4218.

[16] Carter, C.R. and Easton, P.L. (2011), "Sustainable supply chain management: evolution and future directions", *International Journal of Physical Distribution & Logistics Management*, Vol. 41 No. 1, pp. 46-62.

[17] Carter, C.R. and Ellram, L.M. (2003), "Thirty-Five Years of The Journal of Supply Chain Management: Where Have We Been and Where are We Going?", *Journal of Supply Chain Management*, Vol. 39 No. 2, pp. 27-39.

[18] Carter, C.R., Kaufmann, L. and Michel, A. (2007), "Behavioral supply management: a taxonomy of judgment and decision-making biases", *International Journal of Physical Distribution & Logistics Management*, Vol. 37 No. 8, pp. 631-669.

[19] Carter, C.R. and Rogers, D.S. (2008), "A framework of sustainable supply chain management: moving toward new theory", *International Journal of Physical Distribution & Logistics Management*, Vol. 38 No. 5, pp. 360-387.

[20] Chan, H.K. and Chan, F.T. (2010), "A review of coordination studies in the context of supply chain dynamics", *International Journal of Production Research*, Vol. 48 No. 10, pp. 2793-2819.

[21] Charvet, F.F., Cooper, M.C. and Gardner, J.T. (2008), "The intellectual structure of supply chain management: a bibliometric approach", *Journal of Business Logistics*, Vol. 29 No. 1, pp. 47-73.

[22] Cheng, L.C.V. and Grimm, C. M. (2006), "The application of empirical strategic management research to supply chain management", *Journal of Business Logistics*, Vol. 27 No. 1, pp. 1-55.

[23] Chicksand, D., Watson, G., Walker, H., Radnor, Z. and Johnston, R. (2012), "Theoretical perspectives in purchasing and supply chain management: an analysis of the literature", *Supply Chain Management: An International Journal*, Vol. 17 No. 4, pp. 454-472.

[24] Choi, T.Y. and Wacker, J.G. (2011), "Theory building in the OM/SCM field: pointing to the future by looking at the past", *Journal of Supply Chain Management*, Vol. 47 No. 2, pp. 8-11.

[25] Colicchia, C. and Strozzi, F. (2012), "Supply chain risk management: a new methodology for a systematic literature review", *Supply Chain Management: An International Journal*, Vol. 17 No. 4, pp. 403-418.

[26] Crum, M.R. and Poist, R.F. (2011), "IJPDLM's 40th anniversary: an overview and retrospective analysis", *International Journal of Physical Distribution & Logistics Management*, Vol. 41 No. 1, pp. 5-15.

[27] Dasaklis, T.K., Pappis, C.P. and Rachaniotis, N.P. (2012), "Epidemics control and logistics operations: A review", *International Journal of Production Economics*, Vol. 139 No. 2, pp. 393-410.

[28] Defee, C.C., Williams, B., Randall, W.S. and Thomas, R. (2010), "An inventory of theory in logistics and SCM research", *International Journal of Logistics Management*, Vol. 21 No. 3, pp. 404-489.

[29] Delbufalo, E. (2012), "Outcomes of inter-organizational trust in supply chain relationships: a systematic literature review and a meta-analysis of the empirical evidence", *Supply Chain Management: An International Journal*, Vol. 17 No. 4, pp. 377-402.

[30] Ellis, S.C., Shockley, J. and Henry, R.M. (2011), "Making sense of supply disruption risk research: A conceptual framework grounded in enactment theory", *Journal of Supply Chain Management*, Vol. 47 No. 2, pp. 65-96.

[31] Fabbe-Costes, N. and Jahre, M. (2007), "Supply chain integration improves performance: the Emperor's new suit?", *International Journal of Physical Distribution & Logistics Management*, Vol. 37 No. 10, pp. 835-855.

[32] Fabbe-Costes, N. and Jahre, M. (2008), "Supply chain integration and performance: a review of the evidence", *International Journal of Logistics Management*, Vol. 19 No. 2, pp. 130-154.

[33] Fayezi, S., O'Loughlin, A. and Zutshi, A. (2012), "Agency theory and supply chain management: a structured literature review", *Supply Chain Management: An International Journal*, Vol. 17 No. 5, pp. 556-570.

[34] Frankel, R., Naslund, D. and Bolumole, Y. (2005), "The "white space" of logistics research: a look at the role of methods usage", *Journal of Business Logistics*, Vol. 26 No. 2, pp. 185-209.

[35] Ghadge, A., Dani, S. and Kalawsky, R. (2012), "Supply chain risk management: present and future scope", *International Journal of Logistics Management*, Vol. 23 No. 3, pp. 313-339.

[36] Giménez, C. and Lourenço, H.R. (2008), "e-SCM: internet's impact on supply chain processes", *International Journal of Logistics Management*, Vol. 19 No. 3, pp. 309-343.

[37] Giménez, C. and Tachizawa, E.M. (2012), "Extending sustainability to suppliers: a systematic literature review", *Supply Chain Management: An International Journal*, Vol. 17 No. 5, pp. 531-543.

[38] Giunipero, L.C., Hooker, R.E., Sacha, J.M., Yoon, T.E. and Brudvig, S. (2008), "A decade of SCM literature: past, present and future implications", *Journal of Supply Chain Management*, Vol. 44 No. 4, pp. 66-86.

[39] Gligor, D.M. and Holcomb, M.C. (2012), "Understanding the role of logistics capabilities in achieving supply chain agility: a systematic literature review", *Supply Chain Management: An International Journal*, Vol. 17 No. 4, pp. 438-453.

[40] Glock, C.H. (2012), "The joint economic lot size problem: A review", *International Journal of Production Economics*, Vol. 135 No. 2, pp. 671-686.

[41] Gosling, J. and Naim, M.M. (2009), "Engineer-to-order supply chain management: A literature review and research agenda", *International Journal of Production Economics*, Vol. 122 No. 2, pp. 741-754.

[42] Gravier, M.J. and Farris, M.T. (2008), "An analysis of logistics pedagogical literature: past and future trends in curriculum, content, and pedagogy", *International Journal of Logistics Management*, Vol. 19 No. 2, pp. 233-253.

[43] Greening, P. and Rutherford, C. (2011), "Disruptions and supply networks: a multi-level, multi-theoretical relational perspective", *International Journal of Logistics Management*, Vol. 22 No. 1, pp. 104-126.

[44] Gubi, E., Arlbjørn, J.S. and Johansen, J. (2003), "Doctoral dissertations in logistics and supply chain management: a review of Scandinavian contributions from 1990 to 2001", *International Journal of Physical Distribution & Logistics Management*, Vol. 33 No. 10, pp. 854-885.

[45] Gunasekaran, A. and Kobu, B. (2007), "Performance measures and metrics in logistics and supply chain management: a review of recent literature (1995-2004) for research and applications", *International Journal of Production Research*, Vol. 45 No. 12, pp. 2819-40.

[46] Gunasekaran, A. and Ngai, E.W.T. (2004), "Build-to-order supply chain management: a literature review and framework for development", *Journal of Operations Management*, Vol. 23 No. 5, pp. 423-451.

[47] Gunasekaran, A. and Ngai, E.W.T. (2007), "Knowledge management in 21st century manufacturing", *International Journal of Production Research*, Vol. 45 No. 11, pp. 2391-2418.

[48] Harland, C.M., Lamming, R.C., Walker, H., Phillips, W.E., Caldwell, N.D., Johnsen, T.E., and Zheng, J. (2006), "Supply management: is it a discipline?", *International Journal of Operations & Production Management*, Vol. 26 No. 7, pp. 730-753.

[49] Hassini, E., Surti, C. and Searcy, C. (2012), "A literature review and a case study of sustainable supply chains with a focus on metrics", *International Journal of Production Economics*, Vol. 140 No. 1, pp. 69-82.

[50] Hazen, B.T. and Byrd, T.A. (2012), "Toward creating competitive advantage with logistics information technology", *International Journal of Physical Distribution & Logistics Management*, Vol. 42 No. 1, pp. 8-35.

[51] Hazen, B.T., Hall, D.J. and Hanna, J.B. (2012), "Reverse logistics disposition decision-making: Developing a decision framework via content analysis", *International Journal of Physical Distribution & Logistics Management*, Vol. 42 No. 3, pp. 244-274.

[52] Jain, V., Wadhwa, S. and Deshmukh, S.G. (2009), "Select supplier-related issues in modelling a dynamic supply chain: potential, challenges and direction for future research", *International Journal of Production Research*, Vol. 47 No. 11, pp. 3013-3039.

[53] Jensen, J.K. (2012), "Product carbon footprint developments and gaps", *International Journal of Physical Distribution & Logistics Management*, Vol. 42 No. 4, pp. 338-354.

[54] Jiang, B., Frazier, G.V. and Heiser, D. (2007), "China-related POM research: a literature review and suggestions for future research", *International Journal of Operations & Production Management*, Vol. 27 No. 7, pp. 662-684.

[55] Kanda, A. and Deshmukh, S.G. (2008), „Supply chain coordination: perspectives, empirical studies and research directions", *International journal of production Economics*, Vol. 115 No. 2, pp. 316-335.

[56] Keller, S.B. and Ozment, J. (2009), "Research on personnel issues published in leading logistics journals: what we know and don't know", *International Journal of Logistics Management*, Vol. 20 No. 3, pp. 378-407.

[57] Kleindorfer, P.R., Singhal, K. and Wassenhove, L.N. (2005), "Sustainable operations management", *Production and Operations Management*, Vol. 14 No. 4, pp. 482-492.

[58] Kouvelis, P., Chambers, C. and Wang, H. (2006), "Supply chain management research and production and operations management: review, trends, and opportunities", *Production and Operations Management*, Vol. 15 No. 3, pp. 449-469.

[59] Kremic, T., Tukel, O.I. and Rom, W.O. (2006), "Outsourcing decision support: a survey of benefits, risks, and decision factors", *Supply Chain Management: An International Journal*, Vol. 11 No. 6, pp. 467-482.

[60] Kumar, V. and Kwon, I.W.G. (2004), "A pilot study on normalized weighted approach to citation study: a case of logistics and transportation journals", *International Journal of Physical Distribution & Logistics Management*, Vol. 34 No. 10, pp. 811-826.

[61] Labro, E. (2006), "Is a focus on collaborative product development warranted from a cost commitment perspective?", *Supply Chain Management: An International Journal*, Vol. 11 No. 6, pp. 503-509.

[62] Li, X., Chung, C., Goldsby, T.J. and Holsapple, C.W. (2008), "A unified model of supply chain agility: the work-design perspective", *International Journal of Logistics Management*, Vol. 19 No. 3, pp. 408-435.

[63] Liao-Troth, S., Thomas, S. and Fawcett, S.E. (2012), "Twenty years of IJLM: evolution in research", *International Journal of Logistics Management*, Vol. 23 No. 1, pp. 4-30.

[64] Meixell, M.J. and Norbis, M. (2008), "A review of the transportation mode choice and carrier selection literature", *International Journal of Logistics Management,* Vol. 19 No. 2, pp. 183-211.

[65] Metters, R., Zhao, X., Bendoly, E., Jiang, B. and Young, S. (2010), "'The way that can be told of is not an unvarying way': Cultural impacts on Operations Management in Asia", *Journal of Operations Management*, Vol. 28 No. 3, pp. 177-185.

[66] Miemczyk, J., Johnsen, T.E. and Macquet, M. (2012), "Sustainable purchasing and supply management: a structured literature review of definitions and measures at the dyad, chain and network levels", *Supply Chain Management: An International Journal*, Vol. 17 No. 5, pp. 478-496.

[67] Mills, J., Schmitz, J. and Frizelle, G. (2004), "A strategic review of 'supply networks'", *International Journal of Operations & Production Management*, Vol. 24 No. 10, pp. 1012-1036.

[68] Minner, S. (2003), "Multiple-supplier inventory models in supply chain management: A review", *International Journal of Production Economics*, Vol. 81, pp. 265-279.

[69] Miragliotta, G. (2006), "Layers and mechanisms: A new taxonomy for the bullwhip effect", *International Journal of Production Economics*, Vol. 104 No. 2, pp. 365-381.

[70] Mollenkopf, D., Stolze, H., Tate, W.L. and Ueltschy, M. (2010), "Green, lean, and global supply chains", *International Journal of Physical Distribution & Logistics Management*, Vol. 40 No. 1/2, pp. 14-41.

[71] Naim, M.M. and Gosling, J. (2011), "On leanness, agility and leagile supply chains", *International Journal of Production Economics*, Vol. 131 No. 1, pp. 342-354.

[72] Natarajarathinam, M., Capar, I. and Narayanan, A. (2009), "Managing supply chains in times of crisis: a review of literature and insights", *International Journal of Physical Distribution & Logistics Management*, Vol. 39 No. 7, pp. 535-573.

[73] Pazirandeh, A. (2011), "Sourcing in global health supply chains for developing countries: Literature review and a decision making framework", *International Journal of Physical Distribution & Logistics Management*, Vol. 41 No. 4, pp. 364-384.

[74] Pettit, S. and Beresford, A. (2009), "Critical success factors in the context of humanitarian aid supply chains", *International Journal of Physical Distribution & Logistics Management*, Vol. 39 No. 6, pp. 450-468.

[75] Pilbeam, C., Alvarez, G. and Wilson, H. (2012), "The governance of supply networks: a systematic literature review", *Supply Chain Management: An International Journal*, Vol. 17 No. 4, pp. 358-376.

[76] Rao, S. and Goldsby, T.J. (2009), "Supply chain risks: a review and typology", *International Journal of Logistics Management*, Vol. 20 No. 1, pp. 97-123.

[77] Reichhart, A. and Holweg, M. (2007), "Creating the customer-responsive supply chain: a reconciliation of concepts", *International Journal of Operations & Production Management*, Vol. 27 No. 11, pp. 1144-1172.

[78] Sachan, A. and Datta, S. (2005), "Review of supply chain management and logistics research", *International Journal of Physical Distribution & Logistics Management*, Vol. 35 No. 9, pp. 664-705.

[79] Sarac, A., Absi, N. and Dauzère-Pérès, S. (2010), "A literature review on the impact of RFID technologies on supply chain management", *International Journal of Production Economics*, Vol. 128 No. 1, pp. 77-95.

[80] Sarkis, J., Zhu, Q., Lai, K.-H. (2011), "An organizational theoretic review of green supply chain management literature", *International Journal of Production Economics*, Vol. 130, pp. 1-15.

[81] Schoenherr, T. (2009), "Logistics and supply chain management applications within a global context: an overview", *Journal of Business Logistics*, Vol. 30 No. 2, pp. 1-25.

[82] Scudder, G.D. and Hill, C.A. (1998), "A review and classification of empirical research in operations management", *Journal of Operations Management*, Vol. 16 No. 1, pp. 91-101.

[83] Seuring, S. and Gold, S. (2012), "Conducting content-analysis based literature reviews in supply chain management", *Supply Chain Management: An International Journal*, Vol. 17 No. 5, pp. 544-555.

[84] Selviaridis, K. and Spring, M. (2007), "Third party logistics: a literature review and research agenda", *International Journal of Logistics Management,* Vol. 18 No. 1, pp. 125-150.

[85] Simpson, N.C. and Erenguc, S.S. (1996), "Multiple-stage production planning research: history and opportunities", *International Journal of Operations & Production Management*, Vol. 16 No. 6, pp. 25-40.

[86] Skipper, J.B., Craighead, C.W., Byrd, T.A. and Rainer, R.K. (2008), "Towards a theoretical foundation of supply network interdependence and technology-enabled coordination strategies", *International Journal of Physical Distribution & Logistics Management*, Vol. 38 No. 1, pp. 39-56.

[87] Stevenson, M. and Spring, M. (2007), "Flexibility from a supply chain perspective: definition and review", *International Journal of Operations & Production Management*, Vol. 27 No. 7, pp. 685-713.

[88] Stock, J.R. and Boyer, S.L. (2009), "Developing a consensus definition of supply chain management: a qualitative study", *International Journal of Physical Distribution & Logistics Management*, Vol. 39 No. 8, pp. 690-711.

[89] Tang, O. and Nurmaya Musa, S. (2011), "Identifying risk issues and research advancements in supply chain risk management", *International Journal of Production Economics*, Vol. 133 No. 1, pp. 25-34.

[90] Tavares Thomé, A.M., Scavarda, L.F., Fernandez, N.S. and Scavarda, A.J. (2012), "Sales and operations planning: A research synthesis", *International Journal of Production Economics*, Vol. 138 No. 1, pp. 1-13.

[91] Terpend, R., Tyler, B.B., Krause, D.R. and Handfield, R.B. (2008), "Buyer–supplier relationships: derived value over two decades", *Journal of Supply Chain Management*, Vol. 44 No. 2, pp. 28-55.

[92] Tokman, M. and Beitelspacher, L.S. (2011), "Supply chain networks and service-dominant logic: suggestions for future research", *International Journal of Physical Distribution & Logistics Management*, Vol. 41 No. 7, pp. 717-726.

[93] Van der Vaart, T. and van Donk, D.P. (2008), "A critical review of survey-based research in supply chain integration", *International Journal of Production Economics*, Vol. 111 No. 1, pp. 42-55.

[94] Van Hoek, R.I. (2001), "The rediscovery of postponement a literature review and directions for research", *Journal of Operations Management*, Vol. 19 No. 2, pp. 161-184.

[95] Van Hoek, R.I., Ellinger, A.E. and Johnson, M. (2008), "Great divides: internal alignment between logistics and peer functions", *International Journal of Logistics Management*, Vol. 19 No. 2, pp. 110-129.

[96] Visich, J.K., Li, S., Khumawala, B.M. and Reyes, P.M. (2009), "Empirical evidence of RFID impacts on supply chain performance", *International Journal of Operations & Production Management*, Vol. 29, No. 12, pp. 1290-1315.

[97] Waters-Fuller, N. (1995), "Just-in-time purchasing and supply: a review of the literature", *International Journal of Operations & Production Management*, Vol.15 No. 9, pp. 220-236.

[98] Williams, B.D. and Tokar, T. (2008), "A review of inventory management research in major logistics journals: Themes and future directions", *International Journal of Logistics Management*, Vol. 19 No. 2, pp. 212-232.

[99] Williams, Z., Lueg, J.E. and LeMay, S.A. (2008), "Supply chain security: an overview and research agenda", *International Journal of Logistics Management*, Vol. 19 No. 2, pp. 254-281.

[100] Wong, C., Skipworth, H., Godsell, J. and Achimugu, N. (2012), "Towards a theory of supply chain alignment enablers: a systematic literature review", *Supply Chain Management: An International Journal*, Vol. 17 No. 4, pp. 419-437.

[101] Yang, B., Burns, N.D. and Backhouse, C.J. (2004), "Postponement: a review and an integrated framework", *International Journal of Operations & Production Management*, Vol. 24 No. 5, pp. 468-487.

[102] Zachariassen, F. and Arlbjørn, J.S. (2010), "Doctoral dissertations in logistics and supply chain management: a review of Nordic contributions from 2002 to 2008", *International Journal of Physical Distribution & Logistics Management*, Vol. 40 No. 4, pp. 332-352.

[103] Zhang, X., van Donk, D.P. and van der Vaart, T. (2011), "Does ICT influence supply chain management and performance?: A review of survey-based research", *International Journal of Operations & Production Management*, Vol. 31 No. 11, pp. 1215-1247.

Appendix B: Overview of article distribution to categories (Source: Author)

#	Corresponding articles identified	1.1 SCM view of literature (SCV)	1.2 Conceptual framing of SCM (CFR)	1.3 Business functions involved (BSF)	2.1 Types of flow (TFW)	2.2 Direction of flow (DFW)	3.1 Collaboration (COL)	3.2 Integration (INT)	3.3 Information sharing (IFS)	3.4 Process improvement orientation (PIO)	3.5 Leadership (LSP)	4.1 Supply chain risks (RSK)	4.2 Rewards sharing (benefits) (RWS)	4.3 Supply chain performance (PER)
[1]	Abbasi and Nilsson (2012)	x	x	x	x	x	x	x				x	x	x
[2]	Afshin Mansouri *et al.* (2012)	x	x	x	x	x	x					x		x
[3]	Anderson *et al.* (1989)	x	x	x	x		x	x			x			x
[4]	Aronsson and Brodin (2006)	x	x	x	x			x				x		x
[5]	Akyuz and Erkan (2010)	x	x	x			x	x		x		x		x
[6]	Ashby *et al.* (2012)	x	x	x	x		x	x	x			x	x	x
[7]	Atasu *et al.* (2008)	x	x	x	x	x					x	x		
[8]	Babbar and Prasad (1998a)	x	x	x	x		x	x		x	x	x	x	x
[9]	Babbar and Prasad (1998b)	x	x	x	x		x	x		x	x	x	x	x
[10]	Beamon (1998)	x	x	x	x	x	x	x		x		x		x
[11]	Blankley (2008)	x	x	x	x	x	x	x	x	x	x		x	x
[12]	Boone *et al.* (2007)	x	x	x	x	x	x			x		x		x
[13]	Burgess *et al.* (2006)	x	x	x	x		x			x	x			x
[14]	Cantor (2008)	x	x	x	x		x					x		x

#	Corresponding articles identified	5.1 Supply chain planning (PLN)	5.2 Innovation (INO)	5.3 Customer focus (CUF)	5.4 Top management support (TMS)	5.5 Competitive advantage (CPA)	5.6 Information technology (IT)	5.7 Lean and agile supply strategies (LAS)	5.8 Sustainability (SUS)	5.9 Outsourcing (OUT)	6.1 Economics theory (ECT)	6.2 Strategic management theory (SMT)	6.3 Operations management theory (OMT)	6.4 Psychological/sociological theory (PST)
[1]	Abbasi and Nilsson (2012)	x			x	x	x	x	x					
[2]	Afshin Mansouri *et al.* (2012)			x		x	x	x			x		x	
[3]	Anderson *et al.* (1989)	x	x		x	x	x	x						
[4]	Aronsson and Brodin (2006)	x						x	x					
[5]	Akyuz and Erkan (2010)		x			x	x	x		x				x
[6]	Ashby *et al.* (2012)	x	x			x			x					
[7]	Atasu *et al.* (2008)			x				x	x					
[8]	Babbar and Prasad (1998a)			x	x	x	x	x		x				x
[9]	Babbar and Prasad (1998b)			x	x	x	x	x		x				x
[10]	Beamon (1998)	x		x				x	x		x			
[11]	Blankley (2008)	x		x	x		x	x	x					
[12]	Boone *et al.* (2007)	x	x	x				x		x		x		
[13]	Burgess *et al.* (2006)						x	x			x	x		x
[14]	Cantor (2008)			x		x	x	x	x					

#	Corresponding articles identified	1.1 SCV	1.2 CFR	1.3 BSF	2.1 TFW	2.2 DFW	3.1 COL	3.2 INT	3.3 IFS	3.4 PIO	3.5 LSP	4.1 RSK	4.2 RWS	4.3 PER	5.1 PLN	5.2 INO	5.3 CUF	5.4 TMS	5.5 CPA	5.6 IT	5.7 LAS	5.8 SUS	5.9 OUT	6.1 ECT	6.2 SMT	6.3 OMT	6.4 PST
[15]	Caridi *et al.* (2005)	X	X	X	X	X	X	X	X	X				X													
[16]	Carter and Easton (2011)	X																				X		X	X		
[17]	Carter and Ellram (2003)	X	X	X			X	X			X	X		X						X		X	X				
[18]	Carter *et al.* (2007)	X	X	X			X	X				X		X		X		X						X			X
[19]	Carter and Rogers (2008)	X	X	X			X	X	X			X		X	X	X	X	X	X		X	X		X	X		
[20]	Chan and Chan (2010)	X	X	X	X	X	X		X			X	X	X					X	X	X						
[21]	Charvet *et al.* (2008)	X		X			X		X												X						
[22]	Cheng and Grimm (2006)	X	X	X	X	X	X	X	X			X	X	X		X	X		X	X		X	X	X	X		X
[23]	Chicksand *et al.* (2012)	X	X	X		X	X	X					X						X		X	X		X	X	X	X
[24]	Choi and Wacker (2011)	X	X	X	X	X	X						X	X									X		X		
[25]	Colicchia and Strozzi (2012)	X	X		X	X	X	X	X			X	X	X													
[26]	Crum and Poist (2011)		X	X			X	X				X					X			X		X	X				
[27]	Dasaklis *et al.* (2012)	X	X	X	X		X		X	X		X			X						X			X			
[28]	Defee *et al.* (2010)	X	X	X	X		X	X				X		X		X				X	X		X	X	X	X	X
[29]	Delbufalo (2012	X	X	X			X	X	X			X	X			X			X		X			X	X		
[30]	Ellis *et al.* (2011)	X	X	X	X	X	X	X	X			X		X	X	X		X			X		X	X	X		X
[31]	Fabbe-Costes and Jahre (2007)	X	X	X	X	X	X	X	X				X	X					X	X							
[32]	Fabbe-Costes and Jahre (2008)	X	X	X	X	X	X	X	X	X			X	X		X				X	X						
[33]	Fayezi *et al.* (2012)	X	X	X		X	X	X	X			X	X	X									X	X			
[34]	Frankel *et al.* (2005)																										
[35]	Ghadge *et al.* (2012)	X	X	X	X	X	X	X	X			X		X						X	X	X	X				
[36]	Giménez and Lourenço (2008)	X	X	X	X	X	X	X	X	X				X	X	X	X		X	X	X	X		X			
[37]	Giménez and Tachizawa (2012)	X	X	X			X	X		X		X		X	X		X	X		X		X					
[38]	Giunipero *et al.* (2008)	X	X	X	X	X	X	X	X			X	X	X	X		X		X	X	X	X	X	X	X		
[39]	Gligor and Holcomb (2012)	X	X		X	X	X	X	X			X		X		X	X		X	X	X						
[40]	Glock (2012)	X	X	X	X	X	X	X		X		X	X	X	X				X	X							
[41]	Gosling and Naim (2009)	X	X	X	X	X	X	X		X		X		X					X	X	X						
[42]	Gravier and Farris (2008)	X	X	X			X	X		X		X		X		X				X							
[43]	Greening and Rutherford (2011)	X	X	X	X	X	X	X	X			X	X	X		X	X		X		X			X	X		X
[44]	Gubi *et al.* (2003)	X	X	X	X		X	X									X		X	X	X	X	X	X	X		X
[45]	Gunasekaran and Kobu (2007)	X	X	X	X	X	X	X	X	X		X		X		X	X		X	X	X		X				

#	Corresponding articles identified	1.1 SCV	1.2 CFR	1.3 BSF	2.1 TFW	2.2 DFW	3.1 COL	3.2 INT	3.3 IFS	3.4 PIO	3.5 LSP	4.1 RSK	4.2 RWS	4.3 PER	5.1 PLN	5.2 INO	5.3 CUF	5.4 TMS	5.5 CPA	5.6 IT	5.7 LAS	5.8 SUS	5.9 OUT	6.1 ECT	6.2 SMT	6.3 OMT	6.4 PST
[46]	Gunasekaran and Ngai (2005)	X	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X		X				
[47]	Gunasekaran and Ngai (2007)	X	X	X	X	X	X	X	X	X				X		X	X		X	X	X				X	X	
[48]	Harland *et al.* (2006)	X		X	X		X	X																X			
[49]	Hassini *et al.* (2012)	X	X	X	X	X	X				X	X	X	X		X	X		X	X	X	X					
[50]	Hazen and Byrd (2012)	X	X	X			X	X	X	X		X		X		X				X	X				X		
[51]	Hazen *et al.* (2012)	X	X	X	X	X	X	X						X			X		X	X	X	X	X				
[52]	Jain *et al.* (2009)	X	X	X	X	X	X	X	X	X	X	X	X	X			X		X	X	X	X	X		X	X	X
[53]	Jensen (2012)	X	X	X	X	X								X								X					
[54]	Jiang *et al.* (2007)	X	X	X				X		X		X			X				X	X			X			X	
[55]	Kanda and Deshmukh (2008)	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		X	X	X		X	X	X		
[56]	Keller and Ozment (2009)	X	X	X	X		X	X			X			X			X	X	X	X	X	X					X
[57]	Kleindorfer *et al.* (2005)	X	X	X		X	X	X	X	X		X		X		X	X		X		X	X		X			
[58]	Kouvelis *et al.* (2006)	X	X	X	X	X	X	X	X	X	X	X	X	X			X			X	X	X	X	X			X
[59]	Kremic *et al.* (2006)	X	X					X		X		X	X				X						X				
[60]	Kumar and Kwon (2004)			X																							
[61]	Labro (2006)	X	X	X			X	X	X	X			X		X		X	X	X	X							
[62]	Li *et al.* (2008)	X	X	X	X		X	X	X	X		X		X		X	X		X	X	X				X		X
[63]	Liao-Troth *et al.* (2012)	X	X	X			X	X				X		X					X	X			X	X	X	X	X
[64]	Meixell and Norbis (2008)	X	X	X			X	X					X	X			X		X	X	X	X	X				
[65]	Metters *et al.* (2010)	X	X	X			X	X		X		X		X						X	X		X				
[66]	Miemczyk *et al.* (2012)	X	X	X		X	X	X				X				X					X	X					X
[67]	Mills *et al.* (2004)	X	X	X	X	X	X	X	X	X		X		X		X					X		X			X	
[68]	Minner (2003)	X	X	X	X	X		X		X		X	X	X	X		X		X		X	X		X			
[69]	Miragliotta (2006)	X	X	X	X	X	X		X	X		X	X							X					X		
[70]	Mollenkopf *et al.* (2010)	X	X	X	X	X	X	X	X	X		X		X		X	X		X	X	X	X		X	X		X
[71]	Naim and Gosling (2011)	X	X	X	X	X	X	X			X	X	X	X		X	X		X	X	X						
[72]	Natarajarathinam *et al.* (2009)	X	X	X	X	X						X		X	X				X	X			X				
[73]	Pazirandeh (2011)	X	X	X	X	X				X		X		X	X	X					X	X					X
[74]	Pettit and Beresford (2009)	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X		X	X		X				X
[75]	Pilbeam *et al.* (2012)	X	X		X		X	X	X	X	X	X		X		X				X	X	X	X	X	X		
[76]	Rao and Goldsby (2009)	X	X	X	X		X	X		X		X		X	X	X				X	X	X	X				

#	Corresponding articles identified	1.1 SCV	1.2 CFR	1.3 BSF	2.1 TFW	2.2 DFW	3.1 COL	3.2 INT	3.3 IFS	3.4 PIO	3.5 LSP	4.1 RSK	4.2 RWS	4.3 PER	5.1 PLN	5.2 INO	5.3 CUF	5.4 TMS	5.5 CPA	5.6 IT	5.7 LAS	5.8 SUS	5.9 OUT	6.1 ECT	6.2 SMT	6.3 OMT	6.4 PST
[77]	Reichhart and Holweg (2007)	X	X	X	X	X	X	X	X			X	X	X			X		X	X	X		X				
[78]	Sachan and Datta (2005)	X	X	X	X		X							X			X				X						X
[79]	Sarac *et al.* (2010)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				X	X						
[80]	Sarkis *et al.* (2011)	X	X	X	X	X	X	X	X	X		X	X	X		X			X		X	X	X	X	X		X
[81]	Schoenherr (2009)	X	X	X	X		X	X				X	X	X		X			X	X	X	X	X	X	X		
[82]	Scudder and Hill (1998)																										
[83]	Seuring and Gold (2012)							X				X		X							X	X					
[84]	Selviaridis and Spring (2007)	X	X	X	X	X	X		X	X		X	X	X	X	X	X	X	X	X	X	X	X		X		X
[85]	Simpson and Erenguc (1996)	X	X																								
[86]	Skipper *et al.* (2008)	X	X	X	X	X	X	X	X			X		X	X				X	X				X			X
[87]	Stevenson and Spring (2007)	X	X	X	X	X	X	X	X	X		X	X	X	X		X		X	X	X		X				
[88]	Stock and Boyer (2009)	X	X	X	X	X	X	X	X	X	X			X			X	X	X	X	X						
[89]	Tang and Nurmaya Musa (2011)	X	X	X	X	X	X	X	X	X		X		X							X	X	X	X	X		
[90]	Tavares Thomé *et al.* (2012)	X	X	X			X	X		X	X	X	X	X			X		X	X							
[91]	Terpend *et al.* (2008)	X	X	X			X	X	X	X		X		X					X	X	X	X		X	X		X
[92]	Tokman and Beitelspacher (2011)	X	X	X	X	X	X	X			X			X		X				X	X						X
[93]	Van d. Vaart and van Donk(2008)	X		X		X	X	X	X	X		X	X	X			X		X	X	X						
[94]	Van Hoek (2001)	X	X	X		X	X	X		X		X		X	X		X		X	X	X			X			
[95]	Van Hoek *et al.* (2008)	X	X	X			X	X	X	X	X	X	X	X	X		X	X	X	X	X						
[96]	Visich *et al.* (2009)	X	X	X	X		X	X	X	X		X	X	X		X			X	X	X	X					
[97]	Waters-Fuller (1995)	X	X	X	X	X	X	X	X	X		X	X	X				X	X		X						
[98]	Williams and Tokar (2008)	X	X	X	X	X	X	X	X	X		X	X	X			X			X							
[99]	Williams *et al.* (2008)	X	X	X	X	X	X	X	X	X	X	X	X	X	X				X	X	X		X	X			X
[100]	Wong *et al.* (2012)	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X		X	X						
[101]	Yang *et al.* (2004)	X	X	X	X	X	X	X	X	X		X					X			X	X		X				
[102]	Zachariassen and Arlbjørn (2010)	X	X	X	X		X	X				X					X			X		X					
[103]	Zhang *et al.* (2011)	X	X	X	X		X	X	X	X	X	X		X		X			X	X	X		X		X		X
	Total number of articles	*98*	*95*	*94*	*72*	*57*	*89*	*82*	*52*	*54*	*23*	*77*	*42*	*83*	*29*	*38*	*48*	*18*	*55*	*68*	*73*	*40*	*39*	*32*	*28*	*8*	*28*

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Information is one of the key enablers of modern business. The ever expanding availability of digital information, however, brings with it the challenge of handling this information appropriately. While related challenges now appear in our daily lives, this is even more the case along supply chains, where a multitude of actors is involved. This doctoral thesis addresses the topic by linking theoretical rigor with practical relevance. By assessing the current state of research in supply chain management represented in literature reviews, a range of under-represented areas of research as well as potential future research directions in the field of supply chain management are identified.

Focusing on one selected exemplary under-represented area of research, the thesis takes the digital business transformation perspective, portraying the value and role of digital information in a business function context.

As research on the intersection of Big Data Analytics and supply chain management is still scarce, the conceptual work offers first insights into an emerging topic, both on the internal operations level and on the supply chain level. This is beneficial from a scientific as well as a managerial perspective, as a thorough understanding of the constituents of a digital ecosystem is a key ingredient for the competitiveness and overall productivity of the company and ultimately of the supply chain as a whole.