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OPPORTUNITIES OF BIG DATA ANALYTICS IN SUPPLY MARKET INTELLIGENCE TO REINFORCE SUPPLY MANAGEMENT

Master's Thesis

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ABSTRACT

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The purpose of this thesis is to structure *supply market intelligence* (SMI) as an entity and recognize the importance of different aspects to companies and to identify how *big data analytics* (BDA) can be used to create systematic SMI. These objectives are studied through qualitative research with inductive approach consisting of some features of abduction due to the new and continuously developing topic. Data collection methods of semi-structured interviews and focus group discussions are selected. Data triangulation is applied via sources of supply management professionals and BDA solution providers / experts to ensure validity of the data and results.

Findings of the study indicate that there is great potential in creating SMI to support strategic supply management via BDA. Value is realized through actions such as creating competitive advantage via informed decision-making, improving supply risk management and identifying opportunities in the supply markets. An overall picture of the supply markets, value nets and supply chains can be obtained by creating comprehensive SMI. External solution providers can conduct the analysis in collaboration with the focal company. Analytical mindset and understanding of the analysis are important for integrating SMI into processes. This study provides novel results both managerially and in academic discourse by examining the opportunities and value that can be achieved through SMI.

TIIVISTELMÄ

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Tämän tutkielman tarkoituksena on jäsennellä *toimittajamarkkinatietämys* (Supply Market Intelligence - SMI) kokonaisuutena ja tunnistaa eri osa-alueiden merkitys yrityksille, sekä tunnistaa miten *big data -analytiikkaa* (BDA) voidaan käyttää systemaattisen SMI:n muodostamiseksi. Näitä tavoitteita tutkitaan laadullisessa tutkimuksessa induktiivisen lähestymistavan kautta, sisältäen joitakin abduktiivisen päättelyn tunnusmerkkejä, johtuen uudesta ja jatkuvasti kehittyvästä aiheesta. Työn tiedonkeruumenetelminä on käytetty puolistrukturoituja haastatteluja ja kohderyhmäkeskusteluja. Tietolähteinä olleet hankintatoimen ammattilaiset ja BDA palveluntarjoajat / asiantuntijat mahdollistavat aineistotriangulaation, kerätyn datan ja tulosten oikeellisuuden varmistamiseksi.

Tutkimustulokset osoittavat, että SMI:n muodostaminen strategisen hankintatoimen edistämiseksi BDA:n avulla sisältää mittavia mahdollisuuksia. Arvoa luodaan erilaisilla toimilla, kuten kilpailuedun luomisella tietoon perustuvan päätöksenteon kautta, toimitusriskien hallinnan kehittämisellä ja toimittajamarkkinoiden mahdollisuuksien tunnistamisella. Kattavan SMI:n muodostaminen mahdollistaa kokonaiskuvan luomisen toimittajamarkkinoista, arvoverkoista ja toimitusketjuista. Ulkoiset palveluntarjoajat voivat toteuttaa analyysin yhteystyössä ostavan yrityksen kanssa. Analyyttinen ajattelutapa ja analyysin ymmärtäminen ovat tärkeitä SMI:n yhdistämiseksi prosesseihin. Tämä tutkimus tarjoaa uusia tuloksia sekä yritysten päätöksentekijöille että akateemiseen keskusteluun tarkastelemalla mahdollisuuksia ja arvonluontia, jotka voidaan saavuttaa SMI:n avulla.

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During the past six months, I have experienced moments of enlightenment, anxiety and excitement. I can state that I have managed to fulfill a potential in this work of which I can be proud. I have learned many new aspects about the fascinating world of big data analytics and deepened my knowledge in the field of supply management. Even though finishing this thesis concludes one project, many interesting research subjects remain. I am fortunate to be able to continue the research work for VTT even after this master's thesis.

I would like to thank my supervisor and first examiner Professor Veli Matti Virolainen for sharing his expertise and knowledge regarding my work. Veli Matti has challenged me especially in defining proper terminology and delimitation of the work. I also want to thank my second examiner Associate Professor Katrina Lintukangas in showing interest towards my work and sharing her valuable comments during this process. Furthermore, I want to thank the rest of the Supply Management faculty, Professor Jukka Hallikas and Associate Professor Anni-Kaisa Kähkönen, for their involvement and comments during the research plan and preliminary master's thesis presentations.

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In Espoo 17.5.2017
Salla Paajanen

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LIST OF ABBREVIATIONS

3Vs	Volume, Variety and Velocity
AI	Artificial Intelligence
BDA	Big Data Analytics
BI	Business Intelligence
CPO	Chief Procurement Officer
ERP	Enterprise Resource Planning
FMCG	Fast-Moving Consumer Goods
GIS	Geographic Information System
IR	Information Retrieval
IPR	Intellectual Property Rights
IS	Information System
IT	Information Technology
KBV	Knowledge-Based View
KPI	Key Performance Indicator
M&A	Mergers and Acquisitions
MI	Market Intelligence
MPP	Massively Parallel Processing
MVP	Minimum Viable Product
NPD	New Product Development
PSM	Purchasing and Supply Management
RBV	Resource-Based View
R&D	Research and Development
RFx	Request for Information / Proposal / Quotes
SMI	Supply Market Intelligence
SMA	Social Media Analytics
TCO	Total Cost of Ownership
VUCA	Volatility, Uncertainty, Complexity and Ambiguity

1 INTRODUCTION

Increasing globalization and complexity of the economic environment as well as decreasing margins drive companies to focus on their core competencies and outsource non-core activities. Goods and services provided by suppliers add up to 80 percent of an organization's revenue, so utilizing suppliers' capabilities requires new skills and frameworks (Keith et al. 2016, 47). Consequently, managing suppliers and supplier networks has become a critical competitive advantage for companies. Suppliers and other external resources, such as suppliers' resources, customers and competitors, are critical for value creation. The need for more customized products and services can be turned into a value creating supply management process through long-term strategic relationships and integrated data systems (Handfield 2006, 3-4). Instead of utilizing suppliers and other external resources only in price-based competition and for producing products and services, they should be seen as value co-creators through new ideas, innovations, knowledge, know-how and process development. Hence, merging internal resources with suppliers and other external resources is vital for company's competitiveness in creating new business as well as in developing existing business. (Gadde et al. 2011, 3-9)

Business environments have become more dynamic and complex throughout the 21st century (Rausch et al. 2013, 3). Today's business environment includes characteristics of *volatility, uncertainty, complexity and ambiguity* (VUCA), deriving from military vocabulary. Uncertainty for the buying company refers to the unpredictable variability of outcomes in the supply market (Schoenherr et al. 2011, 4564). The changing business environment consisting of drivers that transform supply management, are referred to as the new economy in this study. The new economy is driven by globalization, volatility and risk, consumer-driven society, service economy, value creation and capabilities of cloud computing. (Keith et al. 2016, 1-2) These factors have an effect on dynamic sourcing strategies, requiring deeper knowledge of the impacts on interoperability and vertical cross-sections. The dynamic sourcing strategies indicate a need for intelligent and autonomic actions, through collaborative activities. (Demirkan et al. 2013, 414)

Utilizing suppliers' capabilities, selecting the most suitable suppliers, making good contracts and developing collaboration business models requires creating systematic *supply market*

intelligence (SMI) (Iloranta et al. 2015, 28-29). SMI is defined in this study as "the ability to develop deep insights into key supplier market characteristics, including emerging technologies, price and cost trends, *mergers and acquisitions* (M&A), capacity requirements, quality and delivery performance, and other key supplier capabilities that form the basis for sound strategic sourcing" (Handfield et. al. 2009, 103). A fundamentally sound strategic sourcing forms the foundation to *supply chain management* (SCM), can differentiate the company from competitors and help in achieving corporate goals through discovering opportunities for improvement, recognizing risks and gaining better understanding of the key suppliers (McKenna 2011, 56). SMI facilitates examining suppliers and enables identifying potential cost-effective markets, new technologies and innovations before competitors (Iloranta et al. 2015, 30), in addition to forecasting market price fluctuations and monitoring cost compliance (Shi 2004, 221-222). As high quality SMI provides access to up-to-date supply market visibility, companies can handle supply chain disruptions, while achieving savings (Chithur 2014, 3).

Challenges in the new economy can be managed by deploying *information technology* (IT). Consequently, increasing volumes of data need to be handled, requiring storing and accessing data, intelligent *information retrieval* (IR) and new decision-making mechanisms. (Rausch et al. 2013, 3-5) When data, businesses and supply chains become more complex, managers need sufficient tools for generating insights to support smart decision-making (Sahay 2008, 39). The amount of generated data continues to increase rapidly, which has resulted to the development of big data. Big data is defined in this study as "high-volume, high-velocity and/or high-variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision-making, and process automation" (Gartner 2017). Big data is critical to decision support, since rapid innovation and globalization have created notable opportunities in the marketplace for companies (Sahay 2008, 39).

Big data analytics (BDA) applications are becoming increasingly important in strategic sourcing. The ability to capture, store, aggregate and analyze data in order to extract intelligence from them is quickly becoming a prerequisite for all organizations. (Sanders 2016, 26 & 32) Technology and analytics tools can be leveraged to create SMI that provides insights into main features of demand and supply trends, commodity price structures, global capacity and business environment changes that affect global sourcing (Chithur 2014, 3). Organizational leaders need

to consider and recognize potential opportunities, in addition to strategic threats associated with big data, and close existent gap between their IT capabilities and strategy. This includes defining which big data opportunities are relevant for their business in a proactive manner in order to create value. (Manyika et al. 2011, 13)

This master's thesis originated from the prevailing importance of SMI as company's competitive advantage. Due to the development of IT and constantly increasing amount of data, combining BDA applications' potential in creating systematic SMI brings new value for companies. BDA in the context of SMI creates novel insights into the supply markets as a substantial element of supply management.

1.1 Scope of the thesis

The research context in this study is *supply management*, consisting of strategic and mature sourcing processes, instead of the entire supply chain or corporate strategy. The importance of shifting from tactical purchasing to strategic supply management was recognized in the literature already in the 20th century (Kraljic 1983), whereas companies are realizing the benefits of strategic collaboration only more recently. The same observation is made in this thesis as Lintukangas (2009) discovers in her doctoral dissertation, that purchasing is too limited term when referring to a company's entire operative and strategic activities associated with supply and supplier management. Gadde et al. (2010) replace the function of purchasing with an approach of purchasing as supply network management. Supply network approach is seen in this thesis from value creation perspective. Several authors, (Leenders et al. 2008; Van Weele et al. 2010) have distinguished the discipline of *purchasing and supply management* (PSM), referring to external resource management. PSM refers to the interaction with the upstream supply chain while taking into account the needs of internal functions and the downstream customers interests and demands (Van Weele et al. 2014, 57). The discipline of PSM is agreed in this study, but the term supply management is further adopted through theory and empirical research, since strategic sourcing is under closer examination due to the influence of SMI. In order to emphasize the importance of combining internal and external resources in an optimal manner, definition of supply management is adopted in this study from Cox et al. (1997) as "the

strategic management of external and internal resources and relational competencies in the fulfilment of commitments to customers".

In this study, focus of the external market view and more specified context of *supply market intelligence* is selected. Koivisto-Pitkänen (2011) discovers in her master's thesis that there is no generalizable set of supply management skills, which bring competitive advantage for all firms, but total cost analysis, customer focus, general business view, market knowledge and supplier relationships are the most important factors of supply management capability. Since creating SMI forms the basis for sound strategic sourcing (Handfield et. al. 2009, 103), related processes are studied in more detail.

Theoretical background of *resource-based view* and further *dynamic capabilities theory* and *knowledge-based view* are introduced in this study, concentrating on the context of SMI. This is based on the recognition "whether PSM is strategic depends on its ability to develop superior PSM skills, capabilities, and experience of PSM professionals, to develop and sustain superior codified knowledge of markets and supply chains, to develop superior power resources over suppliers, and to secure and protect superior procurement competence" (Van Weele et al. 2014, 68).

The decisive focus of this study is to discover opportunities of BDA in the context of SMI to reinforce supply management, excluding technical execution of the analytics applications. The interconnected practices needed for creating insights from big data are divided in this study to two main processes of data management and analytics (Gandomi et al. 2015, 140), and the integration of external data to internal data and company's context to support decision-making is emphasized.

1.2 Research gap

SMI is needed to closely monitor prevailing supply market conditions and to respond to changes through enhanced supply strategies. However, many organizational leaders still lack understanding of the value that SMI can bring to competitive advantage, corporate strategy, market pricing and budgeting, in addition to sourcing cost savings. This leads to limited resources available for creating systematic SMI, or outsourcing supply market research without

internal understanding of the applications. (Handfield 2014, 38-39) Iloranta (2016) discusses in his doctoral dissertation that there has been a research gap in linking PSM to a company's long-term performance and understanding the strategic role of external resources. The relationship of PSM and company's financial performance still has opportunities for further examination (Schoenherr et al. 2011, 4568). Van Weele et al. (2014) state that current PSM research reflects the strategic priorities only to a limited degree, and should be addressed more in order to increase its acknowledgement in the academic domains as well as relevance to practitioners.

Big data technologies have developed in fast pace, and the concept has quickly been accepted by public and private sectors (Gandomi et al. 2015, 137). The academic and scientific sectors are looking for unprecedented opportunities from analyzing big data to understand the world in an enhanced manner, while businesses are looking for technology based competitive advantage. This has resulted BDA becoming an imperative for businesses across all industry sectors. (Sanders 2016, 26) The fast development of BDA has left only little time for developing and maturing discourse in the academic field, while practitioners and authors have published books and other electronic media for instant and wide circulation of big data literature. Therefore, there still exists a need to document the evolution of big data concepts and technologies in the academic publications (Gandomi et al. 2015, 137), while managerial literature is more obtainable.

Based on previous studies it can be seen that BDA has many possibilities that are still not applied in business processes for creating SMI. Utilizing BDA in creating systematic SMI is a new and continuously developing topic due to the development of IT and the increase in data generation, as well as greater understanding of SMI's importance in supply management.

1.3 Background and objectives of the study

This master's thesis is part of research project Supplier Innovation Management (SIM) conducted by VTT Technical Research Centre of Finland and Aalto University. The project studies SMI through the particular capabilities allowing firms to develop and maintain knowledge of their supply markets. The project was initiated in the beginning of 2015, and the need for further research in the framework of this thesis refined in the end of 2016. The study is conducted from the perspective of finding new and innovative solutions for the benefit of

Finnish companies in reinforcing their strategic supply management processes in order to develop their business and enhance practices.

The objectives of the thesis are twofold, combining two rather large aspects into a novel entity. This master thesis aims 1) to structure SMI as an entity and recognize the importance of different aspects to companies and 2) to identify how BDA can be used to support systematic SMI. In order to reach these objectives, one main research question and three supportive research questions are formed.

The main research question of this study is:

> ***RQ1:*** *What are the most potential big data analytics applications and opportunities in creating systematic supply market intelligence?*

The research questions that help in reaching the objectives and the main research question are as follows:

> ***RQ2:*** *What is the importance of supply market intelligence in strategic supply management?*
>
> ***RQ3:*** *How can big data be categorized and what are the data sources in the context of supply market intelligence?*
>
> ***RQ4:*** *What are the most suitable big data analytics methods in creating supply market intelligence?*

The following definitions of the main concepts are adopted in this study:

Supply management is "the strategic management of external and internal resources and relational competencies in the fulfilment of commitments to customers" (Cox et al. 1997, 62).

"Strategic sourcing is an organizational procurement and supply management process used to locate, develop, qualify, and employ suppliers that add maximum value to the buyer's products or services" (Sollish et al. 2011, 1).

Supply market intelligence (SMI) is "the ability to develop deep insights into key supplier market characteristics, including emerging technologies, price and cost trends, mergers and

acquisitions, capacity requirements, quality and delivery performance, and other key supplier capabilities that form the basis for sound strategic sourcing" (Handfield et. al. 2009, 103).

Big data can be defined as: "high-volume, high-velocity and/or high-variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision-making, and process automation" (Gartner 2017).

Big data analytics (BDA) "is the union of two disciplines intrinsically linked: big data and advanced analytics" (Varela et al. 2014).

1.4 Research methodology

Qualitative research with inductive approach is chosen as the methodology of this study due to the new and continuously developing topic. Since pure induction is rare and can even be considered impossible, features of abduction are also applied in this study. Inductive research complies with the logic of starting from empirical research and continuing to theoretical results, whereas deduction is based on the baseline that theory is the first source of knowledge. Abduction can be considered combining these two logics as an iterative process, referred to as exploratory data analysis. (Eriksson et al. 2008, 22-23) Qualitative research is particularly relevant when there are only minor previous insights about a phenomenon under study, which indicates that qualitative research is exploratory and flexible due to unstructured questions (Eriksson et al. 2008, 5). Therefore, qualitative research enables to reach the objectives and answer to the research questions of this study. Data collection methods of multiple case study consisting of semi-structured interviews, focus group discussions and semi-structured interviews of individuals are chosen to gather empirical data in this study. Triangulation of data is used via different data collection techniques. Based on the gathered empirical data, conclusions are formed through analysis.

Semi-structured interviews are a very useful base for other qualitative techniques. It is a flexible empirical data collection method, which enables tailoring for the purposes of the research objectives and questions of the study (Lee et al. 2008, 217). Semi-structured interviews of supply management practitioners from Finnish companies are carried out in the SIM research project as a multiple case study. Six of the case companies, consisting of ten interviewees are

utilized for answering to research question RQ2. Moreover, six BDA solution providers / experts are interviewed to study the main research question, through support research questions RQ3 and RQ4, and to endorse findings from the literature and other empirical research.

Focus group discussion refers to a gathered group of individuals who discuss and comment on the subject of the research. In the focus group discussions, interactive discussion among participants is in the focus, and participants answer to each other's comments more than the moderators' proposed questions. This enables collective examination of the research topic. (Eriksson et al. 2008, 173-177) Focus group discussions have potential of being an excellent source of qualitative data, enabling the observation of transactions and reactions between participants (Byers et al. 1991, 64). Focus group research is used in this study in a workshop for supply management professionals, organized in collaboration with the Finnish Association of Purchasing and Logistics (LOGY), Aalto University and VTT. Interactive group work among approximately 40 participants is used to study the main research question RQ1 through the support research questions.

1.5 Organization of the study

Theoretical background information is studied in the form of literature review. In chapter 2, supply management in the new economy is studied, focusing on the importance of SMI. Figure 1 below shows a theoretical framework of BDA applications in SMI to reinforce supply management. First, drivers of the new economy transforming traditional supply management are identified, followed by examining the connection of SMI to strategic sourcing. Importance of SMI in supply risk management and in driving innovation is recognized. Due to the changing business environment, the framework is cyclic following the values of continuous development, connecting distinct areas of the framework.

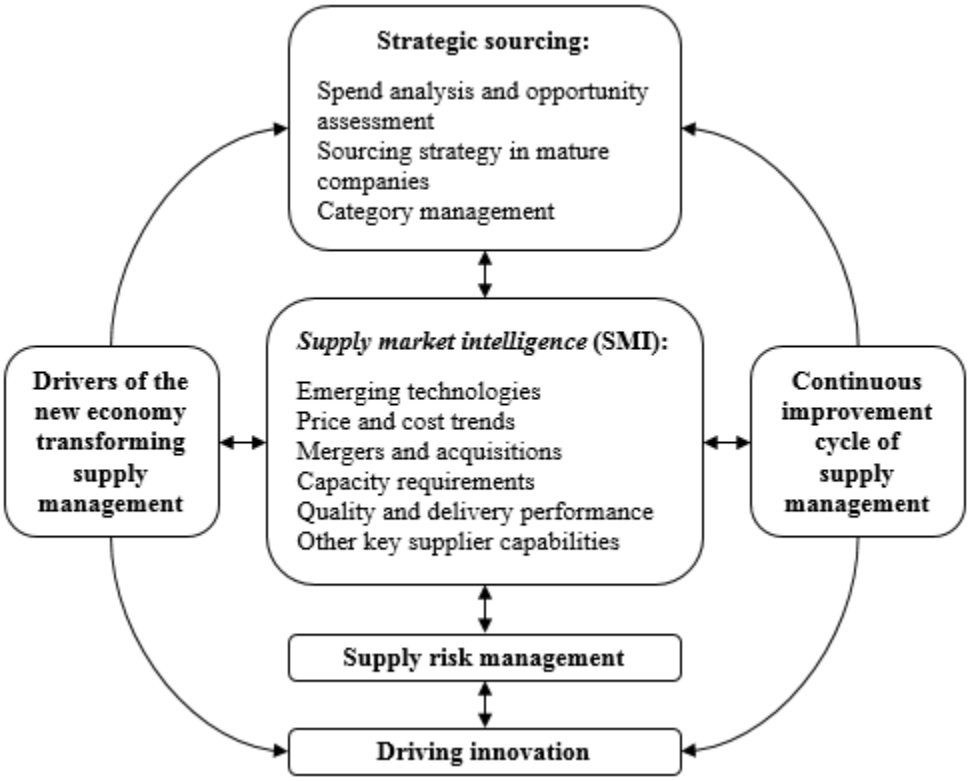

Figure 1. Conceptual framework of supply management in the new economy (modified from Handfield 2009, 103; Sanders 2016, 38)

The conceptual framework is reflected throughout the research. In chapter 3, BDA for strategic actions is examined, followed by chapter 4 consisting of some of the main BDA applications and opportunities in SMI. The methodology of qualitative research and research design of inductive approach with features of abduction is explained in more detail in chapter 5. In the following chapter 6, the empirical findings from qualitative interviews and focus group research are described, followed by analysis of the results. The empirical research consists of three subfields, including case company interviews of supply management practitioners, focus group research of supply management practitioners and BDA expert / solution provider interviews. Finally, in chapter 7, discussion and conclusions of the analysis are presented, including answering the research questions, recognizing theoretical contributions and managerial implications of this thesis, followed by validity considerations and limitations of this study and recommendations for further research. Below in figure 2, the overall organization of the study

is shown divided into four sections: introduction (chapter 1), theoretical background (chapters 2-4), qualitative research (chapters 5-6), and conclusions and discussion (chapter 7).

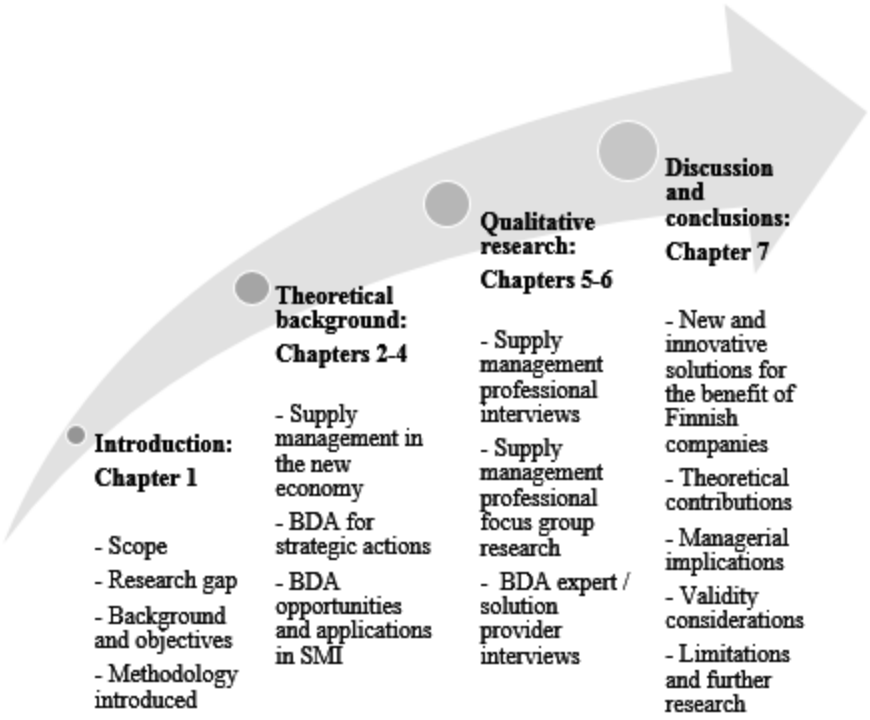

Figure 2. Organization of the study

Due to the novel subject of this research, the existing scientific literature is supplemented with white papers, and related research of subject professionals and consulting firms. The comprehensive empirical data provides great value in this study through different sources and viewpoints.

2 SUPPLY MANAGEMENT IN THE NEW ECONOMY

Supply management during the previous decades has consisted mainly of cost reductions from suppliers through negotiations. This prevents leveraging spending opportunities from various business units, does not encourage suppliers for improvements in technology, quality or cost savings in long-term and disregards customer requirements as well as changes in the business environment and the supply market. Therefore, supply management is continuously moving from tactical towards a strategic approach, by improving supply chains through competitive advantage (Handfield 2006, 2-4), and involves much more than simply finding, contracting, purchasing and paying for outsourced products or services (Keith et al. 2015, 19). Differentiating from the competitors in supply management, supplier relationships and supplier network management requires implementing inter-organizational processes, in addition to taking into account total costs of the entire network, cost impacts of different factors, sources of value and benefits perceived by customers (Iloranta et al. 2015, 29).

Supply management involves overlapping functional decisions, such as spend analysis, sourcing strategy development, *request for information, proposal, and/or quotes* (RFx) and contract databases, involving several key supply management stakeholders (Huang et al. 2015, 7). Below in figure 3, the common supply management process consisting of sourcing and procurement practices is shown. Since SMI forms the basis for sound strategic sourcing (Handfield et. al. 2009, 103), it is studied in more detail in this chapter. Through strategic sourcing, SMI affects the entire supply management process, which in turn is part of an even wider perspective of SCM, having an influence on business. SCM usually focuses on business function coordination within and across organizations in the supply chain, in order to improve the long-term performance of the organization as well as the supply chain as a whole. (Van Weele 2014, 57)

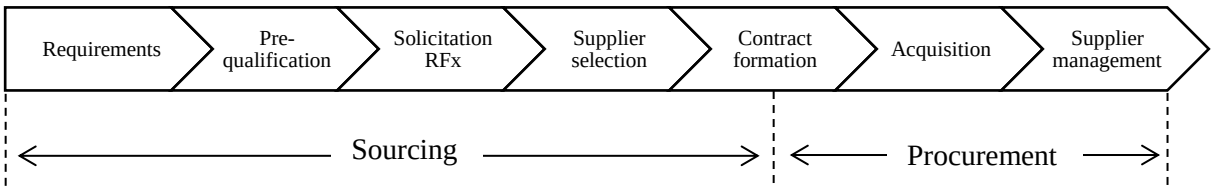

Figure 3. Common supply management process consisting of sourcing and procurement (Sollish et al. 2011, 2)

Power relations between suppliers and companies outsourcing products and services have changed due to the dynamic business environment, including technological development, emerging trends and supply risks. Supply management in the 21st century is focused on creating dynamic and sustainable relationships between extended business units and suppliers, in order to utilize new technologies and suppliers while ensuring quality products and services. This requires strategic supplier evaluation and selection, based on the suppliers' strengths, capabilities and quality output. (Keith et al. 2016, 21) Supply management activities need to be strategically aligned with corporate strategy in terms of time, measurement, specificity and focus (Handfield 2006, 20). Strategies in the new economy are contingent mostly on technology and information (Eris et al. 2007, 6). Managers' willingness to share information depends on the level of trust and mutual benefit in the relationship, because information is perceived as power (Fawcett et al. 2011, 52). Therefore, trust-based buyer-supplier relationships result to more proficient and sustainable competitive advantage than power-based relationships (Keith et al. 2016, 32). Collaboration in strategic supplier relationships requires active interaction, sharing information as well as systematic monitoring, evaluation and development through *information systems* (IS) (Nieminen 2016, 171-173).

2.1 Drivers transforming supply management

The new economy that is formed of the VUCA business environment is driven by globalization, volatility and risk, consumer-driven society, service economy, value creation as well as capabilities of cloud computing, which transform the understanding of strategic supply management (Keith et al. 2016, 1-2), and increase the importance of SMI. These areas are discussed in more detail in the following chapters.

Globalization accelerates market interconnectedness, forming a network of integrated organizations (Keith et al. 2016, 1-2). Competitive forces have created global scale sourcing, increasing product offerings and opportunities in the market place (Sahay et al. 2008, 39). The explosion of IT and lower entry barriers to markets worldwide have accelerated industrial development (Manyika et al. 2011, 76-77). As supply chains become increasingly global, companies need to apply in-depth market data and intelligence to understand market dynamics, supply risks as well as cost and pricing issues on a global scale (Accenture 2017). When

networks become more complex, novel analytical tools are needed for generating intelligence to support decision-making (Demirkan et al. 2013, 419).

Volatility and risk have increased in the new economy, challenging the business environment with issues such as international terrorism, natural disasters, sovereign debts and strikes (Keith et al. 2016, 2). Increased uncertainty and volatility of global business processes and market trends result insights into supply market conditions becoming critical in price negotiations, cost management and contract renewals (Handfield 2014, 36). Creating SMI for ongoing supply risk assessment and management is therefore critical in strategic supply management (Jones et al. 2015, 29).

Consumer-driven society incudes most important elements of combining products, services, support and knowledge (Lee et al. 2014, 4). The trend of customer focused business processes requires agile and flexible supply chains (Keith et al. 2016, 2). Detailed consumer data are available in various sources, such as social media and sensor reports. By processing and utilizing this data, companies can create competitive advantage compared to businesses tied to traditional business models and infrastructures. (Manyika et al. 2011, 4)

Service economy refers to the strategic innovation of an organization's processes and capabilities in order to sell an integrated product or service delivering value in use. Both service and manufacturing industries can improve their core competencies by focusing on innovative value-added service development. (Lee et al. 2014, 4) Service economy moves from tactical outsourcing to a strategic approach (Keith et al. 2016, 2), and is one of the fastest developing paradigms in the new economy (Demirkan et al. 2013, 414). Service economy and service oriented computing modify the balance between companies' computing infrastructures and the support provided for service generating business processes (Demirkan et al. 2013, 414).

Value creation has shifted from simply buying goods and services from suppliers, to strategic collaboration by forming relationships with particular suppliers in order to create value (Keith et al. 2016, 1-4). Collaboration with suppliers drives innovation in addition to cost reductions (Keith et al. 2016, 21). Companies collaborating in flexible and dynamic networks, which have an emphasis on value creation to all participants, can be called value nets (Ahtonen et al. 2009, 269-270). A supply network approach in supply management improves opportunities for

developing efficiency and long-term innovation, creating value in the network (Gadde et al. 2010, 14).

Capabilities of cloud computing consist of a powerful technology for performing large scale and complex computing without expensive computing hardware and software (Hashem 2015, 98). Cloud computing places different forms of data, information and knowledge to various servers (Erickson et al. 2012, 15). Supporting flexible resource utilization is one of cloud computing paradigm's key capabilities and features, enabling users to scale up and down their resources based on demand (Abdelwahab 2014, 283). Capabilities of cloud computing are not limited to data or text mining, since it can be used for extensive optimization, highly-complex multi-criteria decision issues and distributed simulation models (Demirkan et al. 2013, 419).

Cloud computing enables using resources on-demand, pay-as-you-go pricing and infinite capacity on the cloud (Assunção 2015, 4). Cloud computing is a paradigm with highly scalable computing resources, provided as a service through a network (Manyika et al. 2011, 32). Capacities can be reserved in advance and released when they are not needed. (Dobre et al. 2014, 270) Concepts such as *software-as-a-service* (SaaS), *platform-as-a-service* (PaaS) and *infrastructure-as-a-service* (IaaS) are some of the most common cloud service models (Demirkan et al. 2013, 413; IBM 2017). SaaS consists of a remote accessed cloud network software and applications that are provided by a service provider through the Internet. The application enables storing and analyzing data as well as collaborating through the network. PaaS allows developing, customizing and testing own applications in the cloud environment, in addition to storage and other computing resources. IaaS is a cloud computing infrastructure provided by a vendor, allowing access to storage, servers and networking. It is constructed of company's own platforms and applications within a service provider's infrastructure. (IBM 2017)

2.2 Strategic sourcing

The main objective of strategic sourcing is to engage suppliers that align with the strategic business and operational goals of the organization through a long-term plan of supply chain actions (Sollish et al. 2011, 1). Strategic sourcing focuses on supplier relationship management through collaboration, analyzing costs and acquiring commodities and services on a cost-

effective basis (Wang et al. 2016, 101), based on identifying the right suppliers which offer highest overall net benefit to the organization (Jones et al. 2015, 20). Strategic sourcing consists of combining the supply network's present and future needs to internal goals, strategies and development (Freytag 2003, 138). The fundamentals that are required to shift from traditional purchasing to strategic sourcing are 1) focus on total delivered value rather than purchase price, 2) collaborate with suppliers rather than oversight, 3) focus on improving profitability rather than cost savings (Parniangtong 2016, 6).

2.2.1 Spend analysis and opportunity assessment

Supplier segmentation means the division of supply base into groups in a way that enables the determination of preferred supplier relationship for each supplier (O'Brien 2014, 50-51). The process of segmenting suppliers is the basis for strategic sourcing, requiring an ability to negotiate prices based on leveraged volumes of purchases from across the organization (Handfield 2006, 263). The criteria for supplier segmentation depend on organizational goals and objectives (O'Brien 2014, 62). One of the most common supply base segmentation viewpoints is the Pareto principle which is based on an idea that 80 percent of spend is associated with 20 percent of suppliers (Jones et al. 2015, 27). Spend analysis enables the differentiation of suppliers, in addition of business units or critical commodity groups, based on the financial point of view (Gadde et al. 2010, 26). One of the critical inputs to strategic sourcing and gaining intelligence is understanding of historical expenses, in order to examine dynamically segmented spend by different dimensions. Spend visibility creates value through an ability to develop fact-based sourcing and category strategies (Still et al. 2011, 61).

Spend analysis is linked with opportunity assessment, which is needed for strategic decision-making. (Jones et al. 2015, 23-24) Once an opportunity with high returns is identified, spend data across business units needs to be collected, so that potential savings, risks and obstacles can be considered (Handfield 2006, 61-63). SMI provides visibility to internal categories of spend in contrast to external alternatives. External data can be used to benchmark current prices and risk levels of particular suppliers. The main aspects that the opportunity assessment should capture are level of competition for available business and how much control a particular supplier has over its costs. (Jones et al. 2015, 24)

2.2.2 Sourcing strategy in mature supply management

Sourcing strategy consists of a set of rules that guide the formation of a company's supply management efforts in response to changes in the business environment and competition, taking advantage of profitable opportunities. As the strategic importance of supply management has increased, the role of supply strategy has correspondingly become more important (Ahtonen et al. 2009, 263). Without a supply strategy, multiple forms of transaction channels may be used, such as purchase cards, online vendor websites or purchase orders, which can be referred to as maverick buying. This results into weakening of supplier leverage and keeps the focus on transactional activities, excluding value adding strategic supply management activities. (Huang et al. 2015, 15) To avoid using several overlapping transaction channels, cross-functional sourcing teams are important in implementing supply management strategies (Handfield 2006, 77-82). The supply strategy needs to be based on strategic principles and objectives of the firm, integrated into the business and corporate strategies (Lintukangas et al. 2013, 398), as well as aligned with the dynamic nature of the business environment (Keith et al. 2016, 212).

The theoretical background of transaction cost economics consists of the principle that if the marginal costs of using markets become higher than the cost of organizational hierarchy, the transaction should be organized within the company and vice versa (Coase 1937, 392). The *resource-based view* (RBV) on the other hand is a theoretical framework for achieving and sustaining competitive advantage via acquiring and controlling resources (Rungtusanatham et al. 2003, 1087). Teece (1997) defines *dynamic capabilities theory* as a company's ability to integrate, construct and reconfigure internal and external firm-specific competences to address fast changing business environments. Dynamic capability approach of RBV helps to understand how capabilities are developed and modified in a dynamic business environment. One of the main elements of supply strategy is the make-or-buy decision, based on the strategic approaches of concentrating company's own resources on core competencies where it can create value, and strategically outsource other activities without strategic need or special capabilities. When the markets are uncertain, exploiting markets is not as attractive for the buying company as internal hierarchy. (Ahtonen et al. 2009, 265-267) The intermediate governance structure between markets and hierarchies can be called hybrid or partnership, referred to as individual contracts between parties (Blomqvist et al. 2002, 1).

Sourcing business model continuum is adopted in this study from Keith et al. (2016) and Vitasek (2016), referring to the different supplier governance options. It is not interchangeable with *business model*, defined by Osterwalder et al. (2005) as a conceptual tool, comprising of a set of objectives, concepts and their relationships with the aim to express business logic of a particular firm. The sourcing business model refers to the supply strategy, whereas the business model refers to the entire corporate strategy. The supplier relationship models can be divided into a continuum of transactional, relational and investment models, consisting of different provider models (Keith et al. 2016, 52-55). After selecting the best relationship model, the best economic model needs to be determined for managing the economics of the relationship. The economic models can be divided into transaction-based models in which economics is tied to activities, output-based models in which economics is tied to supplier output or outcome-based models in which economics is tied to business outcomes.

Mapping the best sourcing business model includes detecting the most appropriate buyer-supplier relationship as well as the best economic model. (Vitasek 2016, 32-34) The sourcing business model continuum is presented below in figure 4, showing the relationship of dependency and value of different sourcing business models. Compared to the traditional transactional models, alternative sourcing business models pursue to align interest through incentives as well as shared risk and reward economics (Keith 2016, 26). Strategic sourcing business models are particularly relevant and viable in the new economy (Vitasek 2016, 35).

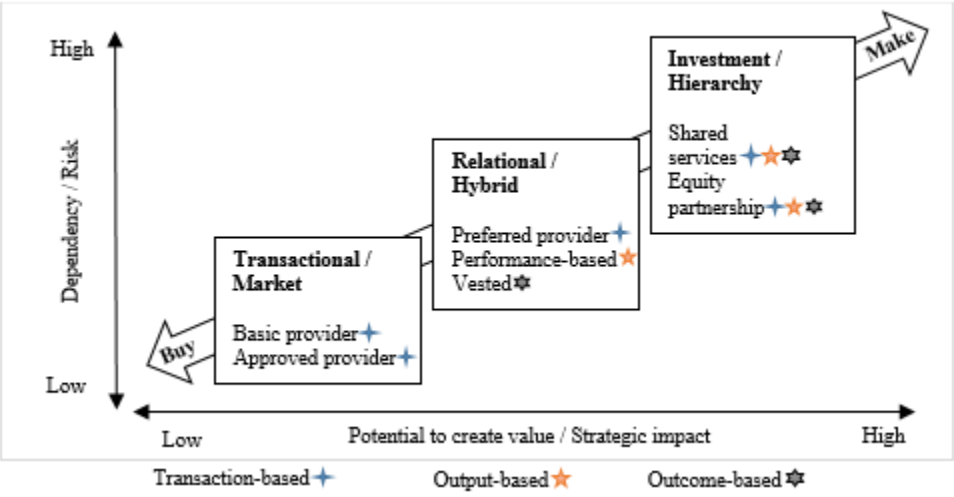

Figure 4. Sourcing business model continuum (Keith et al. 2016, 67; Vitasek 2016, 28)

When evaluating the sourcing business models, it is necessary to gather data from different stages of the sourcing process (Handfield 2006, 98). Analyzing supply market trends in addition to suppliers' inputs and economics enables the assessment of the optimal sourcing business model (Wang et al. 2016, 101), emphasizing the importance of SMI in supply strategy formation. When proceeding in the sourcing business model continuum, more effort should be used to conduct the supply market assessment. More complex sourcing business models, especially codependent performance-based and vested models, require suppliers' financial visibility and sustainability. (Keith et al. 2016, 241) Therefore, the selected sourcing business model determines the scope of the supply market analysis and prior to conducting more comprehensive external analysis or strategic change implementations, the current state of the organization needs to be assessed (Handfield 2006, 105). When using a basic provider to procure goods or services, supply catalogues and competitive market testing for prices can be enough for standard items, whereas more complex sourcing business models require wide-ranging supply market analysis via more advanced analytical tools (Keith et al. 2016, 234-235).

Sourcing maturity means the strategic management of spend requirements of an organization. Sourcing maturity level affects a company's ability to adopt and implement the sourcing business models. When the strategic sourcing maturity level increases, so does the ability to use more sophisticated sourcing business models. (Keith et al. 2016, 316) The maturity model can be used to assist in initiating best practice sourcing projects through evaluating strategic capabilities and relative maturity of sourcing operations (Handfield 2006, 57). In companies with high sourcing maturity level, insights into operational decision making and SMI need to be connected, such as aligning cost models with savings projects and profit objectives for business units, as well as corporate budgeting (Handfield 2014, 40). Below in figure 5, the sourcing maturity levels are shown as a process from tactical sourcing to integrated sourcing.

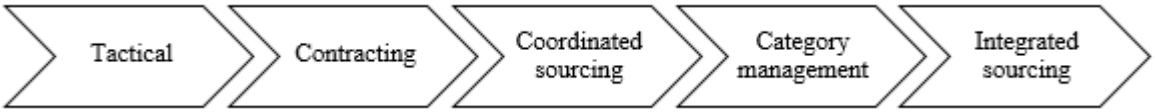

Figure 5. Sourcing maturity levels (Keith et al. 2016, 313)

Companies often undergo a development of sourcing maturity levels, starting from tactical quality and cost teams, and moving towards strategic cross-locational global teams and supplier base reductions. As the company moves from tactical maturity level towards later stages of strategic sourcing, delivery systems and global sourcing generate visibility throughout the supply chain, suppliers' capabilities are jointly improved and non-core competences can be outsourced. (Handfield 2006, 16-17) In integrated sourcing, category cross-functional teams are involved in decision-making, and buyers possess full visibility of spend and performance reports (Keith et al. 2016, 316). The most mature sourcing level drives value for business units by integrating sourcing as part of the corporate planning processes (Keith et al. 2016, 316). Integrating SMI into operational decisions, such as market pricing, technology insights and global expansion, facilitates competitive strategy (Handfield 2014, 39). Overall, companies with more mature sourcing approach perform more efficiently in the key areas of supply management consisting of responsiveness, flexibility, cost and distribution (Handfield 2006, 14), and supplier management is engaging and value is generated in the marketplace (Keith et al. 2016, 312-316). Due to integrated and dynamic processes, systematic SMI is vital in the mature sourcing levels.

2.2.3 Category management

Category management refers to a coherent group of supplied products, materials or services managed by a category manager (Nieminen 2016, 48). Best practices for managing suppliers require a category specific context, driven by an understanding of applicable market forces, making SMI vital (Jones et al. 2015, 27). Decisions regarding supplier relationship strategies can be based on the features of the supplied items (Ahtonen et al. 2009, 269). During the previous decades, the most used methodology in category management and supply strategy valuation has been the purchasing portfolio analysis, as introduced by Kraljic (1983). Kraljic's purchasing portfolio is based on minimizing supply risk, while maximizing buying power. It includes four category segments of leverage items, strategic items, non-critical items and bottleneck items. In case of strategic items, collaboration with suppliers should be utilized, whereas in case of non-critical and leverage items competitive strategy can be more suitable. (Ahtonen et al. 2009, 269). Other category management approaches, such as Porter's Five Forces (1979) by Michael Porter, the Purchasing Chessboard (2008) by A.T. Kearney and Sourcing Portfolio Analysis (2014) by Andrew Cox, have also been introduced in the literature.

In general, the paradigm shift in category management focuses on a strategic view of categories of supply, rather than categories of spend. (Cox 2015, 717 & 735)

While moving to a strategic, complex or risky category, the company needs to facilitate and support a formal governance structure for managing the category (Keith et al. 2016, 278). SMI is not as important for low value and easy to secure goods and services. Comprehensive SMI might not be needed either for leverage items that can be procured from many sources and are easy to secure, even though they have higher profit impact. High quality SMI is especially important for strategic items, when spend value is high and supply risk is high due to, for instance, limited choice of suppliers or complex technology. Furthermore, bottleneck items with low profit impact, but which are critical to business require extensive SMI. (Chithur 2014, 7) Below in figure 6, the supply positioning model is shown containing the importance of SMI in different categories.

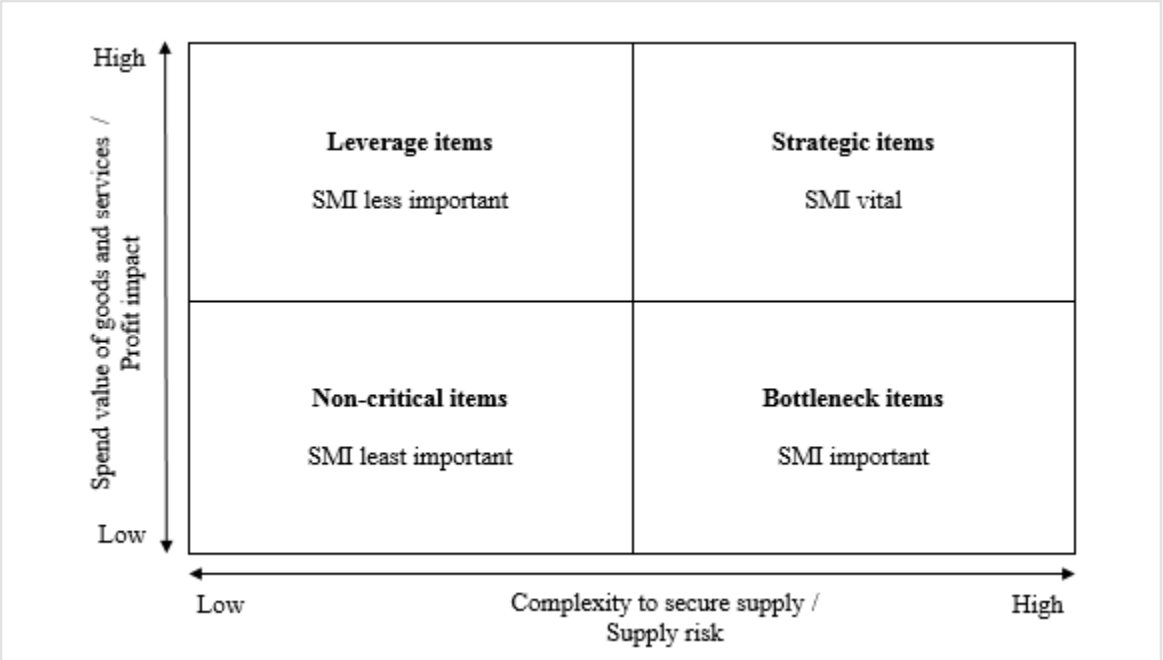

Figure 6. Supply positioning model of items and importance of SMI (modified from Kraljic 1983, 111; Chithur 2014, 7)

Overall, category management is based on adequate knowledge of supply management processes, their contents, needs and suppliers (Iloranta et al. 2015, 104), which can be achieved by creating comprehensive SMI. Since category managers are often responsible for creating

SMI, and their knowledge of the supply markets is used to identify risks, communication between categories and business units is imperative (Handfield 2014, 39). When designing and executing category management, aspects that need to be considered are the sourcing business model, complexity of the sourcing solution, geographical coverage, corporate management structure as well as culture and behaviors (Keith et al. 2016, 279). Category management can create value beyond savings in terms of product improvements and technological developments when taking into consideration the entire supply management process (Jones et al. 2015, 34). Hence successful category management takes into account the entire landscape of the supply markets by identifying potential suppliers and evaluating potential risks (Chithur 2014, 5).

2.3 Supply market intelligence (SMI)

SMI is a central attribute in supply management and category strategy development as well as other strategic business decisions (Handfield 2014, 36). SMI is part of *market intelligence* (MI), which involves gathering and analyzing data about customers, competitors and the markets to facilitate better decisions (Hargraves 2008). MI is linked to the entire supply chain management (Sanders 2016, 29), whereas SMI is related more specifically to supply management. MI can be created by conducting an external analysis to asses and benchmark the marketplace. MI consists of external factors, including markets, industries, economics, suppliers, competitors (Handfield 2006, 34-35), consumer trends, changes in the global business environment impacting supply and demand, technology platforms affecting design and communication, new products replacing previous ones in some market segments as well as geopolitical actions that affect delivery of supply requirements. Understanding the flow of supply, including location of suppliers and management of upstream supply flows for raw materials, and semi-finished and finished products, helps in understanding the external market. (Keith et al. 2016, 233-234)

SMI is defined in this study as: "the ability to develop deep insights into key supply market characteristics, including emerging technologies, price and cost trends, mergers and acquisitions, capacity requirements, quality and delivery performance, and other key supplier capabilities that form the basis for sound strategic sourcing" (Handfield 2009, 103). The main objective of conducting a supply market analysis is to develop the needed intelligence to drive better sourcing decisions. Understanding key elements of the supply market is the basis for

creating an inclusive analysis of the supply market. (Hargraves 2008) Due to this cognitive component, asking the right questions is a vital element of the SMI process (Handfield 2014, 37). Discovering new suppliers and opportunities through systematic SMI increases competitive advantage and determines position in the value net through strategic supply management decisions (Iloranta et al. 2015, 28). SMI enables gaining visibility to global supply chain trends, becoming more agile and interacting with other supply chain partners. These capabilities create competitive advantage, but require new technologies and adjusted business processes, in order to reduce risks and to establish contingency plans. (Handfield 2006, 192) Leading supply management organizations consider the function as a source of innovation via supplier knowledge utilized for new and improved products rather than designing products to costs (Niezen et al. 2007, 7).

Overall, SMI is a central prerequisite in order to select the right suppliers, make good contracts and develop the best collaboration models. Supply market analysis provides intelligence for identifying optimal sourcing strategy options and insights for determining the best prices (Hargraves 2008). SMI includes monitoring the business environment, detecting and understanding supply and demand data of business partners, development trends, economic indicators, social and political changes in the key areas and the development of price indices (Iloranta et al. 2015, 368). Supply market assessment reveals market leaders in size and innovation, potential candidates for acquisitions, long-term competitive solution providers, suppliers that can meet sustainability criteria versus minor business objectives and the ones that are able to integrate with the company (Keith et al. 2016, 240).

Business intelligence (BI) on the other hand refers to internal elements, such as total company spend, demand, internal business units' performance, quality reports and internal finance budgets (Handfield 2006, 34-35). BI is an integrated, company-specific, IT-based total approach for managerial decision support (Rausch et al. 2013, 4). BI and MI are principally opposite views, consisting of internal versus external interpretations, but are linked via corporate strategy and decision-making. Moreover, some of the factors in creating intelligence, such as insights into economic situation and new technologies, have an effect on both sides. Below in figure 7 the connections of BI, MI and SMI as well as subfields of SMI are demonstrated as interpreted in this study.

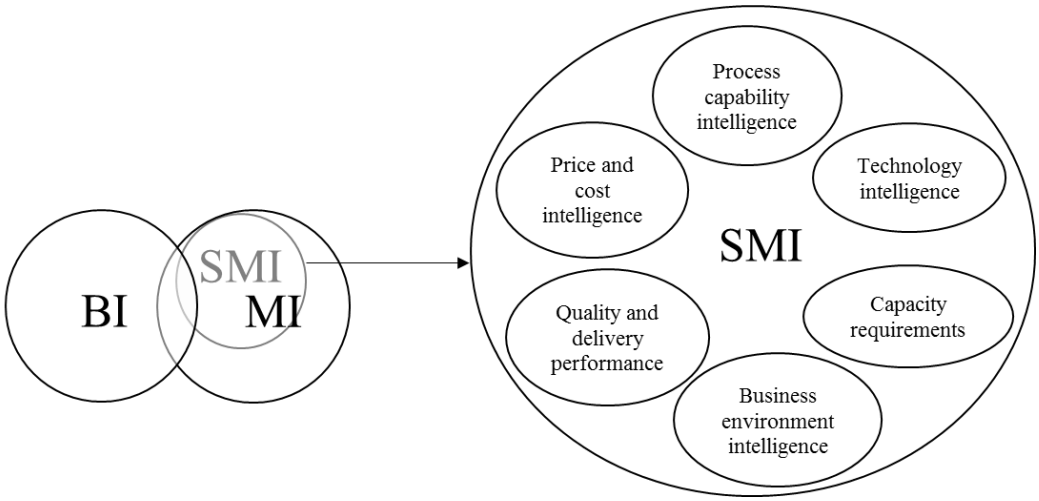

Figure 7. Connections of BI, MI and SMI, and subfields of SMI (modified from Handfield 2006; Shapiro 1985)

The importance of the subfields of SMI is company and category specific, but consist of value-added activities. This involves spend analysis, reporting, process improvement and other market analysis. (Keith et al. 2015, 309)

2.3.1 Key supply market characteristics

Key supply market characteristics included in creating SMI are emerging technologies, price and cost trends, M&A, capacity requirements, quality and delivery performance, and other key supplier capabilities (Handfield 2009, 103), which are examined in this chapter.

Emerging technologies evaluation is important in order for companies to gain competitiveness (Lee et al. 2013, 38). Technology intelligence is based on continuous search for new sources of front-line technology even in new areas of business (Shapiro 1985). Technology valuation makes it possible to invest in technologies, plan *research and development* (R&D) activities as well as transfer, license and market technologies (Jun et al. 2015). Emerging technologies, such as IT, wireless data communication, advanced robotics, bio-technologies, on-demand printing and man-machine communication influence emerging markets by changing business models and social environment (Vong et al. 2015, 1).

It is challenging to have all resources needed for maintaining present technological capabilities, as well as building new ones. The supply base is therefore seen as a major source for innovation, in addition to providing products and services. (Cousins et al. 2011, 930) Companies that

endorse innovations in product design and manufacture by engaging advanced technologies and collaborative methods, compete on their ability to acquire and evolve new methods to resolve product and process issues. Due to mutual dependency, trust among the parties reduces holdup uncertainty. (Kaufman et al. 2000, 655) Knowledge management and practices of using internal and external data have a substantial importance on future IT capability in adopting emerging technologies before others (Kwon et al. 2014, 389).

Price and cost trends require identifying the optimal market indicators for a particular industry, commodity or area of spend, which is critically important but also one of the most challenging tasks in the supply market analysis (Hargraves 2008). Supply risks increase if a company is not able to predict fluctuations in the market prices of financial and non-financial assets (Shi 2004, 221). Price intelligence is based on detailed IS for tracking raw material prices and predicting prices of derivative products, whereas cost intelligence is a thorough understanding of the economics of suppliers' manufacturing facilities and processes in order to be able to predict suppliers' costs for negotiating prices downward. (Shapiro 1985). By evaluating spend data (O'Brien 2014, 63), and competitive product pricing, cost estimations can be formed (Handfield 2014, 38). Cost analyses facilitate competitive negotiations and contract renewals with suppliers (Handfield 2014, 37). Supply management processes need to balance between reducing cost structures and driving innovation (Vitasek 2016, 35).

Factors affecting the prices include employees, raw materials, technology, energy and logistics, in addition to geographical, social and political aspects (Iloranta et al. 2015, 229). Technical analysis examines patterns from market indices, price inflation and cost economics in order to form price and cost trends to forecast product or service estimates, while fundamental analysis looks for core structures and foundations to explain reasons for the valuations (Chang et al 2014, 73). Changes in foreign exchange rates are relevant for the income statement and balance sheet, especially if a company has operations in several countries. Interest rate changes have an effect on interest expense, value of loan portfolio and market value of debts. Furthermore, price changes for commodities, such as electricity and heating oil, have an impact on the costs of operating factories and office buildings, while price changes for supplies, such as copper and steel, can affect the cost of goods sold. (Shi 2004, 221) Researching market indicators provides insights into current state of the market and may codify previous research findings. The

indicators can provide data for identifying market trends, such as seasonality and cyclicality, when observed over time. This delivers value by enabling the analyst to create a warning system for future shifts in the marketplace that might have an effect on continuity of supply or pricing. (Hargraves 2008)

M&A offer potential for rapid growth, development of new capabilities and access to new markets (Hassett et al. 2011, 16). Strategic acquisitions create leverage by acquiring new production facilities and production technologies (Shi 2004, 233), thus M&A often occur in an attempt to acquire innovative R&D capabilities (Phillips et al. 2012, 34). Process capability intelligence refers to knowledge of the capabilities of supplier's technology and design for the use of capturing innovation. Two-way information flow enables insights into suppliers' technologies as well as capabilities and limitations of the buyers' processes. (Shapiro 1985)

Business development through acquisition highlights understanding of innovation and linkage to R&D. Proactive M&A are driven by the need to create new business, including taking risks. Most acquisitions take place within the same industry or related business fields. (Hassett et al. 2011, 8-12) Therefore, understanding the structure and history of the supply base is fundamental in creating SMI. Supply market research should begin with identifying recent M&A activities, number of suppliers, fragmentation and consolidation of the industry, availability of low cost country suppliers, possible supply channels and geographic distribution of suppliers. (Hargraves 2008)

Capacity requirements that can be quantified are the objective of a capacity forecast, which can be used to develop operating budgets. Capacity refers to inventory, human resources, warehouse space, transportation and machine time. (Handfield 2006, 167) Interpretation of the capacity requirements from forecasts is needed in effective capacity planning. In addition, accurate demand forecasting and supply chain operations that are capable of meeting estimated demand are required in the capacity planning. Demand planning is therefore crucial to supply chain operations planning. (Wang et al. 2016, 103)

Quality and delivery performance are features, in addition to price, in which suppliers compete in the markets (Kaufman et al. 2000, 651). Performance optimization requires transparency, defined in this context as the ability to determine and quantify uncertainties in

order to define an objective estimation of manufacturing capability and readiness. In order to achieve transparency, advanced prediction tools need to be utilized for systematically processing data into information, explaining uncertainties and enabling more informed decision-making. (Lee et al. 2013, 39)

Other key supplier capabilities are connected with business environment intelligence, consisting of impacts and understanding of foreign cultures, politics, trade barriers and the effects of other government constraints and incentives (Shapiro 1985). According to RBV, in order to achieve long-term competitive advantage, resources need to be valuable, rare, inimitable and non-substitutable (Barney 1991, 105-107). Traditional RBV focuses on identifying and analyzing superior resources. Due to the dynamic business environment, dynamic capability view can be added to the traditional RBV to increase understanding of how capabilities mature in the dynamic environment. Increased access to capabilities and resource collections of specialized suppliers in the field drives companies to outsource non-core competencies. (Ahtonen et al. 2009, 267)

2.3.2 Data, information, knowledge and intelligence of SMI

Data exists in every sector, economy, organization and user of digital technology (Manyika et al. 2011, 2), and the amount of generated data continues to grow rapidly. However, data facilitates no actions without a context and understanding, which has resulted to using a knowledge hierarchy, where data transforms into information and knowledge, answering to questions what and how. Pure data contains symbols, information consists of data that is processed to be useful in a particular context, and knowledge is the application of information in decision-making. Data and information can also be called pre-knowledge since they are a prerequisite for knowledge formation (Erickson et al. 2012, 15). Often a fourth level, wisdom is added as the highest level of the hierarchy, describing evaluated understanding and application of knowledge, while answering to question why. Moreover, enlightenment can be used as an additional level, for achieving the sense of truth. (Rowley 2007, 167) In this study, the highest level of the hierarchy is considered as intelligence, defined as the capacity to acquire knowledge to facilitate actions (Goertzel et al. 2007, 6). Data, information, knowledge and intelligence are reviewed in the context of SMI in the following subchapters.

Data layer stores structured and unstructured data from different internal and external sources (Rausch et al. 2013, 5). SMI data are formed from, for instance, disconnected trends in various supply markets, industries and technologies, commodity pricing, financial status of suppliers and M&A. The data are located in diverse and difficult to identify sources, which constantly need scanning, filtering, reading and summarizing them into organized information. (Handfield 2006, 34-35)

Information generation, storage and distribution layer provides the ability to analyze data content and furthermore distribute relevant knowledge (Rausch et al. 2013, 5). Supply market information is needed for supply management processes, such as sourcing and category strategies, as well as continuous risk and opportunity monitoring. Much of this information is publically available from various sources but require effort and resources for synthesizing and making the information useful. (Accenture 2014) Information needs to be communicated to key decision makers in an effective, efficient and timely manner to support decision-making (Handfield 2006, 36).

Knowledge that is unique and possessed to create value creates competitive advantage. In the context of SMI, knowledge consists of creating insights into strategic sourcing processes like supplier evaluation and strategy formation. New opportunity identification and validation involve researching data from the external markets and transforming them into knowledge to support strategic sourcing decision-making. (Handfield 2014, 35-38) The ability to identify, assimilate and exploit knowledge from the environment can be referred to as absorptive capacity (Cohen et al. 1990, 128), who argue how some organizations can utilize external information in a better manner. More important than heavy investments on knowledge management, is knowing what the key knowledge assets are, where they are and how they could best be employed if needed, when the industry circumstances are considered (Erickson et al. 2012, 2). Osterwalder et al. (2005) state that capturing, storing and following company's business models are an important form of knowledge management, and the first step of managing business model knowledge is describing the company's model explicitly. Consequently, the first step of managing supply management knowledge is determining the best sourcing option, consisting of defining the key sourcing categories and the best sourcing business model, consisting of the best supplier relationship model and the best economic model (Vitasek 2016, 32-33).

Intelligence from the supply markets is generated when external information is collected and analyzed to form actionable conclusions that affect a company's ability to strategically locate, secure, and manage sources of supply (Jones et al. 2015, 3). Data can be formed into intelligence and meaningful insights can be created through analytics (Sanders 2014, 7). However, creating systematic SMI requires more than simply a set of analytical tools. Effective SMI formation requires collecting and analyzing data, engaging stakeholders in defining information requirements, and sharing knowledge for applying insights in key impacted business sectors across the organization. (Handfield 2014, 36-37) Once deep understanding of knowledge is extracted as intelligence, it is important to utilize it in supply management processes through various actions, including people, computer applications or automated systems (Justus 2017). In reference to understanding and context, data and information (pre-knowledge) are related to the past, knowledge concerns the current time and intelligence is associated with the future. Figure 8 below shows the creation of data into intelligence in the context of SMI.

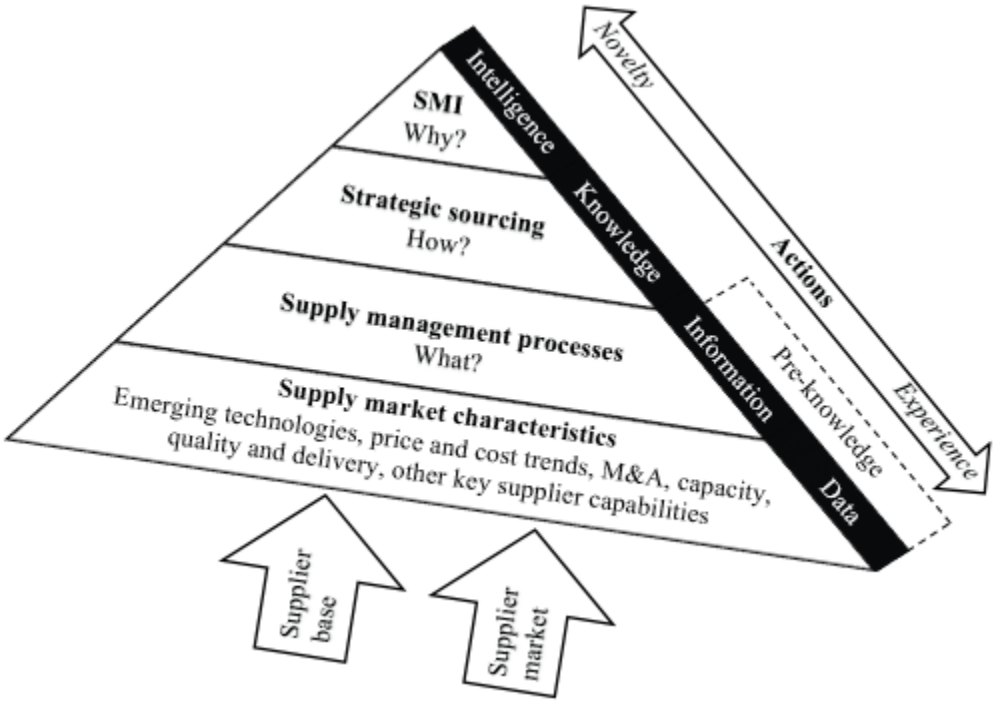

Figure 8. Data, information, knowledge and intelligence in the context of SMI (modified from Aydın et al. 2015, 94; Handfield 2006, 35; Handfield et. al. 2009, 103; Rowley 2007, 167)

Various actions are needed for transforming data into intelligence. The below intelligence cycle (figure 9) includes the actions that are usually needed for composing intelligence from raw data to support decision-making. Intelligence is created after the analysis phase in this cycle. Active collaboration is needed during the entire process. The most important aspect is to generate intelligence on a timely and precise manner. (Aydın et al. 2015, 96)

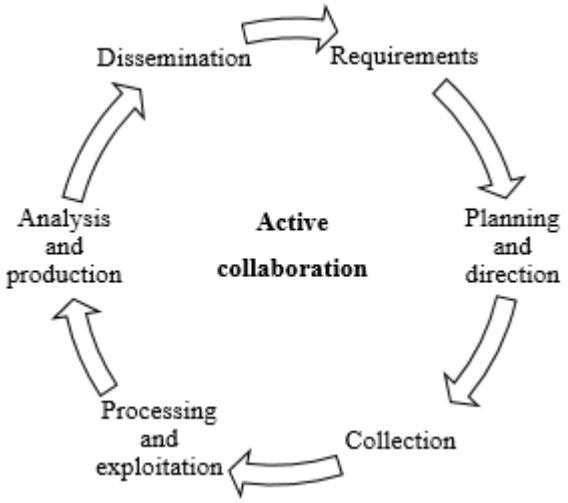

Figure 9. Intelligence cycle (Aydın et al. 2015, 96)

Due to huge amounts of data, an unambiguous conceptualization of the intelligence cycle may not be useful. Instead, it is important to apply methods that meet anticipated needs and filter non-relevant data. (Aydın et al. 2015, 98)

2.3.3 Challenges in SMI

Many managers recognize the challenges in establishing focused SMI creation (Handfield 2014, 39). Issues related to in-depth understanding, internal resources and valuable pre-knowledge are recognized and studied in more detail in this chapter.

In-depth understanding of internal supply management processes and requirements, supply constraints, cost modeling and analysis, upstream and downstream supply chain as well as suppliers for each product or category are required for creating SMI (Hargraves 2008, 8). The value of SMI in creating competitive advantage and importance in supply management needs to be initially recognized. Creating systematic SMI requires recognition from the company and

category managers who are usually responsible for its creation. A common mistake is creating centralized SMI teams without understanding for what and how the collected information will be used. (Handfield 2014, 37)

Internal resources of subject matter experts, such as *chief procurement officers* (CPOs), procurement specialists or category managers, may provide inaccurate information regarding the supply base because they tend to narrow their views in order to become knowledgeable in a specific function. Due to limited resources in time, workload and expenses, many companies face challenges in applying internal resources to focused and extensive SMI (Handfield 2014, 37). This results in becoming unaware of recent changes in the supply market or specific supplier capabilities. Additionally, hiring, training and retaining professionals with capabilities to conduct supply market research and analysis is challenging. (Hargraves 2008, 8)

Valuable pre-knowledge can be collected directly from the suppliers, authors or subject matter experts via RFx or focused interviews. Primary research is often more insightful than secondary research (Hargraves 2008), providing insights into market conditions through cost estimations and competitive information. However, in many cases RFx are biased or incomplete and do not reflect the actual supply market conditions. Wide enough interviewing and analysis of the results on the other hand requires expertise and is time consuming. (Handfield 2014, 38-39) This results to acquiring additional supply market information from across the supply chain network, involving subscribing to expensive industry journals, investing in document management services or requiring category managers to gather data and information from various sources, such as websites, income statements and financial balance sheets (Chithur 2014, 8).

Nowadays, huge amounts of information are available online, but the challenge is to acquire relevant information to support the strategy and business of a particular company and supply management processes. Cost trends and competitor intelligence for a particular category, for example, are difficult to obtain. Available information on the Internet is obtainable by the competitors as well, and therefore does not create competitive advantage for the company (Hargraves 2008). Furthermore, the validity and authenticity of online sources is often difficult to examine and may require an expensive specialist intelligence provider. *Intellectual property rights* (IPR) issues might also rise when exploiting online sources. (Chithur 2014, 8) External

market research can be executed by constructing own benchmarking surveys or through third party outsourced providers. (Handfield 2014, 38-39) Comprehensive research is often difficult and costly to execute in-house, and therefore in many cases more benefits can be obtained by outsourcing the research (Hargraves 2008, 8).

2.3.4 SMI outsourcing

Companies may not have enough resources to execute benchmark breakdowns, best practice studies, competitive landscape reports and strategic analyses needed for strategic sourcing (Hedin et al. 2014, 209). The challenges in creating SMI steer companies towards utilizing external resources for gaining SMI through outsourced data collection, synthesis, analysis and reporting. Especially organizations applying centralized teams often use external resources to collect market data. (Handfield 2014, 38-40). SMI outsourcing can reduce costs and increase effectiveness by achieving high scale, controlling costs, automating processes and bringing efficiencies to supply market insights. Even when choosing the option of third party sourcing of SMI, in-depth understanding needs to be established in-house. Therefore, collaborating with SMI providers as partners, rather than traditional arm's-length relationship, is a notable opportunity. (Hargraves 2008, 9)

SMI service providers have comprehensive knowledge of different markets, cost drivers and demand variation indicators due to their constant market presence and monitoring. An experienced SMI partner with a global network can provide a distinct viewpoint of an optimal supply strategy and supply markets, while considering the interchange between global commodities, suppliers and customers (M-Brain 2017). They can provide information regarding new market entrants, emerging technologies, innovations, M&A activity as well as risks using technological developments, analytics tools and customized reporting. (Hargraves 2008, 9-11) Some of the main areas where SMI outsourcing is used consist of global market analysis, benchmarking, value chain mapping, pricing, emerging market sales and channels as well as cost reductions (Handfield 2014, 40). Overall, collaborating with specialized service providers enable companies to optimize the cost of high quality market information, focus on strategic sourcing decisions instead of collecting supply market data and adopt global best practices. This enables companies to forecast and manage supplier risks, besides attaining cost savings.

(Hargraves 2008, 9-10) Examples of SMI solution provider services and case studies are gathered in appendix 1.

2.4 Continuous improvement cycle of supply management

Since the business environment is increasingly dynamic and volatile, the supply strategy and other supply management processes need to be proactively reevaluated and adapted to the continuously transforming marketplace (Keith et al. 2016, 208). Sourcing decisions should not be based only on suppliers' ability to provide goods or services but also on the ability to drive improvements based on core competencies (Vitasek 2016, 29). Therefore, in order to stay competitive, companies must actively develop processes in interaction with other actors in the supply chain (Heide et al. 2008, 1). This consists of balancing with reducing costs while mitigating risks and driving innovation (Vitasek 2016, 25). Therefore, supply risk management and driving innovation are examined in this chapter.

It is important to apply strategically aligned metrics for continuous improvement (Sanders 2014, 163). *Key performance indicator* (KPI) is a metric that is used to measure a quantifiable component of a company's performance. KPIs are used to initiate improvements and focus resources on central aspects of the organization, connected to the company's goals. Proper KPIs drive strategy and performance, support decision-making, evolve and are clearly communicated. (Sanders 2014, 172-173).

2.4.1 Supply risk management

Supply risk can be defined as a possibility of an undesired occurrence related with the inbound supply of goods or services, which have a damaging effect on the buying company, and avert it from meeting customers' demands within expected cost and time (Hoffmann et al. 2013, 201). Volatility of commodity prices and currency fluctuations create economic uncertainty in the new economy, which is a vital issue due to the interconnectedness of global supply chains (Schoenherr et al. 2011, 4564). There is an increasing need for supply market risk information and establishing risk-monitoring assessments, caused by financial risks in the supply base and insufficient processes for continuous supply risk monitoring (Handfield 2014, 37 & 40). In

addition to financial risks, environmental, operational and strategic risks need to be taken into account (Hoffmann 2013, 209).

Supply risk management consists of different actions of recognizing, monitoring and mitigating supply risks (Hoffmann 2013, 201). Different authors recognize different stages of supply risk management, but risk factors affecting supply can be addressed via methodology of identification, assessment, management and monitoring (Hoffmann et al. 2013; Hallikas et al. 2004). Managing risks is a continuous process during which risks are analyzed systematically (Östring 2004, 22-23), across business units, functions and sources of risks (Shi 2004, 221).

The importance of lower-tier suppliers should be taken into account in risk management. Supply failures from second and third tier suppliers, such as implications of earthquakes or raw material shortages, involve defining and studying supply risks at various inter- and intra-organizational levels (Zsidisin 2003, 223). Furthermore, suppliers that work in several markets may observe shifts in the economy promptly. Without close relationships with the suppliers, companies may miss opportunities to adjust orders and prices. Furthermore, sustainability risk may increase if no proper relationship is formed with lower-tier suppliers and their performance is not monitored. (Choi et al. 2011, 114) In the current interconnected supply chain environment, the focal company needs to certify environmental consciousness, traceability and transparency of first-, second and third-tier suppliers (Schoenherr et al. 2011, 4566).

SMI can reduce supply risks via knowledge of the supply market dynamics and supply base composition. An inclusive understanding of the supplier characteristics, such as amount, type and structure of the supply market, is the basis for supply risk management. Risk of supply interruptions can be minimized by analyzing supplier size and capabilities in comparison to critical to quality needs of a company. Risky supply markets include, for instance, highly concentrated supply markets, in which only a few suppliers can meet required needs, or heavily fragmented supply markets, consisting of small and financially instable suppliers. Defined market indicators can provide warning signals of occurrences that may disturb supply continuity or unbalance the buyer-supplier relationship. These indicators may even be incorporated into contracts, permitting allowances for fluctuations in the markets. (Hargraves 2008)

2.4.2 Driving innovation

Innovation influences companies' success in the competitive business environment (Jean et al. 2012, 1004), since taking advantage of an extensive range of external sources of innovation enables to build and sustain competitive advantage in the marketplace (Henke Jr. et al. 2010, 41). Supply market opportunities consist of innovative utilization of supply network resources and capabilities, in addition to cost effective supply chains (Laiho 2015, 41). The ability to scan the business environment for breakthrough innovations and *new product development* (NPD) is increasingly essential for the success of companies (Cousins et al. 2011, 930). Handfield et al. (2015) recognize the importance of supply management in combining internal stakeholder needs and suppliers' interpretation of the needs. These strategies have an effect on many value adding business areas, such as product innovation, technology development, knowledge sharing and new process capability development as well as multi-tier supplier integration (Handfield et al. 2015, 4).

Innovation outsourcing has become more common and facilitated many companies, such as Dell, HP and IBM, to reduce R&D resources due to relying on external suppliers (Jean et al. 2012, 1004). Companies need to take into account key players across multiple tiers (Schoenherr et al. 2011, 4563), because lower-tier suppliers can provide valuable information about newest manufacturing developments and technological innovations (Choi et al. 2011, 114). Therefore, it is vital to view the supply base as an interactive network rather than arm's-length chain of suppliers, in which at most only first tier suppliers' capabilities are taken into consideration (Hedin et al. 2014, 209-210).

The acquisition and transfer of knowledge between suppliers and focal company characterize a fundamental driver of innovation, which allows managing and discovering new solutions to technical and commercial challenges in the marketplace (Cousins et al. 2011, 940). Therefore power relations between suppliers and buyers have an important role in driving innovation, since suppliers are more willing to share and invest in innovative ideas and technologies when the buyer-supplier relationship is collaborative and open (Henke Jr. et al. 2010, 44).

3 BIG DATA ANALYTICS (BDA) FOR STRATEGIC ACTIONS

The use of digital technologies has resulted to BDA becoming a critical business capability for creating value from large amounts of data in order to gain competitive advantage. Big data refers to the capability to process and utilize data that has features of *volume, variety, velocity* (3Vs), and other granular and complex properties that distinguish big data from traditional data. (Chen et al. 2014, 314-315). Analytics is the ability to gain insights from data via statistics, mathematics, econometrics, optimizations, simulations or other techniques to support decision-making (Wang et al. 2016, 99). Big data is worthless without leveraging the potential value into decision-making (Gandomi et al. 2015, 140), and further actions. The processes needed for creating insights from big data can be divided into two main processes of data management and analytics (Gandomi et al. 2015, 140), which are studied in this chapter.

3.1 Evolution of big data generation

After the research of opportunities and potential of big data, conducted by McKinsey Global Institute (MGI) and McKinsey's Business Technology Office (2011), the amount of data has continued to explode. The hype associated to big data is related to the promotional initiatives and investments in the analytics market by leading technology companies such as IBM (Gandomi 2015, 138).

Even though big data has become a buzzword in recent years, it has been used in data mining since human generated content was composed in the social network (Lee et al. 2014, 4). The World Wide Web (WWW), commonly referred to as web, was initiated in 1989 by Tim Berners-Lee, who had an idea of a global hypertext space where users could communicate by sharing accessible information. The former web was a static read-only web, where users visited the sites without own contributions or linking capabilities. In 2004, Dale Dougherty defined Web 2.0, which was a read-write web, facilitating more flexible web design, creative reuse, updates, modifications, collaborative content creation and collective intelligence gathering. (Aghaei et al. 2012, 2-3) Web 2.0 focused on human generated or related data, and big data was used in social and commercial mining, such as sales predictions, as well as user relationship mining and clustering (Lee et al. 2014, 4). In 2006, Web 3.0 was introduced consisting of an idea of linked data, implying that data can be linked, integrated and analyzed from various datasets in order to

acquire new information. It can be referred to as semantic web, in which data is readable and understandable by machines. (Aghaei et al. 2012, 5-7)

In the 2010s, emerging technologies have facilitated automation in order to adapt and respond to dynamic market requirements. Web 4.0 consists of intelligent analytics and cyber-physical systems that use sensors, signals and historical data for further data mining. (Lee et al. 2014, 4-5) It can be referred to as the symbiotic web in which interaction between humans and machines is in symbiosis (Aghaei et al. 2012, 8). Web 5.0 is predicted to focus on the emotional interaction between humans and computers based on neurotechnology (Benito-Osorio et al. 2013, 277).

Three basic laws of IT development can be recognized to provide technology foundation for the rapid increase of basic Internet finance (Fan et al. 2015, 319). Firstly, Intel cofounder Gordon Moore defined *Moore's Law*, which argues that the number of transistors that can be placed on an integrated circuit doubles about every two years, which means that the amount of computing power that can be purchased for the same amount of money doubles approximately every two years (Manyika et al. 2011, 2). A strategy called *More Moore* refers to a road map that is released every two years by the semi-conductor industry to coordinate how the manufacturers and suppliers stay in pace with the law (Waldrop, 2016, 145). Secondly, *More than Moore* (MtM) refers to an even faster information exchange (Fan et al. 2015, 319). MtM starts with the applications, for instance, in smart-phones and supercomputers or data centers in the cloud, continuing downwards to combine chips that are needed to support them, instead of making the chips better, and letting the applications follow (Waldrop, 2016, 145). Thirdly, *Metcalfe's Law* refers to a wider social linkage (Fan et al. 2015, 319). It is a network effect describing the increasing value of a service to a user as the amount of users grow (Hendler et al. 2008, 14). Furthermore, cloud computing continues to lower costs and technology barriers (Manyika et al. 2011, 2).

In order to obtain an overview of the development of the concepts big data and BDA, Google search trends of the terms are analyzed below worldwide (figure 10) and in Finland (figure 11), in comparison to term supply management as a dotted line. Timespan is from the beginning of year 2004 until the end of year 2016. The scale is from 0 to 100, where 100 represents an area where a certain term has been the most popular, 50 where half as much searches were made as

in the highest area and 0 where the share of the searches was less than 1 % of the highest area. Figure 10 also discovers developments of Web 2.0, 3.0 and 4.0 during the timespan as interpreted in this study.

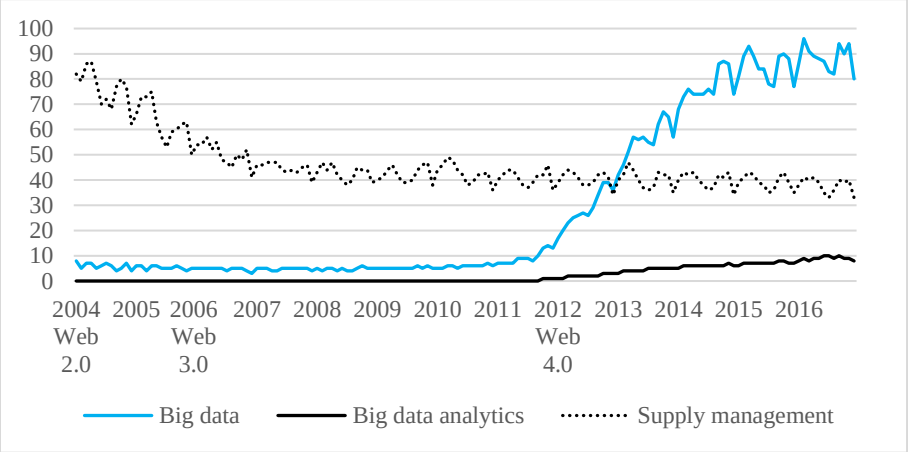

Figure 10. Google search trends of big data, BDA and supply management worldwide (Google Trends 2017)

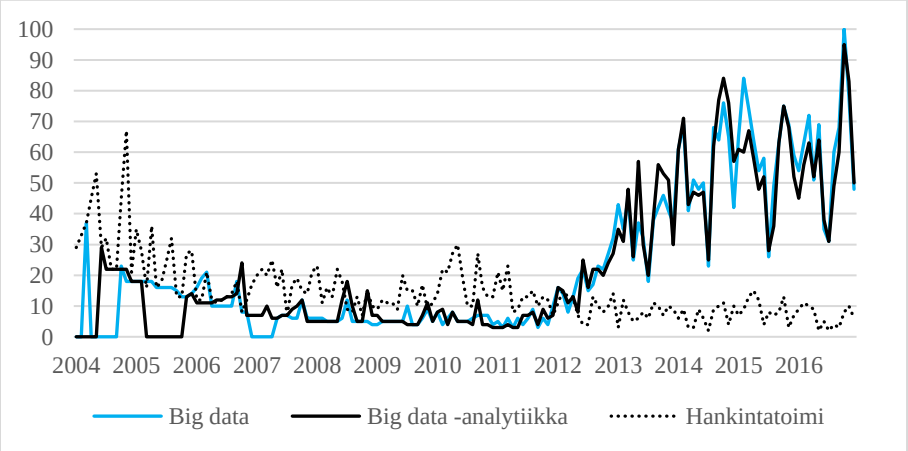

Figure 11. Google search trends of Finnish terms big data, BDA and supply management (Google Trends 2017)

Since the sample size is smaller when gathering search trends data in Finland, the dispersion is shown more visibly. Difference of the Finnish terms big data and BDA is considerably smaller than between the terms in a worldwide range, which indicates of the global big data hype. A clear difference is seen among popularity of terms big data and BDA worldwide.

Academic literature related to big data and BDA has increased in a similar pace as Google search trends. Figure 12 below shows yearly frequency distribution of ProQuest Research Library documents containing terms big data and BDA, and supply management as comparison presented as lined column, on a timespan from year 2004 until 2016.

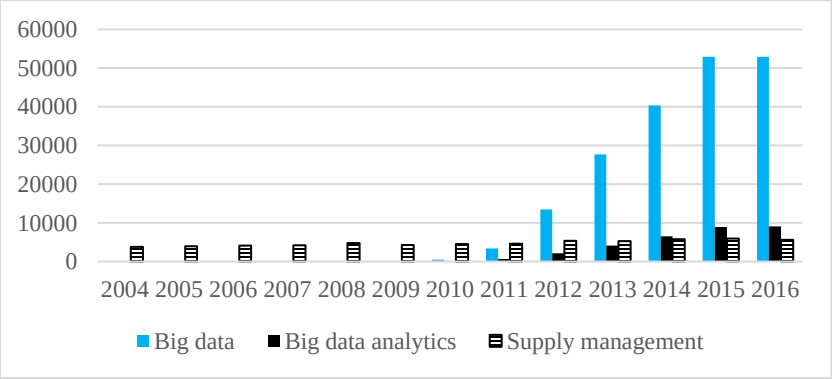

Figure 12. Frequency distribution of terms big data and BDA in ProQuest Research Library

Data generation expands in fast pace, and is expected to increase fourfold by the year 2020. Furthermore, it is projected that in 2020 more than third of the produced data will be stored in the cloud. Drivers for this transformation consist of technologies converting from analog to digital, and the increased data generation of both individuals and companies. Individuals generate more than 70 % of digital content but companies have responsibility to storage, secure and manage 80 % of that data. Rest of the data is managed by individuals or unorganized in different databases and IS. (CSC 2016) Expected evolution of data generation is presented below in figure 13 from year 2009 until predicted year 2020. Values are presented in zettabytes.

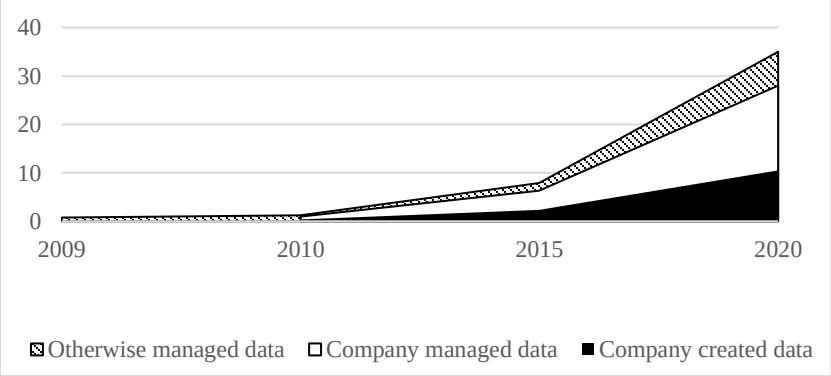

Figure 13. Expected evolution of data formation (CSC 2016)

It can be seen that the amount of data will continue to grow exponentially in high speed. Due to the increased data and development of IT, the definition of big data continues to evolve. Companies still waste increasing volumes of transactional data that capture enormous amount of information about suppliers, customers and operations (Manyika et al. 2011, 1).

3.2 Definition and categorization of big data

Definitions of big data have evolved rapidly, which has caused confusion among many users of digital services. Some definitions focus on what it is, while others describe what is does (Gandomi et al. 2015, 138). Commonly big data is referred to when the size of the datasets grows so large that they cannot be captured, stored, managed or analyzed using the capacity of typical database software tools. The definition of big data keeps developing due to increased data generation and IT, resulting to more sophisticated processing power and analytical tools. (Manyika et al. 2011, 1-2) In the definition of big data, explanations of 3Vs, and later on additional Vs, are introduced. Initially Gartner analyst Douglas Laney used volume, variety and velocity as the 3Vs to characterize the concept of big data. (Chen et al. 2014, 314-315). Using these concepts, big data can be defined as: "high-volume, high-velocity and/or high-variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision-making, and process automation" (Gartner 2017). Consequently, the definition is threefold including 1) characteristics of big data, 2) ways of processing and analyzing the data and 3) use cases of the analyzed data.

Volume stands for the massive size of various datasets (Chen et al. 2014, 314). A survey conducted by IBM in 2012 discovered that most global executives considered over one terabyte datasets being big data. Intel on the other hand considers that organizations that generate weekly around 300 terabytes of data are big data volume generators (Varela et al. 2014). However, there is no absolute limit in terms of volume when referring to big data, because IT and storage capacities keep increasing, enabling bigger datasets to be captured. (Gandomi et al. 2015, 138) There is still much hidden potential and value in the volume of big data (Chen et al. 2014, 314), since the amount of generated data continues to grow exponentially (Sanders 2014, 11).

Variety stands for the range of data types and sources (Chen et al. 2014, 314), referring to structural heterogeneity in datasets (Gandomi et al. 2015, 138). Different types of data are

created via consumer devices, such as social media sites, smartphones, computers, multimedia sites and networked sensors embedded in devices (Brown et al. 2011, 9). The data types include for instance video, image, text and audio in structured, unstructured (Hashem et al. 2015, 100), or semi-structured format (Assunção 2015, 6). Structured data consists of formal schema and data models whereas unstructured data has no pre-defined data models (Assunção 2015, 6). As the volume of big data keeps growing, so does the variety of different combinations of data (Sanders 2014, 12).

Velocity stands for the speed of data moving in and out (Chen et al. 2014, 314). Moreover, it refers to the data generation rate as well as the speed that is needed for analyzing data, followed by actions based on the analysis (Gandomi 2015, 138). The increase of digital devices, such as smartphones, smart energy meters, industrial machines and automobiles has resulted to unprecedented rate of data generation. These devices capture and communicate data in the era of Internet of Things. Companies and individuals generate huge amounts of digital exhaust data. (Sanders 2014, 11-12) Businesses applying information driven business models generate valuable exhaust data produced by business transactions, acting as an intermediary role in the value chain (Brown et al. 2011, 10). The development of data in terms of velocity requires real-time analytics and evidence-based forecasting (Gandomi 2015, 138), through capturing, aggregating and disaggregating data to numerous combinations, in order to optimize and assess the best strategies (Sanders 2014, 12).

Veracity as the fourth V was added by IBM to describe data uncertainty, reliability and trust. In addition to the 4Vs, Microsoft added variability and visibility to the definition. (Buyya 2016, 8-9) Moreover, concepts such as value and virtual (Assunção et al. 2015), vision, verification and validation (Berman 2013) have been used to describe the fourth V, depending on special requirements of the context in which big data is used. There are no universal benchmarks for the interdependent characteristics of big data, since the defining parameters continuously progress and depend upon sector, size and location of the company (Gandomi et al. 2015, 139).

As big data can be defined in various ways based on interpretation and context, it can also be categorized in several ways. In this study, big data is categorized based on the form and ownership of data. Figure 14 below shows the categorization of data as per existing literature.

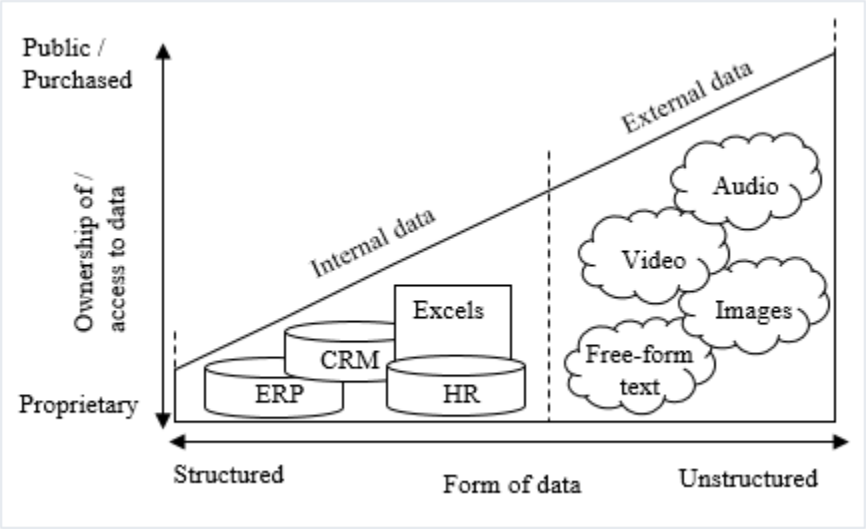

Figure 14. Data categorization as per existing literature (modified from Manyika et al. 2011, 33; Chang et al. 2014, 78; Hashem et al. 2015, 102)

The formation of unstructured data to structured data is a continuum, which includes semi-structured data that does not follow a conventional database system (Hashem et al. 2015, 102). Structured data is stored in fixed fields, such as relational databases and data spreadsheets, whereas unstructured data resides in various sources and formats, such as free-form text, image, video or untagged audio. (Manyika et al. 2011, 33) Secondly, big data can be categorized based on the ownership or access to the data. Typically, collected data in business context are proprietary and contain non-disclosure agreements, but nowadays companies are becoming aware of the strategic importance of investing in insight based decision-making and value co-creation (Chang et al. 2014, 78). As data can become a key competitive asset, companies need to understand the data assets, which they hold or have access to. This can be achieved by first making an inventory of own proprietary data, followed by cataloging external data, which can be accessible in the public domain or require purchasing. (Manyika et al. 2011, 111) It is important that companies need to organize their proprietary data before acquiring external data (Sanders 2014, 49).

Furthermore, big data can be divided into existing and open data. Open data is based on openness, participation and collaboration, and value of the data for society can be realized through sharing, transparency and working together. Anyone is free to use, reuse and distribute

open data, emphasizing the social aspect of the data. (Kitchin 2014, 48-50) Due to the scope of this study, focus is on existing data from the supply markets, such as market indices. Even though the aim of this study is to discover potential BDA applications and opportunities in creating systematic SMI, traditional data in corporate relational databases is included in the examinations since collecting, analyzing and monitoring both supply chain internal data and environmental data are needed for benefiting from big data technologies and analytic methods (Fan et al. 2015, 283).

3.3 Data management

Due to the fast development of IT, the amount of acquirable big data increases (Fan et al. 2015, 286), and data can be recorded in diverse systems for different uses (Manyika et al. 2011, 126). When the amount of acquired data increases, data management capabilities need to be improved (Hazen et al. 2014, 73). Data management is challenging due to the complex features of big data, since same size datasets may need different data management technologies based on data type, such as video or tabular data (Gandomi et al. 2015, 138). Traditional data management systems cannot handle big data instantly and therefore new technologies need to be utilized for managing big data (Gandomi et al. 2015, 138).

The 3Vs characteristics of big data require leveraging additional flexibility and capabilities through cloud computing, which is inevitable in data management and distribution in the big data environment (Lee et al. 2014, 4). Clouds for data management can consist of a private network, a public cloud or hybrid environment consisting of both cloud types. Data management is an essential requirement for implementing BDA, but it is also one of the most labor intensive and time consuming big data processes. (Assunção et al. 2015, 4-5) The acquired raw data needs to be converted to higher-level context data, in order to use it for decision-making (Dobre et al. 2014, 269). Since many companies acquire big data, the key to competitive advantage is accelerating managerial decision-making by providing managers with guidelines that can be implemented for the application of analytical skills in business processes (Chang et al. 2014, 78-79).

Data management consists of processes and technologies for acquiring and storing data, in addition to preparing and retrieving them for analysis. These processes are systematic solutions

in order to reduce the complexity of the data, to accelerate the computation time of insight discovery and to improve accuracy of the analytical results (Furht et al. 2016, 17). Structuring the generated data for further analysis eliminates errors and ensures data quality and reliability (Sanders 2016, 41). Data availability consists of providing the right data, in the right form to the ones who need it, where and when they need it. Available data creates value when integrating datasets to generate business insights (Sanders 2016, 41). Data extraction and cleaning are pre-analysis processes, which attempt to extract useful data from the raw data and refine them for further data analyses. The data needs to be cleaned if they are incomplete, noisy, inconsistent, or include duplicate copies. (Furht et al. 2016, 17) Integration and aggregation of big data on the other hand consist of a set of techniques that combine data from multiple sources in a manner that is more efficient and accurate than analyzing a single source of data for insight discovery (Manyika et al. 2011, 28).

Even though nowadays a high volume of generated data is unstructured, many companies store their internal data in relational databases. As data managed by traditional database management systems reaches a tipping point, it is moved to data warehouses for analysis and for IR. (Assunção et al. 2015, 7) Data warehouses support data integration and aggregation by handling numerous data records (Sahay et al. 2008, 31). New service oriented architecture tools provide interfaces to various data types and enable integrating data sources (Sahay et al. 2008, 35). Integrated systems can provide information of new and innovative materials, services, products and technologies within the enterprise as well as between suppliers (Handfield 2006, 57-61).

3.4 Analytics

Analytics can be considered as the discipline that applies logic and mathematics to data in order to provide insights for enhanced decision-making (Herschel et al. 2015, 18). BDA involves applying statistics and quantitative applications to big data (Sanders 2014, 193), consisting of techniques that are used to analyze and acquire intelligence from big data. There are numerous big data techniques available, so a relevant subset of analytics tools is researched in this study. (Gandomi et al. 2015, 140) BDA derives from data mining, which can also be called knowledge discovery, since it is the process of identifying new insights consisting of emerging trends in

data. Insights resulting from data mining have potential to provide great economic value, which is critical to businesses creating competitive advantage (Kohavi 2001, 30-31).

Analytics maturity is categorized in the literature in several ways. Lustig et al. (2010) divide analysis of structured data into three categories of analytics: descriptive analytics describing what happened, predictive analytics forecasting what will happen and prescriptive analytics indicating what should be done. In addition, Herschel et al. (2016) recognize diagnostic analytics as examining data to answer why an event occurred. However, often two basic categories of analytics are identified as descriptive and predictive analytics (Sanders 2014, 193-194). In the simplified categorization, descriptive analytics can be perceived as basic analytics and predictive analytics as advanced analytics (Sanders 2016, 42; Lustig et al. 2010). Traditional IS processes separate transactions for automating tasks, such as account transactions or order entries, but do not support extracting data at different aggregation levels. Therefore, advanced analytical methods are needed for enterprise, supply chain and supply market wide big data analysis. (Sahay et al. 2008, 31) Proceeding through the stages of implementing BDA maturity levels ensures data quality, enhancement of KPIs and timely access to information by key decision-makers (Sanders 2016, 27). However, it is notable that not all companies need the highest level of analytics to achieve extensive gains and can success without investing in most advanced technologies (Sanders 2016, 42).

Descriptive analytics is used to summarize, aggregate, correlate and describe datasets, such as the amount of returned products, received calls at a call center or people looking for a particular word on Google search engine (Sanders 2014, 193). Descriptive analytics uses historical data to identify patterns and create management reports by modelling past behavior (Assunção et al. 2015, 4). Descriptive analytics uses only simple statistics and computations (Sanders 2014, 193-194).

Diagnostic analytics is a form of advanced analytics including examining data to answer why something happened via techniques such as drill-down, data discovery, data mining and correlations (Gartner 2017). This stage of analytics can also be classified under descriptive analytics (Lustig et al. 2010).

Predictive analytics attempts to forecast the future by analyzing present and historical data (Assunção et al. 2015, 4). It can create radical new insights and new opportunities with third parties via automated algorithms and real-time data analysis (Sanders 2016, 42). This is one of the most significant aspects of BDA (Sanders 2014, 14). Predictive analytics uses machine learning techniques and other computational algorithms of data mining to model the future (Varela et al. 2014). These statistical techniques consist of, for instance, time series analyses to extract meaningful patterns (Wang et al. 2016, 104), spatial regression models to predict network availability factors like time, cost and quality of deliveries (Varela et al 2014), and regression analysis to understand causality (Wang et al. 2016, 104), and dependencies between variables (Manyika et al. 2011, 30).

Prescriptive analytics facilitates decision-making by defining actions and assessing their impact on business requirements, objectives and restrictions (Assunção et al. 2015, 4). Prescriptive analytics uses predictions based on data, and recommends actions that will provide benefit for the company or help to avoid an undesirable outcome. In addition, it includes analyzing variability of the expected outcomes by for instance scenario analysis or game theory. (Varela et al. 2014) Prescriptive analytics includes for instance multi-criteria decision-making, optimization and simulation (Wang et al. 2016, 100).

In this study, an analytics maturity model is adopted from Gartner, presented below in figure 15. Business value is added to the maturity model, to emphasize the value creation process in the horizontal axel. Not all companies need the most mature analytics, but if the analysis is not truly integrated into actions, the data does not provide value for the business. Furthermore, formation of data into intelligence is added to the process. Even though *artificial intelligence* (AI) can be used in data-driven decision-making and automations, such as full-fledged member of Tieto's management team Alicia T (Tikka 2016), it can be argued that machines can conduct smart actions, but intelligent actions require human input (Lee et al. 2014, 3). However, as software and embedded intelligence are integrated in systems and products, intelligent algorithms can be used to autonomously manage and optimize product service needs (Lee et al. 2014, 3).

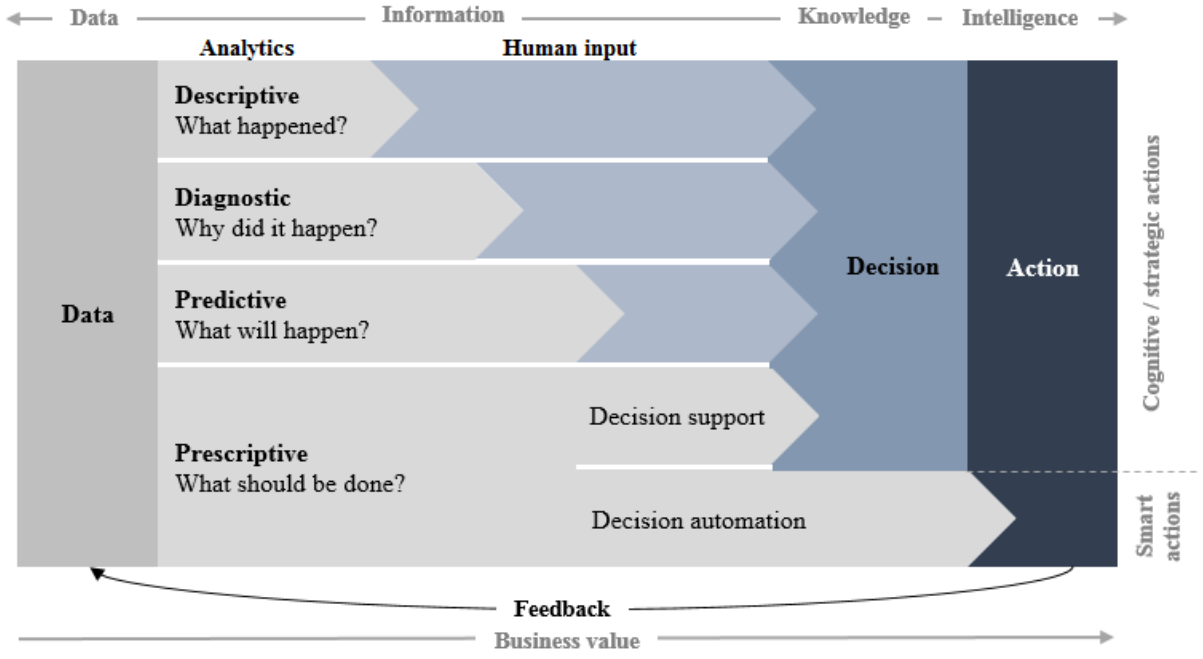

Figure 15. BDA maturity levels and workflow (modified from Herschel et al. 2015, 20)

Especially the manufacturing sector and operational processes can highly benefit from IT and automation (Manyika et al. 2011, 76), but at present in-depth understanding is needed for cognitive and strategic supply management decisions. Examples of BDA platforms and software are presented in appendix 2.

Visualization of BDA consist of techniques that are used for creating images, diagrams or animations in order to communicate, understand and improve results of big data analyses (Manyika et al. 2011, 31). Tools that consider the quality of data and presentation to enable navigation are important due to the increasing amounts of data that is processed in analysis. Visualization can assist in all BDA maturity levels. (Assunção 2015, 31) Managers can attain insights when internal information, such as invoice and contract information, is combined with external information like market and demand information. Interactive dashboards enable easy what-if analysis presented in a visualized format. (Sanders 2014, 136) Examples of big data visualization are shown in appendix 3. Data can be presented as simple overviews, such as tag clouds, or in complex dashboards consisting of diverse and dynamic charts.

3.5 Challenges in BDA

In addition to the benefits BDA can generate, there are challenges that need to be addressed when implementing analytics. The biggest challenges in BDA are staying ahead of technological development in a cost-effective manner as well as developing organizational decision-making processes for utilizing data, absorbing information and turning them into intelligence. (Sanders 2014, 43-44) Furthermore, there are often issues related to data policies, data quality and analytical talent.

Data policy issues grow in importance when data are increasingly digitalized and moves across organizational boundaries. These issues consist of, for instance, data privacy, security, IPR and liability. (Mayika et al. 2011, 11) Better access to information creates privacy issues that need to be evaluated in contrast to the convenience of having information available. (Brown et al. 2011, 10-12) When outsourcing technological and analytical capabilities, risks and dependencies related to data security and IPR need to be recognized. Adding explicit data security requirements into contracts and specifying liability for data breaches can be used (Sanders 2016, 43), to protect, for instance, competitively sensitive data (Mayika et al. 2011, 11). New European Union (EU) General Data Protection Regulation (GDPR) will become in force on 25th of May 2018, having an impact on EU citizens' data privacy protection and organizations' data privacy approaches. The aim of the regulation is to protect all EU citizens from privacy and data violations in an increasingly data-driven world. The biggest regulatory change will be the extended jurisdiction of the GDPR, applying to all companies processing the EU members' personal data, irrespective of the company's location. Organizations in non-compliance of the GDPR may face a maximum fine of 4 % of annual global turnover or 20 million euros in case it is a greater amount. It is notable that the regulations apply to both data controllers and processors, including cloud warehouses. (EU GDPR Portal 2017)

Data quality consists of data consistency and data completeness. Big data originates from various sources, which are not all verifiable (Hashem et al. 2015, 110). Trust in data quality is weakened if data inconsistency or incompleteness become issues caused by, for instance, data input errors, faulty system design or data operator's subjective judgement (Kwon et al. 2014, 389). The amount of increasing unstructured data creates challenges in organizing and

structuring quality data in order to create value (Sanders 2016, 41). Data quality issues are included in the pre-analysis processes, consisting of generating, structuring and organizing the data for further use or analysis (Manyika et al. 2011, 112).

Analytical talent is needed in leveraging big data, so many companies use resources to obtain big data abilities and continuously improve their processes through learning when implementing BDA. However, while technological capabilities continue to develop, the abilities required to use analytical tools also increases. (Sanders 2016, 42-43) Companies need to recruit and retain deep analytical talent, in addition to establishing a culture that values the use of big data in decision-making (Manyika et al. 2011, 13). However, the key is not to recruit only analytics professionals for mining and preparing data, conducting statistical operations, building models and programming business applications. Equally important are the analytical businesspeople who are prepared, capable and willing to utilize better information and analyses to reinforce their work, in addition to collaborating with analytics professionals. (SAS 2014, 34)

3.6 BDA outsourcing

If the company does not have necessary resources or capabilities to implement BDA internally, external vendors are increasingly used for analytics, including specialized software, additional databases and the orchestration of technological elements. Furthermore, many external providers specialize in specific industry segments, enabling to combine technical knowledge and the company's needs. (Sanders 2016, 43) Fan et al. (2015) suggest that supply chain external big data should be outsourced to third-party analysis companies due to the difficult requirements of data collection and analysis.

BDA service providers provide opportunities by making information more valuable. However, principles, policies and frameworks affecting stability between risk and value can create challenges due to increased data size and requirements for faster data management technologies. (Hashem et al. 2015, 112) Therefore, companies need a proficiently formed analytics outsourcing strategy, outlining which analytical capabilities are outsourced and which are established internally. The strategy should include a long-term plan for building capacities as well as meeting short-term objectives. (Sanders 2016, 43-44)

4 BDA OPPORTUNITIES AND APPLICATIONS IN SMI

In the context of supply management, the opportunities refer to possibilities to add value in terms of time efficiency as speed-to-market strategies, cost reductions as company profit margins and product pricing, as well as quality improvements as the competitive strategy of a company (Handfield 2006, 54-55).

In this chapter, BDA opportunities in supply management and applications in creating SMI are studied based on references to other research and existing literature. Chapter 4.1 discusses about the potential benefits that can be achieved by using BDA. In chapter 4.2, different areas in which BDA can be applied are analyzed, including a discussion of related tools and technologies.

4.1 BDA opportunities in supply management

Quickly shortening product life cycles, competitive global markets and volatile market behavior requires companies to analyze accurate and timely information (Sahay et al. 2008, 29). Development of new data management technologies and analytics enables organizations to leverage big data in their processes in innovative ways. Big data technologies enable creating real-time intelligence from high volumes of data, which is not possible with traditional data management systems. (Gandomi et al. 2015, 138) In supply management, BDA enables to refine real time data for faster and more informed decisions, maximize the amount of preferred suppliers and automate administrative and tactical tasks in order to focus on strategic and relationship management activities (O'Donnell 2016, 5). Fulfilling the BDA opportunities requires investments in IT solutions as well as organizational changes (Manyika et al. 2011, 83).

Capturing the full potential of value creation from big data requires access to third-party big data sources that may be public or purchased, and involve different data types (Manyika et al. 2011, 108-113). Value creation through big data consist of: creating transparency, enabling experimentation to discover needs, expose variability and improve performance, segmenting populations to customize actions, replacing and/or supporting human decision-making with automated algorithms as well as innovating new business models, products and services (Manyika et al. 2011, 4-6). Interpretation of important business information brings value from the analysis (Sahay et al. 2008, 42), so analyzed information needs to be communicated on a

timely, effective and efficient manner to key decision makers (Handfield 2006, 35-36). The potential value of big data is realized only when leveraged to initiate decision-making (Gandomi et al. 2015, 140). BDA can be used to optimize value creation at the level of individual companies, sectors and economies as a whole (Manyika et al. 2011, 12).

As an extension of RBV, the theoretical framework of *knowledge-based view* (KBV) can be linked to BDA by considering big data transformed into knowledge as such a resource that needs to fulfill the requirements of valuable, rare, inimitable and non-substitutable source of supply. The resource requirements of KBV can be achieved through a high level of data quality. (Hazen et al. 2014, 77) Moreover, the dynamic capabilities theory is based on an assumption that core competencies should be used to convert short-term competitive positions that can be employed to form longer-term competitive advantage. This assumption extends to BDA, since big data, as raw data before data management and analysis, can be considered as an undifferentiated resource that is not yet transformed into an empowering capability. (Richey et al. 2016, 729-730)

Improved forecasting and decision-making can be achieved by utilizing big data through assessing an extended set of forecasts and carrying out strongly informed decisions (Richey et al. 2016, 722). Interconnected supply chains, markets and businesses require integrating data from different internal and external sources, applying analysis tools and techniques to understand the information from the data, make decisions and take actions based on the insights (Sahay et al. 2008, 30). Demand forecasting that includes trends and seasonality require short-term predictions via predictive analytics (Wang et al. 2016, 103). Improved forecasting expands the company's ability to address risks associated with decision-making (Richey et al. 2016, 722), hence supply risk management has great potential to benefit from big data by collecting and analyzing the data, and utilizing it to detect risks (Fan et al. 2015, 283). Predictive and prescriptive analytics facilitate companies to make effective decisions to the strategic direction (Demirkan et al. 2013, 414). BDA can be applied to address issues related to changes in organizational culture, sourcing decisions, supply chain configuration as well as design and development of products and services (Wang et al. 2016, 100).

Utilizing BDA improves ability to discover insights, improving company's performance and risk management. BDA supports evaluating of an optimal sourcing strategy and enables to manage capacity and delivery of products from manufacturers to customers. BDA enables data scalability via collecting granular big data consisting of infinite range of possibilities, enabling supplier segmentation based on key characteristics, supporting the sourcing strategy and balancing costs versus risks. (Sanders 2016, 32-41) The more suppliers and customers a company has, the bigger potential there is to use BDA for segmentation (Manyika et al. 2011, 123).

4.2 BDA applications in creating SMI

Improved access to external market and internal enterprise information supports the supply management process through integrating software between enterprises and supply chain partners (Shi 2004, 222). Big data applications in SMI consist of the areas, which provide insights into key supply market characteristics, consisting of emerging technologies, price and cost trends, M&A, capacity requirements, quality and delivery performance and other key supplier capabilities.

4.2.1 Emerging technologies

Patents are an important knowledge resource in identifying technology development trends and opportunities, specifically emerging technologies (Ma et al. 2014, 811). New technological innovations and development can be reflected by patent databases containing patent documents and award information (Bai et al. 2016). Patent documents contain information about registered technology, such as abstract, title, inventor, date, claims, international patent classification codes and citations. Through descriptive statistics, such as the frequency table, mean and variance, retrieved patent documents can be summarized using representative variables. Furthermore, relationships between patents and technologies can be found via multiple regression analyses, and technological clusters can be formed via clustering and classification. Patent documents provide novel data for technology forecasting and analysis, and can include more comprehensive and diverse information about emerging technologies than just articles or papers. (Jun et al. 2015, 963-964)

Both free patent sources, such as Google Patents, Espacenet and PatentScope, and commercial databases, such as Orbit, PatBase and Thomson Innovation can be used, based on budget and scope of needed data. Extensive results can be obtained by understanding synergies and differences of diverse patent systems (Marley 2014, 235). International innovation collaboration can be extracted using patent data mining and content visualization tools (Bai et al. 2016). Effective analysis of patents' contents and understanding topical information to identify innovations and technology opportunities is the key in patent mining (Ma et al. 2014, 812).

Research publications of emerging technologies might expose new topics that do not appear frequently in patents' titles, abstracts or manual codes (Ma et al. 2014, 823). Topical content of research publications is easier to generalize via keywords, which are missing from patent documents. Furthermore, due to technology protection, titles and abstract descriptions of research publications are more comprehensible than patents. This reduces time to process and analyze the content of research publications. (Ma et al. 2014, 811-812) Research publications can be acquired from databases managed by organizations such as VTT Technical Research Center of Finland and the Research Institute of the Finnish Economy (ETLA). In the past, new technological developments appeared initially in technical and academic publications (Gandomi et al. 2015, 137), which supplement patent documents in conducting a comprehensive analysis of emerging technologies.

Scientific and engineering literature contains technological information that can be searched effectively via analytics (Ma et al. 2014, 812). Literature is increasingly available in digital form from databases such as ProQuest, Materials Science & Engineering Database and NASA Scientific and Technical Information (STI) Program. When inventing new technologies, it is important to know whether the invention is novel, which can be referred to as novelty or prior art research. Scientific and engineering literature journals, conferences and websites can be searched to supplement patent documents and scientific research. Google's Prior Art Finder is an available tool for including non-patent literature into the search. (Marley 2014, 227) Text summarization techniques can be applied to scientific and engineering literature, by generating a concise summary of the documents (Gandomi et al. 2015, 140).

Technical media is a useful source in gaining a better understanding of emerging technology development patterns and trends (Ma et al. 2014, 825). Finnish magazines, such as Tekniikan Maailma and Tekniikka&Talous (T&T), contain information about emerging technologies. Technical media is an example of textual data that can reveal insights by using text mining. Text analytics enable companies to transform human generated data into meaningful summaries to support decision-making. (Gandomi et al. 2015, 140). Information from media is diversified in terms of format and content as well as language and reliability (Fan et al. 2015, 288). Development of IT increases access to media sources, new devises for gathering data as well as cloud computing to support heavy storage and analytical needs of big data (Brown et al. 2011, 11).

News and press releases contain current information about technological developments. Finnish organizations such as Finpro and Technology Academy Finland (TAF) publish up-to-date news and press releases. Furthermore, companies might release information of their newest technological developments to attract investors. Public news and press releases can reveal disasters and uncertainties, as well as opportunities in external environments that have an impact on technologies. The news contain information such as date, focus, contents, sources and potential risks in the business environment, which can be analyzed using big data technologies. (Fan et al. 2015, 287)

4.2.2 Price and cost trends

Financial media via text mining can be used to forecast market prices such as stocks (Gandomi et al. 2015, 140). Finnish financial media consists of for example magazines such as Kauppalehti, Talouselämä, Taloussanomat and Yle News. Global financial news are available for instance via Bloomberg News and Financial Times (Östring 2004, 206-207). However, it is important to note that critical thinking is needed when analyzing economic media. Ahern et al. (2014) discovered that companies have an incentive to manage their media coverage to influence stock prices during significant corporate events. Therefore, the timing and content of financial media coverage might be biased. (Ahern et al. 2014, 241) Furthermore, *social media analytics* (SMA) can be utilized in the financial field to analyze worldwide consumer patterns and trends through social media channels (Gandomi et al. 2015, 142).

Inflation and deflation statistics are among the elements that need to be researched when evaluating price and cost trends (Handfield 2014, 38; O'Donnell 2016, 8). Supply contract terms and conditions might include pricing linked to commodity prices or foreign currency. In order to avoid mispricing, analyzing the price inflation is essential. (Shi 2004, 239) Databases such as the Organisation for Economic Co-operation and Development (OECD) and Statistics Finland provide inflation and deflationary pricing information. Data collection, synthesis, analysis and reporting of inflation and deflation data are increasingly outsourced, due to limited internal resources and the wide scope of external data needed (Handfield 2014, 40).

Interest and exchange rates analysis is an important part of financial risk management. Interest rate and currency exchange rate can pressure prices to fluctuate (O'Donnell 2016, 8). Especially when organizations have global operations, fluctuations in foreign exchange rates and changes in interest rates can have a substantial influence on the income statement as well as the balance sheet. In an unstable economic environment, even highly rated companies will encounter difficulties (Östring 2004, 41). Therefore, risk management and analytics tools and techniques are needed for enhanced assessment of interest and exchange rates. (Shi 2004, 221-222) Exchange rate movements can be forecasted, for instance, from time series of social media channels, such as Tweet counts (Fan et al. 2015, 287). In addition, interest and exchange rates can be analyzed using databases maintained by different financial and statistics institutions such as Bank of Finland and the Statistical Office of the European Communities (Eurostat).

Market indices consist of pricing indicators, such as consumer pricing index, employment indicators, such as unemployment rates, and production indicators, such as *gross domestic product* (GDP) (Hargraves 2008), growth according to capacity or percentage of GDP in short term describing services value added (O'Donnell 2016, 8). Economic indicators' research and reporting steer the corporate as well as business unit level financial budget planning (Handfield 2014, 38). Global market index listings are provided in sources such as Reuters (Östring 2004, 41), Nasdaq and Nordnet. Furthermore, TradingView is a social network for traders and investors, providing free stock charts and quotes online. The hourly value of a stock market index can be forecasted for instance using time series analysis (Manyika et al. 2011, 31). Osterwalder et al. (2005) learned that in the beginning of the 21st century the figure of the Nasdaq market index reminded of the frequency curve of the term business model in business

journals. This indicates that different trends and correlations can be extracted from market indices via analysis. Even technological developments can be examined via market indices. (Osterwalder et al. 2005, 4)

Company databases such as Asiakastieto, Europages, Kompass and Thomas Global contain information about a wide range of existing and potential suppliers (Iloranta et al. 2015, 231). Asiakastieto provides credit information about Finnish companies as well as companies outside of Finland (Östring 2004, 206). However, company databases should be used as supplementary sources in financial market analysis since data in the databases is limited. Most important information provided from the company databases are identification and contact information of the suppliers. (Iloranta et al. 2015, 231)

Publications from banks contain information about suppliers' financial risks and facilitate company databases (Iloranta et al. 2015, 231). Bank of Finland releases a bulletin consisting of articles concentrated on the Finnish economy whereas the World Bank publishes publications on a global scale.

The corporate internal relational databases contain information about supplier transactions and prices (Manyika et al. 2011, 70). Knowledge of the supplier's financial performance can be used to negotiate concessions on key products (Varela et al. 2014). The major challenge in utilizing relational databases is integrating the data on an organizational level between departments, such as supply management, R&D and manufacturing or service operations. Lack of access to databases prevents timely exploitation of the information, resulting to incoherent view of individual suppliers and poor understanding of links among financial markets. (Brown et al. 2011, 4) Development of IT supports integrating business processes and using online marketplaces and collaboration networks to generate available transactions and exchange information (Shi 2004, 236).

4.2.3 Mergers and acquisitions

Competition policies have an impact on corporate M&A actions (Ahern et al. 2014, 288), from the perspective of acquiring needed resources for corresponding to the competition. The theoretical framework of RBV can be used as the framework to assess competition between companies and supply chains (Hazen et al. 2014, 77). Sources such as European Commission,

Finnish Competition and Consumer Authority as well as Ministry of Economic Affairs and Employment provide information about competition policy regulations and changes that can be utilized in predicting potential M&A. While competition policy can be analyzed on the retail sites, the social side can also reveal insights into current competition. SaaS company Unmetric, for instance, provides SMA solutions, through which companies can monitor different brands' interest on social media and counteract the competition. (Kaye 2015, 19)

Emerging technologies are closely linked to M&A via opportunity identification. Opportunity identification requires examining future market and technological changes, such as sources of new ideas and business opportunities as well as right partners. Market and technology foresight are needed to support the strategic decision-making process, including vision and strategic M&A decisions. (Hassett et al. 2011, 42) Investments in IT and employment in technology sectors can reveal insights into the prevailing market forces (O'Donnell 2016, 8).

Price and cost trends can be used to evaluate potential M&A among suppliers. As researched by Ahern et al. (2014), financial media can reveal insights into M&A, since companies increase the amount of firm-originated news after merger negotiations have started. The incentive is to increase a company's share of the merger gains. (Ahern et al. 2014, 288)

Company databases include information about M&A in addition to company credit information, which support assessing the viability and profitability of yet unknown suppliers (Iloranta et al. 2015, 231). Online databases, such as industry web sites and consolidated catalog sites, can provide useful information and additional insights (Sollish et al. 2011, 72). M&A Research Catalyst offered by Bureau Van Dijk for instance delivers reports for M&A research.

4.2.4 Capacity requirements

Meteorological databases consist of daily weather forecast data, which can be integrated from an outside partner into the demand and capacity planning processes. By analyzing data points, such as temperatures, rainfall levels and the duration of sunshine, capacity requirements related to meteorological issues can be assessed. Data can be collected, for instance, as time series for long-term and near real-time processing guarantees (Dobre et al. 2014, 272). Processing and analyzing satellite imagery exposes facility capacities and shipping movements, revealing insights into expansions and business constraints. (Brown et al. 2011, 4-9) In addition to third

party service providers integrating meteorological data into capacity planning processes, free sources such as Finnish Meteorological Institute provide open data that is freely available for public use.

User demographics can be utilized to find patterns and create insights into usage clusters in order to create multidimensional segmentations and evaluate capacity requirements (Varela et al. 2014). Open data and interfaces of Finnish user demographics are available for instance provided by Statistics Finland. Algorithms can detect relationships between demographics variables and filtering them without human intervention (Sanders 2016, 28). Smart algorithms can collect demographic information while companies collect data from their processes. Valuable insights can be created by correlating this data in the decision-making processes. (Gandomi et al. 2015, 141) Technology improvements enable segmenting and analyzing close to real time (Manyika et al. 2011, 99).

The corporate internal relational databases contain data such as sales histories and seasonal sales cycles. This data can be aggregated and useful information for evaluating capacity requirements can be extracted using analytics. (Manyika et al. 2011, 70) Analytics can be used in capacity expansion evaluation, in addition to inventory management, procurement and logistics functions as coordinated supply chain management processes (Sanders 2016, 32).

4.2.5 Quality and delivery performance

Geographic information systems (GIS) facilitate delivery performance monitoring and optimizing by using GPS-enabled big data telematics, such as remote reporting of positions and route enhancement, (Manyika et al. 2011, 70), traffic density, weather conditions, transport systems constraints, intelligent transport systems (Varela et al. 2014) and RFID sensors (Sanders 2014, 34). Examples of applications consist of integrating spatial data into regressions or simulations (Manyika et al. 2011, 30). This kind of prescriptive analytics, consisting of large-scale optimization, complex multi-criteria decision issues and distributed simulation models, require large scale computational resources (Demirkan et al. 2013, 419). Free global GIS information is available from for instance Google Earth, Gapminder World, Pitney Bowes and Statplanet. Finnish GIS data can be found from ArcGIS Online, Karttakeskus and Paikkatietoikkuna.

The corporate internal relational databases consisting of performance requirements contracts, such as service level agreements or other quality measures should be analyzed in order to asses quality and delivery performance of suppliers. In addition, data about existing suppliers' former transactions, such as lead times and delivery locations can be extracted from relational databases if the data are available. (Varela et al. 2014) A large amount of internal data in supply management is generated from different sources, via supplier performance valuations, spend information and negotiations. These data sources provide decision-makers consistent data for business issues, such as quality problems and material availability. (Wang et al. 2016, 103)

4.2.6 Other key supplier capabilities

The trend towards increased globalization and outsourcing, as well as focusing on capability- and innovation-driven supply management, increases the dependence on suppliers (Schoenherr et al. 2012, 4556). In the new economy, companies search for new capabilities for managing web-based interactions with suppliers, partners and customers (Eris et al. 2014, 6). Fawcett et al. (2011) discover that investments in IT contribute the most, when they enable dynamic collaboration capabilities in the supply chain. Regardless of the company's particular focus, the fundamental objective is to accomplish alignment between the buying company's needs and the suppliers' capabilities, from technical as well as cultural and behavioral perspectives. All of these standpoints have an influence on the buying company's ability to interact with the suppliers effectively. (Petersen et al. 2004, 384)

Below in table 1, some examples of BDA applications for creating SMI are extracted and demonstrated as per existing literature and previous research. Additionally, examples of databases in creating SMI are gathered in appendix 4 consisting of web links for the aforementioned pre-knowledge types.

Table 1. Examples of BDA applications in creating SMI as per existing literature (Demirkan et al. 2013, 419; Dobre et al. 2014, 272; Fan et al. 2015, 287; Gandomi et al. 2015, 140-142; Jun et al. 2015, 963-964; Kaye 2015, 19; Manyika et al. 2011, 30; Varela et al. 2014)

Supply market characteristics	Pre-knowledge	BDA solutions	BDA techniques
Emerging technologies	Patent databases; patent documents and award information	Descriptive analytics Predictive analytics	Frequency table Mean Variance Clustering Classification Regression
Price and cost trends	Financial media Interest and exchange rates Market indices	Predictive analytics	Time series SMA
Mergers and acquisitions	Competition policies	Predictive analytics	SMA
Capacity requirements	Meteorological databases User demographics	Predictive analytics Predictive analytics	Time series methods Clustering
Quality and delivery performance	Geographic information systems (GIS)	Predictive analytics Prescriptive analysis	Regression Multi-criteria simulation and optimization

Predictive analytics is represented the most due to its relevance in forecasting and decision-making support. The benefits of descriptive analytics are limited to basic analytics whereas prescriptive analytics is more recently becoming increasingly applied due to its high level of analytics maturity.

To conclude the synthesis of the literature, table 2 below presents a summary of BDA opportunities and applications in SMI. The sources are concentrated on the period of 2010s, which in turn demonstrates the current nature of the subject.

Table 2. Summary of BDA opportunities and applications in SMI as per existing literature

		Technologies					Price and cost trends							M&A				Capacity			Q&D	
BDA opportunities and data applications in SMI **Authors**	Forecasting and decision-making	Patents	Research publications	Scientific / engineering literature	Technical media	News and press releases	Financial media	Inflation and deflation statistics	Interest and exchange rates	Market indices	Publications from banks	Relational databases	Company databases	Competition policies	Emerging technologies	Price and cost trends	Company databases	Meteorological databases	User demographics	Relational databases	GIS	Relational databases
Östring (2004)							X		X	X			X			X	X					
Shi (2004)								X	X			X				X						
Osterwalder et al. (2005)										X						X						
Sahay et al. (2008)	X																					
Brown et al. (2011)					X							X			X	X		X				
Hassett et al. (2011)															X							
Manyika et al. (2011)	X									X		X				X			X	X	X	
Iloranta et al. (2012)											X		X			X	X					
(Demirkan et al. 2013)	X																					
Ahern et al. (2014)							X							X		X						
Handfield (2014)								X		X	X					X						
Hazen et al. (2014)														X								
Ma et al. (2014)		X	X	X	X										X							
Varela et al. (2014)												X							X		X	X
Fan et al. (2015)	X				X	X			X						X	X						
Gandomi et al. (2015)			X	X	X		X								X				X			
Jun et al. (2015)		X													X							
Marley (2015)		X		X											X							
Bai et al. (2016)		X													X							
O'Donnell (2016)	X							X	X	X					X							
Richey et al. (2016)	X																					
Sanders (2016)	X																		X	X	X	
Wang et al. (2016)	X																					X

5 METHODOLOGY AND RESEARCH DESIGN

In this chapter, the research approach is explained by interconnecting the chosen data collection methods and data analysis to the context of this study. Chosen methodology of qualitative research is explained in more detail in the following subchapter 5.1. The research design follows the features of inductive logic via starting with empirical data collection instead of theoretical background. However, due to the iterative nature of moving between empirical data and theory, features of abduction are included. This master's thesis is part of the SIM research project conducted by VTT Technical Research Centre of Finland and Aalto University, so comprehensive resources for gathering empirical data were available. Empirical data is gathered from Finnish companies, since the conclusions are addressed to profit local companies. BDA in the context of SMI is rarely researched topic, so the empirical data contributes high value in this study.

Threefold data collections methods of 1) supply management professionals' semi-structure interviews in a multiple case study, 2) supply management professionals', including a few BDA solution providers, focus group discussions and 3) BDA solution providers' / experts' semi-structured interviews are selected to ensure large variety of data in the novel research area. Therefore, triangulation of data is used to enhance validity of the study (Lee et al. 2008, 239). Triangulation refers to the use of different independent sources and data collection techniques within the study for certifying that the data is answering to the objectives correctly. Qualitative data collected using semi-structured interviews is a valuable way of triangulating data from the focus group discussions. Moreover, a case study strategy of multiple cases is selected in order to be able to generalize the findings to various companies in different industries. The unit of analysis consists of embedded cases that are linked to the main topic of this study. (Saunders et al. 2009, 146-147) The unit of analysis in this study consists of sub-fields of supply management in the new economy and BDA for strategic actions. Last, analysis of the empirical data with qualitative data analysis software NVivo is described in subchapter 5.2.

5.1 Data collection methods

Data collection methods of multiple case study involving semi-structured interviews, focus group discussions and semi-structured interviews of individuals were chosen to answer the

objectives and research questions of this study. Semi-structured interviews included a list of themes that varied in the context of the research situation (Saunders et al. 2009, 601), whereas the focus group discussions were constructed on predefined topics facilitated by a moderator (Saunders et al. 2009, 592). Below in table 3, overview of the data collection is shown.

Table 3. Overview of the data collection

Method	Objective	Number of informants	Role of informants
Multiple case study	The receive an understanding of the importance of SMI in strategic supply management	10	Supply management professionals
Focus group discussions	To examine what are the fundamentals, pre-knowledge, methods and use cases of systematic SMI by utilizing BDA	40	Supply management professionals and BDA solution providers
Semi-structured interviews	To answer how can big data be categorized, what are the most suitable BDA methods in creating SMI, and how can BDA provide value	6	BDA solution providers / experts

Multiple case study comprising of semi-structured interviews of supply management professionals in different industries were conducted to study the importance of SMI in strategic supply management. The case companies were selected based on their mature supply management organization and relevance in utilizing SMI. The interviews consisted of discussion about the central characteristics included in SMI, need for forecasting events in the supply markets, methods for creating SMI and use cases in which gathered data and information can be used. The interview questions were based on a category perspective since the interviewees are positioned in category management related processes.

Most of the case study interviews for the SIM research project were already executed when starting the research of this thesis. The last two interviews were conducted during the work of this thesis in December 2016 and April 2017. In total, six of the case study companies, consisting of ten interviewees, were selected for further analysis in this thesis, in order to answer to RQ2. Two of the case company interviews consisted of one supply management professional, and four interviews consisted of two professionals. In table 4 below, the supply management

professional interviewees are shown based on industry of the case company and title of the interviewees.

Table 4. Supply management professional interviewees

	Industry of the case company	Title
1.	Pharmaceutical industry	Head of Purchasing
		Category Manager
2.	Metal and mining industry	CPO
		Technology Sourcing Manager
3.	Technology industry	Sourcing Manager
		Sourcing Manager
4.	Environmental and industrial measurement	Category Manager
5.	Telecommunications industry	Head of Innovation Collaboration Ecosystems
6.	Loading solutions manufacturing	Sourcing Manager
		Category Director

The interviewees are presented anonymously and their answers are used solely for research purposes. The interviews were recorded and transcribed for further analysis with permission of the interviewees. Two of the interviews were held in English and the remaining eight of the interviews were held in Finnish and translated into English when analyzing the data.

Focus group discussions were organized in collaboration with the Finnish Association of Purchasing and Logistics (LOGY), Aalto University and VTT as a workshop on January 31, 2017. The focus group discussions consisted of approximately 40 participants, including mostly supply management professionals and a few BDA solution providers. The participants were divided into six groups, in which 1-2 mediators guided the discussions and made notes of the participants' answers. In addition, two group discussions were recorded for more thorough analysis with the participants' permission. The empirical data from the focus group discussions were utilized in studying the main research question, through the support research questions. The discussions addressed topics of ideal situation for creating SMI to reinforce supply

management, supply risk management, resource usage in creating SMI as well as descriptive and predictive analytics in the context of supply management.

BDA solution provider / expert interviews were conducted in three solution provider companies, two of the interviews were executed in a research center and one in a university of applied sciences. The interviews provided valuable insights for the main research question through support research questions RQ3 and RQ4. The discussions concentrated mainly on the potential and benefits BDA can create for business through strategic supply management. These interviews were executed during January 2017 until April 2017. All of the interviews were recorded and transcribed for further analysis with permission of the interviewees. In the below table 5, the solution provider / expert interviewees are presented based on type of company and title of the interviewees.

Table 5. BDA expert / solution provider interviewees

	Company	Title
1.	BDA solution provider	Vice President Sales and Marketing, Co-Founder
2.	Research center	Research Scientist
3.	Research center	Senior Scientist
4.	University of applied sciences	Principal Lecturer
5.	BDA solution provider	Data Engineer
6.	BDA solution provider	Cloud Solution Architect

One of the BDA solution provider interviews were held in English and rest five of the interviews were held in Finnish. Some of the answers from the solution providers contained confidential information regarding their customers, but data that is presented in this thesis is publicly obtainable as part of the empirical data.

5.2 Data analysis

Analysis of the empirical data was conducted through inductive coding, using a qualitative data analysis software NVivo. Following the characteristics of an inductive approach, the coding nodes were not predefined, but evolved during the coding process. However, as the research

also has features of abduction, the multiple case study interviews of supply management professionals were coded through reflecting theory of supply management in the new economy. These interviews were analyzed in order to study the importance of SMI in strategic supply management, and the theoretical background was used to support the empirical findings. In order to reduce the amount of data and display the results in a comprehensible manner, the codes were grouped into contextual categories. (Hüttinger et al. 2014, 701) Appendix 5 visualizes the frequency of the nodes as tree maps by comparing the number of items coded. Node that includes the most references / topics is shown in green, whereas least appeared node is shown in dark red. Nodes that appear with intermediate frequency are shown in different shades of orange and yellow. Amount of references in each node is presented in square brackets after the nodes.

Supply management professionals' semi-structured interviews were analyzed via nodes: spend analysis and opportunity assessment, sourcing strategy, category management, supply risk management and driving innovation. The most frequently appeared node in the case company research is sourcing strategy (30 references) and the least appeared node is spend analysis and opportunity assessment (10 references).

Focus group discussions were analyzed via nodes: SMI fundamentals, pre-knowledge, methods, use cases, supply risks, supply risk management, ideal use of resources, current use of resources, descriptive analytics in SMI and predictive analytics in SMI. The most frequently appeared node in the focus group discussions is pre-knowledge (55 references) and the least appeared node is descriptive analytics (2 references).

BDA solution providers' / experts' semi-structured interviews were analyzed via nodes: BDA fundamentals, big data, BDA solutions, value from BDA, challenges in BDA and future trends in BDA. The most frequently appeared node in the case company research is BDA solutions (37 references) and the least appeared node is big data (12 references).

Below in figure 16, summary of the research process of this thesis is presented. Following the features of induction, the research process develops by starting from empirical data collection and further continuing to theory (Eriksson et al. 2008, 22).

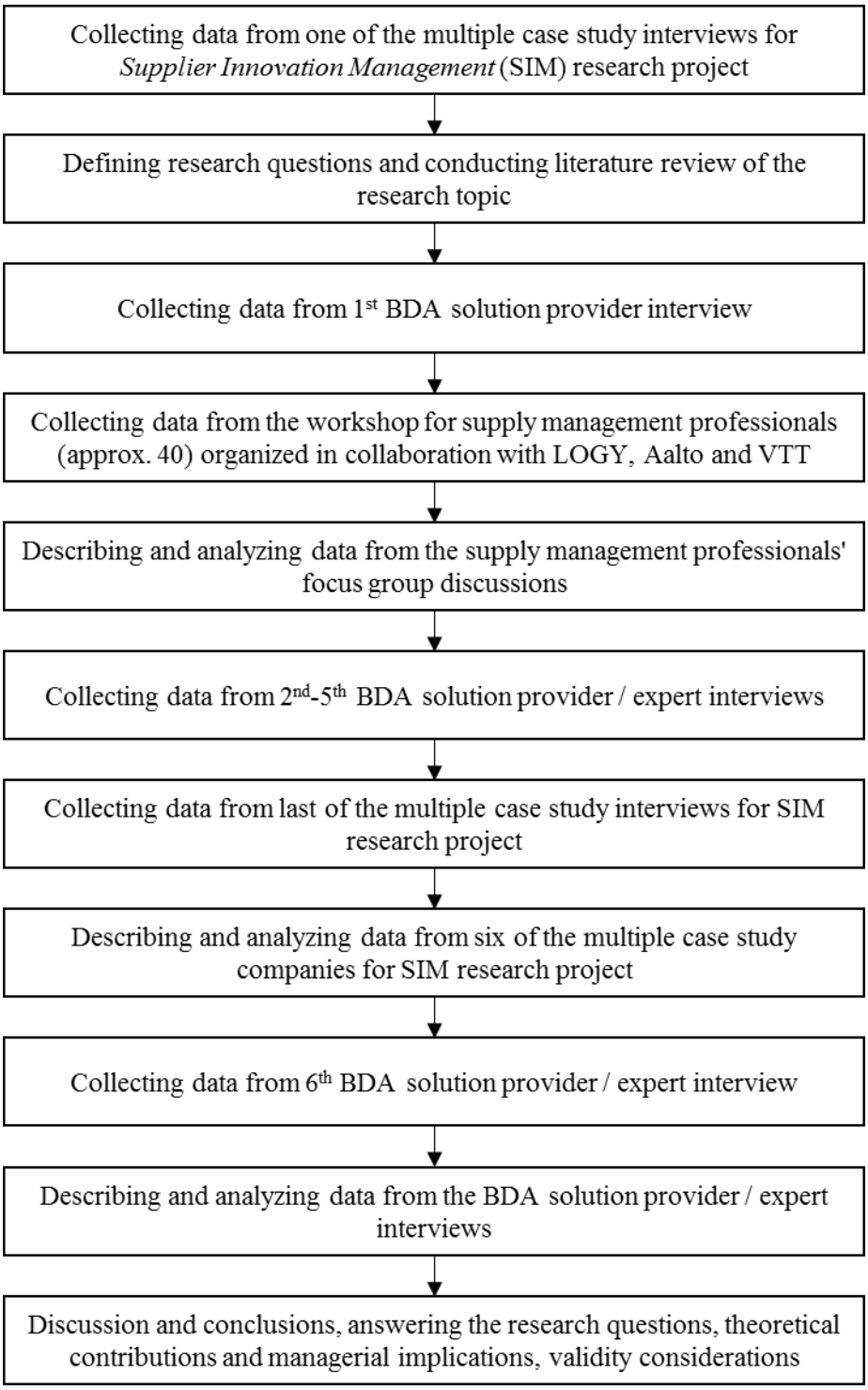

Figure 16. Summary of the research process of this thesis

6 FINDINGS AND ANALYSIS OF THE RESULTS

This chapter includes describing the empirical data from the multiple case study, focus group discussions and BDA solution provider / expert interviews, followed by summary and analysis of the results.

6.1 Describing the empirical data

The empirical data is described in the following subchapters as rephrased text and summarized into tables to demonstrate the results. The tables are sorted from the most frequent themes to the least appeared topics. Amount of interviews / groups in which the following topics were raised are presented in brackets after each topic. Most appeared topic is highlighted in dark grey and topics that were discussed in at least half of the interviews / groups are emphasized in different shades of grey depending on the frequency.

6.1.1 Importance of SMI based on multiple case study

Qualitative interviews of case companies in several industries were executed as part of the SIM research project conducted by VTT and Aalto University. The research addresses research questions of why and how companies are conducting SMI. In this thesis, the empirical data from the case company interviews is studied from the perspective of what is the importance of SMI in strategic supply management as per RQ2.

Sourcing strategy was the most appeared node from the analysis of the case company research. According to the interviews, SMI is important in establishing good contracts and achieving contract compliance with suppliers. This includes negotiating satisfactory price levels, cost breakdown and accurate delivery forecasting, and excludes price increases or at least reasons for the increases should be known. Required timespan for the forecasts depends on the lead-time and project-based orientation of the products in a particular category. Start time of the negotiations has an impact on the negotiated prices depending on prevalent market prices. Knowledge and understanding of components' and products' market price levels and sub costs is important in order to reach the desired solutions. Furthermore, the buying company's attractiveness to suppliers is related to the proportion of spend. When the case company is a small buyer to the supplier and the purchase value is low, the focal company needs to ensure

better treatment and service with negotiations and contracts, which is challenging, but can be facilitated via comprehensive SMI. Attractiveness increases when the share of supplier's revenue increases from the particular buyer, but it can also increase by indicating growth potential for a particular project or product in the contract negotiations. Supply base reduction and centralized spend has been the strategic direction in most of the case companies, for instance following the Pareto principle, emphasizing supplier relationships with strategic suppliers. Therefore, it is important to define strategic criteria for sourcing decisions. The criteria can be, for instance, technical applicability, price, cost reduction, delivery time, flexibility, global footprint or component lifespan. Supplier classification enables to use the same criteria for evaluating different supplier divisions. Suppliers can be categorized in different classifications, such as potential, approved, preferred and strategic suppliers, or transactional and key suppliers.

The issue that strategic importance of the supply management function needs to be recognized in the organization appeared in the discussions. Ultimately, the corporate strategy guides the sourcing and category strategies, consisting of supplier and material selections, but the supply management professionals wish that other units and senior management would recognize the strategic benefits of supply management and the support it can provide for business. Confidential relationship is the basis for scanning business opportunities in collaboration with other business units. Creating comprehensive SMI assists in reasoning the importance of supply management and related knowledge needed for intelligent decision-making. Furthermore, long-term strategic vision and growth plans require SMI in terms of understanding the business environment and future changes.

Category management was the second least appeared node in the analysis of the supply management professionals' interviews. The categories are mainly based on component characteristics, but can be formed based on required technologies or suppliers in which SMI is needed. Usually a category manager is responsible for managing the category as well as for creating SMI. Three of the interviewees brought up that their aim is to have minimum of two suppliers, so-called twin sourcing, who fulfill the defined criteria per category whereas one of the case companies stated that the aim is to have only one main supplier per component. Systematic SMI is needed for regular scanning of actors in the categories, their market positions and changes in growth rate, which are important for category strategies.

Spend analysis and opportunity assessment node appeared the least in the analysis. Spend analysis enables category ranking and supply base segmentation based on the range and priorities of the categories and suppliers. When first segmenting the largest spend suppliers, they can be further monitored through SMI in terms of growth, development, investments, strategic alignment and price fluctuations. Therefore, it is vital to have visibility into the company's spend and the supply market prior negotiations. Discussion of the proportion of the buying company's spend compared to supplier's other customers revealed that the case companies' share of their suppliers' revenue is mainly rather small. For example, in a region where the supplier's revenue adds up to 10-20 percent of the total revenue, the case company's share is only 3-5 percentages. Aftermarket sales opportunities can exclude component suppliers with their own strong networks, in the fear of losing spare part sales, whereas expanding business to global markets requires efforts but increases resources available from suppliers. Last, spend should be integrated from *customer relationship management* (CRM) and *enterprise resource planning* (ERP) systems automatically, reducing manual work in handling spend figures. In the below table 6, aspects of strategic sourcing are shown based on the case company interviews.

Table 6. Importance of SMI in strategic sourcing

Unit of analysis	Strategic sourcing		
Coded node	Spend analysis and opportunity assessment	Sourcing strategy	Category management
Reference (topic)	Category and supplier segmentation (4)	Negotiating good contracts (6)	Categories based on components, technologies or suppliers (5)
	Share of suppliers' revenue (3)	Buyer's attractiveness (5)	Aim to have minimum of 2 suppliers per category (3)
	Market development / aftermarkets (2)	Supply base reduction (5)	Category strategy consists of regular scanning / value stream mapping (2)
	Integrated spend (1)	Strategic criteria defined (5)	Aim to have one main supplier per component (1)
		Supplier classification (4)	
		Strategic importance of supply management (3)	
		Strategic future vision (2)	

Supply risk management was the second most frequent node in the case company research. Availability of materials and reliability of delivery and quality were considered as some of the most important measures in supply risk management. Active supplier performance ratings or scorecards, in addition to ad hoc supplier management and auditing are implemented within available resources, but could be reinforced through SMI. Strategic supplier base reduction and focusing resources on a few suppliers is connected to averting quality risks under stricter monitoring. It includes finding alternative suppliers or materials in order to avoid single source suppliers and last time buy occurrences. One of the companies revealed that they have to exploit low cost country sourcing for the last time buy products. The case companies still have unwanted single source suppliers, over half of the supply base in one of the case companies, due to limited resources used for supplier selection and changes in the business environment. Therefore, management of change and communication with suppliers is essential in order to find out about supplier strategy alterations, M&A as well as production relocations, adjustments or shutdowns. Moreover, changes in software and technology, such as cloud computing, can change the way sourcing is done and affect the product categories.

Knowing the financial situation of suppliers is important for anticipating possible bankruptcies or delays in payments. Country risk mapping across borders increases importance before making contracts with foreign suppliers. This can include, for instance, coordinates or aerial photos of manufacturing plants. If both potential suppliers for a particular product or component are selected from Asia, in case of a natural disaster like a tsunami, the consequences are more severe than if an alternative supplier would be located in Europe. Furthermore, being able to conduct proactive actions to new regulations emphasizes the necessity for creating SMI. Authority regulations might require contracts that include code of conducts and environmental, health and safety systems auditing or other terms and requirements. Finally, the importance of knowing different aspects of suppliers before committing to a collaborative relationship with dependency of each other, as well as anticipating cost increases were raised as important aspects of supply risk management.

Driving innovation is an important aspect in strategic supply management that can be facilitated via SMI. In total, it was the third most appeared node in the analysis of the case company research, but it includes the most frequent reference of supplier technology roadmaps

in collaboration with R&D and business. One of the case companies has R&D resources in sourcing, meaning that one person represents sourcing in NPD projects, delivering knowledge of technology roadmaps and business needs back to the sourcing department. Another company has a unit for forecasting changes three years ahead that provide growth opportunities for business. The unit consists of supply management, business and IT professionals that have an expertise for innovation platform development. The innovation platform concept is based on an open platform allowing companies to promote their current innovation and technology needs for suppliers who can approach the companies instead of focal companies approaching suppliers. Other three case companies considered collaboration with R&D important but did not have as sufficient operating models between the R&D and supply management departments. SMI can increase the desirability of the supply management function to be integrated with R&D.

The need for SMI often derives from NPD processes, consisting of finding better, more affordable, easier to use and assemble solutions and technologies. In addition to NPD processes, product upgrades require new requisites, such as new hydraulics or mechanics. Furthermore, early supplier involvement with strategic suppliers was considered important and as a field in which more attention could be used to ensure right choices of materials and components. Utilizing existing partners' ecosystems can enable identifying innovative suppliers. By collaborating with other large actors, the companies can provide fast growth pathways for the suppliers to bring new technologies to the market sooner. Systematic SMI enables innovation execution, consisting of scouting disruptive innovations in the supply market. Challenger suppliers are actors that can change the market, and should be searched and analyzed. Startups that are disruptors but compose a risk in terms of financial stability or size of business activity may be merged or acquired by another company in order to be included in the scanning. Table 7 below presents findings from the supply management professionals' interviews regarding supply risk management and driving innovation.

Table 7. Importance of SMI in supply risk management and driving innovation

Unit of analysis	Continuous improvement cycle of supply management	
Coded node	Supply risk management	Driving innovation
Reference (topic)	Reliability of delivery and quality (6) Alternative suppliers / materials (5) Management of change / communication (5) Financial situation of suppliers known (4) Mapping country risks across borders (3) Proactive actions to new regulations (2) Dependency / collaboration (1) Anticipating cost increases (1)	Supplier technology roadmaps in collaboration with R&D and business (7) Need derives from NPD processes (3) Early supplier involvement (3) Utilizing partners' ecosystems (2) Product upgrades require new requisites (1) Innovation execution / scouting disruptive innovations (1)

6.1.2 SMI and BDA in focus group discussions

Focus group research topics that were discussed in the workshop are Q1: daydream of a CPO, Q2: supply risk management, Q3: resource usage in creating SMI and Q4: descriptive and predictive analytics. Blog post, Aminoff & Paajanen 2017, about the seminar is published in VTT's blog and Launonen (2017) talks about the seminar in her article in the membership magazine of LOGY.

Q1: Daydream of a CPO *- Describe an ideal situation of what data from the supply market would you need to reinforce supply management in your company?*

First question for all the groups raised discussion about an ideal situation of creating SMI to reinforce supply management processes. First, discussed topics related to SMI fundamentals are described, followed by pre-knowledge, methods and use cases for SMI.

SMI fundamentals consist of prerequisites that are needed for systematic SMI. One of the most important fundamentals according to the discussions is to define what are the best solutions and suppliers for a particular company, project and/or category on a local and global scale. This

requires describing the need for processes and categories, in addition to specifying criteria for quality. Secondly, creating SMI requires understanding and focusing on areas that are relevant for business. In other words, choosing your own battles is needed for resource allocation. This can also encourage and motivate employees to conduct work assignments that do not contribute to revenue instantly. Furthermore, strategic alignment between business units and suppliers was perceived as one of the most essential fundamentals for SMI through innovation, strategic collaboration and in defining future needs. Currently most of the time different units and processes do not discuss with each other, resulting to disconnections in data transfers.

In addition to defining best solutions and suppliers, it is important to define what data is needed, why it is needed and how it is utilized to support supply management processes. Internal communication is important also in this characterization. Since the supply market consists of large amounts of data, it is not possible or even worthwhile to attempt to gather all feasible external data. Existing suppliers' and different business units' data has to be organized and integrated more proficiently for data availability and decision-making support. When the home base is in order, employees should be motivated and competent to utilize the gathered and analyzed data into intelligent decisions. Moreover, central real-time and on-demand data needs to be available for timely and proactive decisions, which can be achieved by using BDA.

Furthermore, data and analytics transparency is needed for creating visibility to the category and supplier levels. Data can be acquired from external parties, but understanding and know-how of interpreting the supply market analysis and relevance for business needs to be included in company's internal capabilities, in order to create sustainable competitive advantage. As was found out from the case company interviews, the issue of valuing supply management function in innovation and business development activities was raised in the focus group discussions as well. Lastly, somewhat controversial to other findings, one of the groups regarded market data so different from internal data that external data could be acquired before internal data is gathered or organized. Results from other research indicate that it is specifically important to first organize internal data, such as spend before acquiring external market data. Below in table 8, the fundamentals for creating SMI according to the focus group discussions are shown.

Table 8. Fundamentals for creating SMI as per focus groups

SMI fundamentals
Define best, for company, project and/or category, suppliers locally and globally (3)
Understand and focus on what is relevant for business (3)
Strategic alignment / communication between business units (3)
Define what data is needed, why it is needed and how it is utilized (2)
Internal data integrated and analyzed with external data (2)
Central real-time / on-demand data available in a clear and manageable form (2)
Data / analytics transparency (1)
Data / analysis can be acquired from external parties / third party research (1)
Internal understanding and know-how of interpreting analysis (1)
Supply management processes should be valued in the company (1)
Market data differs from internal data, hence external data may be acquired before internal data (1)

Pre-knowledge needed for creating SMI consists of data and information before refining them into knowledge. It was the most frequently appeared node in the focus group discussions, which strengthens the recognition that the supply markets consist of a wide range of important data and information. One of the most appeared topics was recognizing future market trends and megatrends, but also their influence on suppliers' strategy and value proposition. Supply management professionals need to be able to justify their decisions to other business units, such as sales and marketing department, which can be endorsed via trend forecasts. In the consumer market environment, for instance, increased demand for pulled oat is a current trend that influences product sales. Another example is the influence of weather conditions to clothing sales. BDA can be used as a tool to forecast different market trends as accurately as possible. Second, visibility of emerging technologies and innovations, including digital transformation, was considered as one of the most important aspects of SMI. Innovations need to provide new opportunities for value proposition synergies. Being able to absorb new technologies, the personnel need strategic and analytical competences.

Suppliers' quality and delivery performance concerns especially existing suppliers according to the focus groups. KPIs are needed for measuring and monitoring the suppliers' performance via both qualitative and quantitative measures. The quality and delivery performance measures include mapping current status quo as well as forecasting future changes. Fourth, *total cost of ownership* (TCO) consists of understanding the factors of cost structures and opportunities. It is not adequate to keep track on just the purchase prices, but to understand the economics of the full life cycle of the business case. SMI includes recognizing and understanding supply market competition, dependencies and dynamics in global supplier corporate hierarchies, networks and linkages. Furthermore, existing suppliers' abilities and possible changes need to be identified, in order to be able to uncover use cases for their skills.

In half of the groups, discussion was formulated concerning the following six issues. First, recognizing new suppliers and solutions, in addition to existing suppliers' abilities is vital and is one of the essential aspects of SMI. Next, suppliers' financial performance and cost indices' influence on purchase prices is as important as creating knowledge about global price levels. Material and component availability in product categories, and workforce availability in service categories should be considered in evaluating potential capacity problems and production delays. Forecasting customer needs and providing accurate delivery times is especially important for *fast-moving consumer goods* (FMCG). Suppliers that can offer short delivery times support in responding to demand fluctuations and therefore increase revenue. Additionally, attractiveness and importance of the buying company compared to suppliers' other customers can be examined by acquiring knowledge about the focal company's share of suppliers' entire sales and discovering who are the supplier's other customers.

Two of the groups discussed about the importance of transparency in the supply and demand chain, since changes in the supply affect the product and service offerings. Information about contract and cost compliance is needed for ensuring that negotiated terms are realized. This data can be linked to the order-delivery process. Recognizing potential suppliers and key players in the industry is based on evaluating compatibility with the focal company. It is important to have spend visibility and know the purchase prices per supplier, but evaluating suppliers' impact on revenue and business should consist of other measures than simply spend. Especially single source suppliers should be surveyed through, for instance, to how many products the supplier is

delivering components. Finally, topics that occurred in one of the group discussions were suppliers' corporate reputation, commodity MI linked to information of own purchases, suppliers' alignment with strategy and accountability, M&A and personnel turnover as well as business environment drivers.

Methods for creating knowledge from data and information consist of different tools and sources according to the workshop discussions. In an ideal situation, specified KPIs could be automatically compared to different reference groups, from which informed price and cost comparisons were considered the most interesting. Therefore, according to majority of the participants, global price benchmarking is one of the most important methods for creating SMI. Another important aspect is the automation of data collection, processing and analysis methods. Even with the help of BDA, there will always be unforeseen incidents, but automatic scanning of the business environment assists in planning and conducting quick changes to action plans if needed.

Receiving comprehensive information about the suppliers by integrating datasets, or so called *supplier management 360°*, as a method for creating systematic SMI was discussed in two of the groups. However, this kind of tool requires committing to its usage in order to gain benefits. Secondly, collaboration with other business units, such as supply management with marketing and sales departments, enables gathering internal data. Practically in all of the companies, the data are decentralized in different systems and cannot be retrieved at once. Data integration is therefore vital inside the company, in addition to integrating external data with internal data. Furthermore, many tools and solutions that are used in the business-to-consumer market could be applied also in the business-to-business market. Systematic supplier ratings reveal other opinions and experiences of suppliers in a same way as consumers rate purchased items online. As an example, the application Uber for ordering car rides from registered users uses a 1-5 star rating system to rate driver-partners by their riders. This kind of rating system could be applied also for two-sided buyer-supplier ratings. This method would however require critical designated people in order to function properly.

The following remaining methods for creating SMI were discussed in one of the groups each. Online stores often aim at up selling by suggesting further items in which the consumers could

be interested based on previous purchases. This could be applied for creating SMI by IS suggestions of potential suppliers based on company's needs and requirements. Events, trade fairs and corridor discussions provide much information about suppliers at present. However, aggregating the data and sharing them adequately, in order to provide understanding for all necessary individuals is very challenging via these methods since they are not utilizing the analytical capabilities. Calling and inquiring acquaintances and partners in the collaboration network received much support in one of the groups, but these sources involve same challenges as the former methods. Furthermore, social media channels, such as Facebook and Yammer, can be used to communicate internally and externally. Pre-knowledge can also be gathered to internal portals, or so called "Google light sites", in which data can be analyzed and quiet signals can be noticed. Moreover, due to large amounts of data, filtering and visualizing is needed for comprehending the information.

Use cases consist of supply management processes in which the processed pre-knowledge can be applied. First, supply risk management, comprising of for example country and image risks, was considered important in all of the groups. Second question involved discussion about SMI in risk management, so it is described in more detail in the following chapter. Secondly, SMI can be used to identify joint development opportunities with suppliers. Companies seek to benefit from suppliers' ideas and capabilities in cooperation by forming win-win relationships. Emphasis on innovations and willingness to invest can create notable opportunities. As another use case, SMI can be used to find new suppliers and replace old ones.

Rest of the topics were raised in one of the groups each. First, a rather trendy term *cognitive procurement* was raised, referring to the application of analytics and AI to procurement. Moreover, related to knowledge of the company's attractiveness according to the suppliers, *supplier journey mapping* was discussed. The term is an analogy for another trendy term *customer journey mapping*, and refers to receiving knowledge of how suppliers perceive the buying company and how have they reacted to the buying company's actions. By positioning the focal company from the point of view of the supplier, the future actions of the supplier can be attempted to anticipate. Last, product or supplier categories can be defined and prioritized via spend, but SMI enables to go further and deeper in a particular area. Below in table 9, the SMI pre-knowledge, methods and use cases are presented as per the focus group discussions.

Table 9. Pre-knowledge, methods and use cases in SMI as per focus groups

Unit of analysis	Key elements in creating and applying SMI		
Coded node	Pre-knowledge	Methods	Use cases
Reference (topic)	Future market (mega)trends and their influence on suppliers' strategy and value proposal (4) Innovations and technologies / digital developments (4) Quality and delivery (4) TCO - structures / opportunities (4) Global supplier corporate hierarchies / networks and linkages (4) Existing suppliers' abilities (4) New suppliers and solutions (3) Suppliers' financial performance (3) Global price levels (3) Product and service availability / capacity (3) FMCG + possible suppliers (3) Focal company's share of suppliers' sales / suppliers' other customers (3) Demand and supply (2) Contract compliance (2) Potential suppliers / key players (2) Spend / purchase price per supplier (2) Suppliers' corporate reputation (1) Commodity MI (1) Strategic alignment / accountability (1) M&A and personnel turnover (1) Business environment drivers (1)	Global price benchmarking (4) Automatic data collection, processing and analysis (4) Supplier management 360° - integrating datasets and committing to usage (2) Collaboration with other business units (2) Systematic supplier ratings (2) IS suggestions of potential suppliers (1) Events, trade fairs, corridor discussions (1) Calling / inquiring acquaintances and partners (1) Social media channels and internal portals (1) Filtering large amounts of data (1) Visualization (1)	Supply risk management (table 10) (6) Joint development opportunities (2) Supplier selection (2) Cognitive procurement (1) Supplier journey mapping (1) Categories defined by spend → able to go further via SMI (1)

Q2: Supply risk management *- Which changes in the supply market are most relevant in supply management? How can intelligence be used to prepare for changes in the supply market?*

Second question for all the groups involved discussion about SMI in supply risk management. Participants perceived SMI in risk management important overall, and more important than simply cost reductions. Therefore, early involvement in setting KPIs is important for strategic supply management. One of the central thoughts that derived during the discussions is that it is not worthwhile to prepare for all possible risks, but to identify core risks and create risk mitigation plans for them. The evaluation of risk versus opportunity is also one of the core challenges. BDA can decrease unexpected events, so called *black swans,* and response times through automatic action planning.

Supply risks that were discussed in all of the groups were political country risks deriving from suppliers in different countries. Risks in the political environment consist of, for instance, customs regulations and trade agreements that can have an effect on product or material deliveries. Knowledge of the worldwide circumstances, such as Brexit or the United States presidential election, is needed for mapping the political impacts on business. In addition, financial risks can include, for instance, currency and commodity price fluctuations or suppliers' poor financial performance leading to bankruptcies. However, factors that affect the economic situation of the company depend on the industry. Company reputational and image risks on the other hand require accountability and transparency as IS evolve. Risks that affect the company's image involve corporate social responsibility, child labor, code of conduct and ethics related issues. Geographic risks consist of natural catastrophes, such as Fukushima, and other global weather conditions that have an effect on the suppliers and therefore product categories.

Even though new technologies provide great opportunities for enhancing supply management processes, they form respectively risks. When a supplier directs to new technologies and ecosystems, the focal company might have to find alternative suppliers that still provide the technology they need, or adapt their processes. Furthermore, changes in the supply market such as unforeseen supplier M&A, industry consolidations and suppliers' high personnel turnover rate can change the dynamics of the buyer-supplier relationship. This might change the focus of strategy in complex supply chains. Supplier dependence is a notable risk, especially if the

suppliers from which the buying company is completely dependent on are not identified. A balance between dependency and commitment needs to be obtained in the buyer-supplier relationship. When other customers compete on the same products or the amount of actors in the market increases, the competition becomes tougher. Moreover, inadequate quality performance of the materials and products, as well as poor data quality, transparency, security and accountability were considered as risks in the supply market of the new economy. One of the groups raised the issue of poor company's resilience and adaptation to change, which is a necessity in the constantly changing business environment. Last, sustainable development issues in the supplier base were held increasingly important in several companies.

Supply risk management is different between categories as well as between strategic suppliers and tactic suppliers, and therefore require different risk management platforms. Foremost, it was considered important to identify strategic suppliers, and form iterative risk evaluation, mitigation and contingency plans with them. Risk mitigation practices can consist of, for instance, recognizing new customer segments, technological developments and cooperation possibilities. Alerts of threats (red flag) and possibilities (green flag) in an interactive map that can be zoomed to view further details were considered as an important risk management practice. Technology and ecosystem risks can be managed, for instance, by receiving information of which suppliers are making significant innovations, and ensuring that the company is involved in a developing ecosystem instead of a withering one. Financial risks can include warning flags such as frequently changing accounting policies, suddenly increased substantial losses and significant selling of assets. Another important risk management method was discussed as real-time simulation and optimization, enabling forecasting different sales and delivery scenarios or price developments. Moreover, external information can be purchased via databases, such as Tilaajavastuu, for managing risks related to suppliers. Identifying and finding alternative suppliers for single and sole source suppliers was discussed in two of the groups.

Rest of the supply risk management practices were discussed in one of the groups each. Sustainability risk can be managed by requiring specified standards and certificates from the suppliers. Informal inquiries about suppliers with several partners in the supply network can reveal possible risks related to availability of products, since suppliers might not admit when they encounter problems. Even though external information can be purchased to assist supply

risk management, one of the groups raised the importance of developing own organizational strategic and quantitative competencies to manage risks. Furthermore, applying supplier credit ratings, following news streams, conducting supplier network risk monitoring dashboards and managing second (et cetera) tier suppliers in addition to first tier suppliers can be used to manage the risks. Finally, forming multidimensional and dynamic contracts, consisting of incentives and metrics for wanted performance should be used for managing potential supply risks. Below in table 10, the supply risks and supply risk management practices are presented as per the focus group discussions.

Table 10. Supply risks and supply risk management as per focus groups

Supply risks	Supply risk management
Political country risks on a global scale (6)	Identifying strategic suppliers → iterative risk evaluation, mitigation and contingency plans (4)
Financial risks (4)	Alerts of threats and possibilities (3)
Reputational / image risks (4)	Real-time simulation and optimization (2)
Geographic risks (4)	Purchasing external information (2)
New technologies / ecosystems (3)	Identifying and finding alternative suppliers and materials for single / sole source suppliers (2)
Unforeseen M&A, industry consolidation and suppliers' high personnel turnover rate (3)	Sustainability standards and certificates (1)
Supplier dependencies / commitment (2)	Informal inquiries with partners (1)
Competition becomes tougher (2)	Developing organizational competencies (1)
Quality issues (2)	Supplier credit ratings (1)
Poor company's resilience and adaptation to change (1)	News streams monitoring (1)
Sustainability risks (1)	Supplier network risk monitoring dashboard (1)
	Managing second (etc.) tier suppliers (1)
	Dynamic contracts (1)

Q3: Resource usage in creating SMI *- Who creates SMI in your company? Who should do it?*

Two of the groups had time to discuss resource usage in creating SMI. The discussion concerned current resources used to create SMI, followed by deliberation of which resources should be used in order to create systematic SMI.

Current use of resources in SMI is concentrated on category managers. Category or product managers are mainly responsible for creating SMI in the companies. However, if there is a lack of knowledge internally, contacts and partners across networks can be used to create SMI. Knowledge is shared across business units inside the company through different internal channels and portals.

Ideal use of resources in SMI requires that everyone in the organization is involved in creating SMI as well as understand the value for strategic decision-making. In order to engage several units in creating SMI, the importance of supply management for the company needs to be recognized. Category managers' job description should contain creating SMI with adequate resources. A person creating SMI needs a profound understanding of the supply markets, supply management as well as business. Secondly, identifying, collecting and distributing quiet signals across business units should be carried out more efficiently in the companies. Automatic IT and integrated databases can spare resources, when manual work is reduced, so a data analysis team should be provided to support the supply management processes. Table 11 below shows the current and ideal use of resources in creating SMI as per the discussions.

Table 11. Resource usage in creating SMI as per focus groups

Current use of resources in SMI	Ideal use of resources in SMI
Category / product managers mainly responsible (2)	Everyone in the organization involved in creating SMI and understand its value (2)
Contacts and partners across networks utilized (1)	Identifying, collecting and distributing quiet signals across business units (2)
Communication across business units via internal channels and portals (1)	Utilizing automatic IT and integrated databases (1)
	Data analysis team to support supply management processes (1)

Q4: Descriptive and predictive analytics *- Which supply management processes can benefit from descriptive analytics? Which processes require and can benefit from predictive analytics?*

One of the groups discussed about the needs and differences of descriptive and predictive analytics in creating SMI. Sample size of these results is small and appeared topics reflect opinions of only one group. Since most companies still have room for improvement in basic analytics as well as internal data management and integration, it was found that the descriptive and predictive division provides useful information comparing the forward and backward focused approaches. Diagnostic analytics was considered as part of descriptive analytics in this discussion and prescriptive analytics was excluded from the discussion due to its advanced analytics maturity.

Descriptive analytics was perceived sufficient only in operative purchasing. Descriptive analytics does not enable proactive actions since it is backward oriented. Nevertheless, it can be beneficial in analyzing historical data of realized prices or quality based on delivery times and amount of claims to evaluate organizational performance.

Predictive analytics on the other hand is needed for strategic supply management. Predictive analytics facilitates proactive actions and therefore provides more value in supply management processes. This includes, finding innovations and solutions via new partners and suppliers, estimating prices and forecasting future customer needs and trends in a particular field in business. In addition, predictive analytics can be used to analyze supply market and network strategies as well as changes in the supply market. The subjects are shown below in table 12.

Table 12. Descriptive and predictive analytics in creating SMI as per focus groups

Descriptive analytics in SMI	Predictive analytics in SMI
Operative purchasing Measuring: - Quality - Realized prices	Strategic supply management Innovations and new solutions Price estimations Future customer needs / trends in business Supply market / network strategies and changes in the supply market

6.1.3 Creating SMI according to BDA solution provider / expert interviews

BDA solution provider / expert interviews provided valuable insights to creating SMI by using BDA from the perspective of analytics professionals. The interviews were examined in order to answer to the main research question *RQ1: What are the most potential BDA applications and opportunities in creating systematic SMI*, through the supportive research questions *RQ3: How can big data be categorized and what are the data sources in the context of SMI?* and *RQ4: What are the most suitable BDA methods in creating SMI?* This chapter describes the subjects of BDA fundamentals, followed by big data, BDA solutions and value from BDA, concluding to challenges and future trends in BDA.

BDA fundamentals consist of different fields that are needed in order to utilize analytics to support supply management processes. First, the analytics solutions need to be linked to the KPIs and strategy on a category and corporate level, in order to facilitate intelligent decision-making and management. Intelligent systems in the organization are linked to different units such as supply management and sales, and should be aligned. Before implementing BDA solutions, it is necessary to carry out comprehensive background research about the particular company and industry. There should be a long dialogue process between several employees and the BDA solution provider for tailoring the most suitable services. Best results come from an extensive collaboration of the technical and business professionals. Another BDA fundamental is that the CPO or category manager who is responsible for creating SMI and engaged in the supply management does not have to understand the technical execution of the analysis, but needs to be enlightened about the importance of analytics and its relevance to business, and be able to utilize the big data platforms. This requires recognizing the different concepts of analytics, in addition to which indicators are relevant and should be measured.

> *"When it comes to big data, you can use any data, even that kind of data that would primarily seem irrelevant, but it can still make a difference."*

Analysis of both internal and external data should be transparent for the decision-maker rather than simply generating final figures from the analysis. Many supply management professionals are used to dealing with numeric data, so it might come as a surprise that large part of big data

is in other forms like textual and graphic. In order to integrate BDA to continuous decision-making support, internal data transfer and IR needs to be first organized. When the basics are in order, it is possible to add external data and gradually utilize more advanced analytics. Moreover, BDA requires mature supply management and SMI functions. If a small company has only one or a few employees handling the supply management processes, the company might be lacking the maturity and resources for implementing advanced BDA. In an ideal situation the company has high turnover and a comprehensive supply management team that might even include an own analyst. Finally, it is often forgotten that big data can consist of data that might primarily seem irrelevant, but can provide valuable results when analyzed and combined to the company's requirements. Below in table 13, the BDA fundamentals are summarized according to the BDA solution providers / experts.

Table 13. BDA fundamentals according to BDA solution providers / experts

BDA fundamentals
Analytics linked / aligned with KPIs and strategy (+ business processes) (4)
BDA implementation requires extensive background research / collaboration (3)
Understanding and enlightenment of CPOs / category managers (3)
Data, analytics and processes transparent (2)
Large part of big data is other than numeric (2)
Internal data / basics organized before integrating external data / advanced analytics (1)
BDA requires mature supply management and SMI (1)
With big data any data can be utilized (1)

Big data from the supply markets consist of a wide variety of subjects. However, since needed big data is case specific, the BDA interviews concentrated more on how BDA could be utilized and on the opportunities in creating SMI. The supply base consists of key information about the suppliers like spend data, contracts and sales forecasts that can be specified to particular suppliers, categories, products or materials. The supply management function's applicable financial data and cost structures consist of the working capital and savings that have an impact

on the financial performance of the company. Some of the external commodity market prices and trends can be available publicly, such as oil price or labor costs in some countries. However, market price data might require accessing proprietary indices. The supplier background information consists of different fields, such as physical location, complexity and timeliness of deliveries, productivity, trade registries and product catalogues. Rules and regulations are publicly available data, and concept *My Data* works based on an idea that people share personal data to a common database for decision-making support. Moreover, social media posts can be mined by keywords in order to analyze cause-effects and impacts of defined occurrences, and traffic data provides insights into various factors such as insurance purposes.

BDA solutions are based on the technical capabilities of big data technologies. The solution providers can execute underlying data crunching and enrichment, consisting of aggregating, cleaning and clustering the data, to which it is not worthwhile to use resources internally. Integrating internal and external data into the cloud is one of the core solutions that are needed for utilizing the potential of BDA. The solution provider can combine company's own data to data from across the supply chain, but also to their own big data that consists of data from their other customers. The solution provider can offer a single point of truth user interface, from which all data analyses can be accessed via devices such as a computer or mobile phone. After that, they will execute a *minimum viable product* (MVP) of the technical solution and leave room for developments according to customer preferences. A current technology innovation called *massively parallel processing* (MPP) database or other big data technologies can be used to provide real-time ad hoc analytics in addition to traditional reporting of the integrated data.

"The system must be able to present somehow visually, easily understandable, quickly readable, and in a manner that contains as little as possible risk for misunderstanding."

Interactive and consolidated reporting with visualization is imperative for comprehending BDA when the recipient is not familiar with the technical execution of the analytics applications. It can be referred to as interactive data exploration platforms or dashboards. Currently there are tremendous amounts of data available through search engines like Google, but the solution

provider can deliver an automatic daily or weekly report about the needed statistics without separate searching of information. The reporting should be available in an intuitive user interface that shows the overall picture and needed information through unambiguous visualization, such as color or symbol coding, graphs and diagrams or animations. However, the reporting should allow the user to go deeper into the analysis to different groups of variables, to examine different interconnections and alter variables under examination. Since understanding of the analysis is vital for actually integrating the information to the decision-making process, if the supply management function lacks this talent despite of sufficient user interfaces, the solution provider can provide an analyst when needed, for instance once a month, to explain the figures and results of the analysis.

Basic analytics can be used to conduct spend analyses that are at the moment widely applied by companies that exploit the services of BDA solution providers. One of the solution providers revealed that 70-80 percent of their business is still conducting spend analyses, for instance, from 60 different suppliers in different countries using different systems. The analyst can connect to the systems, absorb the data and generate total spend in supplier or category perspective. In addition to spend analysis, the BDA solution providers can offer "basic procurement analytics" to observe terms of payments and processes in the supply base. The solutions are based on best practices learned from other customers and expertise. The analysts can build a system that can be altered to meet different criteria and does not have to be constructed from the start each time. However, this analytics is concentrated on the operative processes and corporate internal data. Dynamic price benchmarking on the other hand can reveal huge opportunities in amending cost structures. The analysts can compare prices to the company's own categories and suppliers but also to the competitors' suppliers and other external metrics. This enables also dynamic prices with different suppliers such as tactical and strategic.

"It is not enough that the system gives an alert, but it needs to justify why it was distributed and what should be done."

One of the most important BDA solutions is that the solution provider can code an external standardized signal that alerts and provides information when it meets tailored internal criteria

of changes in the supply base or market that need actions. The alert should automatically be distributed to the correct person in charge of the particular field. Often managers are interested only on the critical values, but the analysis should provide more thorough descriptions than simply "something is going on with supplier X". The system should recommend further actions based on analysis, or in some cases even automatically solve the issue. Intelligent algorithms can learn from experience and inputted data, being able to handle different situations. Sublime identification on the other hand is a solution that can be used to suggest potential suppliers based on current suppliers. An American electronic commerce and cloud computing company Amazon applies this method to suggest further items based on previous purchases. Statistical breakdown of data can be used to build a ranking method to compare suppliers. Overall, advanced BDA solutions can be based on predictive modelling of decision structures or using exploratory data analysis. When modeling the future, the decision-maker can change the variables, like time span or budget, in the system and inspect how they will change the outcome. Exploratory data analysis on the other hand can be applied using neural networks in which data is inputted in the system and important aspects will be raised from the data. After all, it should be noted that there will always be a gap in the real world and BDA, but with advanced analytics, the gap can be diminished. The current trend in BDA is AI based machine learning that enables to meet the 3V characteristics of big data in real time. AI can even be built into the interactive dashboards, enabling a "digital assistant" to alter variables in the analysis.

"The model always deviates from the real world and ultimately human must control the difference between the model and occurrences in the real world."

Value from BDA is derived from applying the analyzed information to decision-making and actions. In supply management, the value from BDA can be divided into backward and forward oriented as well as reactive and proactive processes. BDA can be used to analyze the past via historical data, describe the present in real time and forecast the future. The value comes from being able to view forward and backward in the supply chain, such as comparing negotiated prices to market prices and the causal connections of price fluctuations to profitability of products. An ability to accomplish backward focused cost-follow up is needed in order to move

to a forward oriented cost forecasting that is linked to the KPIs and helps in negotiating prices with suppliers, which many companies still currently fail. Decision-makers want to see the overall picture of the supply chain and market, and BDA can provide this further visibility. SMI can facilitate forming partnerships and alliances with suppliers, or originating ecosystems. When the perception of the supply markets changes, there might derive a need to reform existing business and position the company in the market.

"Often companies start to resolve one issue, receiving some benefits, then resolving another issue and receiving new benefits, then conducting SMI and receiving some benefits, but really, the super value is in that you are able to do something in the intersection of the information clusters."

Often companies apply BDA and process improvements on an ad hoc basis, receiving benefits from one field and then continuing to another. However, the radical new source of value and competitive advantage in supply management originates in the intersection of different sources of data. Incorporating quiet signals into the analytics and bringing existing data to the company's context provides the real benefits. Companies that are able to capitalize this radical new source of value for the benefit of their business will receive competitive advantage over competitors.

"In principle, any analyst can conduct the analysis, but incorporating the quiet information that is not written anywhere into the analytics delivers the real benefits. But it is not done a lot."

One of the supply management activities that BDA can bring value to is supply risk management versus opportunity identification. This requires defining criteria for risks in the particular company and category. Different factors concerning supply risks, such as price compared to quality or amount of returns, can be evaluated via BDA. The level of risk exposure, such as image risk from the use of child labor, world market volatility and commodity costs, depend on the business and industry. Scaling suppliers on predefined criteria can be used as a decision-support system when selecting suppliers. The system can rank the suppliers and even contact them automatically in an advanced system. However, the system should not only provide lists

of suppliers, but also reasons for the selections. BDA enables human centered design that is needed in the new economy to meet changing requirements of the customers. Furthermore, BDA enables proactive pipeline management as well as demand and supply forecasting which are needed for estimating the company's contribution in the future in terms of savings, risk reductions and other benefits. This provides extensive benefits for the company and is rather easy to execute by a solution provider. Below in table 14, the BDA solution providers' and experts' answers regarding big data, BDA solutions and value from BDA are presented.

Table 14. Big data, BDA solutions and value from BDA as per solution providers / experts

Unit of analysis	Main components of utilizing BDA to reinforce supply management		
Coded node	Big data	BDA solutions	Value from BDA
Reference (topic)	Social media (3) Supplier spend / contracts (2) Market prices / trends (2) Working capital / savings (1) Supplier background information (1) Rules and regulations (1) My Data (1) Traffic data (1)	Alerts of threats / opportunities (5) Interactive data exploration platforms / dashboards (4) Integrating internal and external data into cloud (4) Modelling the future (3) Exploratory data analysis (3) Dynamic price benchmarks (3) "Basic procurement analytics" (3) Machine learning / AI (3) Underlying data crunching / enrichment (3) Single point of truth user interface (2) Spend analysis (1) Analyst clarifies analysis (1) Sublime identification (1) Statistical scaling (1)	Supply risk / opportunity evaluation (4) Creating competitive advantage (3) Cost follow-up / forecast and price negotiations (3) Overall picture of the supply market / chain (2) Supplier ranking / selection (2) Reforming existing business / market positioning (1) Forming partnerships / alliances / ecosystems (1) Meeting changing customer requirements (1) Proactive pipeline management (1) Demand / supply forecasts (1)

Challenges in BDA were raised during the interviews, in addition to the opportunities that can be achieved using big data technologies. Due to the wide scope and rapid development of BDA, there are several challenges in utilizing BDA for the benefit of supply management processes. Even though there is a lot of discourse about the potential and challenges of the analytics solutions, many companies still fail in aggregating internal data, such as purchase invoices, so integrating comprehensive external data to the unorganized internal data is a major challenge. Data aggregation of both internal and external data is a prerequisite for executing successful analysis. Huge amounts of available algorithms are being developed in fast pace becoming mundane, but aggregating big data with internal resources is often challenging, expensive or time-consuming. Internal data aggregation can be executed with internal IT support if a company has sufficient resources available. However, external data aggregation, in addition to integrating internal and external data, is most efficiently completed by a BDA solution provider. Data is always incomplete and corrupted, which can lead to incorrect actions based on faulty analysis. In business IS there are often several sources and formats of data, resulting to fragmented data management. However, aggregating and applying large amounts of data increases the data quality and reliability of the analysis.

Traditionally spend and savings have been used as metrics when measuring supply management. This becomes confrontational because savings made in a particular category are product specific, instead of finance specific in an organizational scale, which is of interest to the business stakeholders. Even if a company would be using BDA in their processes, often these resources and capabilities are used in other units than supply management, like sales data crunching. One of the solution providers commented that still 99,9 percent of the companies in the new economy are not investing in supply management analytics applications. When the company does not recognize the most suitable BDA methods, they might have difficulties in deciding which analytics functions to outsource to an external solutions provider, especially if they have some internal IT capabilities but not sufficiently. This might result to not deploying the right analytical tools for receiving benefits. On the other hand, companies may trust the analysis too blindly and not recognize the possibilities for errors.

"In a very critical part is that the one who is using the information understands what it is, and that is the biggest challenge."

Even though analytics and/or data aggregation would be outsourced to a solution provider, companies' need internal capacities to absorb and distribute results of the analysis to support decision-making. If the extracted insights are not converted into intelligence across business units, value from the analysis will be unexploited. There often exists a gap between the analyst and business people, since the analyst is not able to explain what is needed for business and the businessperson does not know how to ask the right questions. One of the solution providers commented that they have not worked directly with any supply management professionals since they are reluctant to adopt new mechanisms. The supply management function was compared to laggards in the technology adoption life cycle bell curve, describing the late adoption of innovations. Therefore, realizing the benefits of BDA for supply management and converting the analysis into a relevant context for the category managers in an understandable manner are significant challenges. Lack of analytical know-how of the category managers or CPOs aggravates the gap of understanding and can cause misinterpretations of the analyses. Know-how of BDA is emphasized as big data technologies advance.

"This would be my biggest advice, don't think about the big thing and go in a project spending thousands or tens of thousands of euros and do the big thing, but rather start small and do it in phases."

It is common that companies try to achieve all the benefits and most value too soon and with too little resources, resulting to failure in implementing analytics when the basics are not in order. It is possible to manage one field of data, but when integrating datasets and exponentially increasing the amount of big data, the company will quickly, often from 3-6 months, encounter a tipping point, after which they have not enough resources available for managing and analyzing the data. This results to nonrecurring efforts in implementing analytical tools without generating real value. With the expertise of a solution provider, it is possible to reach more mature BDA level with the same cost, even though the collaboration and implementation

process might require longer time. BDA solution provider can implement basic analytics more affordably, sparing resources for more complex data management and analytics.

Future trends in BDA were envisioned in each of the interviews. First, the interviewees believe that even though there is a lot of discussion about the lack of analysts, not everyone needs to have analytical skills. In the future, there will most likely be a specific amount of super analytical people conducting the technical execution, and the users will be viewing the analysis similarly as search engine results. However, based on the BDA solution providers experience and open job positions, it can be seen that many companies are constantly recruiting analysts. Nevertheless, it can be argued that CPOs and category managers do not have to make the analyses themselves, but possess capabilities for utilizing the analysis for the benefit of business. There are constantly becoming new BDA solution providers and the trend will most likely continue growing. From the point of view of supply management there might be two kinds of solution providers: technology platform providers and providers for utilizing the technology for supply management processes. The supply of different BDA service packages will increase and finding the right partners for implementing analytics will become vital.

"I do believe that every firm can benefit from analytics, and when the world moves forward, basic analytics will become so commonplace and obvious that it is not a question whether you need it or not, but it almost comes automatically."

There is a lot of hype associated with BDA, but many processes will become widely used as automated solutions. Routine functions and processes that are too easy or too complex to conduct by humans are automated ever more, leaving more time for strategic and meaningful tasks. It is not possible to handle big data manually since its 3Vs characteristics require coding with advanced tools. Common databases like My Data will become more common via web and mobile applications to facilitate intelligent decisions. One of the solution providers commented that they strongly believe that when the potential of analytics diversifies, it will increasingly be outsourced to solution providers. However, what to do with the analysis is up to the end user. Moreover, possibilities of cloud computing and productization of machine learning will

continue to increase importance. Cognitive services will be more developed and start to play a large role in predictive and prescriptive capabilities and AI in the future.

> *"Humans are really good at managing a couple of variables, but after 3-5, the time used for conducting analysis increases exponentially. In the case of a machine, it is the opposite. It takes a long time to build automation, but when it is done, it absorbs the variables ever more."*

Below in table 15, the challenges and future trends in BDA are presented according to the solution provider / expert interviews.

Table 15. Challenges and future trends in BDA as per solution providers / experts

Challenges in BDA	Future trends in BDA
Lack of analytical know-how / reluctance to new mechanisms and systems (4)	Automation and advanced tools (robotics) (4)
Incomplete / fragmented data (3)	Super analytical people vs. category managers (3)
Which IT functions to outsource / recognizing and deploying new methods (3)	Larger adoption of cloud computing (3)
Understanding / interpreting analysis (post-analytics) (3)	More BDA solution providers (1)
Data aggregation, cleaning (pre-analytics) (3)	Machine learning productization (1)
Common metrics / appreciation of supply management processes (1)	Common databases (e.g. My Data) (1)
Reaching a tipping point (1)	Cognitive services (1)
Trusting the analysis too much (1)	

6.2 Summary and analysis of the results

This chapter summarizes and analyzes the empirical findings by reflecting the data to the research questions of this study. First, importance of SMI is recognized, followed by data

categorization and sources of data in the context of SMI, potential BDA solutions and how value is generated using BDA, concluding with challenges and future trends in BDA.

Importance of SMI in strategic supply management is primarily realized through sourcing strategy formation, supply risk management and driving innovation. Regarding sourcing strategy formation, SMI can facilitate negotiating good contracts with suppliers and in examining and improving the focal company's attractiveness to suppliers. In addition, supply base reduction can be achieved successfully when concentrating on the strategic suppliers. Furthermore, the strategic importance of the supply management function can be justified to business via SMI. Most important areas of supply risk management that are influenced by SMI consist of finding alternative suppliers and materials, managing change in the dynamic business environment and improving communication internally as well as in the supply network. Moreover, controlling the reliability of desired quality and commissioned deliveries, as well as mapping country risks across borders is vital in supply risk management. Driving innovation on the other hand includes the most important point of conducting supplier technology roadmaps in collaboration with R&D and business. In addition, NPD processes require creating comprehensive SMI in order to find the best and most innovative suppliers.

Big data in the context of SMI consists of several dimensions in the supply markets and social data. The origin of the data is a significant factor in big data, and therefore data sources of focal company, supplier(s) and third party providers are acknowledged. Since integrating internal and external data is one of the most important aspects of BDA, relational databases consisting of corporate internal data and data from suppliers' systems are included in the consideration. Below in figure 17 the pre-knowledge categorization in the context of SMI is presented. Data and information including both relational databases and big data are referred to as pre-knowledge, since they are needed for creating knowledge that can further be analyzed into intelligence.

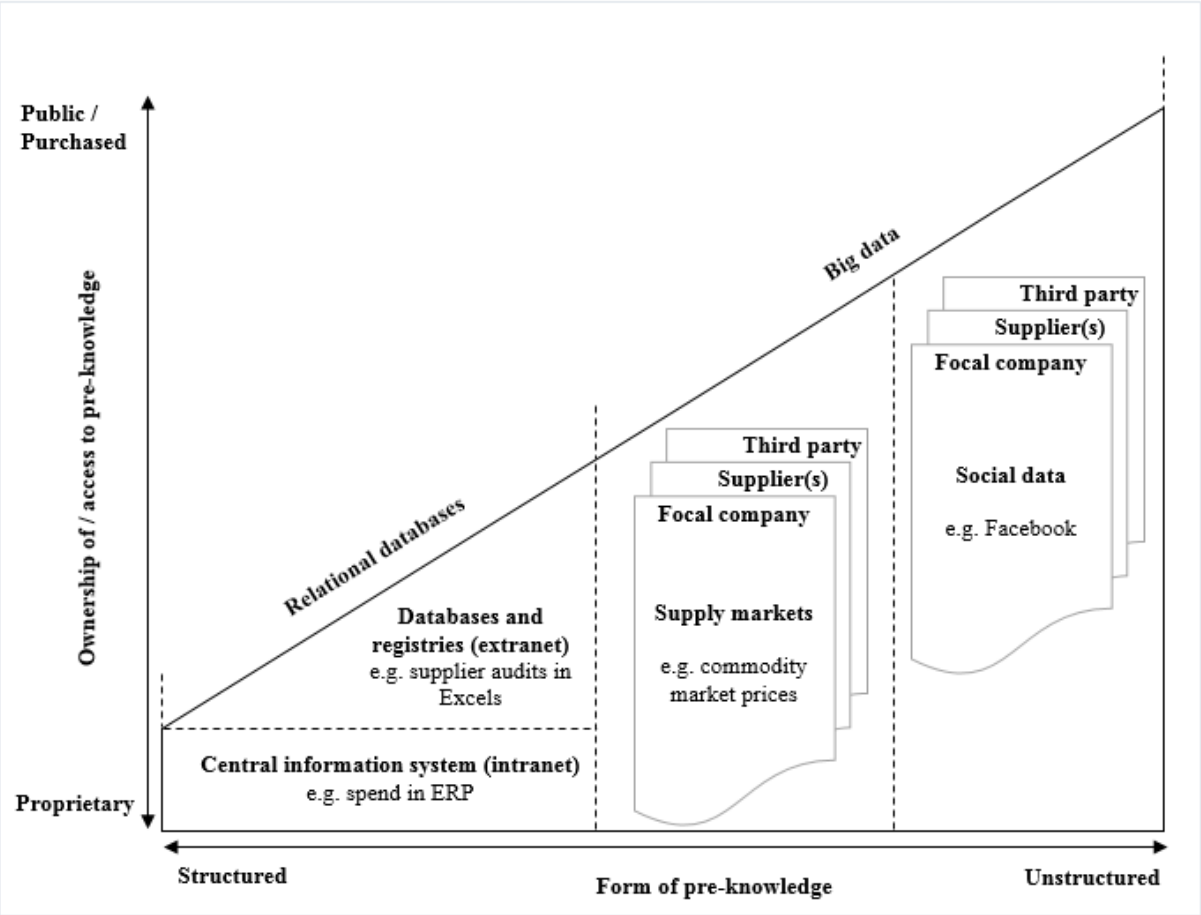

Figure 17. Pre-knowledge categorization in the context of SMI

Table 16 below classifies different data types in the context of SMI as per the realized pre-knowledge categorization above. Some of the most important data and information that is needed from the external supply markets are examining and forecasting future market trends, innovations and technologies, suppliers' quality and delivery performance, existing suppliers' abilities, but also new suppliers and solutions, global price levels as well as product and service availability. Some of the most important aspects of social data include global supplier corporate hierarchies, networks and linkages as well as attractiveness of the focal company compared to suppliers' other customers. The central information system may include different pre-knowledge depending on the company, but often spend data, contract information and working capital is included in ERP or CRM. Other databases and registries can include TCO structures

and enable opportunity evaluation, suppliers' financial performance information and FMCG needs and proportion of spend.

Table 16. Data types in the context of SMI

Central information system	Databases and registries	Supply markets	Social data
Supplier spend (per category, supplier) Contracts (purchase prices, terms of payment) Working capital / savings	TCO (structures / opportunities) FMCG (+ possible suppliers) Proprietary indices Business processes / suppliers' impact on revenue and business Suppliers' strategy and value proposal / accountability Contract compliance Suppliers' financial performance	Global price levels Commodity MI Quality and delivery performance Future market (mega)trends Product and service availability / capacity Innovations and technologies (digital developments) Business environment drivers / key players in the industry Existing suppliers' abilities New suppliers and solutions Suppliers' alignment with strategy and accountability Suppliers' impact on revenue and business / spend Suppliers' personnel turnover / financial performance Demand and supply M&A and personnel turnover Rules and regulations	Attractiveness of the company / importance of suppliers' other customers Suppliers' corporate reputation / experiences perceived by other customers Global supplier corporate hierarchies / networks and linkages My Data Social media

BDA solutions use diverse big data technologies executed by analysts. If the company does not have sufficient internal analytical capabilities and IT capacities, it is more efficient to utilize an external BDA solution provider. Often companies reach the tipping point much sooner with less advanced analytics when implementing BDA in-house. With a solution provider, it is possible

to reach more value and more advanced analytics with the same resources in terms of cost, even though it might take a longer time. Reaching the tipping point in-house compared to a solution provider is shown below in figure 18.

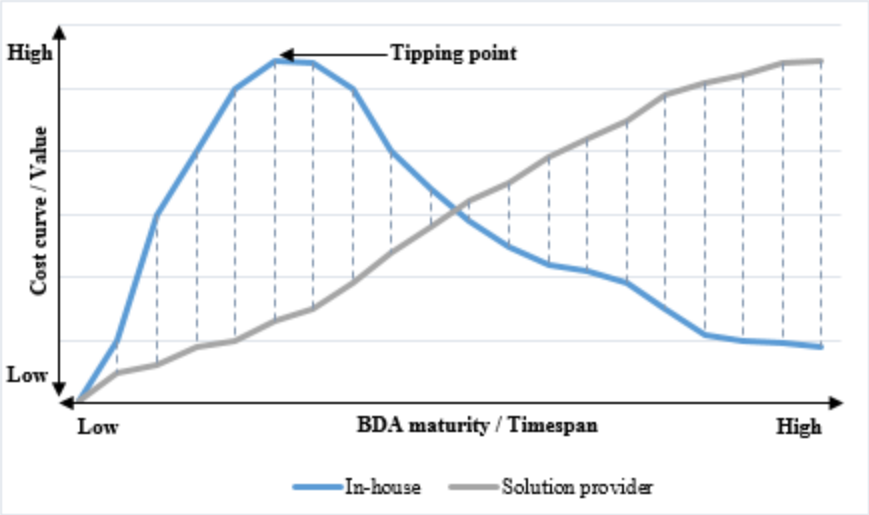

Figure 18. Reaching the most value from BDA

Long-term orientation is the key in creating sustainable competitive advantage through SMI implemented via BDA. Below in figure 19, an example of a BDA solution for creating SMI is shown. The CPO or category manager is involved in the last phase of retrieving the analyzed data from the single point of truth user interface.

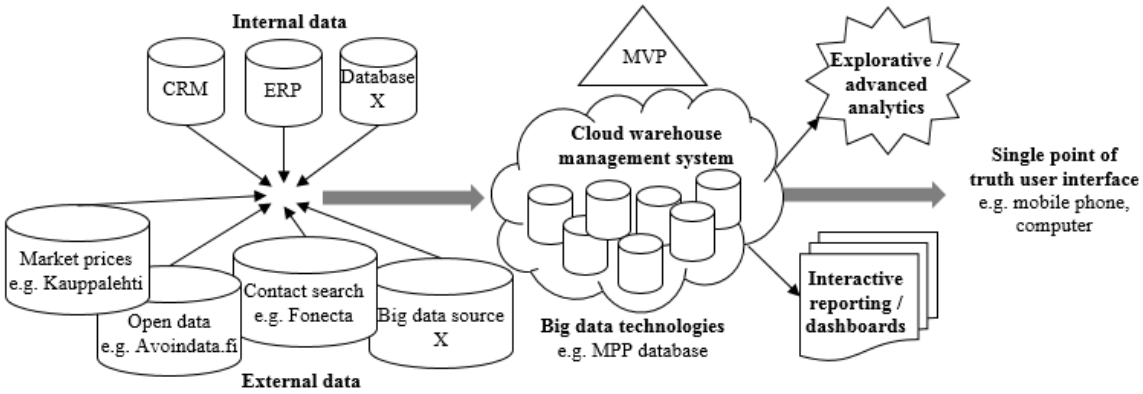

Figure 19. BDA solution for creating SMI

Internal and external data are first integrated from various sources and databases, and transferred into a cloud warehouse management system from which the data is analyzed and reported into

an intuitive single point of truth user interface for the end user. The solution providers often sell their products through cost savings, but in creating SMI, direct savings can be difficult to demonstrate since cost factors are not the only benefit that can be achieved, but rather long-term strategic opportunities.

Value from BDA is realized only when the analysis is implemented into actions. These actions may be creating competitive advantage via more informed decision-making, improving supply risk management and on the other hand identifying opportunities. Furthermore, backward oriented cost follow-up functions as a basis for forward oriented cost forecast that is needed in price negotiations with suppliers. The overall picture of the supply markets, networks and chains can be obtained via comprehensive SMI executed via BDA. Below in figure 20, the radical new source of value in supply management is illustrated.

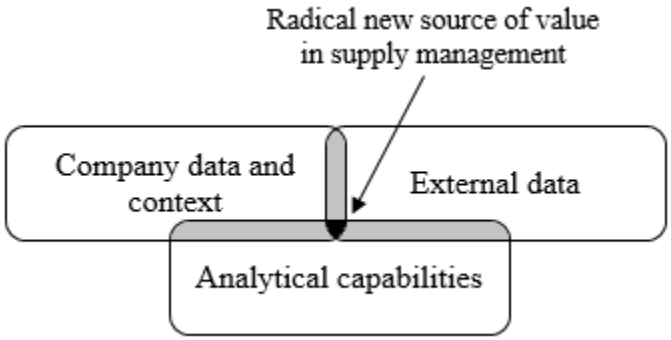

Figure 20. Radical new source of value in supply management

Value is created in the intersection of external data, analytical capabilities and company's data and context. However, the emphasis may fluctuate between these areas depending on the maturity and progression of the company and supply management organization as well as the particular field of business and industry or even category. Nevertheless, it is clear that value can be created when data is considered as an asset.

Challenges and future trends in BDA are an interesting aspect in utilizing big data. These areas were mapped in this study but they include several possibilities for further research. In the below figure 21, big data processes for decision-making support are demonstrated. It is notable that pre- and post-analytics actions are vital big data processes in which resources should be

used in creating SMI, in addition to analytics. Even though BDA is a current theme and a lot of attention is in this field, perhaps the biggest challenges are data aggregation before implementing analytics and respectively distribution and absorption of the analysis. Different parties can be responsible for these processes, but the most important step for creating value from BDA and actually integrating the analysis into actions should be conducted internally in the company.

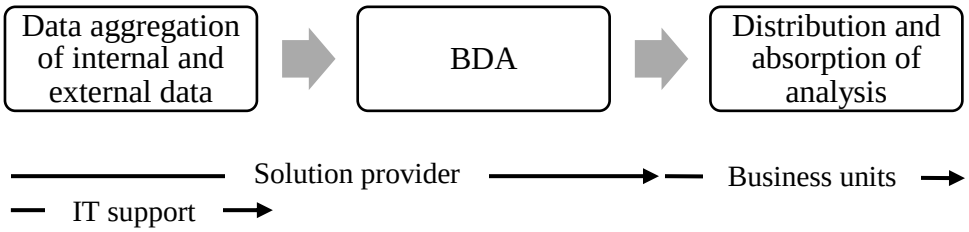

Figure 21. Big data processes for decision-making support

AI based machine learning and automation will continue to increase importance for analyzing big data. Below in figure 22 the difference between humans and machines is demonstrated in terms of handling different variables and the time needed for analysis.

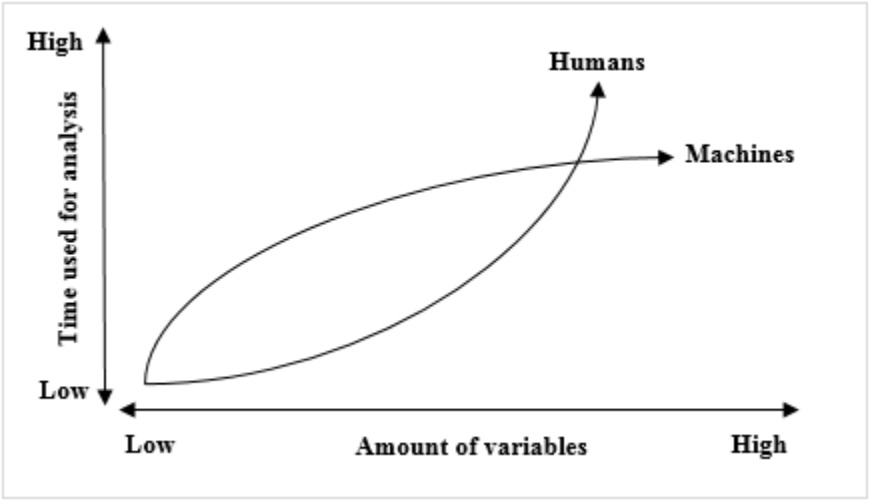

Figure 22. Humans versus machines in executing BDA

It takes a longer time to build machine learning systems but once they are in place, the analysis is conducted more efficiently for multiple variables.

7 CONCLUSIONS AND DISCUSSION

This chapter concludes the results of this study by answering the research questions, followed by acknowledging the theoretical contributions and managerial implications and considering validity of the research. To conclude, limitations and areas for further research are discussed.

7.1 Answering the research questions

Based on the conducted literature review and empirical research the following conclusions are formed by answering the research questions of this study.

RQ1: *What are the most potential big data analytics applications and opportunities in creating systematic supply market intelligence?*

BDA has great potential in creating systematic SMI. BDA can create competitive advantage for companies by integrating external data to company's context via analytical capabilities and providing value through actions. Some of the fundamentals for reaching this potential are that the analytics applications should be linked with the KPIs and aligned with strategy and business processes. Therefore, BDA implementation requires extensive background research and collaboration with the supply management professionals and analysts. The CPOs or category managers do not need to conduct the technical analysis themselves but they need to be educated about the analytical benefits in order to understand the analysis. Incorporating the analysis into actions enhances decision-making through improved forecasting.

One of the most important opportunities that BDA can provide is better supply risk management. In global supply networks, some of the most critical risks are political country risks, financial risks, image risks and geographic risks. Furthermore, emerging technologies and ecosystems as well as unforeseen M&A and industry consolidation might raise novel risks. It is not necessary to prepare for all possible risks, but rather recognize the core risks. This requires identifying strategic suppliers and forming risk mitigation and contingency plans with them. BDA decreases unexpected events and response times through automated action planning. Assessing risks compared to opportunities is challenging but when succeeded, can provide new business development opportunities. Therefore, BDA can provide much more than simply cost related follow-ups and forecasts, which are certainly important for price negotiations.

RQ2: *What is the importance of supply market intelligence in strategic supply management?*

SMI is especially important in driving innovation by forming supplier technology roadmaps in collaboration with R&D and the overall business. If the company already has robust processes for mapping technology roadmaps on a desired timespan, SMI is integrated in these practices. On the other hand, if the supply management function is not included in the innovation enhancing activities, insights derived from comprehensive SMI can be used to justify the importance of strategic supply management to business development, R&D techniques and upgrading NPD.

Regarding sourcing strategy formation, SMI is vital for making good contracts with suppliers, consisting of negotiating desired terms. Knowledge of the predominant supply market conditions provides leverage in negotiating prices and deliveries. Attractiveness of the buying company has great impact on the applicable supplier relationship formation. If the focal company is only a minor fragment of the supplier's revenue, the buying company needs to utilize SMI to prepare for negotiations. Strategic direction of supply base reductions and centralized spend emphasizes relationships with strategic suppliers. Therefore, defining strategic criteria for particular company, category or product needs to be decided in order to search for the right aspects from the supply base and supply markets through SMI.

Supply risk management was considered important overall among the supply management professionals. Identifying, assessing, managing and monitoring risk factors affecting availability of materials and reliability of delivery and quality can be facilitated through SMI. Even though the strategic direction of supply base reduction was realized visibly in the case companies, single / sole source suppliers should be minimized. The importance of SMI is abundant in finding alternative suppliers and materials. Due to the dynamic and complex business environment and supply markets, management of change and staying ahead of market fluctuations is imperative. Forecasting the future and being aware of current market conditions via SMI enables proactive actions and fast reactions to unprecedented events.

The main fundamentals for creating SMI to reinforce strategic supply management include first defining what the best suppliers are for a particular company, project or category on a local and global scale. Strategic criteria and customer needs may range case-by-case, resulting that the

importance of SMI in strategic supply management cannot be defined as undisputed since it is case specific. Therefore, understanding and focusing on what is relevant for the particular business is the second fundamental in creating systematic SMI. Furthermore, strategic alignment and communication between business units is a requisite for innovation activities, strategic collaboration and defining future needs. At present, category managers are mainly responsible for creating SMI but adequate resources are not available in all companies. In an ideal situation, employees from across business units would be involved in creating SMI and would understand its value to business. Value derives from identifying, collecting and distributing signals impacting supply management from internal and external sources.

RQ3: *How can big data be categorized and what are the data sources in the context of supply market intelligence?*

Big data can be categorized based on its form and ownerships. First, data can be structured, semi-structured or unstructured depending on how processed it is. Big data is often unstructured due to its diverse forms. Secondly, big data can be located in publicly available sources or proprietary sources that are owned by other parties but can be retrieved by purchasing access rights. There are different dimensions in the ownership of big data that also affect the data structure. The focal company, suppliers or external third parties might possess the data in their data warehouses or databases. This data might consist of different formats, sizes and values, requiring data management and analysis. Furthermore, big data can consist of existing data in databases, such as commodity market prices, or of social data that can be openly created by users, such as Facebook posts.

There are tremendous amounts of available big data in the supply markets. Some of the most relevant data and information for SMI consist of innovations and technologies, global price levels, global suppliers' corporate hierarchies and networks, new suppliers and solutions as well as market trends influencing the value proposal. Pre-knowledge that can be gathered from both the supply base and market include quality and delivery performance, TCO structures and opportunities, suppliers' abilities, suppliers' financial performance, product and service availability, delivery times of different products as well as the focal company's share of the suppliers' revenue and importance compared to other customers.

RQ4: *What are the most suitable big data analytics methods in creating supply market intelligence?*

An external BDA solution provider partner can be utilized for creating systematic SMI via BDA efficiently. Integrating internal and external data into a cloud warehouse management system is a prerequisite for transferring big data into the company's context. Different big data technologies can be used to conduct advanced analytics and interactive reporting for providing the end user a single point of truth user interface for intelligent decision-making. The analyzed data can be accessed via interactive data exploration platforms and dashboards that enable zooming and mapping the needed knowledge.

One of the most valuable BDA methods is coding a system, which sends alerts of possible threats and opportunities as well as provides reasons for the notices and provides suggestions of actions. Advanced systems can also automate some actions to a certain limit. Other methods for creating SMI include automatic data collection processing, enrichment and analysis, predictive analytics enabling proactive actions and dynamic price benchmarking.

7.2 Theoretical contributions

As realized in the research gap of this study, BDA in the context of SMI is rarely researched topic. Even though the importance of SMI is already widely recognized as a central factor of outstanding supply management and category strategy development (Handfield 2014, 36), there are not much previous research and scientific literature conducted about this particular subject. More research of utilizing BDA in the business-to-consumer markets have already been conducted, but opportunities in the business-to-business are being noted only more recently. Conceptual framework of strategic supply management is studied in this thesis, leaving opportunities for other theoretical research in implementing BDA. This thesis acts as a baseline for establishing definitions and procedures in the context of SMI and BDA.

Since this thesis is part of the SIM research project, various academics have had an influence on the outcome of this thesis. Consequently, this thesis provides novel views to the academic dialogue. For contributing to the theoretical publications, a conference paper of this study is in the making with two other researchers from VTT, Paajanen et al. 2017.

7.3 Managerial implications

SMI is important for companies due to its potential to create value and competitive advantage for business. The fast development of technology and increasing data generation form the basis for utilizing BDA in informed decision-making. This thesis provides knowledge about BDA in the new context of SMI. The benefits of BDA have been more recognized in utilizing the consumer market data for the benefit of business, but the supply market data still includes many uncovered opportunities. It is important that the supply management professionals have interest and understanding of the opportunities and applications of BDA to facilitate strategic supply management. This study reveals some of the main benefits in supply management that can be achieved through BDA and what are the potential tools and methods for the implementation. The results are not limited to a certain industry or category, and offer therefore value to a wide range of businesses in both manufacturing and service industries.

A managerial report of the results of this thesis will be published by VTT. The report will be circulated to supply management professionals in Finnish companies. Furthermore, blog posts about the research and results of this thesis are published in VTT's blog. The aforementioned different sources where the results of this thesis are published and accessible ensure that several parties will receive new knowledge about the subject, which can be used to develop business processes.

7.4 Validity considerations of the study

Data triangulation is applied by using multiple data sources in one qualitative research (Lee et al. 2008, 239). In this study, supply management professionals and BDA solution providers / experts are interviewed via several semi-structured interviews, and focus group discussions of mostly supply management professionals and a few BDA solution providers / experts are observed to ensure valid results. Qualitative data analysis software NVivo is used to analyze the data for reaching valid and defensible conclusions. This study aims to provide an overview of the opportunities of BDA in SMI to reinforce strategic supply management in Finnish companies. Therefore, industries and product or service types are not limited in this examination. BDA applications can even be category specific and therefore absolute definitions or guidelines that would be applicable and generalizable for all companies cannot be formed.

However, this study provides valuable results of the current subject of combining SMI and BDA for the benefit of different businesses.

7.5 Limitations and discussion of further research

This study is conducted to benefit the Finnish businesses and therefore empirical data is collected from local companies, tying the results to local context. However, some of the results, such as data categorization, can be generalized more widely. The scope of this thesis is supply management, concentrating on this specific function of the supply chain. Furthermore, more focused function of strategic sourcing is under examination. This excludes examining other functions and business units in the organizations, even though the importance of collaboration and cohesion between units and strategic alignment is recognized. Since SMI is rarely researched topic, this study focuses on the theoretical point of view of SMI, instead of the wider view of MI or contrasting view of BI. Furthermore, theory of knowledge management is linked to SMI as the basis for creating intelligence, but it is not studied in further profoundness. Further research could therefore be conducted through other theoretical lenses in more detail.

Opportunities of BDA are examined in the context of SMI in this study. Challenges, such as data quality and policy issues are recognized but solutions and overcoming these challenges are not explored in more detail. Furthermore, examples for the technical execution of BDA are presented but the IT expertise of big data technologies is not the objective of this study. Finally, BDA is studied with the scope of supply management excluding the wider range of digitalization in which BDA is included. There are many further possibilities in digitalization for creating economic profit for supply management and businesses. Impacts of developments like cognitive computing, robotics, augmented reality, mobile technologies, Internet of Things and sensor technologies can further be researched.

Understanding the key elements of the supply market and the analyzed data are prerequisites for utilizing BDA in informed decision-making. Therefore, closing the gap between analysts and employees actually utilizing the analyzed data is a determining factor for realizing the value from BDA. This issue requires further attention from BDA service providers to collaborate and tailor services according to the company's needs, and consequently involvement and interest of the supply management professionals. Hence, asking the right questions is vitally important.

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APPENDIX 1. Examples of SMI solution provider services and case studies

GEP: https://www.gep.com/outsourcing/supply-market-intelligence

A comprehensive sourcing strategy for global food and beverage (F&B) company based on in-depth research and SMI

- GEP's global energy experts established a roadmap to help the customer recognize a suitable NG supplier and negotiate terms of contract
- GEP reviewed the pipeline base tariffs for transmission and the contract status of three major Australian natural gas (NG) retailers with natural gas producers
- The experts identified cost structures in NG manufacturing in Australia

M-Brain: http://bit.ly/2nIOb1n

Market intelligence for product innovation at Itella - Earth Class Mail (ECM)

- Potential service concept, made popular in the United States, analyzed by answering to questions:
  - What is Earth Class Mail and the market situation?
  - How does the technology work?
  - Who are the market players?
  - What we can do with it?

Sievo: http://www.sievo.com/solutions/procurement-controlling/

Sourcing function development in Valio for managing spend, performance and other important data

- Integrating data from three different source system (SAP, Oracle and Axapta)
- Establishing KPIs for sourcing
- Extending the system easily and flexible when new needs appear

Solita: https://www.solita.fi/ennakoiva_analytiikka/

Improving predictability of the business by combining data from various departments in Vaasan

- New system for providing comprehensive visibility to organization's figures
- Reducing manual labor with automation, providing more time to support the business

APPENDIX 2. Examples of BDA solutions

Google - Cloud Platform:

https://cloud.google.com/products/big-data/

- Integrated end-to-end big data solution for capturing, processing, storing and analyzing data for finding insights within a single platform

IBM - SPSS Software:

https://www.ibm.com/analytics/us/en/technology/spss/

- Enables to predict with confidence what will happen next to make smarter decisions for the organization

IBM - Watson Analytics:

https://www.ibm.com/watson/

- Cloud-based analytics service for improving data sets, analyzing and visualizing data, and finding the most relevant facts, patterns and relationships within the data

Microsoft - Apache Hadoop:

https://azure.microsoft.com/en-us/solutions/hadoop/

- Open-source software for storing and analyzing enormous amounts of structured and unstructured data, such as emails, sensor readings, server logs to Twitter feeds, and GPS

R:

https://www.r-project.org/

- Free software environment for statistical computing and graphics.

SAS Analytics Platform:

https://www.sas.com/en_us/software/platform.html

- Software foundation for generating insights from data in any computing environment to drive business actions.

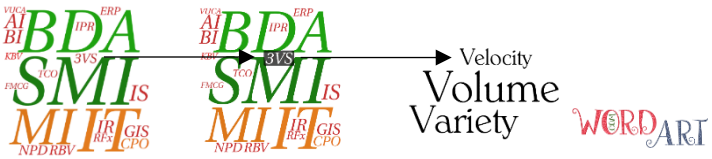
Splunk:

https://www.splunk.com/en_us/solutions/solution-areas/big-data.html

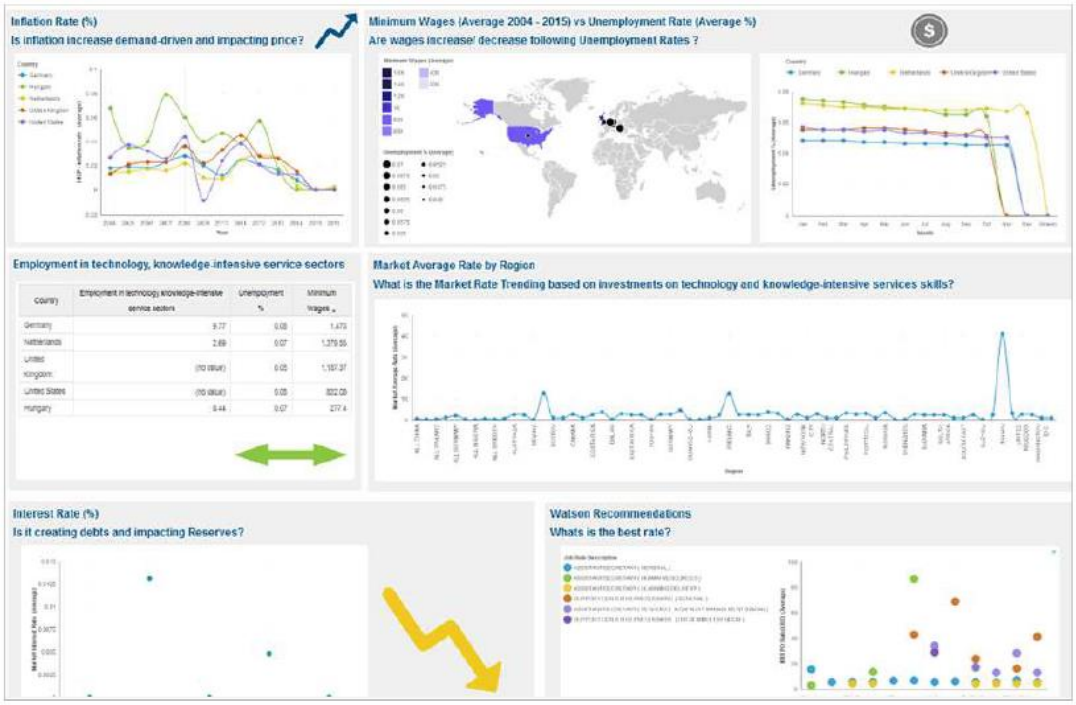
- Splunk software enables to scale the solution to fit big data needs, search across real-time and historical data, analyze diverse datasets in one unified view

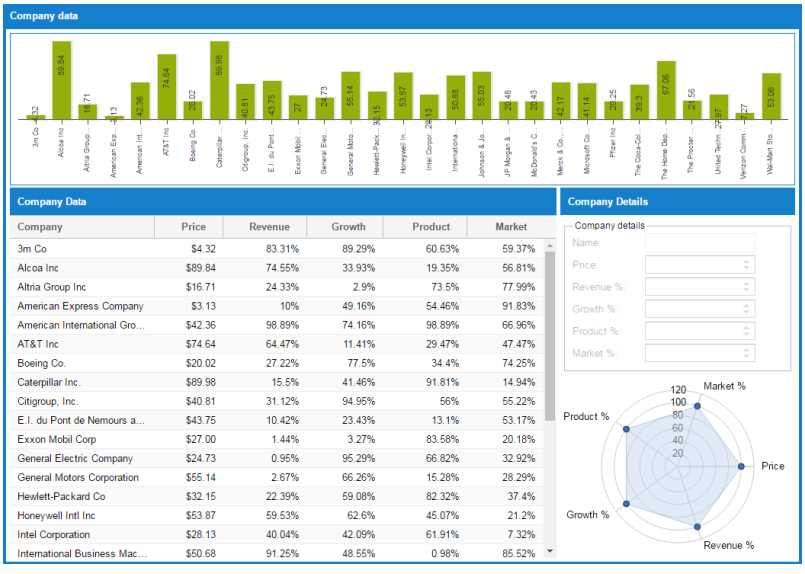
APPENDIX 3. Examples of big data visualization

Simple tag / word clouds



Complex dashboards





Company	Price	Revenue	Growth	Product	Market
3m Co	$4.32	83.31%	89.29%	60.63%	59.37%
Alcoa Inc	$89.84	74.55%	33.93%	19.35%	56.81%
Altria Group Inc	$16.71	24.33%	2.9%	73.5%	77.99%
American Express Company	$3.13	10%	49.16%	54.46%	91.83%
American International Gro...	$42.36	98.89%	74.16%	98.89%	66.96%
AT&T Inc	$74.64	64.47%	11.41%	29.47%	47.47%
Boeing Co.	$20.02	27.22%	77.5%	34.4%	74.25%
Caterpillar Inc.	$89.98	15.5%	41.46%	91.81%	14.94%
Citigroup, Inc.	$40.81	31.12%	94.95%	56%	55.22%
E.I. du Pont de Nemours a...	$43.75	10.42%	23.43%	13.1%	53.17%
Exxon Mobil Corp	$27.00	1.44%	3.27%	83.58%	20.18%
General Electric Company	$24.73	0.95%	95.29%	66.82%	32.92%
General Motors Corporation	$55.14	2.67%	66.26%	15.28%	28.29%
Hewlett-Packard Co	$32.15	22.39%	59.08%	82.32%	37.4%
Honeywell Intl Inc	$53.87	59.53%	62.6%	45.07%	21.2%
Intel Corporation	$28.13	40.04%	42.09%	61.91%	7.32%
International Business Mac...	$50.68	91.25%	48.55%	0.98%	85.52%

APPENDIX 4. Examples of databases for creating SMI

Emerging Technologies

Patents

- Derwent World Patents Index (DWPI): http://ipscience.tr.com/product/derwent/
- European Patent Office (EPO): http://www.epo.org/searching-for-patents.html
    - EP full-text search: https://data.epo.org/expert-services/index-2-3-1.html
    - Espacenet: https://worldwide.espacenet.com/
    - Global Patent Index: https://data.epo.org/expert-services/index-2-3-1.html
- Google: https://www.google.fi/?gfe_rd=cr&ei=k7SqWIWoFI7EZMb5v0g
    - Find Prior Art: https://patents.google.com/?scholar
    - Patents: https://www.google.fi/advanced_patent_search?hl=fi
- Orbit: https://www.orbit.com/
- PatBase: http://www.patbase.com/express/search_basic.asp
- PatentScope (WIPO): https://patentscope.wipo.int/search/en/structuredSearch.jsf
- SFINNO: http://www.vtt.fi/sites/sfinno/en
- STN: http://www.stn-international.de/index.php?id=123
- Thomson Innovation: http://info.thomsoninnovation.com/

Research publications

- ETLA: https://www.etla.fi/en/category/publications/
- European Publication Server: https://data.epo.org/publication-server/?lg=en
- VTT: http://www.vttresearch.com/impact/publications

Scientific and engineering literature

- IEEE Xplore: http://ieeexplore.ieee.org/Xplore/home.jsp
- NASA Scientific and Technical Information (STI) Program: https://www.sti.nasa.gov/
- ProQuest, Materials Science & Engineering Database: http://www.proquest.com/products-services/materials_science.html

Technical media

- Tekniikan Maailma: https://tekniikanmaailma.fi/

- Tekniikka&Talous (T&T): http://www.tekniikkatalous.fi/
- Tieteen Kuvalehti: http://tieku.fi/tekniikka
- Uusiteknologia: http://www.uusiteknologia.fi/

News and press releases

- Finpro: http://www.finpro.fi/web/finpro-eng/news
    - Finnfacts: http://www.finnfacts.fi/eng/for-press/press-releases/
- Team Finland: http://team.finland.fi/en/press-releases
- Technology Academy Finland (TAF): http://taf.fi/en/kategoria/press-releases/

Price and cost trends

Financial media

- Financial Times: https://www.ft.com/
- Bloomberg News: https://www.bloomberg.com/europe
- Kauppalehti: http://www.kauppalehti.fi/
- Talouselämä: http://www.talouselama.fi/
- Taloussanomat: http://www.iltasanomat.fi/taloussanomat/
- Yle News: http://yle.fi/uutiset/18-204933

Inflation and deflation statistics

- The Organisation for Economic Co-operation and Development (OECD): http://stats.oecd.org/Index.aspx?DatasetCode=MEI_PRICES
- Statistics Finland: http://www.stat.fi/til/khi/index_en.html

Interest and exchange rates

- Bank of Finland: http://www.suomenpankki.fi/en/tilastot/korot/Pages/default.aspx
- The Statistical Office of the European Communities (Eurostat): http://ec.europa.eu/eurostat
- Kauppalehti: http://www.kauppalehti.fi/en/money/currencies/

Market indices

- NASDAQ Composite: http://www.nasdaq.com/markets/indices/major-indices.aspx
- Nordnet: https://www.nordnet.fi/mux/web/marknaden/varlden/
- Reuters: http://www.reuters.com/finance/markets/indices

- TradingView: https://www.tradingview.com/

Publications from banks

- Bank of Finland: http://www.suomenpankki.fi/fi/julkaisut/Pages/default.aspx
    - Euro & talous: http://www.eurojatalous.fi/fi/ /
    - Bank of Finland Bulletin: http://www.bofbulletin.fi/en/home/
- The World Bank: http://www.worldbank.org/en/publication/reference

Company databases

- Asiakastieto: https://www.asiakastieto.fi/yritykset/
- Bisnode Selector: https://selector.bisnode.fi/country
- Bureau Van Dijk (Odin): https://goo.gl/ADjSwm
- CorporateInformation: http://www.corporateinformation.com/
- Europages: http://www.europages.fi/
- Kompass: http://fi.kompass.com/

Mergers and acquisitions

Competition policy

- European Commission: http://ec.europa.eu/competition/index_en.html
- Finnish Competition and Consumer Authority: http://www.kkv.fi/en/
- Ministry of Economic Affairs and Employment: https://tem.fi/en/competition-policy
- The Organisation for Economic Co-operation and Development (OECD): https://www.oecd.org/competition/

Company databases

- Bureau Van Dijk: https://goo.gl/7pLdOQ
    - Bureau Van Dijk (M&A Research Catalyst): https://goo.gl/tcEEBW
    - Bureau Van Dijk (Zephyr): https://goo.gl/CMZguv

Capacity requirements

Meteorological databases

- Finnish Meteorological Institute: https://en.ilmatieteenlaitos.fi/open-data

User demographics

- Statistics Finland: http://tilastokeskus.fi/org/avoindata/index_en.html

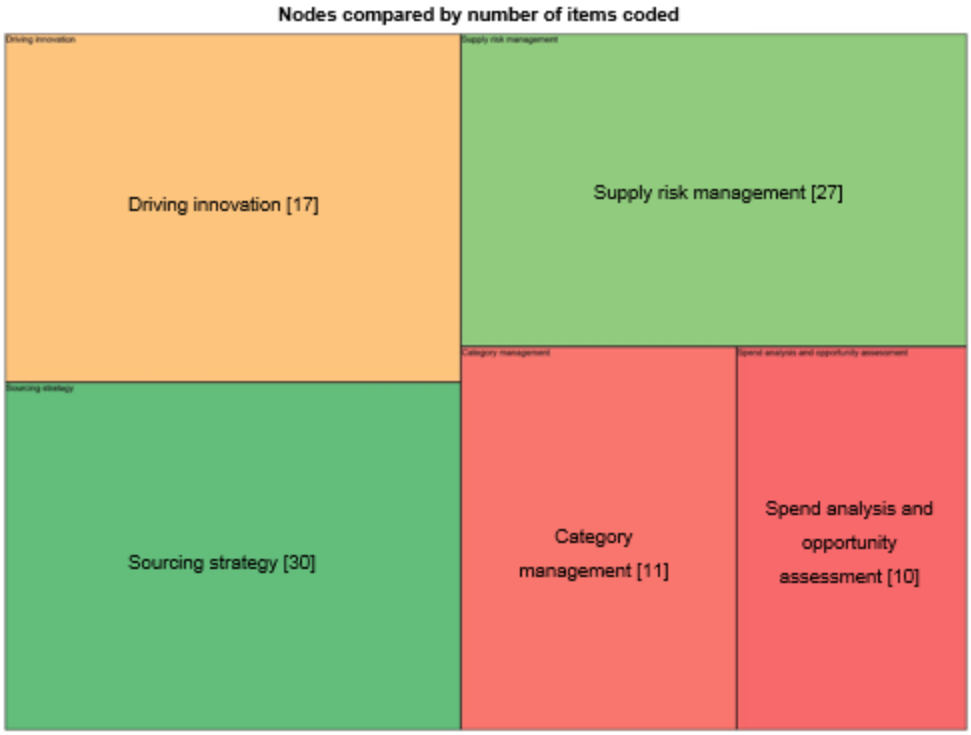
Quality and delivery performance

Geographic information systems (GIS)

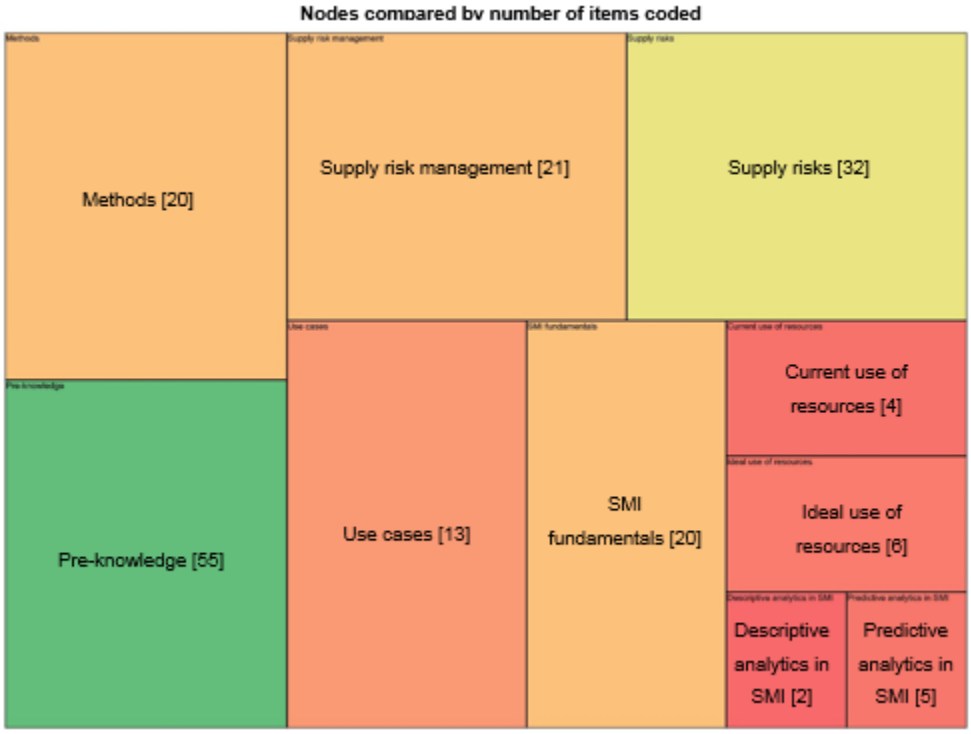
- ArcGIS: http://www.arcgis.com/features/index.html
- Finnish Municipalities Map Services: http://ptp.hel.fi/opaskartat.html
- Gapminder World: https://goo.gl/yxTdH3
- Google Earth: http://www.google.fi/intl/fi/earth/
- Karttakeskus: http://www.karttakeskus.fi/
- Paikkaoppi: http://www.paikkaoppi.fi/fi/
- Paikkatietoikkuna: http://www.paikkatietoikkuna.fi/web/fi
- Pitney Bowes: https://goo.gl/Z4Stmf
- Statplanet: http://www.sacmeq.org/interactive-maps/statplanet/

APPENDIX 5. Analysis of empirical data in qualitative data analysis software NVivo

Case company interviews



Focus group research



BDA solution provider / expert interviews