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Opportunities of big data analytics in supply market intelligence to reinforce supply management

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Abstract
Tiivistelmä

1. Background

Today, innovation collaboration with existing suppliers, as well with new interfaces with communities, has become an essential element for company success. As a result, suppliers and partners can be considered as the external resources of a company (Tanskanen et al. 2017). One consequence of this development is that firms are more and more dependent on various types of external resources, such as suppliers, contractors and partners. Increasingly, the most qualified centers of excellence of the relevant know-how are located outside the boundaries of a company, and that competitive advantage can increasingly be gained rather with the relationships and linkages a firm can forge with external organizations. The high share makes supply, supply markets and supplier relationships a key area of management interest. It is suggested that the actual configuration of the interface between a buyer and a seller (or service provider) determines to a large extent what buyer is able to capture from a supplier in addition to the actual product or service. This development has caused new managerial challenges for companies. As one supply manager stated: “Accessing the knowledge in the heads of 10,000 people in the supply base to improve your product and come up with new ideas is surely an asset worth working for!” (Cousins et al. 2011)

Utilizing suppliers’ capabilities, selecting the most suitable suppliers, making good contracts and developing successful collaborative relationship with suppliers requires creating systematic *supply market intelligence* (SMI) (Iloranta 2015). SMI can be defined 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). SMI facilitates examining suppliers and enables identifying potential cost-effective markets, new technologies and innovations before competitors (Iloranta 2015), in addition to forecasting market price fluctuations and monitoring cost compliance (Shi 2004). As high quality SMI provides access to up-to-date supply market visibility, companies can handle supply chain disruptions, while achieving savings (Chithur 2014). Despite the possibilities and importance of SMI, it is still exploited only a little in companies.

When data, businesses and supply chains become more complex, managers need sufficient tools for generating insights to support smart decision-making (Sahay & Ranjan 2008). The amount of generated data continues to increase rapidly, which has resulted to the development of big data. A widely applied definition of big data is “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 critical to decision support, since rapid innovation and globalization have created notable opportunities in the marketplace for companies (Sahay & Ranjan 2008).

The aim of this report is to give an overview of the possibilities of BDA in SMI. Thus, existing literature and research of the subject is reviewed, followed by findings from interviews of supply management practitioners and BDA solution providers / experts. The results discuss the importance of SMI, data categorization and sources of data in the context of SMI, potential BDA solutions and how value is generated by using BDA, concluding with challenges and future trends in BDA.

This report presents the results of SIM (Supplier innovation management) research project. The main objective of the SIM project was to provide new knowledge by using scientific methods that enable Finnish companies and organizations to benefit from the innovation potential and capabilities of supplier networks

and to stimulate supplier innovations. The project was conducted in collaboration between Aalto University and VTT, and was funded by Tekes, Aalto University, VTT and participating companies.

Qualitative research was chosen as the methodology of this study due to the new and continuously developing topic. Data collection methods of semi-structured interviews and focus group discussions of supply management professionals and BDA experts / solution providers are chosen to gather empirical data in this research. BDA in the context of SMI is a rarely researched topic, so the empirical data contributes high value in this study. Based on the gathered empirical data, conclusions are formed through analysis.

2. Supply market intelligence (SMI)

The main objective of conducting a supply market analysis is to develop the needed intelligence to drive better sourcing related 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). Discovering new suppliers and opportunities through systematic SMI increases competitive advantage and determines position in the value net through strategic supply management decisions (Iloranta 2015).

The concept of SMI is often mentioned in literature as an enabling element, such as for developing sourcing strategies (Handley & Benton 2012), interpreting supplier behaviour and making supply management decisions (Kaufmann et al. 2009), selecting and committing to suppliers (Swink & Zsidisin 2006), and successfully conducting electronic reverse auctions (Hur et al. 2007; Wagner & Schwab 2004). 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) 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).

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 2015). 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).

Best practices for managing suppliers require a category specific context, driven by an understanding of applicable market forces, making SMI vital (Jones & Barner 2015). Category management refers to a coherent group of supplied products, materials or services managed by a category manager (Nieminen, Sanna 2016). Decisions regarding supplier relationship strategies can be based on the features of the supplied items (Ahtonen & Virolainen 2009). In general, the paradigm shift in category management focuses on a strategic view of categories of supply, rather than categories of spend. (Cox & Cox 2015) Below in Figure 1, the supply positioning model is shown containing the importance of SMI in different categories.

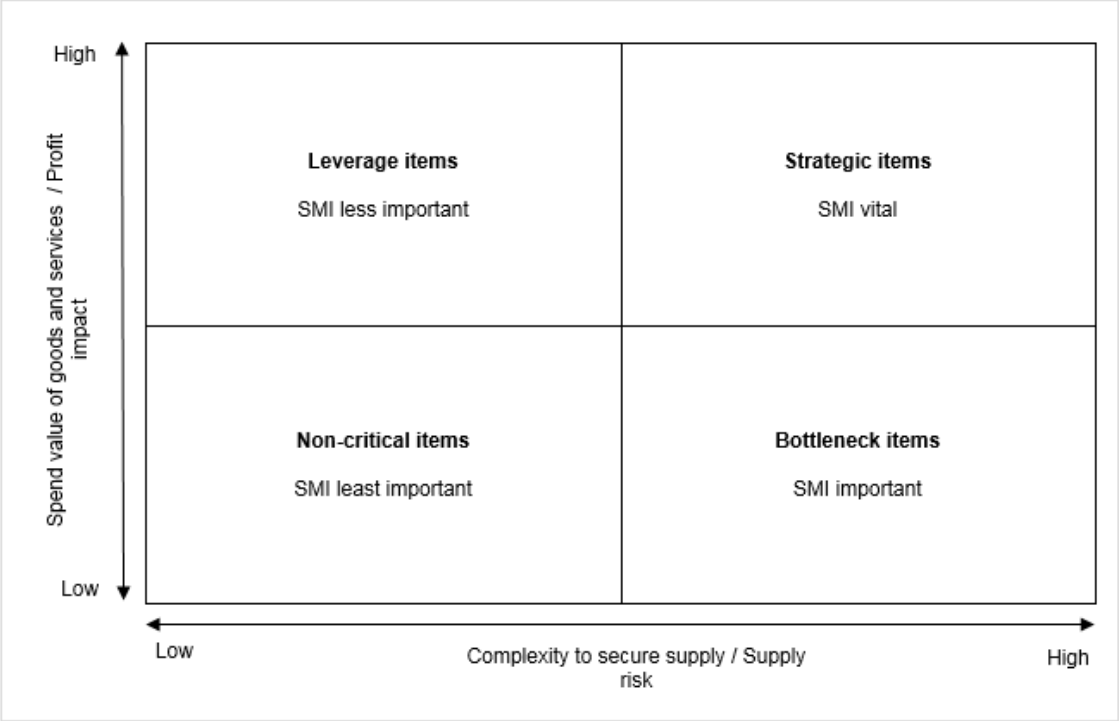

Figure 1. Supply positioning model of items and importance of SMI modified from (Kraljic 1983; Chithur 2014)

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) 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) Below in Table 1 some of the most important benefits that can be achieved from SMI are summarized.

Table 1. Summary of the most important benefits from SMI (Handley & Benton 2012; Handfield 2006; Hargraves 2008; Hur et al. 2007; Iloranta 2015; Kaufmann et al. 2009; Swink & Zsidisin 2006; Wagner & Schwab 2004)

Discovering and selecting the best suppliers / partners and collaboration opportunities	Interpreting and forecasting supplier behavior for making sourcing decisions
Creating competitive advantage by gaining visibility to global supply chain trends	Receiving insights for determining the best prices and making good contracts
Determining position in the value net for developing optimal sourcing strategies	Conducting electronic reverse auctions by utilizing digital platforms

2.1 Challenges in SMI

Many managers recognize the challenges in establishing focused SMI creation (Handfield 2014). 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 modelling and analysis, upstream and downstream supply chain as well as suppliers for each product or category are required for creating SMI (Hargraves 2008). 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)

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). 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)

Valuable pre-knowledge can be collected directly from the suppliers, authors or subject matter experts via *request for information; proposal; quotes* (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) 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).

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) External market research can be executed by constructing own benchmarking surveys or through third party outsourced providers. (Handfield 2014) 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).

2.2 Outsourcing SMI

Companies may not have enough resources to execute benchmark breakdowns, best practice studies, competitive landscape reports and strategic analyses needed for strategic sourcing (Hedin 2014). 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). 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)

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 2015). 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) 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). 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)

Some of the most critical challenges in outsourcing SMI are establishing correct specifications and expectations for structuring the right questions and requests. The solution providers have to customize the data acquisition and analysis according to individual needs, such as gathering raw data, various deep analyses or concrete suggestions for action plans. Otherwise, the reports may not be utilized in improving the processes. (Handfield 2014) Examples of SMI solution provider services and case studies are gathered in Appendix A.

2.3 Data, information, knowledge and intelligence of SMI

Data exist in every sector, economy, organization and user of digital technology (Manyika et al. 2011), 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. Figure 2 below shows the creation of data into intelligence in the context of SMI.

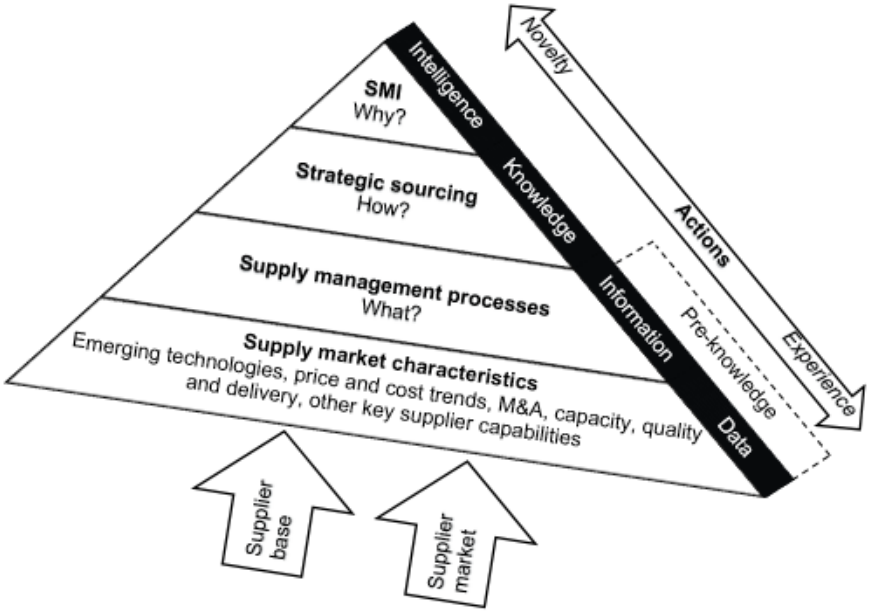

Figure 2. Data, information, knowledge and intelligence in the context of SMI modified from (Aydın & Ozleblebici 2015; Handfield 2006; Handfield et al. 2009; Rowley 2007)

Data

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)

Information

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).

Knowledge

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) 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).

Intelligence

Intelligence from the supply markets is generated when external information is collected and analysed to form actionable conclusions that affect a company's ability to strategically locate, secure, and manage sources of supply (Jones & Barner 2015). Data can be formed into intelligence and meaningful insights can be created through analytics (Sanders 2014). However, creating systematic SMI requires more than simply a set of analytical tools. Effective SMI formation requires collecting and analysing data, engaging stakeholders in defining information requirements, and sharing knowledge for applying insights in key impacted business sectors across the organization. (Handfield 2014) 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.

3. Big data analytics (BDA)

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 & Haider 2015). Commonly big data is referred to when the size of the datasets grows so large that they cannot be captured, stored, managed or analysed 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) 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 & Zhang 2014). Consequently, the definition is threefold including 1) characteristics of big data, 2) ways of processing and analysing the data and 3) use cases of the analysed data.

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. 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). 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) 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). 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 cataloguing external data, which can be accessible in the public domain or require purchasing. (Manyika et al. 2011) It is important that companies need to organize their proprietary data before acquiring external data (Sanders 2014).

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) Collecting, analysing 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).

3.1 Data management

Due to the fast development of IT, the amount of acquirable big data increases (Fan et al. 2015), and data can be recorded in diverse systems for different uses (Manyika et al. 2011). When the amount of acquired data increases, data management capabilities need to be improved (Hazen et al. 2014). 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 & Haider 2015). Traditional data management systems cannot handle big data instantly and therefore new technologies need to be utilized for managing big data (Gandomi & Haider 2015).

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 (Kwon et al. 2014). 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 labour intensive and time consuming big data processes. (Assunção et al. 2015) The acquired raw data needs to be converted to higher-level context data, in order to use it for decision-making (Dobre & Xhafa 2014). 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).

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 & Villanustre 2016). Structuring the generated data for further analysis eliminates errors and ensures data quality and reliability (Sanders 2016). 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). 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 & Villanustre 2016) 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 analysing a single source of data for insight discovery (Manyika et al. 2011).

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) Data warehouses support data integration and aggregation by handling numerous data records (Sahay & Ranjan 2008). New service oriented architecture tools provide interfaces to various data types and enable integrating data sources (Sahay & Ranjan 2008). Integrated systems can provide information of new and innovative materials, services, products and technologies within the enterprise as well as between suppliers (Handfield 2006).

3.2 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 & Davis 2015). BDA involves applying statistics and quantitative applications to big data (Sanders 2016), consisting of techniques that are used to analyse 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 & Haider 2015) 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).

Analytics maturity is categorized in the literature in several ways. Several authors (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. Some others (Herschel & Davis 2015) 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). In the simplified categorization, descriptive analytics can be perceived as basic analytics and predictive analytics as advanced analytics (Sanders 2016; Lustig et al. 2010). Analytics maturity model adopted from Gartner is presented below in Figure 3.

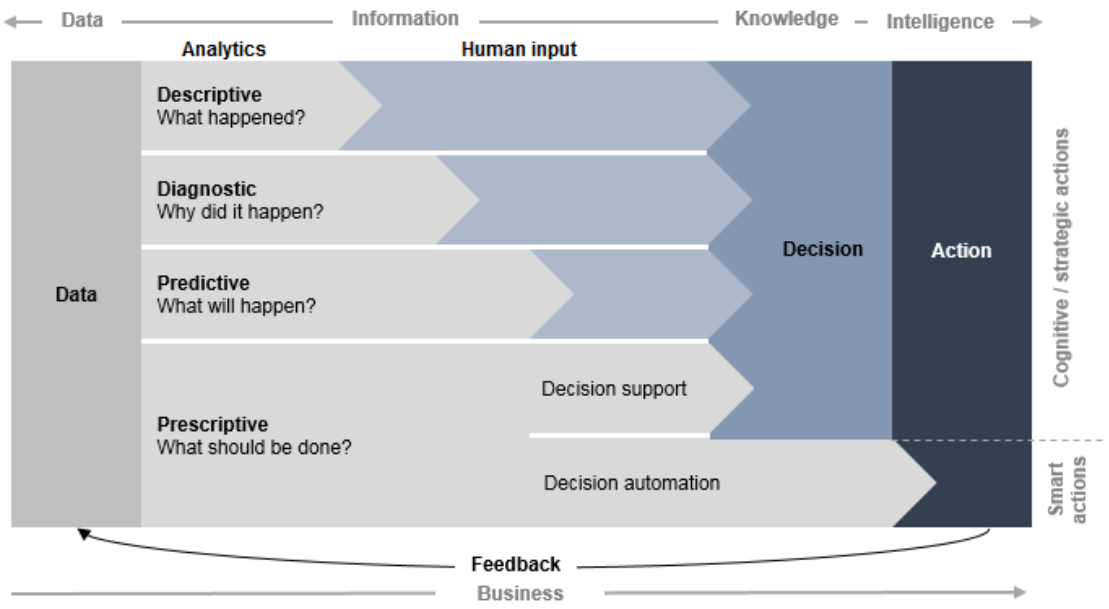

Figure 3. BDA maturity levels and workflow modified from (Herschel & Davis 2015)

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). 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). Traditional information system 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 & Ranjan 2008) 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). Especially the manufacturing sector and operational processes can highly benefit from IT and automation (Manyika et al. 2011), 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 B.

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). 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 et al. 2015) 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) Examples of big data visualization are shown in Appendix C. Data can be presented as simple overviews, such as tag clouds, or in complex dashboards consisting of diverse and dynamic charts.

3.3 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) 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. (Manyika et al. 2011) Better access to information creates privacy issues that need to be evaluated in contrast to the convenience of having information available. (Manyika et al. 2011) (Maniyka 2011) 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), to protect, for instance, competitively sensitive data (Manyika et al. 2011). 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, applying 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). 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). The amount of increasing unstructured data creates challenges in organizing and structuring quality data in order to create value (Sanders 2016). 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).

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) 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). 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)

3.4 Outsourcing BDA

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) Some authors (Fan et al. 2015) directly 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) 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)

4. BDA opportunities and applications in SMI

Quickly shortening product life cycles, competitive global markets and volatile market behaviour requires companies to analyse accurate and timely information (Sahay & Ranjan 2008). 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 & Haider 2015) 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). Fulfilling the BDA opportunities requires investments in IT solutions as well as organizational changes (Manyika et al. 2011).

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). 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) Interpretation of important business information brings value from the analysis (Sahay & Ranjan 2008), so analysed information needs to be communicated on a timely, effective and efficient manner to key decision makers (Handfield 2006). The potential value of big data is realized only when leveraged to initiate decision-making (Gandomi & Haider 2015). BDA can be used to optimize value creation at the level of individual companies, sectors and economies as a whole (Manyika et al. 2011).

Managing external resources of knowledge assets can be linked to BDA by considering big data transformed into knowledge as such a resource that needs to fulfil the requirements of valuable, rare, inimitable and non-substitutable source of supply. These resource requirements can be achieved through a high level of data quality. (Hazen et al. 2014) Moreover, dynamic capabilities need to be acknowledged, since core competencies of a company 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)

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). 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 & Ranjan 2008). Demand forecasting that includes trends and seasonality require short-term predictions via predictive analytics (Wang et al. 2016). Improved forecasting expands the company's ability to address risks associated with decision-making (Richey et al. 2016), hence supply risk management has great potential to benefit from big data by collecting and analysing the data, and utilizing it to detect risks (Fan et al. 2015). Predictive and prescriptive analytics facilitate companies to make effective decisions to the strategic direction (Demirkan & Delen 2013). 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).

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) The more suppliers and customers a company has, the bigger potential there is to use BDA for segmentation (Manyika et al. 2011).

BDA applications are increasingly important in strategic sourcing and collaboration. The ability to capture, store, aggregate and analyse data for extracting intelligence is vital for strategic decisions. (Sanders 2014) 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 and quality and delivery performance. Patents are an important knowledge resource in identifying technology development trends and opportunities, specifically emerging technologies (Ma & Porter 2014). Through descriptive statistics, such as the frequency table, retrieved patent documents can be summarized, using representative variables in order to discover novel data for technology forecasting and analysis (Jun et al. 2015). Interest and exchange rates analysis is an important part of price and cost trends prediction and financial risk management in the global and unstable economic environment. Exchange rate movements can be forecasted, for instance, from time series of social media channels, such as Tweet counts (Fan et al. 2015). M&A actions are influenced by competition policies, which can be analysed and reveal insights from the retail sites as well as the social side via social media analytics solutions (Kaye 2015). Furthermore, 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 & Tjahjono 2014). Finally, geographic information systems facilitate delivery performance monitoring and optimizing by integrating spatial data into regressions or simulations (Manyika et al. 2011).

Below in Table 2, 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 D consisting of web links for the different pre-knowledge types of supply market characteristics.

Table 2. Examples of BDA applications in creating SMI as per existing literature (Demirkan & Delen 2013; Dobre & Xhafa 2014; Fan et al. 2015; Gandomi & Haider 2015; Jun et al. 2015; Kaye 2015; Manyika et al. 2011; Varela & Tjahjono 2014)

SMI characteristics	Pre-knowledge	BDA solutions	BDA techniques
Emerging technologies	Patent databases including patent documents and award information	Descriptive analytics	Frequency table; Mean; Variance
		Predictive analytics	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	Predictive analytics	Time series methods
	User demographics	Predictive analytics	Clustering
Quality and delivery performance	Geographic information systems	Predictive analytics	Regression
		Prescriptive analysis	Multi-criteria simulation; 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. Table 3 below shows a summary of the most significant benefits from BDA in supply management.

Table 3. Summary of the most significant benefits from BDA in supply management (Gandomi & Haider 2015; Manyika et al. 2011; O'Donnell 2016; Sahay & Ranjan 2008; Sanders 2016)

Real-time intelligence from high volumes of data for faster and more informed decisions	Improving company's performance and risk management by balancing costs versus risks
Innovating new business models, products and services	Maximizing the amount of preferred suppliers according to needs
Supplier segmentation based on key characteristics enabled by data scalability	Managing capacity and delivery of products from manufacturers to customers

5. The unexploited potential of BDA in SMI

Based on the conducted research, we present eight messages that every supply management professional should recognize.

Message 1

BDA has great potential in creating systematic SMI in order to create competitive advantage for companies by analysing big data in a company's context via analytical capabilities and providing value through actions.

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.

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 4, the radical new source of value in supply management is illustrated.

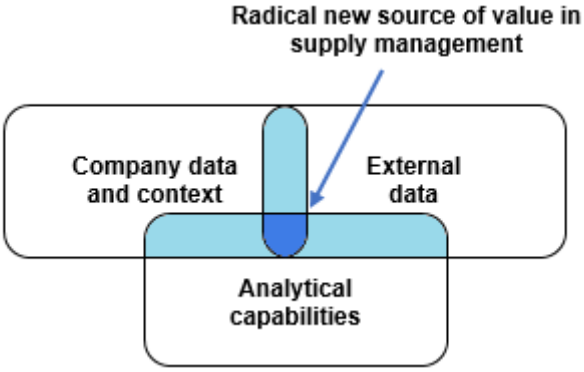

Figure 4. Radical new source of value in supply management

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.

Message 2

Big data can be categorized based on its form (structured/semi-structured/unstructured), and ownership or access to it (proprietary/public/purchased).

Big data in the context of SMI consists of several dimensions in the supply markets and social data. Based on the research, big data is categorized based on the form and ownership or access to it. 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. Below in Figure 5 the pre-knowledge categorization in the context of SMI is presented.

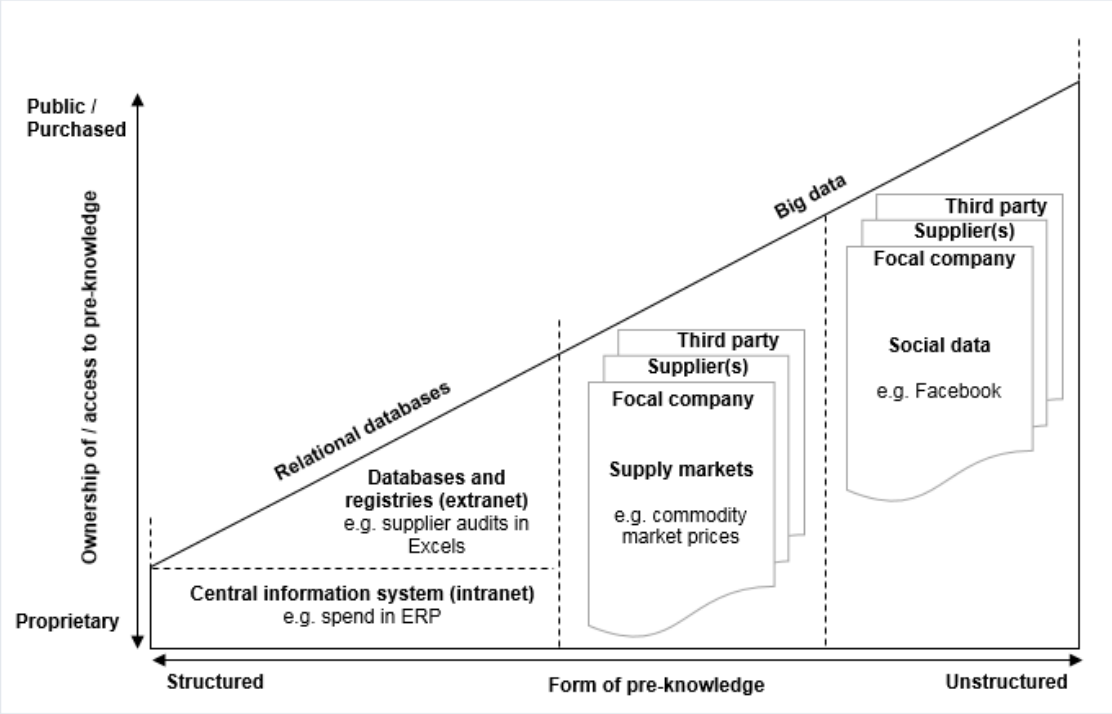

Figure 5. Pre-knowledge categorization in the context of SMI

The origin and 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.

Message 3

Some of the most important data and information (pre-knowledge) 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, new suppliers and solutions, global price levels and product/service availability.

Pre-knowledge needed for creating SMI consists of data and information before refining them into knowledge. 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.

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 in the study. 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.

Existing suppliers' abilities and possible changes need to be identified, in order to be able to uncover use cases for their skills. Furthermore, recognizing new suppliers and solutions is vital and is one of the essential aspects of SMI. 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 enables dynamic price benchmarking that gives visibility to global price levels. Finally, material and component availability in product categories, and workforce availability in service categories should be considered in evaluating potential capacity problems and production delays. Table 4 below classifies different data types in the context of SMI as per the realized pre-knowledge categorization above (Fig. 5).

Table 4. Examples of data types in the context of SMI

Central data system	Databases and registries	Supply markets	Social data
Supplier / category spend	Total cost of ownership	Global price levels	Company's attractiveness
Contract information	Proprietary indices	Commodity MI	Corporate reputation
Working capital / savings	Suppliers' business impact	Quality and delivery	Corporate hierarchies
	Strategic alignment	Market (mega)trends	My Data
	Contract compliance	Availability and capacity	Social media
	Financial performance	Innovations / technologies	
	Existing suppliers' abilities	Key players and drivers	
	Consumer packed goods	New suppliers / solutions	
		Supply and demand	
		M&A and labour turnover	
		Rules and regulations	

Message 4

Humans are really good at managing a couple of variables, but after 3-5, the time used for conducting analysis increases exponentially, whereas with machine learning it takes longer to build automation, but once executed, it absorbs the variables ever more.

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 be built into interactive dashboards, enabling a "digital assistant" to alter variables in the analysis. AI based machine learning and automation will continue to increase importance for analysing big data. 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. Below in Figure 6 the difference between humans and machines is demonstrated in terms of handling different variables and the time needed for analysis.

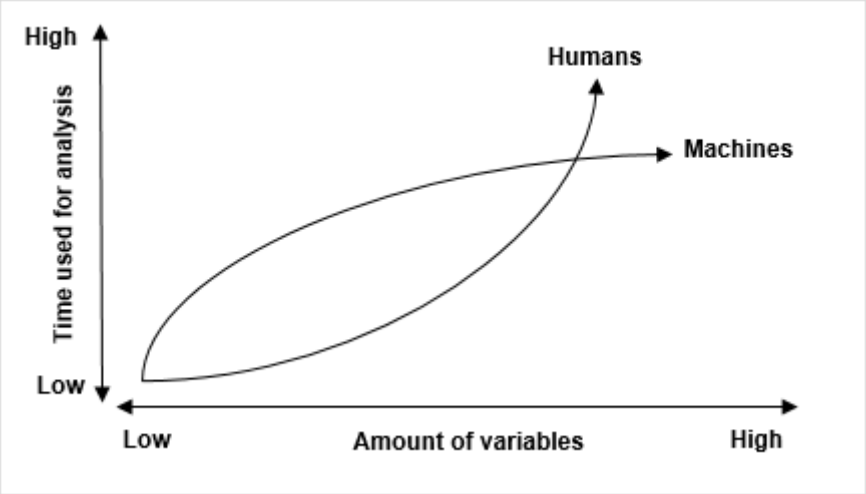

Figure 6. Humans versus machines in executing BDA

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 BDA 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.

Message 5

In collaboration with a solution provider, it is possible to reach value from BDA and advanced analytics (later tipping point) more efficiently than entirely in-house, due to not having to invest in basic analytics, and utilizing wider data sources and analytical expertise.

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 analysing 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. Reaching the tipping point in-house compared to a solution provider is shown below in Figure 7.

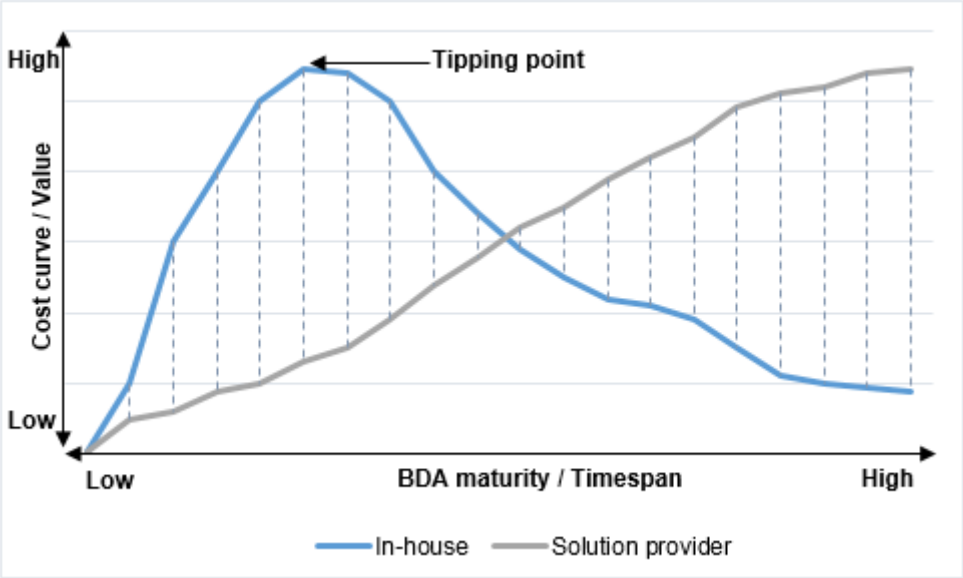

Figure 7. Reaching the most value from BDA

Long-term orientation is the key in creating sustainable competitive advantage through SMI implemented via BDA. 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.

Message 6

An external BDA solution provider enables to create systematic and comprehensive SMI by integrating internal and external data from different sources and databases to a cloud warehouse management system, and implementing advanced analytics and interactive dashboards to create a single point of truth user interface.

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. Below in Figure 8, an example of a BDA solution for creating SMI is shown.

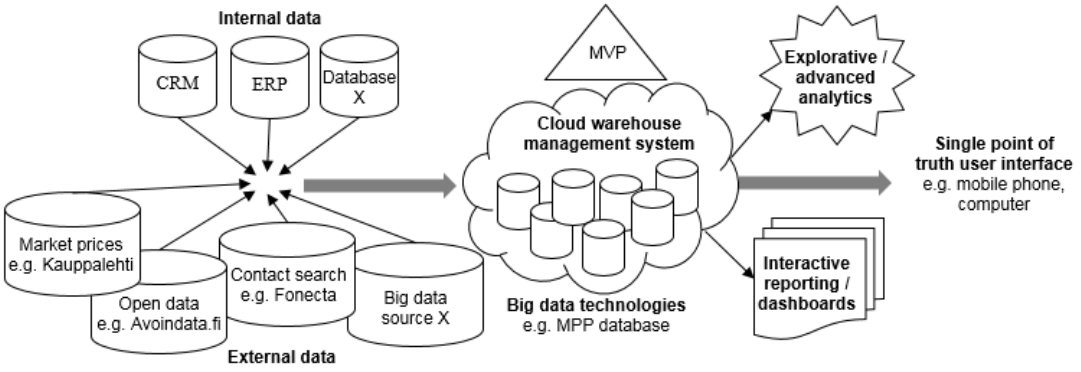

Figure 8. BDA solution for creating SMI

The decision maker, such as a CPO or category manager, is involved in the last phase of retrieving the analysed data from the single point of truth user interface. 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.

Message 7

The importance of SMI in strategic supply management is primarily realized through sourcing strategy formation, supply risk management and driving innovation.

Sourcing strategy formation

According to conducted 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. 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 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 interviewed 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. Ultimately, the corporate strategy guides the sourcing and category strategies, consisting of supplier and material selections. Furthermore, long-term strategic vision and growth plans require SMI in terms of understanding the business environment and future changes.

Supply risk management

Availability of materials and reliability of delivery and quality can be 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 interviewed companies still have unwanted single source suppliers, over half of the supply base in one of the 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

Driving innovation is an important aspect in strategic supply management that can be facilitated via SMI. One of the interviewed 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 interviewed 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 analysed. 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 5 below presents findings from the supply management professionals' interviews regarding sourcing strategy formation, supply risk management and driving innovation.

Table 5. Importance of SMI in strategic supply management

Sourcing strategy formation	Supply risk management	Driving innovation
Negotiating good contracts	Reliability of delivery and quality	Supplier technology roadmaps
Buyer's attractiveness	Alternative suppliers / materials	Need derives from NPD processes
Supply base reduction	Management of change	Early supplier involvement
Strategic criteria defined	Financial situation of suppliers	Utilizing partners' ecosystems
Supplier classification	Mapping country risks	Product upgrades and requisites
Strategic supply management	Proactive actions to new regulations	Scouting disruptive innovations
Strategic future vision	Dependency / collaboration	
	Anticipating cost increases	

Message 8

Pre-analysis processes (data aggregation) and post-analysis processes (distribution and absorption of analysis) are more challenging than the actual analytics implementation, due to unorganized internal and external data in different formats and sources, and the importance of understanding the analysis and collaboration across business units.

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. In the below Figure 9, big data processes for decision-making support are demonstrated.

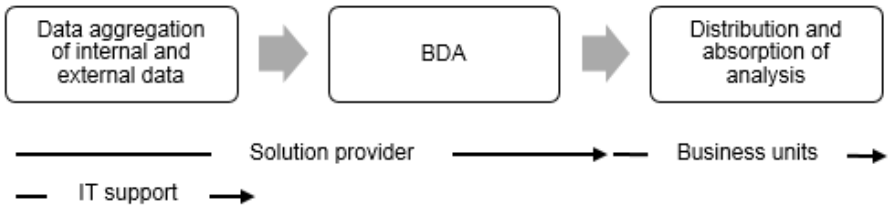

Figure 9. Big data processes for decision-making support

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 interviewed 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.

6. Summary and conclusions

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 is case specific. Therefore, understanding and focusing on what is relevant for the particular business is vital in creating systematic SMI. Furthermore, strategic alignment and communication between business units is a requisite for innovation activities, strategic collaboration and defining future needs. SMI is especially important in driving innovation by forming supplier technology roadmaps in collaboration with R&D and the overall business. 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.

It can be concluded that BDA has great potential in creating systematic SMI. 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. BDA can create competitive advantage for companies by integrating external data to company's context via analytical capabilities and providing value through actions. One of the most important opportunities that BDA can provide is better supply risk management. 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.

An external BDA solution provider 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 analysed 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.

Understanding the key elements of the supply market and the analysed data are prerequisites for utilizing BDA in informed decision-making. Therefore, closing the gap between analysts and employees actually utilizing the analysed 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.

There are many further possibilities in digitalization for creating economic profit for supply management and businesses. Impacts of developments like cognitive computing, artificial intelligence including robotics, augmented reality, mobile technologies, Internet of Things and sensor technologies can further be researched.

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Appendix A: 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 labour with automation, providing more time to support the business

Appendix B: 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 C: Examples of big data visualization

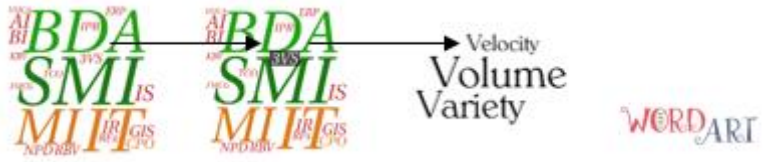

Figure C1. Simple tag / word clouds by WordArt

Figure C2. Complex dashboards by IBM

Figure C3. Complex dashboards by Sencha

Appendix D: 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/

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Title	**Opportunities of big data analytics in supply market intelligence to reinforce supply management**
Author(s)	Salla Paajanen & Anna Aminoff
Abstract	Firms need comprehensive knowledge and understanding of the opportunities available in the supply market. Managing external resources of a company, such as suppliers, is important in order to capture value and utilize innovations in addition to concrete products or services. This can be achieved by supply market intelligence (SMI). SMI can facilitate in finding the best partners and other suppliers, and combination of capabilities. However, despite of its evident managerial relevance, SMI has been a little researched topic in the academia, and inadequately developed and utilized in companies. Simultaneously, big data analytics (BDA) has developed rapidly, becoming vital for businesses across industries. The big data characteristics of high volume, variety and velocity (3Vs) require utilizing advanced analytics. In this report, we will introduce the potential in creating SMI to support strategic supply management via BDA through eight messages that every supply management professional should recognise. We will also unwrap some of the future trends of BDA according to big data professionals. Value can be 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 be utilized to conduct the analysis in collaboration with the focal company. Ultimately, analytical mindset and understanding of the analysis are important for integrating SMI into processes. In the future, artificial intelligence (AI) -based machine learning and automation will continue to increase importance in analysing big data. Technological developments, such as cognitive computing, robotics, mobile technologies and Internet of Things (IoT) create future opportunities that still require further research in order to achieve the best benefits. Digitalisation of supply management and the entire supply chain changes processes and creates new methods of working.
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Nimeke	**Big data -analytiikan mahdollisuudet toimittajamarkkinatietämyksessä strategisen hankintatoimen vahvistamiseksi**
Tekijä(t)	Salla Paajanen & Anna Aminoff
Tiivistelmä	Yritykset tarvitsevat kattavaa tietoa ja ymmärrystä toimittajamarkkinoiden mahdollisuuksista. Yrityksen ulkoisten resurssien, kuten toimittajien, hallinta on tärkeää arvon keräämiseksi ja innovaatioiden hyödyntämiseksi, konkreettisten tuotteiden ja palveluiden lisäksi. Tämä voidaan saavuttaa toimittajamarkkinatietämyksellä (Supply Market Intelligence – SMI). SMI edesauttaa parhaiden kumppanien, muiden toimittajien ja kyvykkyyksien yhdistelmien löytämistä. Vaikka SMI:n merkitys yritysten päätöksentekijöille on ilmeinen, aihetta on tutkittu vain vähän akateemisessa tutkimustyössä ja sitä on kehitetty ja hyödynnetty yrityksissä vasta vajavaisesti. Samanaikaisesti big data -analytiikka (BDA) on kehittynyt nopeasti ja siitä on tullut elintärkeää eri toimialoilla toimiville yrityksille. Suuren volyymin (volume), vaihtelevuuden (variety) ja vauhdin (velocity) big data vaatii kehittyneen analytiikan hyödyntämistä. Nostamme tässä raportissa kahdeksan viestiä jokaiselle hankinnan ammattilaiselle. Viestit kuvaavat SMI:n suurta potentiaalia strategisten hankintojen johtamiseksi BDA:n avulla. Avaamme myös joitakin BDA:n tulevaisuudennäkymiä. 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. Viime kädessä analyyttinen ajattelutapa ja analyysin ymmärtäminen ovat tärkeitä SMI:n yhdistämiseksi prosesseihin. Tekoälypohjaisen koneoppimisen ja automaation merkitys lisääntyy entisestään big datan analysoimisessa. Teknologian kehitys, kuten kognitiivinen tietojenkäsittely, robotiikka, mobiiliteknologia ja esineiden internet (Internet of Things), luo mahdollisuuksia, jotka vaativat vielä lisätutkimusta parhaan hyödyn saavuttamiseksi. Hankintojen ja koko toimitusketjun digitalisaatio muuttaa prosesseja ja luo uusia toimintatapoja.
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