UNIVERSITY
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DOCTORAL DISSERTATION

TOWARDS FACILITATING BI ADOPTION IN SMALL AND MEDIUM SIZED MANUFACTURING COMPANIES

KRISTENS GUDFINNSSON
Informatics

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ABSTRACT

This work concerns how to support Small and Medium sized Manufacturing Enterprises (SMMEs) with their Business Intelligence (BI) adoption, with the long term aim of supporting them in making better use of their BI investments and becoming (more) data-driven in their decision-making processes. Current BI research focuses primarily on larger enterprises, despite the fact that the majority of businesses are small or medium sized. Therefore, this research focuses on the body of knowledge concerning how SMMEs can be more intelligent about their business, and better adopt BI to improve decision-making. Accordingly, the overall research aim is to create an artefact that can support SMMEs to facilitate BI adoption. An understanding of the current situation of BI adoption within SMMEs needs to be attained to achieve this, which is the focus for the first research question: *What is the current state-of-practice in relation to BI adoption in SMMEs?* The research question adds to current knowledge on how SMMEs are taking advantage of BI and highlights which functions within companies are currently supported by BI. Research question two identifies the main challenges that SMMEs are facing in this context: *What are the main challenges for BI adoption in SMMEs?* This question adds to knowledge regarding some of the barriers and hindrances SMMEs face in BI adoption. Finally, the third research question addresses how SMMEs can address the challenges in successfully adopting BI: *How can the main challenges be addressed?* The research question is answered by providing descriptions of work in four participating companies addressing different types of problems. Many of the challenges from literature (and from empirical data from the participating companies) regarding BI adoption are met. The outcome adds to the literature a hands-on approach for companies to address chosen problems in their settings, and addressing many of the factors previously found in the BI adoption literature.

An action design research (ADR) method is used to fulfill the overall research aim. The ADR method is used to guide the development of a framework artefact based on previous literature, and on empirical findings from working with participating companies. Theoretical background was obtained through a literature review of BI adoption and usage. Empirical material was gathered both through interviews and by reviewing documents from the companies. The work that was done in participating companies was supported by previous literature in several ways: through the use of an elicitation activity, through the core concepts of BI, and by focusing on categories presented in a BI maturity model. The principal contribution of the research is in the form of a framework: the Business Intelligence Facilitation Framework (BIFF), which includes four phases. All phases contain activities that support companies in addressing BI adoption

challenges from the literature and empirical data, in order to achieve the overall research aim.

This research contributes both to research and practice. From a research point of view, the framework provides a way to address many of the factors previously identified in literature that need to be in place to increase the likelihood of successful BI adoption. From a practice perspective, the framework supports practitioners offering guidance in how to improve their BI adoption, providing activities for them to take, and guidance in how to carry out the activities

SAMMANFATTNING

Denna avhandling handlar om hur små och medelstora (SME) företag kan stöttas, för att bättre kunna ta till sig och använda Business Intelligence (BI). Generellt sett, fokuserar forskningen på större företag, även om de allra flesta företag är små och medelstora. Fokus för denna avhandling är att bidra med kunskap om hur SME företag, inom tillverkningsindustrin, kan få fler insikter om sin verksamhet, genom att förbättra beslutsfattandet med hjälp av BI. Det övergripande forskningssyftet är att ta fram verktyg som kan underlätta för SME företag att ta till sig och använda BI. Avhandlingen har tre forskningsfrågor. Den första frågan är: *Hur tillämpar små och medelstora tillverkningsföretag BI idag?* Frågan syftar till att bidra till mer kunskap om hur BI används inom tillverkande SME företag. För att kunna stödja företagen, måste först en förståelse finnas för hur de använder BI i nuläget. Den andra frågan är: *Vilka är de största utmaningarna för små och medelstora tillverkningsföretag, för att de ska kunna ta till sig och använda BI?* Denna fråga fångar både vilka utmaningar som företagen har och vilka hinder som möjligtvis finns för att utöka sitt användande av BI. Slutligen den tredje frågan är: *Hur kan utmaningarna bemötas?* Frågan syftar till att undersöka hur företagen kan ta sig an utmaningarna, för att framgångsrikt kunna ta till sig och tillämpa BI i organisationen. Forskningsfrågorna besvaras genom att både granska litteraturen och genom att undersöka sex små och medelstora tillverkningsföretag. Flera av de utmaningar som nämns i litteraturen har stötts på hos de undersökta företagen. Slutresultatet bidrar till både literatur och praktik inom området. Från ett forskningsperspektiv, bidrar avhandlingen med ett ramverk för att hantera och angripa flera av de utmaningar som har identifierats i litteraturen. Utifrån ett praktiskt perspektiv, hjälper ramverket praktiker inom området med vägledning hur införandet och användningen av BI kan förbättras

Forskningen stöds och utformas med hjälp av Action Design Research (ADR) metoden. ADR metoden används som en guide för att utveckla ramverket, som är baserat på tidigare litteratur och empirisk datainsamling från medverkande företag. En teoretisk bakgrund etablerades genom en litteraturgranskning av hur organisationer kan ta till sig och använda BI. Empirisk data samlades in både via intervjuer, observationer och dokumentgransking. Arbetet som utfördes hos de medverkande företagen baserades på tidigare litteratur och identifierade utmaningar inom företagen: Effektivisera processer, identifiera och sätta mål, beslutstöd, och informationsbehov. Huvudbidraget från avhandlingen är ett ramverk: Business Intelligence Facilitation Framework (BIFF), som har fyra faser. Alla faserna innehåller aktiviteter som hjälper företagen, när de tar sig an utmaningar med att ta till sig och använda BI.

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PUBLICATIONS

The following publications have been accepted and are presented here in the order of their relations to the research questions as demonstrated in chapter 4.

PUBLICATIONS WITH HIGH RELEVANCE

1. Gudfinnsson, K., Strand, M. & Berndtsson, M., 2015. Analyzing business intelligence maturity. *Journal of Decision Systems,* pp. 37-54.
2. Gudfinnsson, K., Strand, M., 2018. On transforming into the Data-Driven Decision-Making Era - Current State of Practice in Manufacturing SMEs. In: P. Thorvald & K. Case, eds. *Advances in Manufacturing Technology XXXII*. IOS Press
3. Gudfinnsson, K., Strand, M., 2017. Challenges with BI adoption in SMEs. Proceedings of the 8th International conference on Information, Intelligence, Systems and Applications. IEEE.
4. Karlsen, A., Persson, A. & Gudfinnsson, K., 2016. *The Smallbuild+ business development method: Findings from a longitudinal study in the construction sector*. Bergen, NOKOBIT.
5. Persson, A., Karlsen, A. & Gudfinnsson, K., 2015. Towards a Generic Goal Model to Support Continuous Improvement in SME Construction Companies. In: J. Ralyté, S. Espana & Ó. Pastor, Eds. *The Practice of Enterprise Modelling*. Cham: Springer International Publishing, pp. 27-42.
6. Gudfinnsson, K., Rose, J. & Aggestam, L., 2019. Tackling lack of motivation in aspirational analytics companies: SME examples from the manufacturing industry. *International Journal of Business Intelligence Research (IJBIR), 10(1), 1 – 18*.

PUBLICATIONS WITH LOWER RELEVANCE

1. Gudfinnsson, K., Karlsen, A. & Persson, A., 2017. Towards a digital tool for swapping goals and keeping track of goal achievements in change practice. Oslo, NOKOBIT.

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INTRODUCTION

CHAPTER 1
INTRODUCTION

Decision makers in companies are becoming more and more reliant on computer support and are using various decision support systems (DSS) to help them make better data-driven decisions (Kumar, Chauhan and Sehgal, 2012). In recent years, Business Intelligence (BI) has been gaining momentum as an umbrella term for IT based decision support covering various technological tools and organizational activities. The core concept of BI is to support users to be more intelligent about their business and one way of doing that is to apply analytics. In addition, there are different types of analytics that can be used to support users to achieve that; descriptive analytics, predictive analytics and prescriptive analytics (Sharda, Delen and Turban, 2014). In the end the goal is to provide the right information on a need to use basis both when it comes to BI and BA. BI has become an important part of industry, retail, manufacturing and financial services to name a few (Ali, Miah and Khan, 2018). In some views, BI adoption has become critical for companies to increase process efficiency, improve forecasting and to reach business goals (Qushem, Zeki and Abubakar, 2017). In addition, a large survey (3,160 respondents) by Gartner (a think-tank) in 2017, showed that investing in BI was at the top of the list of investments according to CIOs (Pettey, 2017). Nowadays, organizations can access similar technological solutions to support core business processes e.g. sales, marketing, production and inventory management as such technology has become mainstream and relatively easy to procure. Given this, the ability to gain or sustain competitive edge is not driven by the technology investments per se, but rather based on efficiency and the ability to make use of the particular technology at hand. This means that organizations with the most efficient processes and analytical capabilities, in combination with adequate technology, are most likely to prevail in a turbulent business environment (Davenport and Harris, 2007; Lavalle et al., 2010). Literature supports this and provides many examples on how BI has transformed companies to become more data-driven. However most of these success stories concern large companies, such as; Continental Airlines (Anderson-lehman, Watson and Wixom, 2008), Netflix (Valacich and Schneider, 2010) or Target (Sharda, Delen and Turban, 2014). Published work on small- and medium sized enterprises (SMEs) adoption of BI is rather limited, even though SMEs constitute the backbone of most national economies (99% of all European companies are categorized as small or medium sized (Airaksinen et al., 2015) and are drivers of innovation, regional development and job creation (Rovere, 1998). This research gap has been pointed out

(Grabova et al., 2010; Scholz et al., 2010; Hatta et al., 2015; Llave, 2017) but as demonstrated by Llave (2017) limited effort has been made to fill that gap. An overview of BI research with SME focus is provided in chapter 2.3.1.

Earlier research indicates that SMEs are late adopters of BI solutions and they are lagging behind larger enterprises when it comes to taking advantage of the potential of BI (Voicu, Zirra and Ciocirlan, 2010; Baransel and Baransel, 2012). The literature provides some rather limited examples of how SMEs are using BI and the status of their BI maturity (Darmont et al., 2011; Gudfinnsson, Strand and Berndtsson, 2015; Gudfinnsson and Strand, 2018). Researchers have identified various factors influencing BI adoption, but have also put forward ideas on how SMEs can improve their BI usage e.g. by presenting some critical success factors (CSFs) for BI implementation as done by Olszak and Ziemba (2012). Example of these factors are to make BI part of overall company business strategy, having a sponsor or a champion with authority in the BI project and having the appropriate knowledge and skills for BI implementation. These CSFs align well with many of the factors presented in other research on the subject and therefore emphasizes their importance. Another suggestion has been to apply BI maturity models to help analyze the current state of BI maturity in the company and, based on this evaluation, identify weaknesses and opportunities. The outcome of the maturity evaluation can then be used to guide future actions (Rajterič, 2010). Unfortunately, BI maturity models and CFSs often describe what companies need to achieve or have in place to continue implementing BI but rarely how to achieve it. Although most maturity models do not describe how to actually go from one maturity stage to the next, they provide quite generic steps with the hope that these steps will help the company to increase their maturity. However, these are often based on findings from larger corporations. When it comes to SMEs, they rarely have the financial resources, skills or experience (Olszak and Ziemba, 2012) to implement all the necessary steps and in many cases, achieving the highest level of maturity might not be the ultimate goal for smaller companies, as it might require expensive investments both in infrastructure and people.

In addition to measuring BI maturity, measuring BI readiness has also been suggested in literature as a way to identify if the organization has the necessary components for BI adoption. According to Williams & Williams (2007), BI readiness is the prerequisite for successful BI implementation. This was later supported by Puklavec et al. (2014) during their interview study. Companies assess their BI readiness to get a better understanding of how ready they are to make the changes needed to take full advantage of BI both from an organizational and technological point of view (Williams and Williams, 2007). This is another effort made to support BI adoption, but as with the maturity models, readiness assessments are also based on the needs of larger companies, but do provide valuable insights into what areas SMEs need to pay attention to when size has less importance. An example of that could be management support, aligning BI adoption goals with business goals or to have clean enough data for analysis. In general, it can be said that literature regarding BI adoption has to a large extent identified what conditions are needed for a successful BI adoption, but does not provide much support on how to achieve these conditions, especially for SMEs.

1.1 PROBLEM AREA

Recent interest in big data has refocused research attention on intelligence and analytics, but SME's are still neglected. This should evoke interest among researchers, especially in the era of the forth industrial revolution, industry 4.0 (Lasi et al., 2014).

The core of Industry 4.0 is about taking advantage of technology. Rüßmann et al. (2015) provides nine pillars of technological advancements that form the basis of Industry 4.0. These are *Autonomous Robots, Simulation, Horizontal and Vertical System Integration, The Industrial Internet of Things, Cybersecurity, The Cloud, Additive Manufacturing, Augmented Reality and Big data and analytics* (Rüßmann et al., 2015). Factories are being digitalized and manufacturing is moving towards utilizing the Internet and smart components to a large extent. This revolution elevates factories to become "smart factories". In addition, products or objects are now able to communicate with each other by employing the concept of Internet of Things (IoT) (Shrouf, Ordieres and Miragliotta, 2014). Manufacturing SMEs (SMMEs) will need to adapt to the new era of more digitalized manufacturing processes to keep up with competition. The lack of research indicates that little is known about BI adoption in SMEs in general and SMMEs in particular. The upcoming technological reliance and increased competition with the arrival of industry 4.0 and the evolution of smart factories need to be met by SMMEs if they are to be able to compete with larger enterprises.

The lack of research and suggestions that take into account SMME settings when supporting BI adoption is evident, and calls for research into how to address obstacles for BI adoption have been made - for example in Boonsiritomachai (2014). This needs to be addressed, especially now at the dawn of the new industrial evolution. The majority of the research that has been done has involved demonstrating what BI can offer and identifying various factors that support SMEs with BI adoption or implementation of BI solutions; however literature provides little support on how to address these factors or how to create the prerequisites needed to achieve them. The meaning of "adoption" in this work is based on the definition provided by the Oxford dictionary of the English language where it is defined as *"the action or an act of taking something up or embracing it as one´s own; choosing something for one´s use or practice*[1]*"*. In addition, it is used as an umbrella term covering various support efforts to increase BI adoption success within SMMEs, as demonstrated in chapter 2.3. Given the importance of these type of companies, getting a better understanding of the current situation and providing support for facing future competition is needed.

1.2 RESEARCH AIM AND QUESTIONS

In order to address the issues and research gap presented above, an overall research aim has been identified, which is supported by three research questions (RQs) that provide necessary input for reaching the overall aim. The overall research aim for this work is the following:

Aim: To create an artefact based on research and practice that can facilitate BI adoption within SMMEs.

The artefact will be in the form of a framework that will be based on both previous research and empirical work with companies that can be used to help address challenges identified in literature to facilitate BI adoption in SMMEs. The three research questions provide additional knowledge on the state-of-practice within SMEs, challenges within SMEs and finally paves the way to address the challenges identified both in literature and in the participating companies. The first question is the following:

[1] http://www.oed.com/view/Entry/2677?redirectedFrom=Adoption#eid

RQ1: What is the current state-of-practice in relation to BI adoption in SMMEs?

The first question increases current knowledge regarding state-of-practice of BI adoption in SMMEs that participated in this research. The state-of-practice is based on six specific assessment categories provided by a BI maturity model (Table 4) presented in Lavalle et al. (2010). This maturity model was chosen both because it is the result of a large survey including both academics and practitioners and because about a third of the participating companies in the survey were manufacturing companies. The first assessment category looks at motivation for adopting BI. The second category provides insights into how BI is actually used within the different functions of the company. The third category looks at what business challenges are currently being supported by BI. The fourth category helps to identify the main obstacles for increasing BI adoption. The fifth category measures the ability to capture, aggregate, analyze and share information and insights and the final assessment category looks at how frequently BI is used to support decision making. Question 1 provides insights into how BI is being currently used in these type of companies, and provides a foundation for answering question 2:

RQ2: What are the main challenges for BI adoption in SMMEs?

The investigation of current state-of-practice will, as indicated above, include the identification of challenges faced by SMMEs from different assessment categories provided by Lavalle et al. (2010). Each of those assessment categories can include challenges raised by individual companies, in addition to those the authors of the maturity model (Lavalle et al. 2010) have identified. The findings from this question provide the opportunity to capture the main challenges in all of the assessment categories. These challenges are of specific importance, as they can hinder the SMMEs in their BI adoption. At the same time, they also constitute a vital addition to current knowledge in literature and serve as premise and input to the support for these types of companies, as well as establishing the background to be able to answer research question 3:

RQ3: How can the main challenges be addressed?

Question 3 utilizes the knowledge derived from questions 1 and 2, and uses the material gathered from companies in conjunction with existing literature to identify a way to address the challenges put forward by the participating companies and the challenges identified in literature. The outcome of question three in combination with previous theoretical findings in literature creates the foundation for achieving the research aim by contributing to designing the framework to facilitate BI adoption in SMMEs.

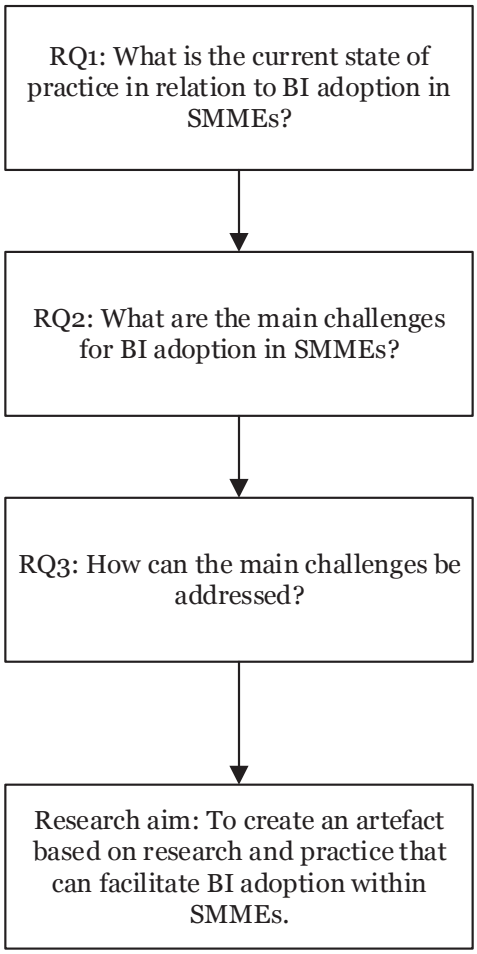


Figure 1: The research questions and their contribution to the overall aim

Figure 1 graphically displays the relationship between the research questions and depicts how each question supports narrowing down to finding the support to facilitate BI adoption. The first two questions are of a more descriptive nature as they provides insights on the current situation while the third question prescribes the "how" for tackling the main challenges.

1.3 THESIS OUTLINE

The following chapter provides the theoretical background for the research. Chapter 3 provides a motivation for the chosen research method, an overview of participating companies and a description of how the chosen method was implemented in the research. Chapter 4 provides a short summary of published papers and the results. Chapter 5 presents the work that was done in the participating companies as they contributed to building the framework. Chapter 6 presents the framework and chapter 7 concludes the work with a summary of contributions and discussion on future work.

THEORETICAL BACKGROUND

CHAPTER 2
THEORETICAL BACKGROUND

This chapter provides an overview of background literature and the core theories this work relies on. The chapter opens with a short discussion on decision support systems to put business intelligence in historical perspective and to provide an overview of the basic concepts. Following the discussions on decision support systems, an overview of what business intelligence is, and what it promises, follows. The core concepts of BI are then summarized in a model for future reference in this work. Next an overview of previous literature regarding BI adoption in SMEs, assessing BI readiness, critical success factors and BI maturity models is presented and the main factors for successful adoption are summarized and put in relation to the core concepts of BI

2.1 DECISION SUPPORT SYSTEMS

Within the information systems discipline, decision support systems (DSS) focus on supporting and improving managerial decision making (Arnott and Pervan, 2014). There is no consensus on a single definition on DSS (Turban, Sharda and Delen, 2007), rather the definitions are often based on the role a DSS plays in a decision process e.g. providing knowledge processing capability or enhancing the decision making outcomes and process (Holsapple, 2008). Keen & Morton (1978), for example, define DSS based on the role of the computer in the decision making process of managers when they say that DSS should *(1) assist managers in their decision processes in semi structured tasks (2) support, rather than replace, managerial judgment* and finally (3) i*mprove the effectiveness of decision-making rather than its efficiency* (Keen & Morton 1978, p 1). However, Moore & Chang (1980) argue that excluding managerial efficiency while designing DSS can result in implementation problems and ineffectiveness of the system. They define DSS as *"an extensible system with intrinsic capability to support ad hoc data analysis and reduction, as well as decision modeling activities"* (Moore & Chang 1980, p. 9). Turban et al. (2007) describe the term *decision support systems* as a content-free expression meaning that it actually can mean different things to different people. Therefore, there is no consensus on a universal one-size-fits-all definition (Turban, Sharda and Delen, 2007).

Since the 1960s, DSS have had a continuous development (see Figure 2) with new terms entering the scene like On-Line Analytical Processing (OLAP), Group Support

Systems (GSS), Executive Information Systems (EIS) and Business Intelligence (Arnott and Pervan, 2014). Just like DSS, these terms can be hard to define which can be problematic when conducting research and when talking to decision makers about decision support systems (Power, 2001).

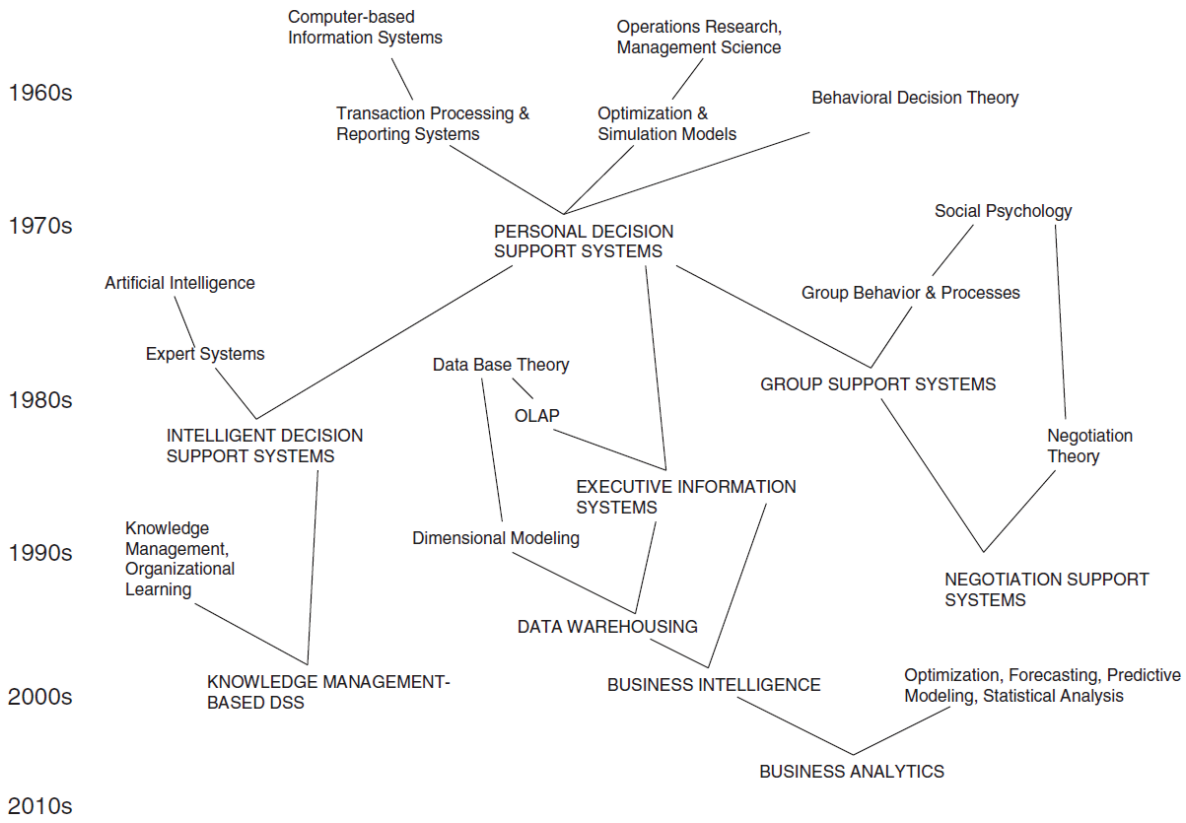


Figure 2: Overview of the evolution of the DSS field (from Arnott & Pervan 2014)

Back in 1980, Steven Alter provided a framework with seven categories based on the operations it performs to help categorizing DSS (Alter, 1980). As the field developed, an extended version of Alter´s framework was suggested by Power (2001). That framework contains one major dimension that contains five generic types of DSS. In addition, the framework describes three secondary dimensions that describe what users are targeted by the system, what the purpose of the system is and the primary deployment technology (Power, 2001).

The first type of Decision Support Systems in the major dimension of Powers´ (2001) framework contains *Data-Driven DSS*. This covers systems such as data warehousing, analysis systems, EIS and BI. These systems provide the opportunity to manipulate and make use of large databases to support data-driven decisions. The second type of systems are *Model-Driven DSS*. This category includes systems that use (for instance) optimization, accounting or financial models where the systems provide the opportunity to manipulate these models, e.g. by customers when choosing or altering a product. Data and parameters can be used to support decision-makers to analyze certain situations. The third generic type of DSS is called *Knowledge-Driven DSS*. These systems can both recommend and suggest actions to their users. According to Power (2001), data mining is a related concept that supports identifying hidden patterns and relationships in large amounts of data. The fourth generic type are *Document-Driven*

DSS or Knowledge Management Systems (KMS). These systems support managers in managing and retrieving unstructured information from websites (like search engines) or documents. The final generic type is called *Communications-Driven DSS and Group DSS*. Supporting collaboration, communications and decision models.

As presented above, there are many types of DSS, and they can be defined in different ways. However they are defined, the important outtake for this work is that the major role of DSS is to support *decision making* by providing *information* to the decision maker. This role strongly relates to BI, making DSS a core discipline for BI. Next is presented an overview of what BI is, its relations to the DSS field and what it promises

2.2 BUSINESS INTELLIGENCE

The term Business intelligence (BI) can be dated back to the 1950´s when it was first coined by Hans Peter Luhn in 1958 (Agrawal, 2009). In the last couple of decades, BI has evolved into an umbrella term for IT based support that companies can utilize to increase their information based decision making to achieve business goals (Wells, 2008). As with decision support systems, there is no general consensus in the literature on a single definition of BI, although some have been used more often than others. Davenport and Harris (2007, p.12) define BI as something that *"incorporates the collection, management and, reporting of decision-oriented data as well as the analytical technologies and computing approaches that are performed on that data"*. This definition highlights the actual process of collecting data, whether it is from business processes, other systems or even from external data sources. It also says the data needs to be decision-oriented, and should therefore support decision making. IT also plays a role as the definition mentions both analytical technologies and computing approaches. Negash and Gray (2008) define BI as *"systems that combine: data gathering, data storage, and knowledge management with analysis to evaluate complex corporate and competitive information for presentation to planners and decision makers, with the objective of improving the timeliness and the quality of the input to the decision process"* (Negash & Gray, 2008, p. 176). Finally, Wixom and Watson (2010) provide the following definition of BI where they say it is *"a broad category of technologies, applications, and processes for gathering, storing, accessing, and analyzing data to help its users make better decisions"* (Wixom & Watson, 2010, p. 14). This definition also highlights the use of technology and the actual process of getting the information required to make more data-driven decisions.

In addition to not having a commonly agreed definition of BI, there is a debate in the literature on whether business analytics (BA) is a subset of BI (Davenport and Harris, 2007) or an advanced discipline under the BI umbrella (Laursen and Thorlund, 2010). The definition of BA provided by Laursen and Thorlund reads "delivering the right decision support to the right people at the right time" (Laursen and Thorlund, 2010 p. Xii). It can be argued that this definition is closely related to the definitions of BI, in fewer words. Power et al. (2018) demonstrate the difficulties of finding a single definition of BA, but point out that the focus in general is on business decision-making (Power et al., 2018). There are many definitions in the literature of both BI and BA, but the key element is providing the right data on a need-to-use basis with the aid of various technologies to support information based or data-driven decision making.

In today's business environment, companies often have similar technological products to capture, share and utilize data. The differentiators for companies lie therefore in process efficiency and analytic capabilities (Davenport and Harris, 2007). This applies to all levels of the organization where processes that are supplied with relevant information become more efficient. Decision makers that use information extensively have been shown to make faster decisions than decision makers using less information, and faster decisions can increase organizational efficiency (Davenport, 2010). In addition, according to Foley & Guillemette (2010), *"informed decisions lead to better, more efficient processes in the actual work environment"*, highlighting the importance of focusing on process flow to increase competitive advantage. (Foley and Guillemette, 2010).

As shown, there are many definitions of BI. Some definitions have a managerial perspective and others a more technical perspective (Foley and Guillemette, 2010). Given this broadness of the term, it could imply that BI not only covers everything, but also promises everything. That would be quite a simplification of the concept and although the provided definitions are quite wide, they do share some commonalities. BI should:

- highlight the importance of supporting achieving *business goals* (Wells, 2008)
- support *business processes* (Davenport and Harris, 2007; Foley and Guillemette, 2010)
- support *decision making* (Davenport, 2010; Wixom and Watson, 2010)
- provide the *right data* when needed (Davenport and Harris, 2007; Negash and Gray, 2008).

Sharda et al. (2014) summarize the role of BI by stating that BI is the *"transformation of data to information, then to decisions, and finally to actions"* (Sharda et al. 2014, p. 44). The actions could then be the decision making itself or an action within a business process.

When looking at the components of BI, it becomes evident that the term BI has roots in many fields and technologies. Although the definitions of BI are many, most of them emphasize the role of BI in providing information to support a more data-driven decision making. In summary, the "core concept" of BI can therefore be said to increase process efficiency, support gathering information and facilitate data-driven decision making to achieve organizational goals with the support of IT. For the purpose of this work, these core concepts of BI are aggregated into a model (Figure 3) that provides an overview of the core concepts and how they are related and linked through IT. The lines between the concepts are for visual purposes to demonstrate how they are linked

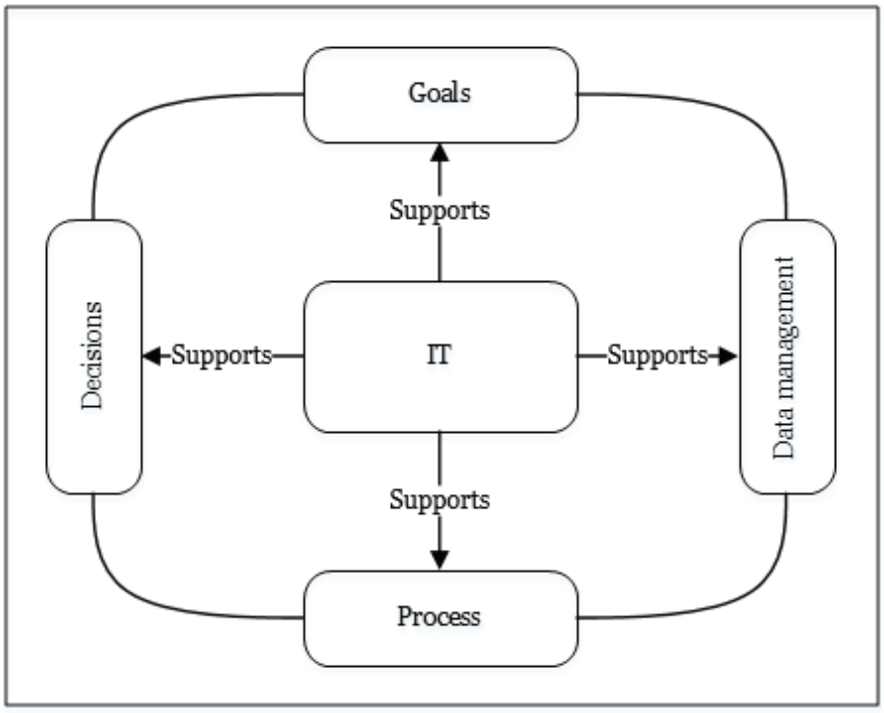


Figure 3: The core concepts of BI

The core concepts are related and should not be regarded as islands - they are all supported through IT, and a fundamental unifying factor is the ability to store, capture, share and aggregate relevant information to provide the necessary support. Goals can guide decisions and decisions affect processes, which in turn contain information that supports achieving business goals and make more data-driven decisions. IT further supports the measurability of business goal achievements. Processes are also in need of information, and both actions and outcomes within processes can affect decisions. All the concepts need to be supported by IT in one way or another. For example, information is stored in IT systems to be used in processes, for decision making, and further provides the opportunity to measure whether business goals are being met. Companies often have massive amounts of data (and often they know in what area data is missing), but are not sure where to start to make better use of their data. For the purpose of this research, these core concepts cornerstones when it comes to facilitating BI adoption.

2.3 BI ADOPTION

IT adoption and user acceptance are two concepts that have been the subject for research in the DSS field for many years. The research aims at increasing knowledge on how IT is adopted, and what influences people to use technology (Gangwar, Date and Raoot, 2014). Davis (1986) proposed a Technology Acceptance Model (TAM) where he suggested that the user´s overall attitude towards a system would have major influence on usage. This attitude is influenced by two beliefs; perceived usefulness and perceived ease of use, and he suggested a causal relationship between these two where ease of use had a direct impact on perceived usefulness (Davis, 1986). Moreover, Davis (1989) proposed measures based on perceived usefulness and perceived ease of use to predict and explain IT usage, finding usefulness to have stronger implications than ease of use (Davis, 1989). When it comes to BI adoption with specific focus on SMEs, they seem in general to be late adopters of BI compared to larger organizations (Voicu, Zirra and Ciocirlan, 2010; Baransel and Baransel, 2012). Moreover, Chao & Chandra

(2012) found significant evidence that SME owner´s knowledge of traditional IT had a strong impact on traditional IT adoption within the company, but also noted no relation between owners´ knowledge and BI adoption (Chao and Chandra, 2012). Implementing a companywide BI support can be seen to be more similar to implementing ERP systems than conventional IT applications, as it shares more characteristics with infrastructural projects like ERP implementation which often cover larger parts of the organization (Olszak and Ziemba, 2012).

Previous research findings suggest different ways of supporting BI adoption and what needs to be considered by organizations when further adopting BI. The following sections provide an overview of some of the research addressing BI adoption. The first section presents adoption research that has more specific SME focus to give insights into what kind of research on SMEs has mainly been conducted with this particular focus. That chapter is then followed by three categories of adoption theories from the literature; assessing BI readiness, critical success factors for BI adoption and finally measuring BI maturity

2.3.1 RELATED BI ADOPTION RESEARCH IN SMES

As demonstrated above the BI term can be elusive, but the possibilities for applying BI, and the areas BI should support are clearer if we focus on the core concepts of BI. According to Ali et al. (2018), the lack of research on BI implementation in SMEs can be considered to be a major concern. This lack of research has also been demonstrated in a comprehensive literature review of BI and analytics in SMEs by Llave (2017) covering the years between 2000 and 2016. This showed that popular topics included data warehousing, dashboards, data mining, cloud services and BI implementation. However, when it came to BI adoption, only nine articles covered that topic from the year 2000 to 2016 (Llave, 2017). The following segments provide a brief overview of the research on BI adoption in SMEs.

Gibson and Arnott (2003) reviewed the literature to identify why BI applications were not widely used in small businesses and present ten characteristics that can affect BI adoption in that setting. In their findings, they identify the importance of owner/manager innovativeness, as innovative managers are more likely to make use of BI solutions for decision making, since they have resources for adoption, knowledge on what BI can do and the understanding that IT investments need to be closely aligned with business strategy (Gibson and Arnott, 2003). Puklavec et al. (2014) interviewed six BI professionals and four BI adopters from SMEs to identify what they considered to be the most important factors when adopting BI. Their results showed that the factors with the most influence on BI adoption are related to internal characteristics of the organization, with management support as the most important factor - supporting the findings of Gibson and Arnott (2003). Other factors that they highlighted as more SME specific factors were the perception of strategic value, project champion, organizational data and organizational readiness (Puklavec, Oliveira and Popovič, 2014). These factors have however also been shown not to be SME-specific in other research - for example in (Williams and Williams, 2007; Yeoh and Koronios, 2010; Anjariny, Zeki and Hussin, 2013). Hill and Scott (2004) used in-depth discussions with eleven Northern Ireland companies to examine their BI usage and implementation of e-business systems. The companies described limited usage of the systems, but highlighted the importance of up-to-date information. However, they rated the use and value of personal contacts as most significant (Hill and Scott, 2004).

Boonsiritomachai et al. (2014) propose a research framework that can be used to measure BI adoption in SMEs. The framework is based on three adoption models

found in the literature, the TOE framework (Technology, Organization, Environment) by Tornatzky and Fleischer (1990), Diffusion of Innovation (DOI) by Rogers (1995) and Information Systems Adoption Model for Small Business by Thong (1999) (Boonsiritomachai, McGrath and Burgess, 2014). These models are consolidated into five maturity levels and four categories important for adoption (technological, organizational, environmental, owner-managers). The authors used the framework to measure the level of BI adoption in a follow up study of 427 Thai SMEs, and found that the majority of the SMEs were classified at the lowest level of maturity for BI adoption. They identified six main factors that impact BI adoption; owner/manager innovativeness and understanding of advantages, perceived usefulness, complexity of implementation, organizational resources (financial and technological), competitive pressure and vendor selection (as SMEs rarely build their own BI systems) (Boonsiritomachai, McGrath and Burgess, 2014, 2016). Their conclusion that the majority of the companies were at the lowest maturity level further demonstrates how SMEs are lagging behind when it comes to BI adoption, and highlights the need to identify ways to support BI adoption for them.

Hatta et al. (2015) also reviewed the literature for factors influencing BI adoption in SMEs and consolidated their findings into four main factors categories based on the DOI by Rogers (1995) and the TOE framework by Tornatzky and Fleischer (1990). They create an integrated adoption model containing 25 enabling factors for BI adoption in SMEs (Hatta et al., 2015). Like Boonsiritomachai et al. (2014), they added a fourth category to the TOE framework based on Rogers DOI model with a more managerial focus called CEO´s Innovativeness, hereby highlighting the importance of owners and managers involvement in BI adoption, and supporting the previous work of Boonsiritomachai et al. (2014). The factors identified in their literature review were then called determinants to be used as indicators for BI adoption in Malaysian SMEs. The technological context of the framework includes both internal and external technologies as well as processes and equipment. The organizational context refers to resources including size, structure, managerial structure and human resources. The environmental context takes into account competitors and regulatory environment and the CEO´s innovativeness context includes the characteristics of managers when making decisions, and the innovativeness of the CEO to adopt IT to improve business performance (Hatta et al., 2015). Chichti et al (2016) also built on the TOE framework to identify what determines BI adoption in Tunisian public organizations when supporting SMEs and found environmental factors from the TOE framework to be important to consider when supporting SMEs, because of their dynamic business environment. They therefore suggested strategic foresight as a way of supporting SMEs in coping with competition (Chichti, Besbes and Benzammel, 2016).

The work of Boonsiritomachai (2014), Hatta et al. (2015) and Chichti et al. (2016) provides a broad overview of important factors when implementing BI in SMEs that mainly build on a framework of categories (TOE) proposed in 1990 by Tornatzky and Fleischer. The additions to that framework (DOI) emphasize the importance of including the management perspective when adopting BI, and can help both to prepare organizations for BI adoption by highlighting key areas of concern, and to support organizations during BI adoption. The findings presented above provide insight into what needs to be considered when adopting BI according to literature, and what has been the main focus of research when it comes to BI adoption within SMEs. These considerations come with different labels - they can be determinants, factors or frameworks - but they all help increase knowledge related to BI adoption within SMEs. Table 2.1 provides an overview of the factors presented above in terms of challenges.

Table 1: Overview of BI adoption challenges in SMEs

Authors	Overview of challenges
Gibson and Arnott (2003)	Owner/Manager innovativeness Knowledge on what BI can do for the business Having enough resources for BI adoption Align BI with business strategy
Puklavec et al. (2014)	Establish management support Perception of strategic value Project champion Organizational data Organizational readiness
Hill and Scott (2004)	Up-to-date information Personal contacts
Boonsiritomachai et al. (2016)	Owner/manager innovativeness and understanding of advantages with BI Perceived usefulness of BI Complexity of implementation Organizational resources (financial and technological) Competitive pressure Vendor selection
Hatta et al. (2015)	Technological context – internal and external Organizational context – size, structure, managerial structure, human resources Environmental context – competitors, regulatory environment CEO´s innovativeness context – decision making, willingness to adopt IT to improve business performance
Chichti et al. (2016)	Environmental context – strategic foresight

Having identified these factors is important, but to make use of them in research (and not just leave them as a laundry list), research needs to identify how these factors can be addressed in order to facilitate BI adoption within SMEs. Therefore, for this work the factors are considered to be challenges that need to be addressed in order to support SMEs with their BI adoption. Viewing the factors as challenges to be faced can be considered the first step in finding solutions – thereby addressing the factors. The list of challenges can continue to grow (and most likely will in the future), but research should also focus on how to address them to move forward.

The following sections provide an overview of some additional findings in the literature related to adopting BI in organizations under three different headings. First, the

literature findings regarding BI readiness are presented as those findings provide insights into what organizations should consider before adopting BI, i.e. assessing readiness. Then factors that have been identified as critical for BI adoption are presented, these factors can be important both when starting BI adoption, and to consider when further adopting BI in an organization. Finally, literature regarding maturity models is presented that demonstrates how organizations that already have started using BI can measure their BI maturity and identify what needs to be in place to further adopt BI.

2.3.2 BI ADOPTION – ASSESSING READINESS

BI readiness has been described as a prerequisite for the success of adopting BI by Williams and Williams (2007). By doing a BI readiness assessment, companies identify "gaps" that highlight where they are not ready to continue with BI adoption and indications for what can be done to close those gaps (Williams and Williams, 2007). Although there is not much research regarding measuring BI readiness in SMEs, Hidayanto et al. (2012) have presented a framework for measuring readiness level based on critical success factors (CSF) identified in the literature for BI implementation. The framework focuses on pre-implementation aspects for SMEs to identify weak areas and consists of three overall categories proposed by Yeoh and Koronios (2010); organizational, process and technology. There are nine organizational factors; *committed management support and sponsorship, clear vision and well-established business case, strategic alignment, effective business/IT partnership for BI, BI portfolio management, continuous process improvement culture, culture surrounding the use of information and analytical application, cross-organizational collaboration culture* and *decision process engineering culture*. The process related factors are four; *business-centric championship and balanced team composition, availability of skilled member team, business-driven and iterative development approach, user-oriented change management*. The last category, technology, has five CSFs; *business-driven, scalable and flexible technical framework, sustainable data quality and integrity, importance of metadata, BI and DW technical readiness, the silver bullet syndrome* (Hidayanto, Kristianto and Shihab, 2012).

Hidayanto et al. (2012) used BI experts to rate the importance of each factor and then measured the consensus of the experts. Three CSFs were found to be considerably more important than others:

- Committed management support and sponsorship
- Clear vision and well-established business case
- Strategic alignment.

Hidayanto et al. (2012) demonstrate how these factors can be used to measure BI readiness before implementation, but do not provide any suggestions on how or what can be done to help achieve these success factors. Understanding that there needs to be management commitment and that the BI implementation requires a clear business purpose is important, but the literature does not provide road-maps or guidelines for SMEs on how they can actually work to better align BI with business goals, or what activities they should take to increase management commitment.

Seven of the CSF factors in Hidayanto et al. (2012) framework come from Williams & Williams (2007) and they call these readiness factors. These factors make the difference of whether the BI investment will be profitable or not according to Williams and Williams (2007). These factors are the following (Williams and Williams, 2007):

- Strategic alignment (consistency among business and IT strategy, processes and infrastructure)
- Continuous process improvement culture (use BI to improve management/business processes)
- Culture around the use of information and analytical applications (embrace the use of analytical applications and information)
- Business intelligence portfolio management (manage BI applications as a portfolio of investments for widespread use)
- Decision process engineering culture (promote structured decision process were applicable)
- Business intelligence and data warehousing technical readiness (the need of technical ability to capture business value)
- Effective business/information technology partnership for business intelligence (having strong partnership between business and IT supports creating business results that actually create business value)

The factors correlate with what BI promises to support and demonstrate that organizations need to understand the strategic value of BI, in the sense that BI should support business goals and processes in addition to supporting more data driven decision making. Two of the factors are related to changing organizational culture, both when it comes to using information when making decisions, and the acceptance and use of the applications that are provided for decision support. Although not explicitly mentioned when listing the factors, the importance of management support is evident, as management needs to endorse culture changes and provide the right resources. Anjariny and Zeki (2014) are more explicit when it comes to the role of management when presenting readiness factors in seven dimensions. Their dimensions show that most aspects of a company need to be considered when assessing readiness demonstrating the potential organizational wide effects of BI. The seven dimensions identified were the following (Anjariny and Zeki, 2014):

- Management related dimension (e.g. support, resources, champion)
- Business related dimension (e.g. vision, business case and measurable benefits)
- Infrastructure (e.g. technical framework, functionality, usability)
- User related dimension (e.g. participation, education, commitment)
- Project related dimension (Planning and scope, delivery approach)
- Teamwork (e.g. skills, consultants, expertise)
- Data (e.g. source systems, quality, and metadata).

Anjariny and Zeki (2014) emphasize the importance of the management dimension for assessing organizations BI readiness, as that dimension deals with decisions regarding providing adequate funding and resources, project champion and sponsors. This dimension stresses the importance of top level management support of the project (Anjariny and Zeki, 2014), supporting the findings of Williams and Williams (2007) and adding additional factors to the list of factors identified by Hidayanto et al. (2012). The importance of aligning business vision, business case and the ability to measure the benefits of BI for the business is explicitly highlighted (Anjariny, Zeki and

Hussin, 2013; Anjariny and Zeki, 2014). The dimensions are not as explicit when it comes to changing organizational culture as those of Williams and Williams (2007), but they identified the importance of including users as a way to commit to the BI adoption project. Their findings also correlate with the perceived role of BI in organizations, as management needs to see how BI supports business goals and processes in addition to support decision making. The data dimension demonstrates the importance of considering the quality of the data within the organization before adopting BI, as poor data can have serious consequences.

The literature on BI readiness is not often specifically aimed at SMEs, although the work of Hidayanto et al. (2012) has a specific focus on measuring BI readiness in SMEs. The factors they use for their measurements are however not particularly SME specific, but rather generic. Puklavec et al. (2014) identified BI readiness to be an important factor for SMEs without really explaining further what BI readiness is in that context, but Hidayanto et al. (2012), Williams and Williams (2007) and Anjarini and Zeki (2014) provide an overview of factors and dimensions to consider when assessing BI readiness, adding knowledge on what areas to consider when planning BI implementation. Table 2 provides an overview of important BI readiness factors according to previous literature:

Table 2: Overview of BI readiness challenges

Author	**Overview of readiness challenges**
Hidayanto et al. (2012)	Committed management support and sponsorship Clear vision and well-established business case Strategic alignment
Williams and Williams (2007)	Strategic alignment Continuous process improvement culture Culture for using information and analytical applications Business intelligence portfolio management Decision process engineering culture Business intelligence and data warehousing Technical readiness Effective business/IT partnership
Anjariny and Zeki (2014)	Management related dimension Business related dimension Infrastructure User related dimension Teamwork Data

When the BI readiness factors are scrutinized and summarized, they emphasize the importance of having the right infrastructure (data), a vision on how BI is going to support the organization (decisions, goals, processes) and the importance of involving

users and having management support. These factors or dimensions should be considered both in SMEs and larger organizations when adopting BI. The factors identified in literature regarding assessing BI readiness can therefore also be viewed as challenges when adopting BI in organizations.

As demonstrated by Hidayanto et al. (2012), critical success factors have been used to assess BI readiness in SMEs, but they can also be used to learn from previous BI implementations and identify important factors to continue with BI implementation regardless of organizational size. The usage of critical success factors to measure BI readiness demonstrates the close relationship between readiness factors and critical success factors. The next section will therefore present some of the findings from literature regarding critical success factors for implementing BI. The goal is not to provide a complete list, but rather to give an overview of the breadth of factors already identified.

2.3.3 BI ADOPTION – CRITICAL SUCCESS FACTORS

Critical success factors (CSF) have been a research topic within BI (Işik, Jones and Sidorova, 2013; Sangar, Binti and Iahad, 2013; Magaireah, Sulaiman and Ali, 2017). Hawking and Sellitto (2010) stated that CSFs in Enterprise Resource Planning (ERP) systems had received much attention from researchers (though efforts to identify CSFs when implementing BI were limited), but Eder & Koch demonstrate in their extensive literature review that CSFs within BI implementation have been getting more and more attention (Eder and Koch, 2018). There is a strong link between ERP systems and BI: ERP systems capture and provide information in relation to processes, while BI tools provide the platform for analyzing the information - thus providing an opportunity to increase process efficiency and business performance. Hawking & Sellitto (2010) provide a list of around 60 CSFs from eleven papers (in some cases, they simply indicate project-related factors or technical factors that constitute an unknown number of factors). After a content analysis of industry presentations to find what CSFs need to be in place in an ERP environment when implementing BI within companies, they proposed CSFs from solution, application and temporal perspectives. According to their findings, the most frequent factors were management support, user participation and team skills (Hawking and Sellitto, 2010).

Yeoh and Koronios (2010) interviewed fifteen BI experts to identify CSFs for implementing BI. The list of factors was then consolidated and distributed to five research participants to compare their views with the experts and rate their importance. They presented a list of seven CSFs in three dimensions. The first dimension is organization related factors; vision and business case, management and championship. The second dimension is process, containing the following factors; team related factors, project management and methodology related factors, data related factors and finally infrastructure related factors. The third dimension is called technology, containing data related factors and infrastructure related factors. The results showed management and championship related factors as top ranking within the organizational dimension, and that the sponsorship should preferably come from the business side of the organization where the sponsor had significant need of BI for specific business purpose. The most common reason for BI implementation failure was not aligning the BI initiative with business vision and therefore not supporting achievement of business objectives. They conclude that BI adoption should be driven by the business, and that there needs to be a strong link between the business vision and the BI implementation. That is a prerequisite for a solid business case for a successful BI implementation (Yeoh and Koronios, 2010).

Olszak and Ziemba (2012) researched CSFs in SMEs and further expanded the categories of Yeoh and Koronios (2010) where each of the categories contained 4 – 6 CSFs, making them almost three times more factors than proposed by Yeoh and Koronios (2010). Examples of organizational CSFs are support from senior management, skilled (qualified) sufficient staff/team/managers and competent BI project manager (leadership). Well defined business problem and processes were amongst the highest determinants for successful BI implementation - again highlighting the importance of aligning BI with business needs to achieve business goals. The biggest barriers for BI implementation were badly defined business problems, lack of management support and lack of knowledge on BI capabilities (Olszak and Ziemba, 2012). From a more technological perspective, issues with data quality, integration between BI and other systems and that the system needed to be "user friendly" were rated as critical factors.

Table 3: Overview of CSF challenges

Authors	**Overview of CSF challenges**
Hawking and Sellitto (2010)	Management support User participation Team skills
Yeoh and Koronios (2010)	Committed management support and sponsorship Clear vision and well-established business case Business-centric championship and balanced team composition Business-driven and iterative development approach User-orientated change management Business-driven, scalable and flexible technical framework Sustainable data quality and integrity
Olszak and Ziemba (2012)	Support from senior management Skilled staff/team/managers Competent BI project manager Well defined business problem Well defined business process Data quality Integration between BI and other systems User friendly system

Organizational related CSFs are currently the most frequently named factors in the literature according to Eder & Koch (2018). Several common findings can be abstracted from the CSF literature. The importance of having management support cannot be understated, and to get that support there needs to be a clear relation between BI adoption, company goals, strategy and vision. Another important factor is to have a comprehensive understanding of business processes to get the most out of BI (Eder

and Koch, 2018). Table 3 provides an overview of the CSFs discussed in this section. As with other factors identified in literature that are deemed important for BI adoption, these factors are viewed as challenges to be faced when adopting BI. The list is by no means exhaustive, but does provide insights into the most common CSFs and often the most important CFSs according to literature.

2.3.4 BI ADOPTION – MATURITY AS A GOAL

The adoption of BI once the solution has been introduced into an organization may be measured in a number of ways. In the literature, maturity models suggest various ways of measuring to what degree an organization has adopted BI, i.e. how mature they have become in their BI endeavors. There is a plethora of maturity models in the literature and some of these are accounted for below. The purpose is not to cover all existing models, but rather to show the different aspects in focus. One model will be given particular attention, since it will be used later on in this work.

Maturity models of different types and shapes have been around in the field of IS and other research areas for a long time. One of the earliest maturity models is Crosby´s (1979) Quality Management Maturity Grid developed in the quality management field (Fraser, Moultrie and Gregory, 2002). In the early 1990s, Carnegie Mellon Software Engineering Institute (SEI) introduced the Capability Maturity Model (CMM), which contained an number of models that later were consolidated and integrated into CMMI (Fraser, Moultrie and Gregory, 2002). Since then many new maturity models have been introduced to help managers to e.g. reduce costs, create new products and increase competitiveness (Mettler, Rohner and Winter, 2010). In general, maturity models are used to describe, explain and evaluate growth life cycles and to give organizations guidance on what areas to focus on to improve maturity (Rajterič, 2010). Most maturity models share the common properties of having a number of dimensions and different stages that illustrate a particular maturity level of an organization or organizational unit. Maturity models can also be hierarchical (using sub-dimensions) and both one- or multi-dimensional (Fraser, Moultrie and Gregory, 2002; Lahrmann and Marx, 2010). The components/units of assessment of maturity models may differ, but common ones are, according to Fraser et al. (2002), the following:

- A number of levels
- A descriptor for each level
- General description of each level characteristics
- Dimensions or process areas
- Elements of activities for each dimension
- Description of activities that might be performed at each maturity level.

The BI literature contains several maturity models that have been created both by researchers and practitioners. They usually contain similar components and follow the same structure as standard IS maturity models. Many BI maturity models have been developed by researchers, e.g. Enterprise Business Intelligence Maturity (EBIM) by Tan and Yeoh (2011), the Ladder of Business Intelligence (LOBI) by Cates and Gill (2005) and the Business Intelligence Development Model (BIDM) by Sacu and Spruit (2010). Companies have also created their own BI maturity models such as TERADATA´s BI and data warehouse maturity model, Hewlett Packard Business Intelligence Maturity Model and SAS Information Evolution Model (Thamir and

Theodoulidis, 2013). Some maturity models have been created in a collaboration between researchers and practitioners. One example of that (Table 4) is the maturity model by Lavalle et al. (2010). That model is the results of a worldwide survey on BI analytics usage and was conducted in the fall of 2010 by MIT Sloan Management Review and IBM Institute for Business Value. The survey received answers from about 3000 executives, managers and analysts from more than 30 industries and 108 countries. The sample consisted of MIT alumni and MIT Sloan Management Review subscribers, IBM clients and other interested parties. In addition, academic and subject experts from a number of industries were interviewed in order to help understand the practical issues that organizations were facing. Experts also helped develop recommendations in response to strategic and tactical questions senior executives address when using BI analytics within their organizations (Lavalle et al., 2010).

Although many maturity models have been created it has been pointed out in research that maturity models have difficulties covering all the areas of BI, and are quite often poorly documented. Furthermore, they often lack description on how they have been constructed or validated (Rajterič, 2010; Chuah and Wong, 2011; Lahrmann et al., 2011). The broad perspective of BI has made some researchers suggest that companies use more than one maturity model to cover more aspects of their organization, but they also point out that it can be time consuming. In addition, different maturity models use different dimensions and evaluation criteria which makes it difficult to compare results (Rajterič, 2010; Chuah and Wong, 2011). Other suggestions on how to support more areas involve (for example) to extend current maturity models as described by (Lahrmann and Marx, 2010). Based on the literature survey for this work, most BI maturity models have an enterprise perspective but despite their generic nature, they still have difficulties satisfying company needs when it comes to help supporting BI adoption and are rarely explicit on how they can be used from a practical point of view. Furthermore, BI maturity models that focus more specifically on SMEs are practically non-existent, which could make it difficult for SMEs to relate to current models and adapt them to their specific needs to support their BI adoption. However, they still point to categories or organizational perspectives deemed important that can be useful for analyzing the current state-of-practice within companies and to identify challenges within those areas. Furthermore, the maturity models can point towards the areas or business functions where companies usually start using BI. This can be used as guidance when companies are starting their BI journey, as well as for research focus when aiming to facilitate BI adoption.

In this research, the maturity model by Lavalle et al. (2010) was used as a lens to analyze participating companies. Despite the fact that the model is based on large companies, there are several reasons for choosing this particular maturity model. Firstly, it has a broader organizational perspective than many other models. Secondly, the assessment categories in the model demonstrate that the driver for increased maturity should be the business, not IT, an important aspect in BI literature as demonstrated in the BI adoption literature above. Thirdly, approximately one third of the corresponding companies were manufacturing companies so their views and challenges are represented in this model to some extent, uncommon in BI maturity models. Finally, the maturity model has been validated by experts, both consultants and academics (Lavalle et al., 2010).

The model proposed by Lavalle et al. (2010) covers six broad assessment categories:

- *Motive* – the motive of using BI e.g. looking backwards to see what has happened or to use BI to guide or prescribe actions.

- *Functional proficiency* – measures how BI is used within different functions of the organization.
- *Business challenges* – highlights the main business areas being supported by BI.
- *Key obstacles* – presents organizational obstacles that impede BI adoption
- *Data management* – measures the ability to capture, aggregate, analyze and share information and insights.
- *Analytics in action* – measures how frequently BI analytics are used to support decision making.

Companies are assessed at one of three maturity levels; *Aspirational, Experienced* and *Transformed* (given in an ascending order of maturity). To be able to move from one maturity level to another, all aspects in previous level need to be fulfilled. The three levels of maturity are presented as three stages of capabilities with distinct opportunities. These stages are described in the following way by Lavalle et al. 2010, p. 5:

- *Aspirational: These organizations are the farthest from achieving their desired analytical goals. Often they are focusing on efficiency or automation of existing processes, and searching for ways to cut costs. Aspirational organizations currently have few of the necessary building blocks – people, processes or tools – to collect, understand, incorporate or act on analytic insights.*
- *Experienced: Having gained some analytic experience – often through successes with efficiencies at the Aspirational phase – these organizations are looking to go beyond cost management. Experienced organizations are developing better ways to effectively collect, incorporate and act on analytics so they can begin to optimize their organizations.*

Transformed: These organizations have substantial experience using analytics across a broad range of functions. They use analytics as a competitive differentiator and are already a depth at organizing people, processes and tools to optimize and differentiate. Transformed organizations are less focused on cutting costs than Aspirational and Experienced organizations, possibly having already automated their operations through effective use of insights. They are most focused on driving customer profitability and making targeted investments in niche analytics as they keep pushing the organizational envelope.

Table 4 presents the maturity model by Lavalle et al. (2010). The first column on the left contains the assessment categories followed by the maturity levels. For a company to be regarded as aspirational, all requirements on the aspirational column need to be fulfilled. The model does not provide hands-on support for moving from one level to the next, only indicating what needs to be achieved in order to be considered to be on the next maturity level. However, the strength of the model is that it highlights specific maturity categories that can guide the measurement and analysis of how far organizations have come with their BI adoption. In addition to helping measure maturity, these categories relate to the core concepts of BI (Figure 3), and can therefore be used to support BI adoption

Table 4: BI and analytics maturity model (by Lavalle et al., 2010, p. 5)

Categories	Aspirational	Experienced	Transformed
Motive	Use analytics to justify actions	Use analytics to guide actions	Use analytics to prescribe actions
Functional proficiency	Financial management and budgeting Operations and production Sales and marketing	All Aspirational functions Strategy/business development Customer service Product research/development	All Aspirational and Experienced functions Risk management Customer experience Workforce planning/allocation General management Brand and market management
Business challenges	Competitive differentiation through innovation Cost efficiency (primary) Revenue growth (secondary)	Competitive differentiation through innovation Revenue growth (primary) Cost efficiency (secondary)	Competitive differentiation through innovation Revenue growth (primary) Profitability acquiring/retaining customers (targeted focus)
Key obstacles	Lack of understanding how to leverage analytics for business value Executive sponsorship Culture does not encourage sharing information	Lack of understanding how to leverage analytics for business value Skills within line of business Ownership of data is unclear or governance is ineffective	Lack of understanding how to leverage analytics for business value Management bandwidth due to competing priorities Accessibility of the data
Data management	Limited ability to capture, aggregate, analyze or share information and insights	Moderate ability to capture, aggregate and analyze data Limited ability to share information and insights	Strong ability to capture, aggregate and analyze data Effective at sharing information and insights
Analytics in action	Rarely use rigorous approaches to make decisions Limited use of insights to guide future strategies or guide day-to-day operations	Some use of rigorous approaches to make decisions Growing use of insights to guide future strategies, but still limited use of insights to guide day-to-day operations	Most use rigorous approaches to make decisions Almost all use insights to guide future strategies, and most use insights to guide day-to-day operations

The first category looks at the motive for using BI, something that needs to be decided from a management perspective. When the motive is established, the type of BI support and its purpose become clearer. If management has no motive for BI use, the possibility of a successful BI adoption can be considered low. However, by raising awareness of possible usability of BI (e.g. strong business case, what decisions to support), motivation can be influenced, as previous adoption theories have shown. Therefore, if there is a lack of motivation, changing the overall attitude towards the system can have profound indications on the willingness to adopt (Davis, 1986).

The second category (functional proficiency) requires managers to analyze the actual use of BI within different parts of the organization. This also provides the opportunity to see other possibilities for BI usage, or, if there is no usage at all (pre-aspirational companies), helps to decide where to start, as the model demonstrates where first stage companies use BI. By analyzing current usage (or non-usage), a business case can be created to guide the BI adoption, in area where it is needed, what decisions need to be supported and what information is needed for that support. When the area for BI need is identified and a business case for that function within the company is made

that supports company business goals and vision, the likelihood of a successful BI adoption within that area should be raised.

The third category looks at what business challenges are being supported by BI, provided that the company has at least reached *aspirational* level. The model then suggests in what areas further usage of BI can help the business to become more mature. In the case of pre-aspirational companies, this category can be used as a guide towards what kind of business problems should initially be in focus. The goal could (for example) to be to reduce costs (a common focus for *aspirational* companies) by analyzing a specific business process (e.g. part of production) and identify bottlenecks (e.g. lack of information) to increase efficiency.

The fourth category identifies key obstacles for BI adoption. Supporting previous findings in literature (e.g. (Yeoh and Koronios, 2010; Olszak and Ziemba, 2012), one of the key obstacles for BI adoption according to the model is lack of executive sponsorship. Previous research has also identified what needs to be in place to overcome that type of obstacle. For example, BI needs to clearly support business goals, demonstrated with a strong business case containing key performance indicators to measure goal achievement. In addition, identifying what decisions can be supported can raise the perceived usability of BI and therefore influence managerial attitudes towards the BI implementation.

The fifth category highlights the importance of data management. Lacking the ability to capture or aggregate data will affect what information is available to use for decision making. Identifying what information is needed, both when it comes to decision making and within processes is therefore a key step towards helping companies specify their information needs.

The last category looks at analytics in action. Aspirational companies rarely use rigorous approaches when it comes to decision making. A similar assumption could be made for pre-aspirational companies. A rigorous approach can be established more easily if there is an agreement on what kind of decisions should be supported, what information is needed, and towards what business goal.

As the work with the participating companies of this research progressed, it became evident that most of the companies were closer to being pre-aspirational than aspirational or experienced according to the maturity categories of Lavalle et al. (2010). SMEs have in general been found to be late adopters of BI (as discussed for example in Voicu, Zirra and Ciocirlan (2010) and Baransel and Baransel (2012)) and the participating companies were no exception. Therefore, when working with the companies, the aspirational category from Lavalle et al. (2010) was used for guidance, for example when identifying what functions within the company they should focus on when working with BI. According to the maturity model, aspirational companies mainly use BI for financial management and budgeting, operations and production, sales and marketing (Lavalle et al., 2010). The main challenges (or key obstacles as category four in the model is called) for aspirational companies are presented in table 5. They concur to a large extent to the factors presented in previous sections and further demonstrate the importance of focusing on organizational factors compared to more IT related factors when adopting BI.

Table 5: Overview of challenges to increase maturity

Author	Maturity challenges
Lavalle et al. (2010)	Lack of understanding how to leverage analytics for business value Executive sponsorship Culture does not encourage sharing information

2.4 SUMMING UP PREVIOUS LITERATURE

Previous literature has identified various factors and dimensions that need to be considered in order to increase the possibility of successful BI adoptions. These are challenges that both this research and future research needs to address. The list of these challenges is quite long, and constantly changing. If we consider the TOE framework with the management consideration addition, we know that over time, technology, organizations and business environment change, as do managers in terms of (for example) education and technical knowledge as digital natives become managers. This can result in new factors being identified during the period of research. However there are already many factors identified - the advance of research requires ideas on how to address these challenges.

Previous research has showed the importance of connecting BI with business goals and processes when adopting BI, and a key role for BI is to support decision making by providing the necessary information. To measure how far an organization has come with their BI adoption, the categories from Lavalle et al. (2010) can be used to guide what to focus on and where to turn next. If a company hasn´t started its BI journey, the *functional proficiency* category provides guidance on where companies usually start with their BI initiatives (financial management, operations, production, sales and marketing). The maturity model also gives insights into what business challenges usually are the main focus, and what obstacles companies commonly face. The model can therefore be used both to help companies start their BI journey, and to measure how far they have come.

Despite efforts to support BI adoption by using maturity models or identifying CSFs and BI readiness factors and dimensions, some research suggests that a large number of BI projects are considered failures (Hawking and Sellitto, 2010; Olszak and Ziemba, 2012). BI adoption projects often fail despite researchers having clearly pointed out what needs to be in place to increase the possibility of successful BI adoption. This research aims to support companies by addressing some of the factors previous research has identified as important when adopting BI. Therefore, these factors are considered as challenges to be faced when adopting BI. Addressing these challenges can therefore both help research forward, and support organizations with their BI adoption.

As stated in chapter 2.2, BI promises to support organizations in a number of ways through IT. This was then summarized in a model of “core concepts” (Figure 3) that showed BI support achieving business goals, support business processes, data management and decision support. Parallels can be found in BI adoption literature with what BI promises to support. Table 6 consolidates the different factors identified as important for BI adoption and relates them to the BI core concepts that were derived

from literature and summarized in Figure 3. For example, for BI to be successfully implemented, a clear vision and a business case is needed. BI promises to support achieving business goals by (for example) providing graphs or numbers of measurements that can explicitly show management whether those goals are being met. Experiencing this kind of business usefulness, can make managers more willing to invest in the BI adoption. BI also promises to support more efficient business processes, and according to Yeoh and Koronios (2010), well defined business processes are important for BI adoption. We can see that there is a correlation between what BI promises to support, and factors that influence BI adoption. The issue therefore becomes more about *how* to tackle these challenges; how to help SMEs to make well established business case, how to increase knowledge on how BI can support decisions, and how to achieve management support - to give few examples. These are the questions this research sets out to answer in order to achieve the overall research aim.

Table 6: Consolidation of challenges related BI support

BI support	**Challenges from literature**
Supporting achieving business goals	Management support and involvement Alignment with business vision and strategy through business cases Business-driven approach with business champions Having resources for adoption Perceived usefulness
Supporting process efficiency	Well defined business process Continuous process improvement culture
Supporting decision making	Knowledge on how BI can support decisions CEO´s innovativeness context – Decision making, willingness to adopt IT to improve business performance Culture for using information and analytical applications for decision support Decision process engineering culture
Supporting data management	Data quality and integrity Up-to-date information
IT support	Integration between BI and other systems Technological context – internal and external Business intelligence and data warehousing technical readiness Effective business/information technology partnership for BI

Table 6 does not contain all the factors identified in the literature as not all factors have strong connections with the core concepts of BI; related factors have been consolidated under a single heading. Examples of factors not strongly linked to what BI promises to support are vendor selection and personal contacts, and factors considering management or personal activities which are not directly related to the core concepts of BI.

The following list contains other factors identified in literature. These factors, and the factors presented in Table 6 will be re-visited in chapter 6.3 of the thesis.

Other factors from literature:

- Competent BI project manager
- Organizational context – Size, structure, managerial structure, human resources
- Personal contacts
- Organizational readiness
- User-orientated change management
- Team skills
- User friendly system
- User participation
- Teamwork
- Business intelligence portfolio management
- Environmental context – strategic foresight
- Environmental context – competitors, regulatory environment
- Complexity of implementation
- Competitive pressure
- Vendor selection

This chapter set out to provide insight into BI and provide an overview of related work regarding BI adoption. The key insights of the chapter are the core concepts of BI, the characteristics of aspirational companies and the identified factors for BI adoption in literature. Rather than adding to exisiting lists of readiness factors, CSFs, dimensions or maturity steps, this work aims to address them by viewing them as challenges to be solved in the development of support for BI adoption.

RESEARCH DESIGN

CHAPTER 3
RESEARCH DESIGN

This chapter outlines the argumentation for the chosen overall research method and design. The chapter starts with a discussion on suitable research strategies, followed by a more detailed description of the chosen research method. Then the companies that participated in the study are presented, and the implementation of the research method is described to demonstrate how the overall method was applied when conducting the research. The chapter concludes with a more detailed account of the work done in collaboration with the participating companies, with a focus on the conduct of the workshops that contribute empirical material for this thesis.

3.1 CHOOSING A RESEARCH METHOD

A close collaboration with companies is necessary, since the research aim is to gain more in-depth understanding of how SMMEs take advantage of BI, and to build an artefact to support further usage. There are established research methods that support both close collaborations with companies and building artefacts. The following sections provide an overview of three appropriate methods, including the chosen method for this research.

3.1.1 ACTION RESEARCH

Action research (AR) has its roots in the 1940s and 1950s and contributes differently to knowledge than positivist science by applying an interpretive philosophical framework (Susman and Evered, 1978). Although there might not be one definitive action research approach, the method aims to produce relevant research findings by merging research and practice (Baskerville and Wood-Harper, 1996). The researcher therefore is not a neutral observer but a participant in the action, where the process of change becomes the research interest (Checkland, 1999). Moreover, action research requires the researcher to be a part of the problem situation and to use the experience as a research object from which to draw lessons (Checkland and Scholes, 1990). It does so in an iterative cycle of plan-act-reflect activities where practitioners and researchers collaborate (Oates, 2012) by taking a particular action in a social setting where the researcher observes the motion of the setting after an event (Baskerville and Wood-Harper, 1998). The role of the researcher is to contribute with theoretical knowledge and experience while the practitioners contribute with their practical experience and knowledge. Both roles therefore seek to contribute from their own perspective to solve

the problem through collaboration, including both actions and evaluation of outcomes (Susman and Evered, 1978).

According to Baskerville and Wood-Harper (1998) there are several forms of action research and they can be categorized into iterative IS action research, reflective IS action research and linear IS action research. Iterative IS action research is characterized by the repeating sequence of diagnosis, action and learning activities until the problem is solved. The various forms of action research in that category are canonical action research, soft systems and prototyping. Reflective IS action research focuses on the distinction between theory-in-use compared to the theory actually adopted. Although researchers reflect on results and learnings from action, in reflective action research it is critical to use diagnosis and iteration to understand where behavior is not explained by their existing understandings. The forms included in this category include action science, participant observation and action learning. Linear IS action research is characterized by a process that is not iterative. The activities are not scheduled to be repeated - instead the process will continue from the beginning to the end. The forms of linear action research include ETHICS (Effective Technical and Human Implementation of Computer Systems), Multiview, Clinical field work and process consultation (Baskerville and Wood-Harper, 1998).

Although there are several forms of action research, they do share certain characteristics. Action research is characterized by (Baskerville and Wood-Harper, 1998):

1. Its multivariate social setting
2. Interpretive assumptions about observation
3. Intervention by the researcher
4. Participatory observation
5. The study of change in the social settings

Some issues have been raised regarding AR, for example that the focus on organizational problems solving might affect the transferability of theoretical understandings (Susman and Evered, 1978) and that there is a lack of epistemological clarity when it comes to developing and testing theory (Rose, 1997). In addition, Rapoport (1970) identified three possible dilemmas when conducting AR; a possible mismatch of goals between the practical problem and the research question, confusion or conflict of roles between researcher and consultant e.g. if a researcher is paid a fee for the work by the client and finally a value dilemma when, for example, participants expect quick results while the researcher desires time for reflection before action (Rapoport, 1970; Baskerville and Wood-Harper, 1998).

The overall goal of action research is to increase the cohesive body of knowledge as well as to improve practice by involving participants and the researcher him/herself, who actively takes part in contributing to a solution to a practical problem (Williamson, 2002). Although the method emphasizes the close collaboration with practitioners (a fundamental part of this work) there is little focus on artefact construction based on that collaboration, or the experiences of conducting the action research rather than participating in problem solving and studying the change in that social setting. Even though (for example) prototyping emphasizes improving the communications between the user and the designer and building prototypes using an iterative process, the main goal is system design, something that is not in focus in the

current research. For this work, the strengths of AR with its focus on close collaboration was acknowledged, but since building and evaluating an artefact was a major part of this work, other research methods could be more appropriate.

3.1.2 DESIGN SCIENCE

In contrast to natural science that aims to understand reality, design science focuses on serving human purposes by creating things. The products of design science come in four types; constructs, models, methods and implementations (March and Smith, 1995). From an even broader perspective, design science can include *"[...] any designed object with an embedded solution to an understood research problem"* (Peffers et al. 2007, p. 49). In the field of IS this can involve a wide range of socio-technical artefacts such as modeling tools, strategies, decision support systems and methods to evaluate information systems (S. Gregor and Hevner, 2013). Characteristics of design science theories is that they concern the use of these artefacts (Gregor, 2006) or how to design and develop these artefacts (Gregor and Jones, 2007). There are two basic activities in design science when it comes to artefacts, building, which is the process of constructing the artifact, and evaluation where the performance of the artefact is determined (March and Smith, 1995). Hevner et al. (2004) argue that IS research falls into two complementary but distinct paradigms, behavioral science with its roots in natural science research and design science. The natural science research method pursues developing and justifying theories to help explain or predict human and organizational phenomena in relation to using, designing, implementing, managing and analyzing information systems. Design science, with its roots in engineering and the artificial (Simon, 1996) is more of a problem solving paradigm that addresses research through the two activities of building and evaluating artifacts to fulfill specific needs (Hevner et al., 2004).

Various design science research models have been suggested, for example in Hevner et al. (2004) and by Kuechler and Vaishnavi (2008) where they suggest a five step process with iterations. These steps are (1) awareness of problem, where it is identified that a problem needs a solution and an initial solution is proposed, (2) suggestion, that focuses on how the suggestion could be realized resulting in a tentative design, (3) development, that realizes the tentative design producing an artefact as an outcome, (4) evaluation, where it is determined if the artefact actually solved the problem and finally (5) conclusion, where performance measures from the evaluation of the quality of the solution are used to determine how successful the design research process has been. Peffers et al. (2007) proposed a design science research methodology process containing six activities (Peffers *et al.*, 2007):

1. Problem identification and motivation

As a basis for the development of an artefact, a specific research problem needs to be identified. In addition, the value of a solution needs to be specified to both motivate the researcher and the audience to both pursue and accept potential results.

2. Define the objectives for a solution

The objectives for the solution are concluded from the problem specification either quantitatively or qualitatively to increase knowledge of what is both possible and feasible.

3. Design and development

At this stage the artefact is created. Desired functionality and architecture is determined with support of theory. The design of the artefact contains the research contribution and the artefact can be any designed object.

4. Demonstration

The artefact is used to provide solution to one or more instances of the problem. This could be done in various settings, e.g. through experimentation, simulations or case studies.

5. Evaluation

At this part of the process observations and measurements are used to determine to what degree the artefact supports solving the problem. Depending on the outcome of the evaluation, the researcher can either iterate back to activity 3 if the artefact needs improvement or move to activity six.

6. Communication

The design, utility, novelty and effectiveness of the artefact in relation to the problem and its importance is communicated to relevant stakeholders.

Although the steps are presented in sequential order, the researcher could actually start with any of the activities and move outward depending on the situation (Peffers et al., 2007). Compared to AR, design science has significantly more focus on designing and creating artefacts. There is, however, not as much emphasizes on continuous collaboration with practitioners, as is demonstrated by both Kuechler and Vaishnavi (2008) and Peffers et al. (2007) when they present their research process. The initial stages of problem awareness (Kuechler and Vaishnavi, 2008) and problem identification and motivation (Peffers *et al.*, 2007) of course indicate the possibility of close collaboration with practitioners or other researchers. Although Peffers et al. (2007) noticeably point out that the research process does not need to be followed sequentially, both processes specify in their flow that after the problem identification, an artefact should be built (either fully or a more tentative version) before entering the evaluation stage. During the evaluation, the collaboration aspect with practitioners is resumed. For this research, close collaboration with practitioners was of high importance to facilitate BI adoption. In addition, designing an artefact to support that facilitation was important as well, so for this work it was deemed that the chosen research method needed to support both the close collaboration aspect of AR, and the artefact building aspect of design science.

3.1.3 ACTION DESIGN RESEARCH

The third possible method for this type of research focuses on close collaboration with practitioners and artefact building. It is called Action Design Research (ADR) and it utilizes the strengths of both previously discussed research methods. It could be described as a hybrid of both action research and design science. ADR is set up to deal with two main challenges (Sein et al., 2011):

- Addressing a problem situation encountered in an organizational setting by both intervening and evaluating
- Constructing and evaluating an artefact that helps to solve the identified problem

According to Sein et al (2011), there are four stages and a set of principles in the ADR method (Figure 4). These stages are then followed in a semi-sequential order since

there is a constant iteration loop for reflection and learning between practitioners and the researcher. The first stage is the problem formulation stage, which draws upon two principles. The first principle is that the problem can be practice inspired where the knowledge creation opportunities come from the intersection of the technological and organizational domains. The second principle emphasizes the use of theories in three ways; to structure the problem, to identify solution possibilities and to guide the design of the solution. At this stage, a problem can therefore be perceived by researchers, end-users, existing technologies, or in previous research. During the problem formulation, there is a transition between stage one and stage three (reflection and learning). This makes the problem formulation stage an iterative process that can strengthen both the collaboration between practitioners and the researcher and the problem identification. During this stage, the scope of the problem is set along with the scope of practitioner participation. There are six tasks to complete at the problem formulation stage. These tasks are (Sein et al. 2011):

- Identify the research opportunity
- Formulate initial research question
- Cast the problem as an instance of a class of problems
- Identify contributing theoretical bases and prior technology advances
- Secure long-term organizational commitment
- Set up roles and responsibilities

Stage two is called Building, Intervention, and Evaluation (BIE). At this stage, the problem formulation and theoretical premises are used as platforms when designing and building the new artefact. As with stage one, there is a constant iteration loop that includes stage three; reflection and learning. In addition, this stage includes a constant evaluation of both the design and the building of the artefact through collaboration. The artefact is therefore not built, and then evaluated, rather it is built in a close collaboration with practitioners through iterative process of collaboration. This collaboration includes intervention within the organization as the artefact is being developed. These are therefore not sequential steps but rather an iterative loop where the activities are intertwined where both the problem and the artefact are continually evaluated. At this stage it becomes clearer where the actual innovation takes place, if it is based on the design of the artefact (IT-dominant), or the organizational intervention (organization-dominant). Stage two contains four major tasks:

- Discover initial knowledge-creation target
- Select or customize BIE form
- Execute BIE cycle(s)
- Assess need for additional cycles, repeat

In cases where the ADR method is used to support creating a more technological orientated design, the BIE form will be more IT-dominant. In that case, end-users participate in the BIE cycle when the artefact has reached Beta version after the researchers and practitioners have evaluated and worked with the Alpha version. Organization-dominant BIE cycle is more suited for organizational intervention efforts. That means involving “end-users” earlier in the process when current ways of doing things or using things is being challenged in order to achieve improvements. Organization-dominant BIE presents the artifact sooner compared to the IT-dominant cycle, and the iterations

continue until the organization decides to either adopt the improved design or reject it.

Stage two draws upon three principles that emphasize the inseparability of the domains influencing the ADR project. The first principle is reciprocal shaping where the inseparability of the IT artefact and the organizational context is emphasized. The second principle is called mutually influential roles, which highlights the importance of mutual learning for all project participants. The final principle is authentic and concurrent evaluation. This principle emphasizes on the key characteristic of ADR, that evaluation is not a phase or a stage that follows the building of the artefact. Rather, the designing and reshaping of the artefact and the intervention of the organizational work practices are to be intertwined with an ongoing evaluation.

Stage three is called Reflection and Learning. It uses the experience of the previous stages to apply lessons learned to a broader class of problems. This stage is continuous and runs in parallel with the first two stages. It highlights the importance of conscious reflections on the problem framing, involved theories and the emerging artefact to ensure identification of the contribution to knowledge. The following tasks are included in stage three:

- Reflect on the design and redesign during the project
- Evaluate adherence to principles
- Analyze intervention results according to stated goals

In addition, stage three draws upon a principle called guided emergence which aims to capture an important aspect of ADR; the interplay between design (intentional intervention) and emergence (a more organic evolution). This stage emphasizes the fact that the artefact created does not only reflect the original design but also on how the organizational use, perspectives and participants in the project have helped to shape the results. Furthermore, this stage also reflects on the outcomes of authentic and continuous evaluations of the artefact, further emphasizing the importance of concurrent evaluation.

The final stage is stage four where the objective is to formalize the learning by describing the accomplishments by the artefact and the organizational outcomes. This stage has the following tasks:

- Abstract the learning into concepts for a class of field problems
- Share outcomes and assessment with practitioners
- Articulate outcomes as design principles
- Articulate learning in light of theories selected
- Formalize results for dissemination

This stage also draws upon the principle of generalized outcomes but because of the organizational specific nature of the ADR method, generalization is challenging. However, this part addresses an important aspect of the ADR method; moving from specific-and-unique to generic-and-abstract. The research addresses a problem and provides a solution to that problem and both can be generalized. In order to make this important move, Sein et al. (2011) suggest three levels of generalization; (1) generalization of the problem instance where the problem is showed as one instance in a class of problems, (2) generalization of the solution instance where the specific solution is shown in a larger perspective, and (3) derivation of design principles from the design

research outcomes where the specific solution provides design principles for a more generic solution.

Figure 4 provides an overview of the ADR stages and the relations between them.

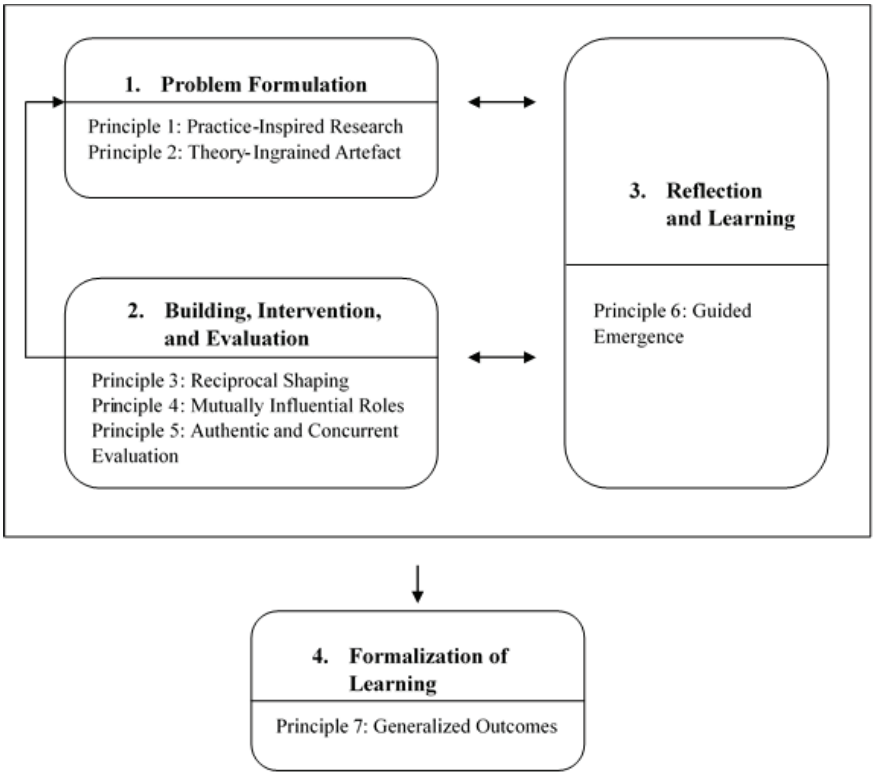


Figure 4: The ADR method stages (by Sein et al. 2011).

According to Sein et al. (2011), the ADR method has seven principles that support conducting ADR research. Table 7 provides a summary of these principles and their descriptions.

Table 7: The ADR principles and their description

Principles	Description
Principle 1: Practice-inspired research	Viewing field of problems as knowledge-creation opportunities that can be applied to a class of problems
Principle 2: Theory-ingrained artefact	Artefacts created and evaluated are informed by theories
Principle 3: Reciprocal shaping	Mutual influence of two domains, the IT artefact and organizational context
Principle 4: Mutually influential roles	Highlights the importance of mutual learning amongst different project participants
Principle 5: Authentic and concurrent evaluation	Designing and shaping of the artefact is interwoven with an ongoing evaluation during the research process

Principle 6: Guided emergence	The artefact continues to evolve through organizational use, perspectives and participants
Principle 7: Generalized outcomes	Captures the generalization of a specific-and-unique problem in a particular settings

As this work relied heavily on close collaboration between the researcher and participants, and building an artefact, the ADR provides the support needed for both purposes. As mentioned earlier, the method is a hybrid method. It captures the strengths of both AR and design science, and was therefore deemed the better candidate method for this work.

The following section will provide a short overview of the participating companies in this research before demonstrating how the ADR supported the research process.

3.2 PARTICIPATING COMPANIES

The empirical data comes from six companies that were used as individual cases for the purpose of the research. Only one of the companies (company 6) was chosen at the time I was starting my research. Companies 1 – 4 had already signed up to join the *Measuring and managing continuous improvements in medium-sized manufacturing companies* (MMC2) project when I was invited to join the project. Company 5 had signed up to the *Smallbuild+* project before I was invited.

Although I did not choose the companies myself, they fit the category of a small and medium sized companies (although some can be viewed as large if they form part of a parent enterprise). They did however express much independency, and, based on previous literature, displayed similar characteristics to other SMEs when it came to BI adoption. The companies are all in manufacturing as well as being SMEs so they provided a good base for analyzing the state-of-practice (RQ1) and to record what challenges (RQ2) they were describing with respect to BI adoption. In addition, they all expressed interest in working with academia to support facing both current and future competitors. All the companies gave the projects the time and personnel that was requested.

Table 8 provides an overview of how each company's participation contributed to the research. The table presents the focus area of each company when working in workshops to solve a chosen problem (participation). The table also presents the number of interviews in each company, along with statistics and to which papers the interviews contributed.

Table 8: Overview of companies' contributions and participation

Company	Participation	Number of interviews	Length of interviews (hh:mm)	Project	Paper
Company 1	Process improvement, BI maturity assessment	9	Longest: 01:50 Shortest: 00:30 Avg: 01:08	MMC2	2,3,6

Company 2	Data management, BI maturity assessment	19	Longest: 01:40 Shortest: 00:18 Avg: 00:48	MMC2	2,3,6
Company 3	Decision making, BI maturity assessment	22	Longest: 02:12 Shortest: 00:16 Avg: 00:53	MMC2	2,3,6
Company 4	BI maturity assessment	6	Longest: 01:49 Shortest: 00:39 Avg: 01:10	MMC2	2,3,6
Company 5	Goal modeling, process improvement	2	Longest: 01:42 Shortest: 01:22 Avg: 01:32	Small-build+	4,5
Company 6	BI maturity assessment	10	Longest: 02:10 Shortest: 00:41 Avg: 01:12	N/A	1

Companies one to four were a part of the Measuring and Managing Continuous Improvements in Medium-sized Manufacturing Companies (MMC2) project and they all contributed to the analysis of the state-of-practice of BI usage. Three of the companies in that project then took part in workshops with specific focus on one of the core concepts of BI. Company five was part of a project called Smallbuild+, and contributed through workshops by focusing on two of the core concepts of BI and by that contributed to designing the final artefact. Company six was used to analyze BI maturity to support researching the state-of-practice of BI usage. A more detailed account regarding the work that was done in companies 1 – 3 and company 5 is presented in chapter 5.

3.2.1 COMPANY 1

Company one manufactures screening equipment for various industries worldwide. Their products are used for screening minerals, gravel, food production and recycling. The company is owned by a large international enterprise group in Germany. There are around 50 employees in Sweden. The company took part in the MMC2 project and focused on process improvement.

There were 9 interviews at company 1, including the roles of CEO, sales manager, production manager, IT manager and procuration manager. In addition to interviews, workshops were conducted focusing on process improvement that are described in more detail in chapter 5

3.2.2 COMPANY 2

Company two is a family-owned company that manufactures in-car accessories for mobile devices that are sold both in Europe and in the US. The company has about 120 employees. The company took part in the MMC2 project and focused on information needs and data management.

The total number of interviews was 19, and all interviews were done onsite. The interviewees had various roles including CEO, production managers, storage manager,

team leaders and sales personnel. Workshops were conducted that focused on information needs from an employee perspective. A more detailed account is given in chapter 5.

3.2.3 COMPANY 3

Company three is a family owned company that produces bookshelves and is a subcontractor to a large Swedish furniture company. The company has about to 220 employees and sell their products mainly in Europe. The company took part in the MMC2 project with a focus on decision making.

There were 22 interviews conducted, all at company location. The participants represented all divisions of the company, including owners, production manager, maintenance machine workers and team leaders. Workshops were also conducted that focused on decision making supporting decisions when production stops. A more detailed account is given in chapter 5.

3.2.4 COMPANY 4

Company four manufactures mainly marine engines, but also products for power generation and off-road applications with worldwide sales. The company is owned by a large international enterprise and has around 250 employees. The company took part in the MMC2 project and contributed to the current state-of-practice analysis of BI usage within SMMEs and their challenges with BI adoption. The company did not take part in any workshops that focused on specific problems, but did join the final seminar of the MMC2 project where they discussed their results from the project.

3.2.5 COMPANY 5

Company five is a Norwegian construction company that manufactures wooden house components (mostly outer walls) in their factory before taking them to the building location for assembly. The company has approximately 40 employees and mainly produces houses for their local market. The company was part of the Smallbuild+ project and focused both on process improvement and goal modeling. Only two interviews were conducted at company 5, most of the work and empirical data collection was done through dialogue meetings and workshops with employees. A more detailed account is given in chapter 5.

3.2.6 COMPANY 6

Company six was established in 1955 and is a subcontractor for the automobile and other industry, producing various coupling products for air and hydraulic equipment. It had around 250 employees in Sweden, and 550 employees worldwide. Most product development is done in cooperation with their customers in a B2B-relationship and the company provides highly customized services and products. The interviewees were mostly at management level: production managers, line managers, controller and owners. The company contributed to the state-of-practice analysis but did not take part in any workshops.

3.2.7 EMPIRICAL DATA GATHERING

The empirical data in this research was gathered through interviews, workshops, seminars, document analysis and observations. This chapter provides more details of the interview part of the data gathering, while other data collection is described in chapter 3.4. Though documented here, the interviews had a key role in the problem formulation stage of the ADR method. The interviews provided insights into how each company operates, how they were using BI and IT in general, along with the challenges they were facing.

The interviews were semi-structured, meaning that there was a set of questions, but during the interviews, some follow-up questions were asked when appropriate (Williamson, 2002; Oates, 2012). The assessment categories of Lavalle et al. (2010) were used as a frame and guide for the questions in all companies. The assessment categories were the following:

- Motive
- Functional proficiency
- Business challenges
- Key obstacles
- Data management
- Analytics in action

A set of questions were designed that focused on each category. For example, questions regarding functional proficiency aimed to understand which parts of the company were using BI, or IT in general. A question regarding motive could then be asked to further understanding of how BI is used within the functions or departments, e.g. whether BI was used to look back to see what happened and justify actions, or to guide actions. All interviews were conducted at the company location.

There were 68 interviews conducted in total in both projects, (Table 8). Interviews were transcribed using InqScribe[2] and the interviews were analyzed in NVivo 11 using the techniques of content analysis (Krippendorff, 2004). Coding was based on categories from the maturity model. A special code called *challenges* was also used for a more overarching analysis of companywide challenges understood as priorities by the companies. A generalized account of these challenges is previously published (Gudfinnsson and Strand, 2017). The results of the interviews provide a view of state-of-practice within each case company and therefore supported answering research question 1 (RQ1) of this research: *What is the current state-of-practice in relation to BI adoption in SMMEs?*

After coding the interviews, the main challenges had been identified to be added to literature and providing answers to research question 2 (Q2): *What are the main challenges for BI adoption in SMMEs?* These main challenges were then discussed during the problem formulation stage of the ADR method, catering for practice-inspired research. Empirical data was also gathered through workshops with participating companies. A more detailed description of how data was gathered and the activities that were conducted is provided in chapter 5.

3.3 ELICITATION PROCESS

An elicitation process was necessary to capture empirical data during workshops with participating companies. Enterprise models have been used in research to e.g. capture organizational structures, describe processes, activities, information needs, roles and goals (Fox and Gruninger, 1998). There are several approaches to capturing data for enterprise models, such as interviews, observations, document analysis, keeping a work diary and participatory modeling workshops. The chosen elicitation process for parts of this work originates from the field of enterprise modelling, particularly from the work of Sandkuhl et al. 2014. Before initiating the elicitation activity, Sandkuhl et al. 2014 provide a checklist that summarize the most important points of preparation:

[2] https://www.inqscribe.com/

1. *Define (as precisely as possible) and agree on the purpose and scope of the investigation between those performing it and those who commissioned it.*
2. *Obtain approval and support from the relevant managers in the enterprise*
    a. *Involve all affected organizational units and don´t forget to involve external stakeholders if needed.*
    b. *Agree sufficient time and resources.*
    c. *Obtain access to existing relevant documentation.*
3. *Involve those affected within the enterprise at an early stage*
    a. *Provide information about the purpose of the activities.*
    b. *Announce the schedule and which activities are planned.*
    c. *Communicate who will be involved or affected and why.*
    d. *Provide information regarding how and in what context the collected information will be used* (Sandkuhl et al. 2014, p.42).

Before initiating a modeling workshop, Sandkuhl et al. 2014 strongly recommend interviewing domain experts as a preparation before the session. The outcome of the interviews should be a common understanding of the goal of the session and the importance of that goal. They should feel that they can contribute to a positive result and that they are comfortable with the rest of the participants.

When the elicitation process was adapted for this research, a smaller scale workshop using elicitation activities was conducted to use as a practice session after interviews with stakeholders had been conducted as recommended. The Sandkuhl et al. (2014) elicitation process covers a broad area, including recommendations for participators, preparations and managing the sessions. For the purpose of this work, in addition to the checklist presented above, some practical tools from the elicitation process were used to capture information during the workshops in the form of an elicitation activity. This involved using small paper notes of different colors representing different concepts. The concepts could be roles, decisions, information or activities, depending on the focus of the workshop. A plastic wall was then used for the notes to be glued on. During elicitation workshops, every participant would have a pen and a stack of notes where they could write down their thoughts and opinions regarding the workshop subject. Those notes would then be shared on the plastic wall. A more detailed account of these workshops is presented in chapter 5.

3.4 IMPLEMENTATION OF ADR

This section provides an overview of the implementation of the ADR method in this research. Moreover, the following sections describe how each step of the ADR method supported the research and achieving the overall research aim and the research questions. The research process was guided by the ADR stages and was supported by both empirical work and literature survey. The adaptation of the ADR process for this research is presented in Figure 5.

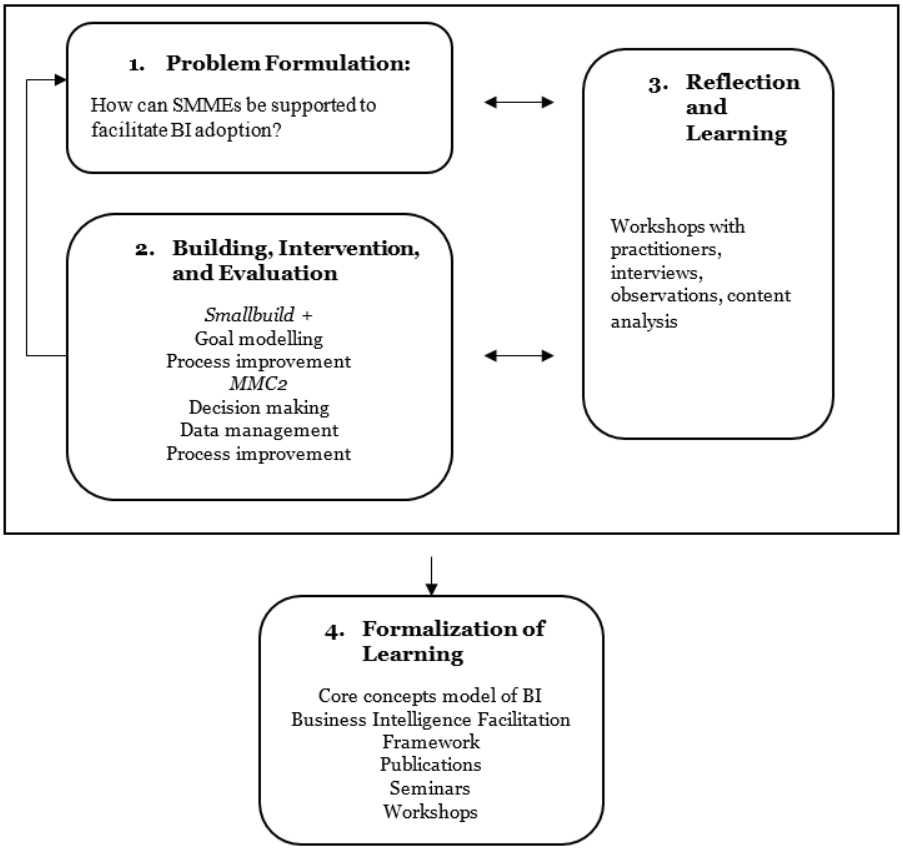


Figure 5: Adaptation of ADR research method

The figure provides an overview of core components within each stage of the research process in relation to the ADR method. The problem formulation stage includes the overall research aim converted to a problem statement, as this was the main goal of the research. For each individual company, there were different problem formulations, but they all contributed to achieve the overall research aim displayed in Figure 5. The building, intervention, and evaluation stage shows what was built, and in what project. Stage three presents the arenas of reflection and learning and stage four gives an overview of the outputs of the research process. A synopsis of the ADR principles and how they were fulfilled is presented in Table 13 in chapter 7 in relation to research validity. The following sections describe in more detail how each stage of the ADR supported the research.

3.4.1 PROBLEM FORMULATION STAGE

The first task of the problem formulation stage is to identify and conceptualize the research opportunity (Sein et al., 2011). This was done with the aid of a literature survey on BI in SMEs. The literature survey was mainly done by using five large databases; Scopus, Sciencedirect, IEEE explore and Springer Link and Google Scholar. The search terms included “BI” or “Business Intelligence” and “SM(M)E” in combination with other concepts such as “Adoption”, “Implementation”, “facilitating”, “Maturity”, “Readiness”, “Usage” and “Critical success factors”.

A snowballing approach was used to follow references provided in the articles to find more literature when appropriate. An example of snowballing is shown in Figure 6 where the website https://kumu.io/ was used to link articles referenced by Olszak and Ziemba, and articles that cited Olszak and Ziemba. The arrows pointing towards Olszak and Ziemba (2012) are citing that article and arrows pointing away are articles

referenced by Olszak and Ziemba. The Norwegian register for scientific journals, series and publishers[3] was used to legend the perceived impact of the publisher on a scale from 0 – 2. Darker green balls represent level 2 (highest impact) while the grey ball represents 0 (lowest impact) and the "1" is the rating of the publisher of the Olszak & Ziemba publication.

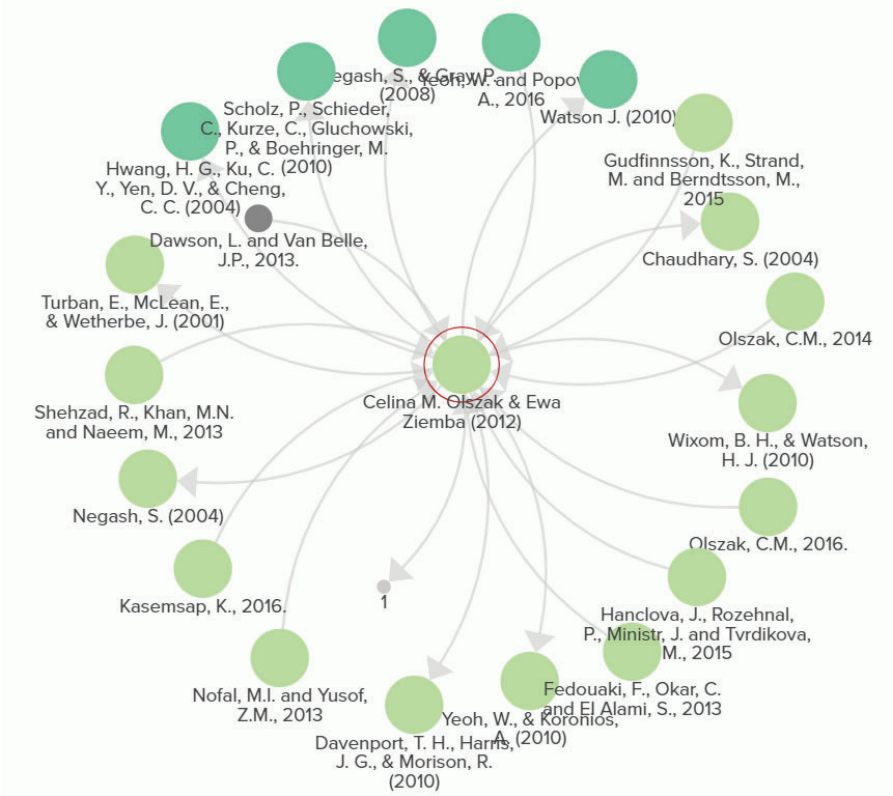


Figure 6: Snowballing Olszak & Ziemba

During the literature survey a research opportunity was identified since there were not many publications on BI usage in SMEs, or how to support increased usage of BI in these smaller companies. As described in chapter 2, most of the research focus was on identifying various factors necessary for successful BI adoption, rather than how to address these factors. Furthermore, despite the buzz around *Industry 4.0* and *Smart Factories*, there was little to be found in BI literature on how SMMEs could be supported to take advantage of BI to help cope with manufacturing of the future. This identification of a gap in literature spawned the initial research aim on how SMMEs could be supported to take advantage of BI.

The results of the literature study indicated that there was a problem, and although this work focused on SMEs in manufacturing, it can also be argued that the problem is an instance of a broader class of problems that concern supporting SMEs and their BI potential in general. As a way to address this problem, a theoretical base was identified. As presented in chapter 2, theories regarding BI adoption and the BI maturity model were applied in order to find a solution to this particular problem. The core concepts of BI were analyzed and synthesized into a model, and the BI maturity model

[3] https://dbh.nsd.uib.no/publiseringskanaler/Forside

provided insights into the characteristics of an aspirational organization and highlighted what areas are perceived important when adopting BI.

After identifying the research opportunity, five companies in two projects (see Table 8), and one company not part of either of those projects were used as individual cases throughout the research. A more detailed account of the work that was conducted with each company in the projects is presented in chapter 5. In addition to identifying the overall research opportunity, principle one of the problem formulation stage was achieved by identifying a practice-inspired problem by collaborating with the participating companies. The problem was identified after several interviews in each of the participating company and dialog meetings with managers. This stage of the ADR method was used to gain empirical data to answer both research questions 1 and 2 presented in chapter 1.2. To be able to understand the specific settings of each company, semi-structured interviews were conducted along with observations and document analysis. The interview process was previously described in chapter 3.2.7. All companies except company 5 contributed with empirical data for the state-of-practice analysis to answer research question 1. Analyzing the current state and identifying the challenges expressed by the interviewees opened for the opportunity to both measure the BI maturity of the companies and to set the groundwork for a practice-inspired problem to focus on during the next steps of the research. The problem formulation stage was therefore used both to identify the overall research opportunity, and a practice-inspired problem within the companies. For each company, there was a theoretical support for structuring the problem as each problem was identified within one of the four core concepts of BI (Figure 3). In addition, the maturity model presented by Lavalle et al. (2010) was used to guide which areas within each company should be investigated for problem identification. Following principle two of the problem formulation state, the theories presented in chapter two were used both for problem structure, identifying solution possibilities and as a guide to build the final artefact of the research.

In total, four companies contributed to this work by identifying specific problems that helped in designing the final artefact. Those were companies 1 – 3 and company 5. Each company chose a problem deemed important for them based on their needs. This was an important step to secure the long-term organizational commitment for this particular part of the projects and to get the necessary ingredients for artefact design. Initially there was a limited interest in further adapting BI within the companies with the explanation that they were not sure on how BI could actually support them in their business. Focusing on an actual practice-orientated problem helped overcome that hindrance. A more detailed account is provided both in paper 6 and chapter 5.

3.4.2 BUILDING, INTERVENTION, AND EVALUATION

In the second stage of the ADR cycle the theoretical premises on the core concepts of BI and BI maturity were used as platforms for designing the artefact to facilitate BI adoption. Each participating company contributed by focusing on at least one of the core concepts of BI through workshops. Workshops were conducted at each case company and the elicitation approach by Sandkuhl et al. (2014) was used to capture the contributions of each workshop participant. According to Sein et al. (2011), there are four primary tasks to consider at this stage. The first two tasks, discovering the knowledge-creation target and the BIE form were conducted in collaboration with stakeholders at each participating company that contributed to the building of the final artefact. This was done prior to the workshops where the “end-users” were involved. The BIE form was organization-dominant as the primary source of both the design of

the artefact and the innovation relied on organizational intervention. The BIE cycles where executed, but with a focus on each individual company problem, rather than a focus on the final artefact itself. The reason is that each company provided individual contribution to the whole artefact, so the artefact could not be built until all companies had contributed with their contributions on each of the core concepts of BI. However, each of the contributions were produced following the iterative approach described by Sein et al (2011) both regarding evaluation and reflection and learning.

At the BIE stage, there are three principles that were taken into account during this work. The first principle was followed as the focus of each participating company was on a particular part of the artefact based on their organizational context. The dialog meetings and workshops supported following the second principle of highlighting the importance of mutual learning for all participants. The final principle emphasizes on authentic and concurrent evaluation. The evaluation was not done on the artefact as a whole for the reasons mentioned previously, but rather for each individual contribution by each company. This was done continuously both through dialog meetings and workshops. After each main workshop, the content and the workshop activity itself was evaluated with key stakeholders. At the end of the MMC2 project, a seminar with all participating companies was conducted where the different interventions in each company were explained along with their results and contributions to the main artefact. The companies were given the opportunity to see what had been done in other companies and ask questions regarding the work that had been conducted. In addition, each company presented their views on the work done, both in terms of the results and valuable lessons learned. During these presentations, each company expressed their content and their willingness to continue working in a similar project in the future. A more detailed account of the work with each of the companies that contributed to the final artefact is presented in chapter 5.

3.4.3 REFLECTION AND LEARNING

The reflection and learning stage is intertwined with stages two and three, and follows the research throughout most of the research process. Because of the close collaboration with the participating companies, previous stages required reflection and learning both in terms of consulting with participants and by continuous literature survey to help moving forward. Different platforms were used for reflection and learning. Workshops with practitioners, observations and interviews including content analysis. Both when conducting the interviews, and during the workshops, field notes were taken for documentation. All interviews were recorded digitally, but not the workshops. The field notes were used to capture posture, facial expressions and the overall atmosphere both during interviews and the workshops. This was to capture things that could not be recorded, and to use for reflection on each data gathering moment of the study. The iterative nature of the ADR method enabled each encounter with participants to support reflection and learning, and to help move the work forward. In addition, each workshop provided learning that could be utilized when working with the next company, specifically when using the elicitation activity by Sandkuhl et al. (2014), as the author gained experience using the tools and facilitating the workshops. After each workshop, all companies discussed workshop outcomes for reflection. In addition, as previously mentioned, at the final stage of the MMC2 project, all companies were gathered at a workshop where they presented their reflections and learning based on the work that was done in the individual companies. That not only confirmed the positive outcomes of the interventions, but also provided learning opportunities for the other

companies that had focused on a different core concept. Close cooperation and frequent meetings with the case companies helped achieve the principle of guided emergence, as it catered for conscious reflection and evaluation of the emerging framework.

3.4.4 FORMALIZATION OF LEARNING

The results of the research are based on findings from the case companies, in combination with the theoretical premises used as a foundation for this work. In addition, the research findings provide a solution to a given problem that can be generalized. One of the critical components of ADR is moving from the specific-and-unique situation of the participating companies to a more generic-and-abstract situation that can be applied to solve broader spectrum of problems. The theoretical premises helped identify the core concepts of BI, which have been synthesized into a theoretical model that is one of the core ingredients of the designed artefact. The artefact itself took the form of a framework as a way to organize the different parts of the theoretical foundations and the lessons learned and outcomes from the organizational interventions. Although much of the framework content stems from specific settings (participating companies) the overall framework can be used in more generic situations and thereby address a broader set of problems within this field in both research and practice. Additional important formalization of learning is through publications, conferences and seminars. This work has produced two peer reviewed journal articles and four conference contributions. Seminars with participating companies have also been conducted, both with each individual company and in a larger group (companies 1 – 4).

RESULTS

CHAPTER 4
RESULTS

This chapter provides summaries of the papers that have contributed to achieving the overall research aim and the research questions. There are six published papers in and the relationship between each publication and the research questions is displayed in Figure 7.

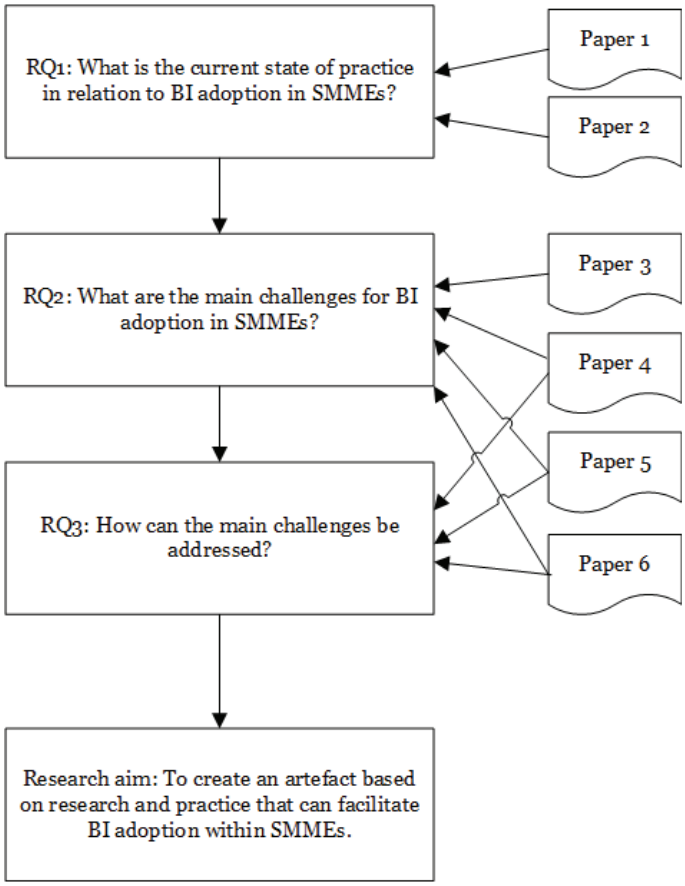


Figure 7: Paper contributions to research questions and aim

Papers one and two demonstrate how far SMMEs have come with their BI adoption, supporting previous findings in the literature that they are lagging behind leading

larger enterprises, but also providing insights into how BI is being used in the companies. Papers three and four provide an overview of the many challenges faced by SMMEs, both in terms of adopting BI, and when it comes to handling changes within the organization. These findings add new knowledge to current BI literature and identify one of the major problems of BI adoption - the lack of motivation for adopting BI. In addition, paper 4 describes case study 4 and introduces the elicitation approach (Sandkuhl et al., 2014). It is also the first time process modeling was used in this research to address specific company challenges. Paper 5 provides a goal modelling approach to tackling company challenges and to identifying key areas for metrics to support healthy business. It thus contributes to answering research questions two and three, both by demonstrating challenges and suggesting a way to address those challenges. Paper six presents an overview of the work that was conducted in three case companies and highlights the major challenges selected by each company. In addition, the paper suggests how to address the challenges, providing input to both research questions two and three. Table 9 provides an overview of the papers that have been published based on this research and my contributions to each paper.

Table 9: Overview of the papers and my contributions

Paper	**My contribution**
Paper 1: Gudfinnsson, K., Strand, M. & Berndtsson, M., 2015. Analyzing business intelligence maturity. *Journal of Decision Systems,* pp. 37-54	I am the main contributor of this paper. I wrote the main parts of it and collected the empirical data and did the analysis with critical input from both Strand and Berndtsson.
Paper 2: Gudfinnsson, K., Strand, M., 2018. On transforming into the Data-Driven Decision-Making Era - Current State of Practice in Manufacturing SMEs. In: P. Thorvald & K. Case, eds. *Advances in Manufacturing Technology XXXII*. IOS Press	I am the main contributor of this paper and wrote the main parts of it. Empirical data was collected by me and two other PhD students in the MMC2 project. The analysis was done by me with critical input from Strand.
Paper 3: Gudfinnsson, K., Strand, M., 2017. Challenges with BI adoption in SMEs. Proceedings of the 8th International conference on Information, Intelligence, Systems and Applications. IEEE	I am the main contributor of this paper and wrote the main parts of it. Empirical data was collected by me and two other PhD students in the MMC2 project. The analysis was done by me with critical input from Strand.
Paper 4: Karlsen, A., Persson, A. & Gudfinnsson, K., 2016. *The Smallbuild+ business development method: Findings from a longitudinal study in the construction sector*. Bergen, NOKOBIT	The lead author of this paper was Karlsen with support from Persson. My main contribution to the writing was in chapter 4. I took part in all workshops and meetings with the company, taking notes and was a part of designing the Smallbuild+ method. I also made about a third of the process models that were made in the project.

Paper 5: Persson, A., Karlsen, A. & Gudfinnsson, K., 2015. Towards a Generic Goal Model to Support Continuous Improvement in SME Construction Companies. In: J. Ralyté, S. Espana & Ó. Pastor, Eds. *The Practice of Enterprise Modelling*. Cham: Springer International Publishing, pp. 27-42	The lead author of this paper was Persson with support from Karlsen. My main contribution to writing was in chapter 4, and I made the goal models presented in the paper that were based on the work done in goal modelling sessions. I participated in the goal modelling sessions, taking notes and creating goal models.
Paper 6: Gudfinnsson, K., Rose, J. & Aggestam, L., 2019. Tackling lack of motivation in aspirational analytics companies: SME examples from the manufacturing industry. *International Journal of Business Intelligence Research (IJBIR), 10(1), 1 – 18.*	This paper was co-written with Rose. Empirical data was collected by me and two other PhD students in the MMC2 project. The analysis was made by me with critical input from Rose and Aggestam.

4.1 RESEARCH QUESTION 1: WHAT IS THE CURRENT STATE-OF-PRACTICE IN RELATION TO BI ADOPTION IN SMMES?

The first research question provides insights into how BI is being adopted in SMMEs. Two papers contributed to answering this question. Paper 1 utilized the maturity model by Lavalle et al. (2010) to analyze BI maturity of a company while paper 2 describes BI usage in three companies. Both papers contribute insights into the current state-of-practice when adopting BI.

4.1.1 PAPER 1: ANALYZING BUSINESS INTELLIGENCE MATURITY

The paper supports previous finding in the literature that SMEs are late adopters of BI. It describes the current BI practices of an SMME, and measures how far they have come by using the Lavalle et al. (2010) maturity model. A total of 10 interviews were conducted that averaged 72 minutes; the questions were structured according to the categories of the maturity model. The study was done in company 6 (see chapter 3.2.6) and the company was not part of any specific research project (unlike the other companies that contributed to this research). The company is a global company with five production plants worldwide and more than half of the employees are stationed abroad. When considering the whole enterprise it hardly falls under the category of SMME but the focus of the interviews and the research was on the Swedish factory and headquarters. However, it should be noted that according to the interviewees, the Swedish factory had come furthest when it comes to BI support, because the headquarters and the IT department are stationed in Sweden. This paper contributes as an input to research question one as it focuses on the state-of-practice in a manufacturing company and shows that, using the maturity measurements provided by Lavalle et al. (2010), the company is on the first maturity level, but demonstrating a will to increase their maturity.

The paper presents examples of BI usage to demonstrate current state-of-practice. Four areas emerged as the main arenas for BI usage in the company; financial support, planning and prognosis, manufacturing and keeping track of product quality (defect

rates). The main application for analysis was MS Excel which was used by all interviewees. Other applications were also used, but to a lesser degree. These applications were the central ERP system called M3 (Movex), Microsoft Reporting Services and a BI application called Cognos. Despite having a dedicated BI application, the interviewees in most cases preferred Excel for analytical purposes, apart from a product line manager and a division manager who preferred using Cognos reports to monitor production and spot deviations from the production plan.

The findings presented in the article comply with the findings of Lavalle et al. (2010) with respect to what areas aspirational companies commonly use BI. Aspirational companies mainly use BI to support financial management and budgeting, production and operations, sales and marketing. The interviewees stressed the importance of monitoring production numbers as a way to keep track of production costs, but had initiated discussions on how their BI applications could support increasing revenue - for example by analyzing new potential markets or product development. These ideas were more an internal discussion at the time of the interviews without any formal plans or strategy. In most cases, BI was used to look back to see what had happened, and to compare with what had been budgeted. The only instances described where BI was used to guide actions was during production planning, and when Excel was used to calculate the potential costs of larger strategic decisions such as opening a new sales office abroad.

In addition to describing the state-of-practice of the company, the paper suggests using CSFs (Shanks and Bekmamedova, 2012) to guide the BI adoption and to increase analytical maturity, without providing a description of how to achieve the CSFs.

4.1.2 PAPER 2: ON TRANSFORMING INTO THE DATA-DRIVEN DECISION-MAKING ERA – CURRENT STATE OF PRACTICE IN MANUFACTURING SMES

Adding to knowledge on current practice, paper two presents the findings from four SMMEs that were part of the MMC2 project. The companies that contributed to this paper are companies 1 – 4. The paper demonstrates how far the companies have come with BI adoption by providing examples of areas of application. The paper describes the current practices based on the assessment categories of the maturity model by Lavalle et al. (2010). The results of this paper further contribute knowledge on current state-of-practice - thus supporting research question one. The main results indicate that the companies at large are not particularly data-driven when it comes to aspects other than production planning. Other aspects such as using analytics or data to gain new insights concerning their business or processes are not explored by the companies to any large extent.

The main data use was of historical data regarding production for improved production planning. This implies that the companies are in need of support for further utilizing BI to face the coming (and current) Industry 4.0 revolution. The paper further describes BI usage in relation to sales and other related financial activities such as budgeting and following production costs.

The results of the paper reveal that the companies are not particularly data-driven in the sense that data is rarely the foundation for process development, monitoring or measurement or as a way to gain further insights into aspects other than financially related. Given the fact that industry 4.0 is heavily technologically driven, the paper highlights the importance of supporting SMMEs to facilitate BI adoption.

4.2 RESEARCH QUESTION 2: WHAT ARE THE MAIN CHALLENGES FOR BI ADOPTION IN SMMES?

The second research question provides insight into the challenges the participating companies are facing as a way both to understand why they are not adopting BI, and to identify opportunities where BI could be applied. Four papers contribute in different ways to answering this question and to adding to current knowledge on challenges faced by SMEs. Paper 3 has a specific focus on challenges while paper 4 focuses on describing a business development method but still contributes to this question by presenting challenges faced by SMEs in the construction sector. Paper 5 demonstrates how goals and goal modelling can be used to identify challenges that management need to be aware of, and paper 6 describes the process of working with three companies addressing specific challenges of their own choice.

4.2.1 PAPER 3: CHALLENGES WITH BI ADOPTION IN SMES

Paper 3 presents the challenges faced by the four companies in relation to BI adoption, adding to current literature on challenges. Companies 1 – 4 contributed to this research, all in the MMC2 project. The categories presented by Lavalle et al. (2010) were used to set focus for both interview questions and analysis. Challenges in each category were identified and then summarized in a catalogue of primary challenges. The challenges were summarized in the following list:

- Current IT support did not fully support the manufacturing processes
- Limited interest from executives and owners on how to use BI as a decision support
- When IT is outsourced, the companies have difficulties getting the support needed
- Limited knowledge on how BI analytics can support production goals
- Difficulties getting data that requires manual input
- Lack of skills to use BI analytics in general
- Lack of KPIs, with focus on more company specific KPIs
- Lack of skills to see how BI can help increase revenue
- Type of ownership, family owned companies seemed less interested in using BI for decision support
- Risk of data overflow
- Having correct data
- Rely on gut-feeling rather than data

Many of these findings can also be identified in previous literature, for example that current IT support is not supporting the organization. In previous literature this is identified as lack of alignment between IT and company goals and strategy. The limited interest of managers has been identified numerous times in the literature, and that there is a lack of knowledge of how BI can support managers in decision making or to support them to become more data-driven in their decisions. However, some challenges were identified that have not received as explicit attention in literature. For example, they expressed problems getting the support they needed when IT services were outsourced. Although this is not a new problem in IT literature, not much is discussed in BI literature about this problem within SMEs.

4.2.2 PAPER 4: THE SMALLBUILD+ BUSINESS DEVELOPMENT METHOD: FINDINGS FROM A LONGITUDINAL STUDY IN THE CONSTRUCTION SECTOR

This paper provides additional insights into the challenges (research question two) faced by SMEs but from different sector than the other companies contributing to this research. This paper builds on the work that was done with company 5, in the Smallbuild+ project. In this paper an overview is given of challenges from an organizational perspective and change perspective. The empirical data was gathered through workshops and dialog meetings with company representatives. In addition to providing insights into challenges, this paper also provides a business development method that supports changes in SMEs. The groundwork of this paper used the elicitation process (Sandkuhl et al., 2014), and that planted the idea of using the approach for other purposes than process analysis. The elicitation activity had raised interest amongst participants to identify measurements and KPIs´ both within and outside the processes that were modelled.

The paper provides a business development method designed to support SMEs in implementing two types of changes; continuous incremental change and discontinuous periodical changes. At the center of the method is a list of company specific goals. The goals help managers to prioritize between changes that are needed within the company. The continuous incremental changes are considered to be smaller improvements to the company in small increments, while discontinuous periodic changes are larger efforts that often require more resources and organization - e.g. in project form with a specific budget and timeframe. Although this paper was not particularly focused on BI and BI adoption, it still provides an overview of challenges SMEs are facing, and also introduces the use of goals to prioritize and identify areas of improvement. The paper further describes the work of analyzing business processes for optimization, something that is strongly related to the BI area as previous literature has emphasized. Good understanding of business processes is key to getting the most out of BI (Eder and Koch, 2018).

4.2.3 PAPER 5: TOWARDS A GENERIC GOAL MODEL TO SUPPORT CONTINUOUS IMPROVEMENT IN SME CONSTRUCTION COMPANIES

This paper supports both research questions two and three. The paper is based on work done in the Smallbuild+ project with company 5. The paper provides an overview of challenges when working with continuous improvements in SMEs, and provides a generic goal model as a way to address challenges and support continuous improvement. Paper 5 is related to paper four as it describes the next steps that were taken with the participating company after doing process analysis. The goal modelling approach was used to identify possible measurements that could be supported by IT, an important contribution to support BI adoption. Supporting business goals is one of the core concepts of BI, so using the goal modelling approach helped managers to identify what data was needed to be able to measure goal achievement. The paper presents a general goal model that then can be specified and adapted to individual company needs. Identifying goals creates the foundation of knowing what to strive for and what to measure in order to know whether the goals are met. This can therefore be the basis for further BI adoption.

4.2.4 PAPER 6: TACKLING LACK OF MOTIVATION IN ASPIRATIONAL ANALYTICS COMPANIES: SME EXAMPLES FROM THE MANUFACTURING INDUSTRY

Paper 6 presents the results of close collaboration with three companies that were part of the MMC2 project. The paper contributes to research question 2 by introducing a chosen challenge by each company, and contributes to research question 3 by demonstrating how those challenges were addressed. The paper provides detailed descriptions of the workshops and some practice recommendations to help support BI adoption based on the research findings:

- Identify a significant, but focused challenge with a core function/operation
- Establish clear ownership of the improvement process, and involve the important actors
- Choose an appropriate analysis strategy – for example, process, data or decision analysis
- Use a simple modelling technique with a small learning curve and don't insist on modelling technique correctness
- Model the existing operation - note problems and defects
- Identify simple metrics for the operation and make certain that base IT systems support them.
- Identify and implement improvements – use the metrics to follow up the changes
- Celebrate improvements and quick wins.

These recommendations are an important input to research question three that focuses on how companies can address the main challenges. They also contributed to the final framework presented in chapter 6. All the recommendations (except the last one) were later incorporated into the framework.

4.3 RESEARCH QUESTION 3: HOW CAN THE MAIN CHALLENGES BE ADDRESSED?

Three papers contribute to answering research question 3. The papers introduce ways that can be used to address specific problems identified by companies, and through this creating the foundation for the main contribution of this research, and achieving the overall research aim. Choosing a current problem in the organization helped increase interest at management level, thus addressing one of the key challenges of BI adoption. Paper 4 introduces the elicitation approach (Sandkuhl et al., 2014) for process analysis and re-engineering. This approach became an important part of the work that was done in later stages of this research. The work presented in paper 4 created the foundation for the work that was later done with company 1 (see chapter 5.1.1), and inspired the work that became phase 2 and phase 3 in the final framework presented in this research (see chapter 6).

Paper 5 presents the goal modelling approach to help address the challenges of aligning BI with company goals and gaining management support. Translating problems into achievable goals enables measurement of key indicators to see if the chosen action helps in achieving them. The problems are addressed through achieving those goals. Finally, paper 6 presents three problems addressed by three companies, using three approaches. Company 1 used process analysis to address communication problems and information flow issues, and to identify important measurements related to that

problem. Company 2 used the elicitation approach by Sandkuhl et al. (2014) to address data management issues that affected the whole company. Company three also used the elicitation approach to identify decision support that was needed during production line stoppages. An extended description of what was done in the companies presented in paper 6 is provided in chapter 5.

TOWARDS A FRAMEWORK TO FACILITATE BI ADOPTION

CHAPTER 5
TOWARDS A FRAMEWORK TO FACILITATE BI ADOPTION

This section provides an overview on the work that was done with the companies that worked with specific problems related to one of the core concept areas of BI that was presented in Figure 3. The work that was done has already been published in Karlsen et al. (2016), Persson et al. (2015) and Gudfinnsson et al. (2019), but not in direct relation to building the framework since the final framework was not finished at the time of publishing. This chapter therefore synthesizes the work that was done into phases that became parts of the building blocks of the framework demonstrating different activities that constitute the framework with the aim to facilitate BI adoption by addressing some of the challenges identified in chapter 2.

All final versions of the models presented below were done by me. All workshops were facilitated by me except the goal modelling workshop where I participated by taking notes and then later created an updated version of the goal models based on the models created at the workshop. Each company was asked to choose a problem that they considered to be of importance for them before the workshops during pre-workshop dialogs. The images below are sometimes in Swedish, and sometimes in English. This is because some of the work was done in Swedish and some were translated. The process models for example in company 1 were first done in Swedish, but later translated in collaboration with the company to English as they wanted to share the models with their German enterprise owners. The “plastic-wall” sessions (elicitation activity) were done in Swedish, but digital versions were translated to English.

5.1 COMPANY 1: PROCESS IMPROVEMENT

Company 1 manufactures screening equipment for other industries. During the first dialog meeting with managers, they expressed problems somewhere in what they called their administration process. They could not clarify where, why, or how BI or IT in general could help making the process more efficient. It was also difficult to define where the so called administrative process started, or where it finished. They could describe the symptoms, such as confusion in communication or miscommunication, resulting for example in wrong parts being built or parts that are used for building

their product being missing. They did however emphasize that all communication between employees was good, without any conflicts. The work done in company 1 was published in Gudfinnsson et al. (2019).

Phase 1: Problem identification

There were 9 interviews conducted in total, including roles like CEO, sales manager, production manager, IT manager and procuration manager. The Interviews confirmed the communication problems between departments. The interviews showed that the main communication problems were between the sales department, designers and production. Some of the symptoms could be that production workers would weld parts according to a design that had wasn't up-to-date; sales information about specific details of the design was absent - halting the production process; procurement was late or parts missing from inventory because of lack of information. During dialog meetings, a white board was used as a way to further identify where the actual problems were (Figure 8). This included capturing activities, information flow and the key roles affected by the communication problem.

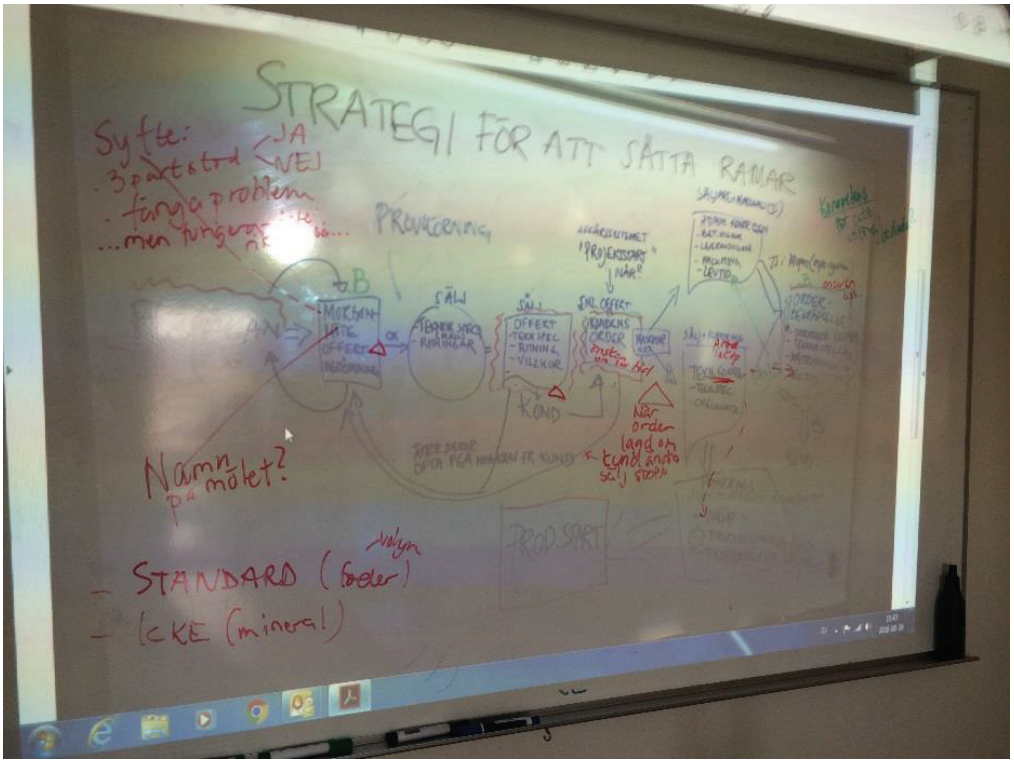


Figure 8: Problem identification at company 1

Participants described the flow of communication from customer contact to production. They also identified the need to set some rules or "boundaries" regarding activities and information flow. For example, they had a meeting every morning called "morning meeting" (the box furthest to the left in Figure 8) where they would give short update on what projects were being worked on. However, some projects that the sales department was working on were not mentioned as it was up to each individual in the sale department to decide if he or she would give information regarding that project or not. As the dialog meetings continued, the focus on communication started drifting more towards analyzing the process from customer contact to product delivery (see an excerpt in Figure 9). That process was named "customer order", and it would start when a contact was made with a customer, and it would end when the customer

received the product. It was decided that the problem understanding phase would focus on analyzing the process to help identify where the communication problems existed and to find ways to improve the process.

Phase 2: Problem understanding

At the beginning of phase 2, dialog meetings were held where a process model based on the whiteboard drawings was updated and corrected using the Visuera modeler[4] tool. Three company participants took part in the initial dialog meetings. During these meetings, the customer order process grew and became more and more complex. It was therefore decided to prioritize specific parts of the process for further problem understanding. Two parts were prioritized; the "Offer process", that would start when a customer sends "a request for quotation" (Figure 10) and end when the role "preparation/purchaser" registered a project in their IT system (Mapaz) and by that initiating the next stage of the process; Production order preparation and planning. Since the first phase of the process focused much on the communication between customer and sales representatives, it was decided that the sales manager would be the owner of that process. The production order preparation and planning process was owned by the production manager.

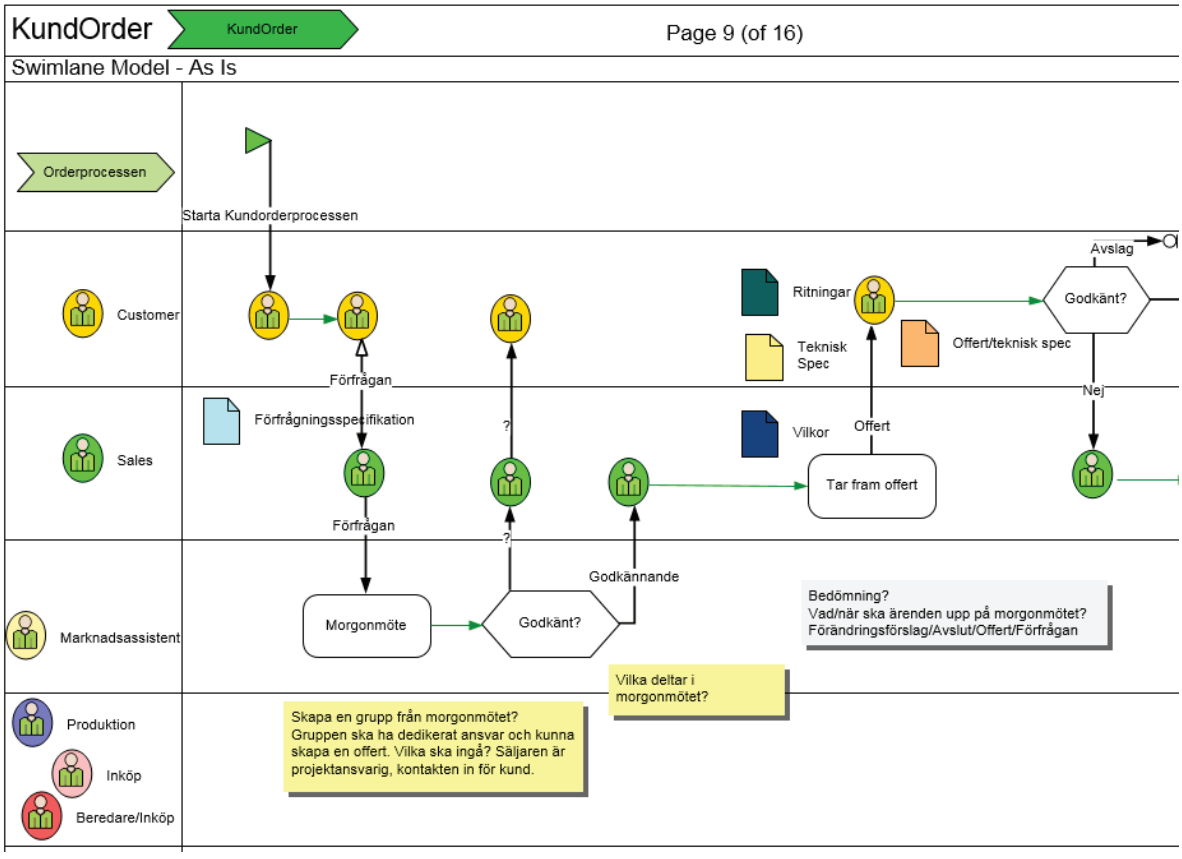


Figure 9: Excerpt from the customer order process

Pre-workshop activities

As a preparation for the main workshop, it was decided to hold a smaller version of the main workshop with five company representatives. These were the CEO, CIO, sales manager, production manager and product designer. Both processes were followed

[4] http://visuera.com/verktyg/visuera-modeler.aspx

step by step, and details either added during the session or written on a note to be added in the process after the workshop. Identifying existing KPIs´ was a bit problematic as the company representatives stated that there were no KPIs´ monitored in these processes. KPIs´ would need to be identified during the solution design. When the workshop was over, the participants felt they had a much more in-depth understanding of the processes and they were satisfied with the outcome. This was confirmed by the production manager who said *"we have tried to do this before, but we always gave up…this is a huge step forward"*. It was decided that the models would be updated according to the notes from the session (by this author) and then there would be dialog meetings where the processes would be updated before the main workshop.

The main workshop

During the main workshop, the updated versions of the process models from the initial workshop were walked through with seven company participants, the five from the previous workshop and two additional members, one from product design and one from sales. The models proved to give a good representation of reality according to the participants, and there were many discussions regarding why things were done in this way and not in another way. Notes were taken, both by hand and by putting notes in the models of potential improvements of the processes. The main workshop help highlights some specific problems that would be the basis for the solution design. Some of the problems that were brought up were that not all projects were presented at the morning meeting, and there was a question if all projects needed to be presented there. It was a bit unclear what documents were sent between employees and when. The communication between sales representatives and customers could be quite ad-hoc, and customers in some cases made changes to offers when they were asked to sign offers that had already been agreed upon. In other words, the company had made an agreement with a customer and sent out a Word document (contract) for signing, but when it came back, some things in the contract had been changed. Finally, the production department frequently needed to stop production and reach out to the sales department for additional information regarding the product they were building. Although some of the problems had been identified earlier, the main workshop helped gain a deeper understanding about the issues and establish a consensus amongst participant regarding the problems. The sales department had for example not realized that a certain document did not reach the production team until late in the process, stalling production planning.

Phase 3: Solution design

After the main workshop of phase 2, the process models were updated according to notes. Dialog meetings were then held for validation until the company representatives agreed that the process models had fairly accurate descriptions on how these processes were performed in the company.

Pre-workshop activities

As a preparation for the main workshop, the suggestions regarding changes were implemented into the models as an initial step to solution design. The production manager, production designer and the CEO participated in the dialog meetings when the models were updated and prepared for the main workshop. In addition, it was decided to conduct another smaller version of a workshop with the same five company representatives again to prepare the solution design for the main workshop. The models were either updated directly during the workshop or notes were taken when there were larger changes needed in the model to save time. Some of the changes that were made to improve the process were the following:

- The morning meeting would change location, from the sales manager office to a new "neutral" location, and would change name to "Project meeting". The purpose of the meeting was made clearer so everyone knew how to prepare and what to expect out of the meeting.
- A checklist would be made to help sellers decide what product requests would be considered to contain products that were considered to be "standard" or if they were not standard. If the offer was for a standard product, the seller would not need to inform about them at the project meetings before moving on with negotiating with the customer.
- Three checkpoints were put in place in the offer process to mark define moments of control, including the maximum number of days to solve each check point. The first checkpoint is for sales to decide the type of request, standard or non-standard. The second checkpoint was at the project meeting to see if the request needed to involve more people to tackle issues such as design problems or if the potential changes were so small that the seller would be allowed to continue negotiating with the customer. The third checkpoint was set when the sales personnel would compare the original offer with the signed offer from the customer. The request would need to pass all the checkpoints before moving forward. Two checkpoints were put in the production order preparation and planning process. The first one during technical specification review and the other one during administration contract review. Both needed to be cleared before moving forward in the process.

The workshop had much focus on the process, but discussions regarding KPIs´ and IT requirements also became an important part of the solution design. New versions of the processes (desired state) were updated according to notes from the workshop and then reviewed at dialog meetings until the solution design was accepted for presentation at the main workshop. During the dialog meetings and previous workshops, discussion regarding the role of IT and potential KPIs´ kept coming up in relation to process activities. These discussions were documented during the modelling sessions (both workshops, and dialog meetings) at the final stages of phase 3, IT requirements and KPIs´ were put forward by managers of four departments for their own departments and some more general for the company as a whole:

Sales office:

1. Improved reporting on sales of spare parts and machines. More thorough reporting on turnover in relation to budget (Hogia)
2. Analyze the number of orders received and orders accepted and produced (Mapaz)
3. Analyze the number of service visits to customer per month in relation to budget (Excel)
4. Service sales in relation to budget (Hogia)
5. Additional sales in relation or as a consequence to service visits (Lime)
6. Number of offers on reserve parts and machines compared to budget, include prognosis for next year (Lime)
7. Actual product costs after delivery (Mapaz)
8. Number of offers sent to customers each month (Lime)
9. Hit-rate on offers (Lime)
10. Follow up on employees budget regarding received orders (Lime)

11. Order analysis, by country and branch (Blåboken, Access database)
12. Number of traveling days for each seller and month, compared to traveling budget (Lime)

Procurement:

1. Inventory value each month compared to inventory baseline for finished products, semi-manufactured products and products currently in production (Mapaz)
2. Register supplier assessment each year (Mapaz)
3. Keep track of new suppliers and removed suppliers (Mapaz)

Production:

1. Estimated production time within each section of the production compared to actual production time in relation to goals (Mapaz)
2. Capacity calculation, number of available production hours (Excel)

Construction:

1. Status report each month, what has been done and what is currently being worked on

All departments

1. Activity plan, capture proposals from all departments regarding continuous improvements (Word)
2. Report unexpected incidents, both verbally at the project meetings, register on whiteboard and in Lime when applicable
3. Report customer visits, 3 days after each visit (template in Lime).

In addition to the requirements and KPIs´ presented above, the production manager added a simple measurement to see if the new process design would increase the effectiveness of communication between production and sales by counting the number of times the production team needed to ask for additional information during the production. The production manager started the counting before implementing the solution to have a baseline.

Changes in both processes mostly involved changes of routines for sales personnel, getting their approval was therefore deemed essential as they were key stakeholders when it came to implement the solution design. Although the sales manager was part of the pre-workshop (and previous activities), it was decided that all of the sales department would take part in the main workshop to ensure their involvement and to capture any views that had not already been expressed earlier by the sales manager.

The main workshop

The main workshop participants included the CEO, production manager, product designer, engineer, sales manager, sellers and the CIO, 9 people from the company in total. The solution design was presented, and each process was thoroughly followed step by step. Some minor changes were suggested, e.g. what the checklist should contain for the sellers and that a routine was needed when sellers were working abroad with customers and could not attend the project meetings. Another suggestion was to combine two documents that are reviewed in the process to one document. The technical specification and the administration contract document. This would help keep all information regarding customer offers in one place.

Figure 10 provides an excerpt from the new offer process presented at the main workshop. The left column presents the involved roles in the process (top to bottom; customer, checkpoint, sales, Lime (sales IT support) and project group. The process starts when the customer contacts sales representative. The sales department then follows new documented guidelines for which projects should be brought to the project meeting, if the request involves a standard machine or a non-standard. Three control points were added (two depicted in Figure 10 to ensure all relevant information was in place and to analyze the request before moving forward. The final outcome of the process is a detailed purchase order from the customer delivered to the production manager, and to the head of procurement as an internal order. Only then would the product be planned and parts procured. The model captured essential components needed to improve the process. It demonstrates activities (oval circles), activity flow (green arrows) dataflow (black arrows), relevant documents (checklist) and decision points (hexagons).

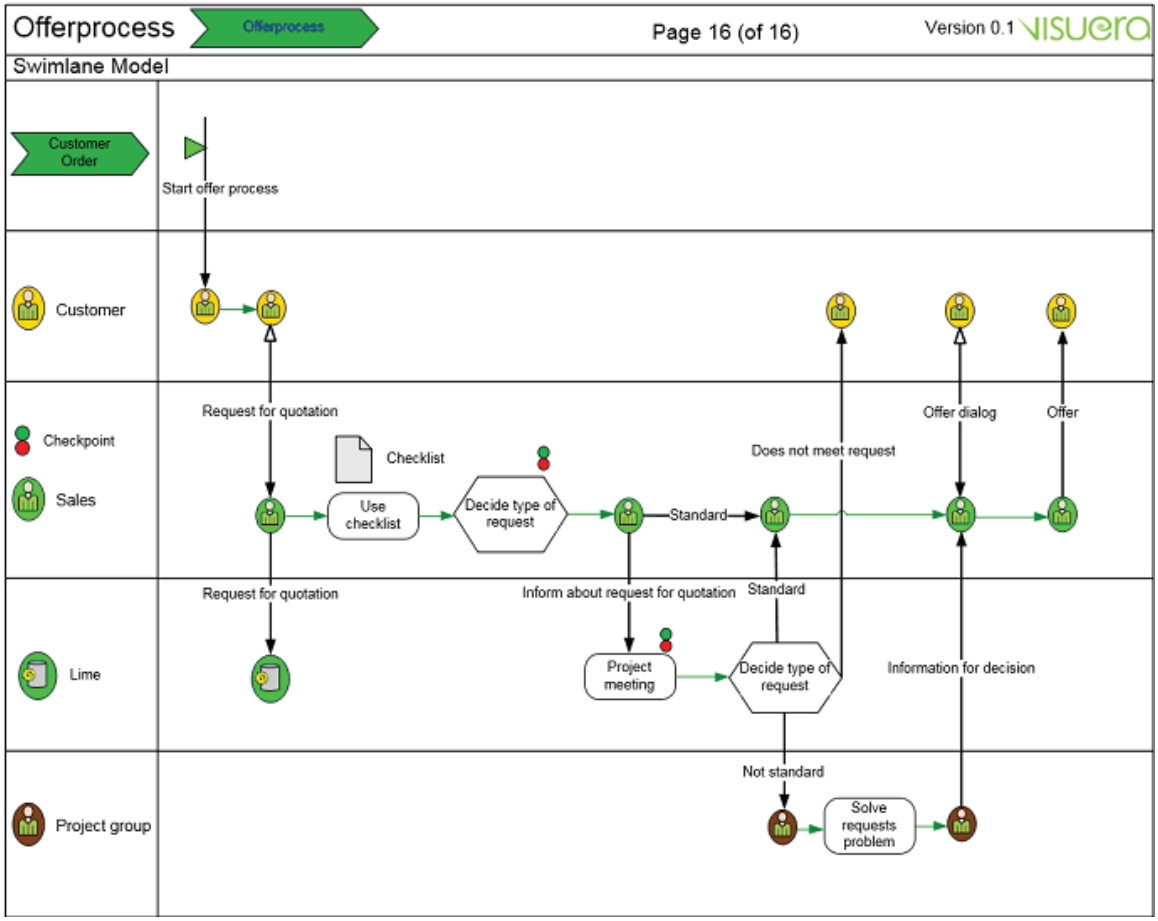


Figure 10: Excerpt from the new offer process

After the main workshop, notes were used to update the models according to the outcome of the main workshop. The updates were however minor. The workshop was deemed successful by all participants, and the involvement of key stakeholders had been secured.

Phase 4: Solution implementation

The managers decided that the new way of working should start on January first the following year. As a way to enforce the new routines, the project meetings were moved

out from the sales managers office to another location, and the process models were put up on a wall in that room for everyone to see. The checklist for the sales department was created and work with combining the two documents, technical specification and the administration contract was carried out by the CIO. The CIO also had the responsibility to contact the system providers to implement the IT changes when the knowledge to do so was not in-house. The production manager who had started measurements before the implementation as mentioned above noticed a significant change in the need to ask the sales department for more information, that number dropped from 20 – 30 a month to almost zero after a month of working with the re-designed processes.

As stated earlier, the company is owned by a large international enterprise group in Germany. During a visit from the German headquarters, the processes were scrutinized. The visitors were very pleased with the work that had been done, and stated that they would like to take a copy of the models to another company in their group located in Spain to implement the same way of working there.

5.2 COMPANY 2: DATA MANAGEMENT

Company two is a family-owned company that manufactures in-car accessories for mobile devices that are sold both in Europe and in the US. The work that was done in company 2 has been published in Gudfinnsson et al. (2019).

Phase 1: Problem identification

The interviews revealed that using BI (or IT in general) outside production planning and standard economic analysis was a low priority, and some interviewees expressed frustration about lack of information or wrong data on all organizational levels. Suggestions for reason were said to be either lack of data or lack of input into the systems by employees. During dialog meetings, the managers stated that they had limited knowledge on how long time a production cycle took and they had no measurements regarding workload on the machines or work cycles in different departments. Absence of information made planning, component assembly, production design and measurements difficult throughout the company. Employees in the assembly line explained that they sometimes lacked plastic components for assembly because component manufacturing information was unreliable. In addition, the sales personnel described how they sometimes promised to send a certain number of accessories (finished products) to a customer but when they went to get the products from storage, the amount of products in storage didn´t match with the amount provided by the information system. Workers producing plastic components sometimes consulted the company webpages to supplement poor design data. However, when the issue of data management problems was raised during dialog meetings, the CEO reassured that this was not that big of an issue, there were other problems that needed to be addressed such as timing certain operations and making sure that priority orders actually were prioritized. According to the CEO, the most important thing for the company was production speed and agility. As soon as a new mobile device was released or a new car model presented somewhere in the world, they would be the first company with an in-car solution. In addition, they had one customer serving the US market that accounted for half of all sales and therefore had priority over other customers when it came to production.

As a way to overcome the problem with missing components or wrong number of components in their systems, the company significantly overproduced plastic components to make sure they had enough inventory for assembly. The managers understood that

this strategy was not sustainable, but it was the easiest solution to the problem. However, during interviews with the employees, it was evident that this strategy was not solving the problem as people could still not rely on the numbers in the systems. Both in terms of plastic pieces for assembly, and for the number of final products. This was discussed during dialog meetings with the managers, and it was decided to focus on data management, particularly on information needs from an employee perspective. This approach was deemed to help identify how the production could be more efficient by increasing speed and agility in the production lines by identifying what information was needed to be able to increase productivity.

Phase 2: Problem understanding

Dialog meetings were held with the production manager and the CEO to try and find the source of the problems brought up during the interviews. It was decided to use the elicitation activity of plastic walls and paper notes to identify roles and their information needs. Following the checklist from Sandkuhl et al. (2014), the scope and purpose of the upcoming workshop was identified along with key stakeholders.

Pre-workshop activity

As a preparation for the main workshop, a smaller scale workshop was conducted both to get management view on what information was needed by different roles and also to try out the elicitation activity using plastic wall and paper notes. A simple information requirements approach was used and the workshop was facilitated by me. Colored sticky notes were used to represent stakeholder roles (sales manager, assembler, sales, logistics etc.) and data requirements. The participants were asked to write down roles on white paper notes and then what information they thought each role needed to conduct their work on a yellow paper note.

The simplicity of the approach evoked some negative body language at first from the CEO - however the production manager became immediately engaged and hesitation disappeared as he started writing down information need for himself. This prompted the CIO to be more active, providing valuable insights into information needs of different roles. Figure 11 displays the results of the workshop. Roles were written on white notes, information needs on the yellow notes and the blue notes where used when they wanted to capture important decisions made by the roles in relation to the information need. The workshop was declared a success and a green light was given for the main workshop with both formal and informal leaders, and representatives from all departments.

Figure 11: The plastic wall from the practice workshop

The main workshop

The main workshop was initiated by the production manager who described the purpose of the workshop and the overall project (MMC2) the workshop was a part of. This signaled a clear ownership of the workshop, project and the task at hand. The total number of participants was 12, representing all departments of the company. Then the elicitation activity was explained and how the paper notes should be used. In the beginning, there was a small hesitation amongst some of the employees but the production manager lead by an example and started putting up notes on the plastic wall. He encourage others to follow and they started writing down their own information needs on paper notes. Within few minutes, the plastic wall was covered with notes of both yellow and white (Figure 12). Moreover, a new plastic wall needed to be added because the notes kept coming.

When the participants were finished writing, they were given the opportunity to elaborate on what they had written on the notes. Slowly the discussion stated leading towards a problem common for many roles, the information regarding inventory. It became evident that having wrong figures affected most roles within the company in one way or the other. The sales personnel couldn't rely on the numbers of products in inventory, the assembly line couldn´t rely on the number of components, the packaging couldn´t rely on the number of finished products, the production planner didn´t know exactly how many components were in inventory when planning production, the sawing department could not rely on the number of components they needed to make and so on. Everyone that took part in the workshop was affected by this problem in one way or the other to the surprise of the CEO. During the meeting he stated "*I knew the numbers were not totally correct, but seeing how this effects the whole organization is a real eye-opener*". Another issue emerged as well as a huge factor for inefficiency in production. When the company received orders from their US customer, it would jump the production queue, requiring all production to be rescheduled. This single customer bought about 50% of all products so their orders had highest priority. The outcome of the workshop spawned an interest in starting measuring the effects of the identified problem. There were no existing KPIs´ that could shine a light on how much effect on production these problems actually had, but it was clear during the workshop that every role was affected.

Figure 12: A plastic wall from the main workshop for simple information analysis

After the main workshop, dialog meetings were held to evaluate both the workshop and the outcome of the workshop. The managers expressed their contentment and felt they had much better insights on what was going on in terms of information flow and information needs within the company. They also expressed to some extent their surprise of the outcome of the workshop, particularly regarding the magnitude of the effects incorrect inventory data had on many departments in the company. They were aware of the problem regarding the US orders, but that was a priority set by top-level management and owners. The workshop had though spawned an interest to measure the effects of these disruptions.

Phase 3: Solution design

As a starting point for the solution design, required KPIs´ that would help capture the effects of the data management issues that were identified. A measurement was started that would count how many times employees in the assembly line noticed that the numbers of components in the storage system was wrong. The production manager would count how many times he needed to make changes to the production plan and the sawing department would count how many times they needed to throw away carved plastic pieces because the design was changed without their knowledge. The measurements were done during three months and collected in an Excel document. The results are presented in Table 10:

Table 10: Results from measuring production disruptions

Month	Wrong number in storage	Change of production plan	Change of design
December	80	100	25
January	92	64	18
February	111	38	20

According to the production manager, the numbers could even be higher as not all personnel participated in the measurements. It was decided to prioritize the assembly line as it was seen as a central hub in all of the production and the division mostly affected by wrong inventory status and changes of production plans. Changes of design had more impact in the sawing department where machines are used to carve out plastic pieces before they reach the assembly line.

The previous workshop had helped identify the symptoms of poor data management and information flow. The measurements done by the production manager confirmed that there were many disruptions each month affecting the productivity. He also stated that after realizing the effects the changes of production planning had throughout the company, he was going to re-design the planning process to try and reduce the effects of incoming orders from the U.S. Both the CEO and the production manager expressed the need to incorporate BI more into their business to help them get more data on what

was actually happening within the company. The importance of having correct information and to measure disruptions showed them the importance and potential opportunities of utilizing BI and IT in general.

Pre-workshop activity

To help with the solution design, it was needed to get more input from the personnel working in the assembly line so additional interviews were scheduled, 7 in total. In addition, a three hour observation at the assembly line was conducted (by me) to gain a better understanding of what had been described as problematic during the interviews and in the workshop. The goal was to try and identify why there was such a mismatch of information in the company systems and what solutions were suggested. Additional interviews and the observation also invited the personnel to be a part of the solution design as they were key stakeholders.

During both the interviews and discussions in relation to the observation, some examples of day-to-day problems were reported, here are some examples:

1. An order is made for 1000 components. These are made in machines, but due to emphasis on fast delivery, the assembly line personnel goes and picks up parts of the batch before they are all finished (e.g. 300). That is not registered in any IT system, so when the machines are finished, the amount of pieces registered in storage is 1000, and not 700. This can mean that the inventory status can at some point show -300.
2. A product can be assembled with 5 pieces of component A, 5 pieces of component B and 5 pieces of component C. If two of components B break during assembly, two new are retrieved from storage, making it 7 of component B, those additional 2 are not registered as being taken from storage.
3. When new products are being developed, the product developers sometimes update older versions. They then retrieve older components from storage for testing and development, which is not registered in any system.
4. A product is made out of three components. Two components are found in storage so they are brought to the assembly line. Because all of the components were not taken, the two are not registered, so according to the system, those two are still in storage. When those two are then not located by another worker at the assembly line, an order can be made to make those components in the machines.
5. If assembling a product required three separate work activities and the employee took components and performed activity one, it was not possible to register in the system that one a part of the assembly was finished, so the components used in that activity could not be drawn from the inventory status.
6. An interviewee provided the following example:
    - The sawing department reports that they have carved out 168 components
    - The assembly line reports they have assembled 160 components
    - Each component is drilled with one hole, the personnel responsible for drilling report they had drilled 200 holes. How is this possible?

The main workshop

The results of the problem understanding workshop, additional interviews and the observation were the foundation for designing solutions. The input from the personnel

was deemed adequate by the CEO and the production managers so the workshop only contained those two, me and the MMC2 project leader. Most of the workshop was about addressing the points given above, but other solutions were addressed as well. The following IT requirements were identified:

- The system needs to be flexible so parts of orders or products can be registered
- Inventory status lower that zero should not be allowed in the system
- When registering components, the system should ask if any components broke during the assembly and provide opportunity to register that
- Access roles need to be updated, product designers should not be allowed to retrieve components from storage without permission.
- Both activities and components should be able to be flagged as "work in progress" when parts of a full assembly is being done.
- Implement product categories in the system, big sellers and small sellers to help decide what components are produced for storage
- Improve measurements regarding quality and delivery precision

The production manager also changed the production planning process to minimize the disruptions of the U.S orders. About 50 % of production capacity was dedicated to U.S orders and the sales department was more involved with the planning. The production manager described the situation like this *"We have had many discussions after the workshop, what are the consequences of prioritizing a customer? I prioritize something that needs to be delivered in two weeks, but if I get orders that need to get in next week then it doesn't work, the planning just doesn't work!"* A closer collaboration with the sales department would help with the planning so that larger orders could be fitted more in line with smaller orders. It was also decided to add a new role in the assembly department, a "picker" or as they called it "*plockare*". This person would look at the incoming orders, and then get the components for the assembly personnel so they would not need to look for them themselves.

Phase 4: Solution implementation

The company contacted their systems providers regarding implementing the new IT requirements. The role of a "picker" was implemented, and according to the production manager, this had a huge effect on the inventory status and efficiency. The productivity in the assembly line had increased by 20 % according to the production managers. Now employees always got the right amount of components, and they didn't have to go around looking for missing components. The delivery precision had also increased, from between 64 % - 67 % to about 85 %. The close collaboration with the sales department had also had very positive effect on the production planning.

At the final dialog meeting with the CEO and the production manager, they explained that the work that had been done in the MMC2 project had major effects on the company, and that improvements were continuously being made as an effect after the project. A nice ending to the collaboration was done by the production manager when he said *"but it all started with these two"* pointing a finger towards me and Lena Aggestam, the MMC2 project leader.

5.3 COMPANY 3: DECISION SUPPORT

Company three is a family owned company that produces bookshelves and is a subcontractor to a large Swedish furniture company. The work that was done in company 3 has previously been published in (Gudfinnsson et al. 2019).

Phase 1: Problem identification

Interviews revealed that the company was already using BI to some extent, for example by real-time monitoring of production output and quantifying truck deliveries. Initial discussions with managers therefore revolved around using existing data and analytics to better support decision-making on all levels of the organization. A variety of potential areas for additional decision support was put forward during the interviews and during dialog meetings with production manager, internal business developer and head of production technology. For example, the procurement department would benefit from better decision support when buying manufacturing raw materials. An example was given where a simple thing as buying few tons of a new type of glue for a better price still required adjustments in the production lines. The questions that arise are therefore, is it worth it to spend hours or days adjusting the machines and buying the cheaper glue, or do we buy the more expensive glue and continue as normal? The glue could be substituted as an example for many other raw materials used in the production. Another area that would benefit from additional decision support was in the production. They had five production lines that were used 24/7. According to the company representatives, they produced about 170.000 products per week, but they could be much more efficient. The production lines were stopping, they needed maintenance and adjustments every day. Deciding on what production lines to focus on for maintenance, what lines should be adjusted or how to minimize stoppages were few of the areas that could use much better decision support. Although procurement, logistics and packing among other functions within the company were important, the core of the business was in the manufacturing part. It was therefore decided that the function in focus would be production and the production manager a problem owner.

Phase 2: Problem understanding

In a company at this size, that manufactures this amount of products each week, many people are involved in the production process. To be able to capture a broad view regarding decisions that needed additional support, it was decided to use the elicitation activity of using plastic walls and notes. The checklist from Sandkuhl et al. (2014) was followed, workshop purpose and scope was set and stakeholders identified.

Pre-workshop activity

As a preparation for the main workshop, a smaller scale workshop was done with four company representatives. Production manager, representative from the IT department, internal business developer and the head of production technology. A stack of paper notes were provided to all participants of different colors. Blue notes represented what decisions needed support, yellow notes for what information was needed to make that decision and white notes represented the roles that made that decision. The results are presented in Figure 13.

Figure 13: Plastic wall from the first workshop at company 3

The workshop capture some important decisions that needed additional support. This included for example support in finding the right components for a machine, help deciding what production line should be turned off for maintenance, support identifying the optimal number of operators working in each production line, decisions regarding what activities can be done to reduce set-up times in the production lines and support in deciding what actions to take to reduce stoppages in the machines. After the workshop, a dialog meeting was held where the workshop was evaluated. The participants were content with the workshop, and the elicitation activity so it was decided to move forward and schedule a larger workshop which would include different level managers in the production lines. A list of 12 stakeholders was made and they were contacted by two of the management representatives.

Main workshop

All 12 stakeholders that were contacted to participate in were able to attend. Four of the participants had also taken part of the previous workshop. At the beginning of the main workshop, the production manager presented the project and the purpose of the workshop, emphasizing his ownership of the problem and the workshop. The workshop then followed the same procedure as the previous workshop with the smaller group, using notes and a plastic wall (Figure 14). Same colors were used as before, blue notes for the decisions, white for roles and yellow for the information needed to make the decision (Figure 16). The decisions that had emerged during the previous workshop quickly became the focus of the main workshop as well even though they were not suggested by anyone attending the previous workshop. Two general decisions got the most attention; decisions on actions that reduce production stoppage and decisions regarding how to choose the correct activities that reduce set-up time in the machines. As the workshop went on, the participants agreed that the focus should be on supporting decisions regarding what actions can be taken to reduce production stoppage. For a company with five large production lines, this was seen as highly important.

Figure 14: Preparing for a workshop

As with most SMME's, frequent stoppages affect the efficiency of many of the company's functions, not only the production lines. Some of the affects were discussed, for example packaging and logistics. To be able to deliver this amount of products, trucks were constantly arriving to the factory for pickups. Stoppage cause analysis can be complicated as expressed by one of the participants: *"when looking at one side* (of a bookshelf) *we might notice there are some assembly holes missing - is that because the drill broke or because a screw got loose?"* – expressing the need to have more precise data. During the workshop, indicators and information were also identified related to the decision (Figure 15).

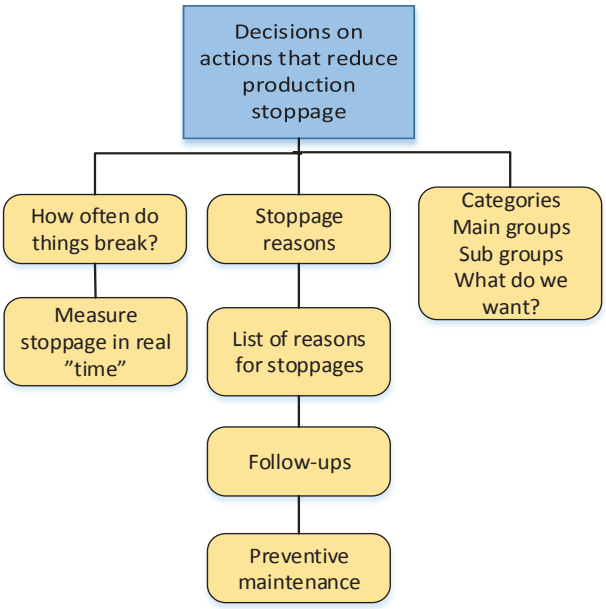


Figure 15: Stoppage action decision and data needs

When asked about existing KPIs´ related to this problem, the workshop participants explained that each operator had an IPad where they could register each stoppage. However, the list of possible reasons for stoppage that needed to be chosen in the system was long and the registration was poor. Some even hinted that operators would register a stoppage as a "machine cleaning" activity to reduce the amount of stoppages hours in their production line. The registration process needed to be evaluated to get better data on stoppages. A digital version of the plastic wall was created (Figure 15 depicts the specific focus area and Figure 16 the plastic wall) where the white notes where left out as the problem identified involved all roles according to the participants of the workshop.

Figure 16: The plastic wall from the main workshop at company 3

After the main workshop, a dialog meeting was held to evaluate the workshop and the output. The managers were happy with both the outcome and engagement level of the participants. Most of the workshop issues were known, but it helped to develop a common understanding of the problem complexity. Although most of the participants had been aware of the issue, the workshop had demonstrated how widespread the effects of these stoppages could be for everyone.

Phase 3: Solution design

The main workshop had produced further insights regarding potential support to reduce production stoppages. The outcomes were analyzed with the production manager and the business developer to set the frame for solution design. A number of KPIs´ and IT requirements were identified, required KPIs´ were the following:

- Statistics on the number of times production lines stop
- Statistics regarding how often different modules of the production line break
- Statistics showing what components of the production line are more prone to stoppages
- Statistics on production cycles
- Data showing the difference between possible capacity and actual capacity
- Actual stoppage time compared to real stoppage time
- Stoppage time calculated in money

- Statistics on most frequent types of stoppages

In addition to adding KPIs´, new requirements for the IT systems had emerged as well:

- Better registration form to register reasons for stoppages
- A link between the production system and maintenance system
- Produce a list of stoppage reasons
- Suggest preventive maintenance
- Create categories of stoppages, main groups and sub-groups to facilitate registration
- Reports summarizing stoppages with respect to stoppage time and frequency

Every morning, there was a meeting at the company (called morning meeting) where production line managers and other key stakeholders in the production would discuss various aspects of the production. As a way to emphasize further the importance of analyzing stoppages, it was decided that stoppages registration would have a more specific focus during the morning meetings. The production manager would be able to have a look at the IT system before each meeting to review all the stops that had happened during the day before, and during the night. As a way to measure how well these stoppages were registered, these measurements were proposed to be addressed by each production line responsible during the morning meetings:

- The number of stoppages not registered in the system before the morning meeting (but are brought up during the morning meeting)
- Number of recurring stoppages
- Number of stoppages that should have been brought up earlier
- How many stoppages are longer than 15 minutes
- How many stoppages are less than 15 minutes

At this point, the production manager and the business developer were content with what the workshops had produced, and the proposed solutions to help increase understanding regarding the stoppages. The morning meeting would play a central role regarding follow up on both registrations and reporting's of stoppages. Key stakeholders participation would be ensured as the production line responsible would report on stoppages every morning.

Pre-workshop activity

After the initial solution design during the following dialog meetings, the focus started shifting towards supporting operators when making a decision on what to do after finding out what the reason for the stoppage was, or as expressed by the production managers *"Ok, now we know this* (the reason for stoppage) *but what happens now? That is what they* (the operators) *are thinking about. It can be a decision on doing nothing, but you still need to communicate that"*. The operators needed some support that would help them decide how to move forward with different types of incidents causing stoppage. In many cases, production leaders were not aware of breakdowns when they arrived at the morning meeting. Sometimes because the incidents had not been registered, but sometimes because the operators had contacted the maintenance department directly without letting anyone else know about the stoppage. This could affect other parts of the production chain with serious consequences. In most of the

cases, the operators were not sure who to contact in what circumstances. It was decided to have a specific workshop where the focus would be to support operators in deciding on how to communicate stoppages as this was seen as a major issue.

The main workshop

The production manager, business developer, me and the project leader for the MMC2 project participated in the workshop. A whiteboard was used to draw a simple model to help understand the flow of information and possible communication paths from the point of view of a machine operator (Figure 17). The modelling exercise showed that the operator had seven different communication paths, and it was up to each individual operator to choose who to contact regarding any type of stoppage. Two problems were identified that needed a solution. First, the operators needed support to make a decision regarding communication, second, the receiver of that communication needed to report about the stoppage in a way that it could be learned from.

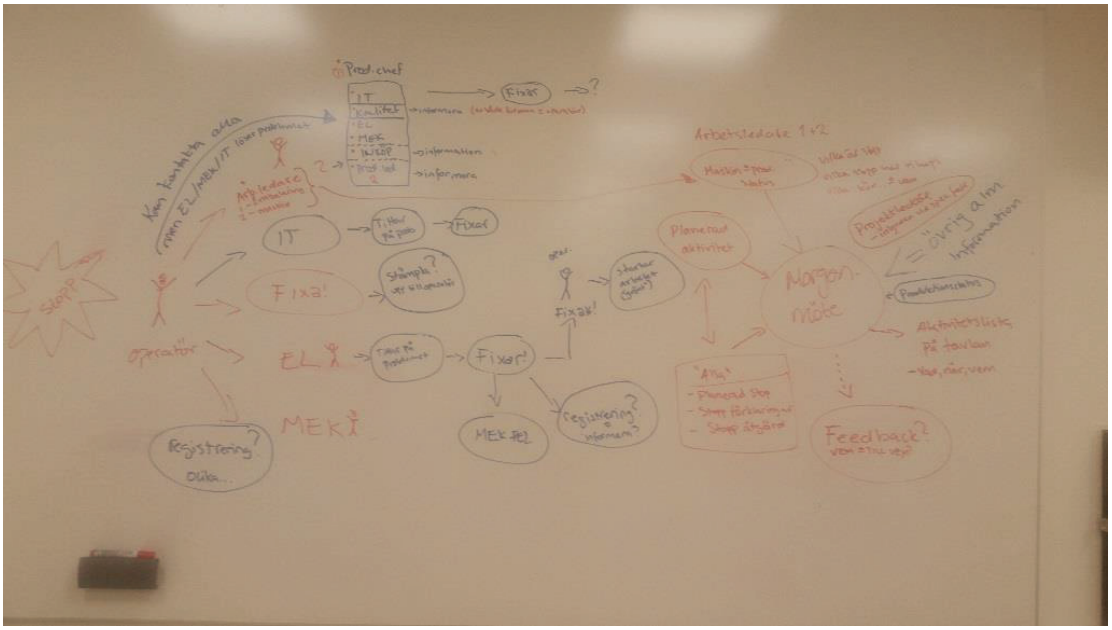


Figure 17: Communication paths for operators

For the solution design for this problem, the managers provided a set of rules for communication paths for operators, supervisors, production line managers and production manager, including three escalating categories of stoppages: quality issue, failure (halts the line) and security risk. The rules stated, for example, that if there is a security risk, contact work leader. When something breaks and it takes less than 15 minutes to fix there is no need to contact anyone. If it takes more than 15 minutes, contact maintenance. The work leader should always be contacted if stoppages take more than 30 minutes.

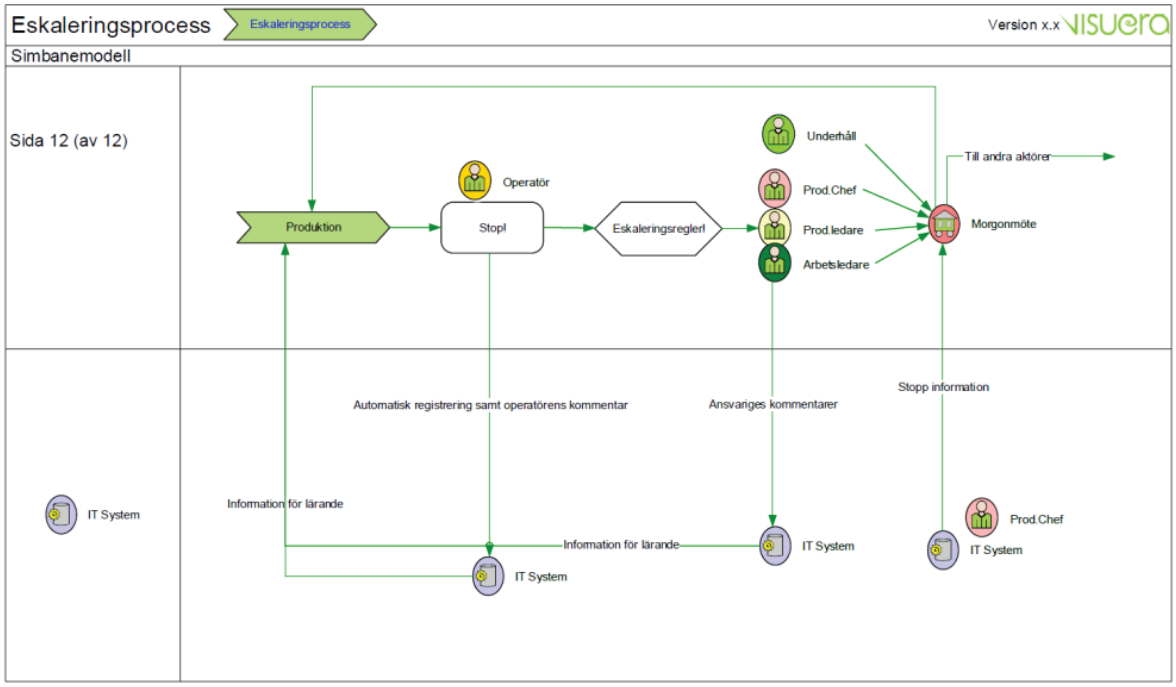


Figure 18: The escalation process

The stoppage would be registered in the central production system so that it could be addressed during the morning meeting. A simple process model was made to show the general idea (Figure 18). The model shows that from the production process comes a stop that needs to be handled by the operator. Depending on the stoppage, the operator contacts one of four roles, maintenance, production line manager, production manager or the work leader. The stoppage is registered in the IT system, with comments from the operator. The role that received the communication then can access the system and add comments that explain what happened during that particular stoppage and what actions were made. This is to support the possibility of learning from previous stoppages. Figure 19 is in Swedish as it is the original model and the company expressed no need to translate the models to English.

Phase 4: Solution implementation

To be able to support the operators on making decision on who to contact when there was a stoppage, the escalation rules were added as IT requirements. During the morning meetings, one of the production line managers brought with him a computer to compare the stoppages that were brought up during the morning meeting with what had registered in the system to help enforce the new routines. In addition, every two weeks, the production manager specifically reminded everyone at the morning meeting to register stoppages, resulting in a significant increase in registrations. Following up on stoppages was easier now because more of them were registered and it was now easier to identify stoppages that were not registered. The measurements showed a significant drop of unregistered stoppages. Other IT requirements and KPIs´ were being implemented when the MMC2 project came to its end.

5.4 COMPANY 5: GOALS

Company five is a Norwegian construction company that manufactures wooden house components (mostly outer walls) in a factory. When the walls have been constructed, they are transported to the building site for assembly. The company was part of the Smallbuild+ project which mainly focused on creating support for business development for small and medium sized enterprises. As a part of that project, processes in the company were analyzed and re-engineered. That part of the project has been published in Karlsen et al. (2016). Following the process analysis, the company representatives expressed their need to identify additional metrics to what they had identified during the work with the processes. Identifying goals and conducting a goal modelling session was used to help achieve that. The goal modelling has been published in Persson et al. (2015).

The Smallbuild+ project was conducted before the framework described in this work only an idea. However, many of the ideas that the framework builds on stems from that work. This means that the guidelines and recommendations in each phase was not followed as well as with the other companies. The following section provides an overview of the activities done in relation to the framework.

Phase 1: Problem Identification

Initially the dialog meetings were held with the CEO and the onsite manager. Both were relatively new at the company, and the prioritization up to this point had been to put out fires and keep the business running. They described problems they were facing and the complexity of the house building process during dialog meetings. They explained, that when building a house, many documents and permits need to be signed and approved by authorities and payments secured but this was not always as simple as one would think. They provided an example that although extreme, did actually happen. A seller had sold a new house to be built at a new area in a small town. The company built the house according to contract, and assembled the house on location as promised. When the walls were up, and the roof in place, they got the message that the municipality had not yet approved to put a road to where the house was built, resulting in a bad situation for both the customer and the company. Another problem at the company was that there was little oversight over many economic aspects of the company. To keep workers busy, and secure income, the company had been focusing on getting more and more housebuilding projects. They had realized though that when you have many on-going project, it strains the company economy, especially cash flow. Much of that had to do with the fact that customers only pay a small portion of the building costs during the building period itself. Most of the payments were done when the house was delivered. This meant the company needed to finance much of the materials and labor costs for up to a year before receiving payments. This resulted in that the company was on the brink of bankruptcy, despite having many housebuilding projects. It was clear that many factors were at play, but they were not sure why the company was not doing as well as they thought it should be doing. As mentioned earlier, both the CEO, and the onsite manager were relatively new at the company. The initial problem identification phase resulted in the conclusion that there was a clear need for a more in-depth understanding of how the company was actually doing. During dialog meetings with the CEO and site manager, it was decided to use goals as a way to get a better problem understanding, and to help identify KPIs´ and other important aspects that they felt needed more attention.

Phase 2: Problem understanding

Identifying goals would help highlight important aspects of the company, and cater for identifying measurements in relation to the goals. If they knew what goals needed to be achieved, they could measure them to see if they actually were achieved. The two managers had different roles in the company, and therefore had the responsibility to focus on different types of goals. The CEO was responsible for economic aspects of the company while the onsite manager had more focus on day-to-day managing of the company. It was decided to have two prioritizations; first more specific economic KPIs´ as it was felt they needed special attention, and then more general goals for the company.

Workshops

Since the work in the Smallbuild+ project had previously been focusing on analyzing various process in the company, it was decided to walk through the process models step by step and use them to identify points in the processes that could be transformed into goals. Workshops were held where both the CEO and the on-site manager were present, but also with each of them individually and then with different focus. Notes were taking during the process walk-through to document the goals.

Table 11: Examples of goals from company 5

Goal n.br	Goal description
1	The goal is to have a visual overview of indirect costs
2	The goal is to have a visual overview of direct and variable costs
3	The goal is to have a visual overview of the organization cash-flow
4	The goal is to have a visual overview of equity in relation to the company total capital
5	The goal is to have a visual overview of the company results before and after taxes in relation to turn-over
6	The goal is to be able to create scenarios regarding effects on cash-flow based on business decisions
7	The goal is to have prognosis for cash-flow, direct costs and indirect costs for the next 6 months
8	The goal is to have a company result of 5 % of annual turn-over after financial costs, but before taxes
9	The goal is to have company working capital twice the size of short-term debts
10	The goal is to have a profit contribution of 20 % or more

After analyzing the processes, the CEO provided additional common goals from the construction sector experience. According to the CEO, although the data existed in company IT systems, not many KPIs´ were currently being extracted or used at the company. The workshops produced both directly measurable KPIs´ and more general

goals related to economic aspects that could be used as bases for IT requirements. Table 11 provides an example of 10 goals that had more economic focus from both IT requirements and KPI perspectives.

The workshop that was conducted with the on-site manager produced a list of more general goals that focused more on what the manager felt was important for him while running the business and general goals for the business as a whole. These goals included for example the following goals:

- The goal is to earn money on the business
- The goal is to have satisfied customers
- The goal is to have sustainable economy
- The goal is to get early warnings of threats to sustainable economy
- The goal is to be able to pay debt when payment is due
- The goal is to have efficient processes
- The goal is to have efficient information flow
- The goal is to have clear roles and responsibilities

Phase 3: Solution design

The first set of the new IT requirements were based on economic goals. The list of goals made while working with the on-site manager were synthesized into goal models where relationships between goals were shown. Two examples are presented below, the model content is in Swedish as they were originally.

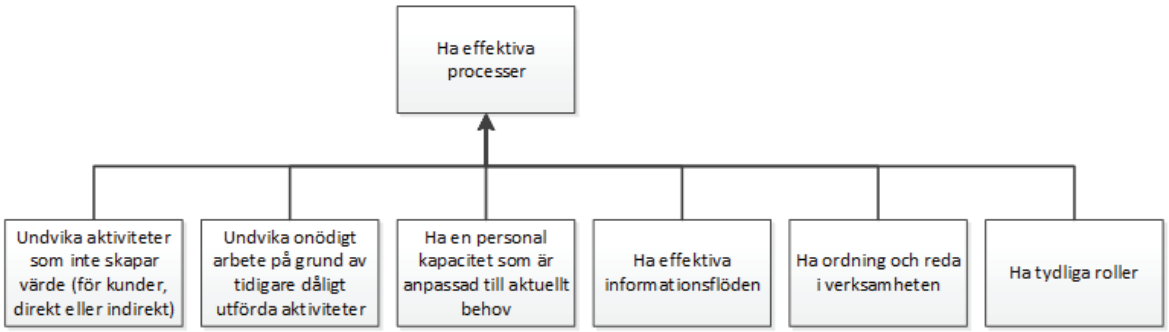


Figure 19: The goal of having efficient processes with sub-goals

Figure 19 shows (in original form, hence the Swedish) the overarching goal of having efficient processes. Six goals were identified that would contribute to achieving that goal. Those activities are:

- Avoid non-value creating activities (for customers, both directly and indirectly)
- Avoid unnecessary work because of poorly conducted activities
- Have the right staff competence according to current needs
- Have efficient flow of information
- Have things in order in the business
- Have clear roles

The second example is the goal of having satisfied customers (Figure 21). That goal has three sub-goals; have the capacity to deliver on time according to contract, have the

capacity to deliver quality according to contract and to have the capacity to deliver according to contracted price.

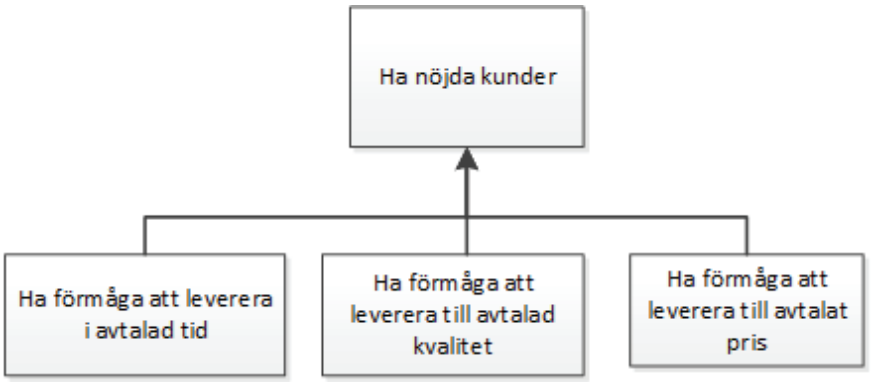


Figure 20: The goal of having satisfied customers with sub-goals

Phase 4: Solution implementation

All IT was outsourced to another company, so the IT requirements were communicated to the IT host. The manager used the goal models as guidance in his work as site-manager and presented the goal models at a staff meeting. The goals were color coded (green-yellow-red) to visually present current prioritization. Red goals were goals that needed immediate attention, yellow needed to be monitored carefully and green meant that the goals had been achieved. This helped employees to see what was deemed as prioritized by the manager. The goal models were printed out and put up on a wall for all to see. Same was done with the process models that had been done earlier in the project (Figure 21).

Figure 21: Models made visible to help enforce new routines

The goal models that were created were later used as a foundation for creating a digital tool for managing and keeping track of goals (Gudfinnsson et al. 2017) in collaboration with the company and Aalesund University.

A FRAMEWORK TO FACILITATE BI ADOPTION

CHAPTER 6
A FRAMEWORK TO FACILITATE BI ADOPTION

This chapter describes the framework that is the major contribution of this research, aimed to address challenges previously identified in literature and to make use of learnings from participating companies to facilitate BI adoption in SMMEs. Various terms are used when conducting research and to describe research outcome and contributions. Terms like taxonomy, framework, typology and conceptual models are frequently used, even interchangeably (Power, 2001). According to Power (2001), frameworks provide an organizing approach to show the parts of a topic and how the parts relate to each other. In this research, the scientific problem is to identify challenges with BI adoption and suggest a way to address these challenges to facilitate BI adoption. The outcome of the research includes various parts and phases that are related in a specific way. Therefore, as a way to present the outcome of this research, the form of a framework was chosen to organize the different parts and actions suggested to address the scientific problem.

The framework shows how each part is connected and what actions are required within each part to achieve the goal of facilitating BI adoption.

6.1 DERIVATION OF THE FRAMEWORK

This section provides a discussion on where the different parts of the framework stem from and why they are needed. According to Morris (2003), users have higher acceptance towards new technology if they see a clear benefit in their day to day work. By demonstrating a clear benefit, the interest for further exploring the use of new technology might rise accordingly. Building on this notion, the framework was designed to provide support and raise interest for utilizing BI by demonstrating potential benefits. During this research, interviews revealed that the participating manufacturing companies were closer to aspirational maturity level, or even pre-aspirational level according to the Lavalle et al. (2010) maturity model and the framework takes that into account when guiding where to begin.

The focus of the participating companies when it came to IT or BI usage was mostly connected to the production part of the company with focus on lowering costs and reports or analysis were mainly used for looking back at what had happened to justify

actions. In addition, the interviewees expressed limited interest in additional IT support in other functions than production and conveyed uncertainty regarding how BI or IT in general could provide further support in other areas. One of the reasons mentioned was lack of knowledge on how IT or BI could provide additional support, a common problem identified in the literature. As a way to address the lack of motivation and knowledge on how BI could additionally support various functions of the organization and facilitate BI adoption, the framework addresses this challenge in phase one (of four phases) by asking its users to start looking at specific functions within the organization provided by Lavalle et al. (2010) to identify a specific problem. Although the maturity model of Lavalle et al. (2010) was helpful as a lens to analyze the organizations, it was not as helpful to guide forwards or as a tool to raise interest amongst managers. The companies were so focused on their primary function (manufacturing/production) that when asked about other categories in the model or application areas, their answers were rather limited and often referred to lack of knowledge on what to do, and how. However, the maturity model does provide information on what areas aspirational companies are using BI, and those areas are where the problem identification starts.

After looking into the areas suggested by Lavalle et al. (2010) the framework makes use of the core concepts derived from the BI literature. A consolidation of the core concepts was presented in chapter 2 (Figure 3) and in the framework these core concepts are used to categorize the problem within the chosen function to link the problem identified with what BI supports. This supports identifying an actual business problem, identified by managers to what BI can support and sets the frame for upcoming activities in the next three phases of the framework.

Figure 22 depicts the theoretical origin of the components within phase one. Even though the smaller images are hard to read, they should be recognizable from previous sections of this thesis. The image with an arrow pointing at the functional proficiency box derives from the maturity model shown in Table 4, chapter 2. The other small figure shows the core concepts of BI model (Figure 3), also in chapter two.

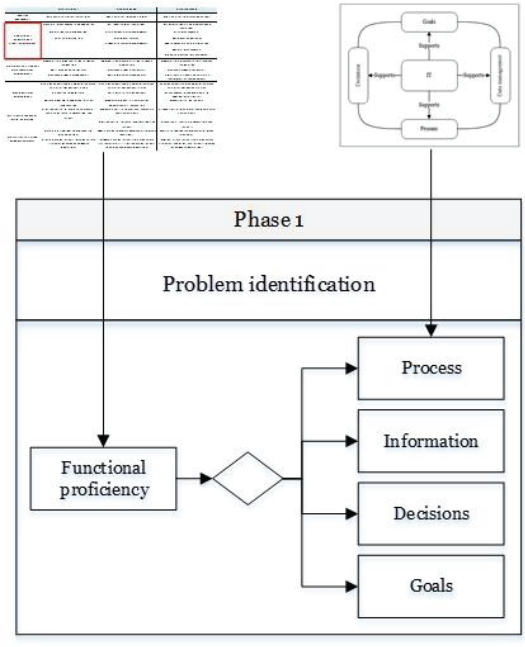


Figure 22: Theoretical origin of components in phase 1

Activities in phases two, three and four are designed to meet many of the challenges described in literature and the challenges identified at the participating companies. Phase two, (problem understanding) guides how to get a deeper understanding of an identified problem and therefore supports creating a business case that needs to be solved. Phase three guides how to design a solution to the problem and phase four helps managers to implement the solution. In addition to stem from previous literature, the activities described in the phases also derive from the work and experiences with the participating companies of this research. For example, the workshops that were conducted helped addressing challenges from literature such as involving users and getting management support. An overview of the relationship and origins to what the phases are addressing are presented in Figure 23.

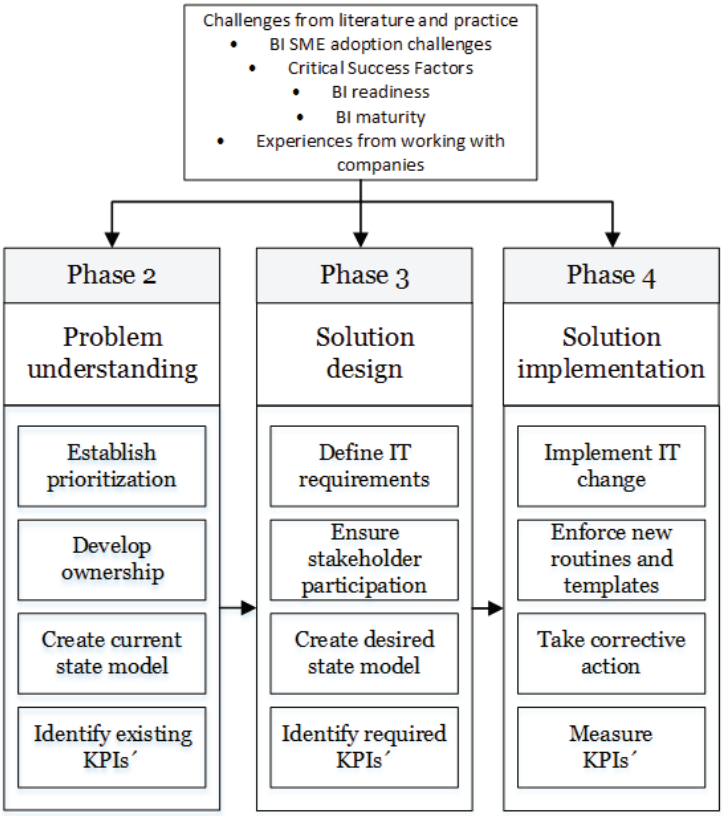


Figure 23: Literature and experiences contribution to phases

Overall, the framework is built based on the experiences of working with the companies, functional guidance by Lavalle et al. (2010), literature on what BI can support, and BI adoption literature. Guidance on what to do in different phases and how to do it are based on the experiences gathered from working with the companies. In other cases recommendations are based on previously published work that has been presented in the theory (BI) and method (elicitation process) chapters. Together with the framework guidance, it provides an approach to support organizations on their BI journey that both raises interest for further BI adoption and helps solving current problems the users are facing at their particular settings.

The following sections describes the framework in more detail along with activities in each phase. In chapter 6.3, the challenges will be revisited, with discussion on how the framework addresses the challenges.

6.2 THE BIFF FRAMEWORK

As stated earlier, using the framework helps to address many of the challenges identified in literature regarding BI adoption. From a more practical perspective, working with the framework helps users to become more intelligent about their business and to identify what is needed to make more data-driven decisions. This section provides an overview of the building blocks (phases) of the framework and what activities those phases contain. Since the goal with the framework is to facilitate BI adoption, the name of the framework became the Business Intelligence Facilitation Framework, or BIFF (Figure 24).

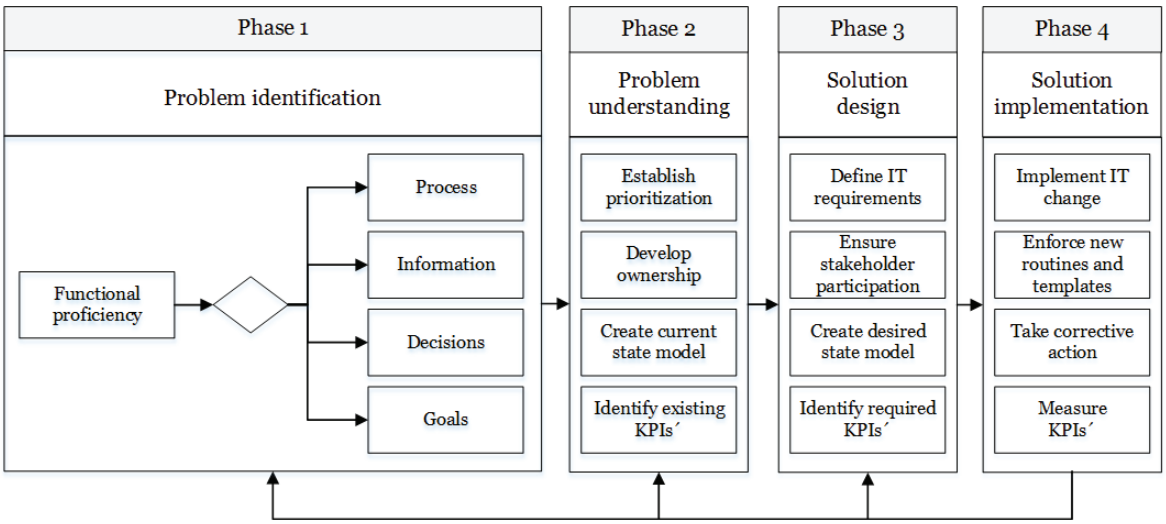


Figure 24: The Business Intelligence Facilitation Framework (BIFF)

The framework consists of four phases where each has a specific purpose. Each phase is further explained in the following sections but here is a general overview. Phase one focuses on identifying a specific problem within a specific function within the organization. In phase two, the current state is analyzed to support mutual problem understanding and consensus of the actual problem. Furthermore, having a mutual problem understanding on the current situation helps setting a baseline that can be used to measure the effects of coming changes. Understanding the problem supports being more intelligent about the business and identifying existing key performance indicators (KPIs´) related to the problem that can be measured with support of IT to set baseline measurements. Phase three focuses on designing the solution with appropriate stakeholders and to identify required KPIs´ that need to be a part of the solution. Phase four is about implementing the solutions designed in the previous stages with a focus on keeping track of the effects the changes have by using BI to monitor KPIs´. One of the key things when working with BI is using appropriate indicators to get a better understanding on the state of the organization. Using the framework helps identifying indicators that both helps monitoring the progression towards solution for the particular problem and potentially spawn interest in identifying additional indicators for the company. Moreover, monitoring the chosen indicators for the particular chosen problem is essential to be able to identify deviations from the solution design and the effects of the solution implementation.

After completing phase 4, the management team can move back to phase 1 to identify additional problems and by that start the process of using the framework again. However, it is likely that during the previous cycle of using the framework, several problems

were identified so the team can move straight into phase 2 or even phase 3. It is also possible that during the solution implementation phase (phase 4), a problem to the solution is identified which requires the team to move back to phase 3 to design a more optimal solution.

To help gather information and perspectives from stakeholders, phases 2 and 3 are broken down into two general activities; the pre-workshop activity and the main workshop. This way of breaking down activities was shown to be very effective as described in previous chapter. This highlights the importance of involving relevant stakeholders, first in a smaller group during the pre-workshop activity and then in a larger group during the main workshop. This is important when using the framework as explained in the following sections, and as demonstrated in chapter 5 helped to engage participants in both the problem understanding phase and the problem solution phases.

6.2.1 PHASE 1: PROBLEM IDENTIFICATION

The *Functional proficiency* category of Lavalle et al. (2010) aims to measure how well various departments within the organization are using BI and analytics. According to Lavalle et al. (2010), aspirational companies tend to use BI to various degree within sales and marketing, financial management, budgeting, operations and in relation to manufacturing and production. These areas are therefore the initial candidates when it comes to problem identification within specific functions of an organization. Managers of a company using the framework need to identify what department needs to be in focus during each iteration of using the framework, starting within the functions provided by Lavalle et al. (2010).

When the problem within chosen function has been identified, relevant stakeholders are acknowledged and the problem categorized into one of the core concept areas (Figure 3) of BI support to help steering the focus of the next phases. This is where managers look at potential problems within different areas of the organization and their level of using BI. During the problem identification phase, managers ask themselves if the problem concerns decision making, data management e.g. lack of information for certain tasks or action, unclear goals or if there are some bottlenecks or issues in processes. The theoretical foundation for phase 1 is based on both the findings of Lavalle et al. (2010) and previous literature on what BI can support organizations with. The relationship is showed in Figure 22. In summary, the problem identification phase helps to guide managers where to start looking, and categorize the problem according to one of the four core concept areas of BI.

Identifying the type of problem sets focus for the next phase of the framework; problem understanding. Problems can be identified through various ways e.g. through workshops/meetings, document analysis or observations. Through those activities, the problem becomes evident enabling management to prioritize what to focus on.

The problem identification phase can be done both with internal personnel only or with external help depending on company situation. There is no right or wrong although it is often suggested that external views can help companies to view things from different or new perspectives. Regardless of whether or not the company chooses to seek external support, the problem identification phase needs to be done in a small group with senior stakeholder manager/s and other core stakeholders. This helps to address one of the key factors from previous research, getting management support. The choice of participants should be done by managers initiating the problem identification phase. During this phase, the functional proficiency of the departments (functions) highlighted by Lavalle et al. (2010) are discussed and the choice of problem area determines what department will be focused on and by that highlights other potential

stakeholders. When the type of problem in a particular function has been identified (categorized into one of the core concept areas), phase 2 of the framework can commence. The outcome of the problem identification phase is a consensus on the categorization of the problem into one of the four core concept areas that will guide the aim of the problem understanding phase (phase 2), a clear view of where the problem is and who the stakeholders are.

Although the core concepts have been discussed in chapter two, a short overview of the areas is given below including the relation with the maturity model provided by Lavalle et al. (2010) and the work done with the participating companies. A more detailed description of what was done in each company was provided in previous chapter and in Karlsen et al. (2016), Persson et al. (2015) and in Gudfinnsson et al. (2019).

The four core concept areas

- Process improvement

The first concepts area involves supporting business processes. There are potentially countless numbers of processes within an organization but the ones that should be focused on should be in the following functions: financial management and budgeting, operations and productions, sales and marketing. According to Lavalle et al. (2010) these are the functions found common within aspirational companies when using BI and should therefore be the starting point when a company might be considered to be pre-aspirational. If the problem is perceived as being within a process, the following workshops will focus on analyzing each step of the process, what activities are being performed, what roles are involved and what information is being stored or transferred within the process. Process modelling can become a complicated exercise, but for this purpose it should be kept simple and focused using simple modelling languages. Keeping things simple proved to be an important key to getting stakeholders on-board in this research. One example is from Company 1 in previous chapter where a whiteboard was initially used Figure 8 to capture the essence of a certain process. Some principal shapes should be used when drawing the process e.g. arrows showing process flow, human figures for roles (or cylinders for components such as IT), a diamond shape where alternative flows or decisions are possible and rectangles with smooth edges to represent activities. When the chosen problem has been identified and the potential “location” of the problem, the next step called pre-workshop can be conducted. The process models should be transferred to digital versions to be able to both share and analyze them during the next steps.

- Data management

Having limited ability to capture, aggregate or share information characterizes aspirational organizations according to Lavalle et al. (2010). When the problem is perceived as being poor data quality or lack of data, the elicitation activity can be used to map the roles that are being affected by that and what information or data is missing. By identifying the roles and what information they need to conduct their work the information need is evident. In addition, identifying where that information should be (or is) coming from and what role is responsible for the data management helps to set focus on where data management needs to be repaired. The effects of poor data becomes evident when the amount of roles affected by it becomes visual when making use of the plastic wall elicitation approach. Poor data quality for example can have profound implications and the affects can be widespread throughout the company.

This can be highlighted and made visual with the support of the elicitation activity and as mentioned earlier by having a plastic wall with relevant notes.

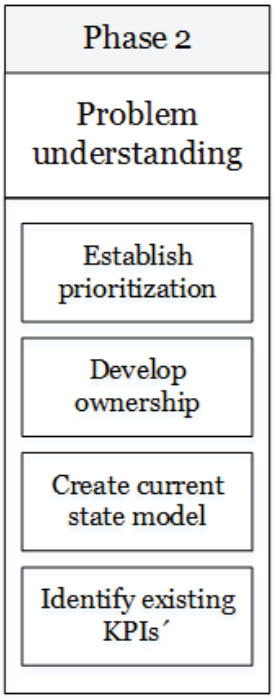
- Decisions

Decision making is done every day in companies but sometimes people need guidance on decision options and data to support decision making. Decision support is also one of the fundamentals of business intelligence and this core concept area supports finding what decisions need to be supported. Another characteristics of aspirational organizations according to Lavalle et al. (2010) is that companies at that level use BI in a limited way to support their decision making and to guide day-to-day operations. During the elicitation activity, particular roles can be identified along with their decision options or decision support needs in certain circumstances. By listing the options, a set of rules can be created as a way to support decision makers in those particular situations to help decision makers to make more correct decisions. In addition, information needs can be identified within that particular circumstances to provide the option of more data-driven decision making. There can of course be an endless amounts of situations, and decision possibilities, it is therefore important to use the elicitation activity to identify those particular situations where it is highly important that certain decisions are made according to certain rules or when decisions need to be more data-driven. For example when it comes to business orientated decisions, or if a particular part in a production line breaks or an injury occurs, employees can make the correct decisions based on predefined options or ruleset. This core concept area supports identifying decisions that lack adequate decision support and where decisions are more based on guesses or “gut-feelings” of the decision maker.

- Goals

Finding measurements and indicators to be able to follow progress and desired results is important in all companies. The elicitation activity helps identifying goals, laying the foundations for recognizing metrics that can show if goals is being met and if the company is moving in the right direction. Organizations monitor many goals when it comes to financial management and budgeting as they are often required by law but in some areas they might have difficulties deciding where to start when it comes to metrics, goals and indicators. In addition to economic related goals, aspirational companies monitor sales, operations, marketing and production. However, there are many other areas within the organization that benefit from having explicit goals. Goals are also important when it comes to strategic planning and if they are not monitored, it is hard to know when the goals have been achieved. A central part of BI is to provide indicators that indicate how the organization is performing from different perspectives. Having goals to aim for helps guide decisions and provide early warnings if some indicators point to potential problems within the organization. The elicitation activity helps visualizing those goals as they are written down, enabling them to be scrutinized so that proper indicators can be identified.

6.2.2 PHASE 2: PROBLEM UNDERSTANDING



The problem understanding phase is divided into two parts; the pre-workshop and the main workshop. Both parts can make use of the elicitation activity with plastic walls, pens and notes, a whiteboard, or a digital tool to help achieve both broader and deeper understanding of the problem. The important thing is to capture different perspectives from stakeholders to gain a deeper understanding of the problem. Based on the experience from the project and based on discussions with the managers of the participating companies, it is recommended that the problem understanding phase initiates with a smaller group of stakeholders that analyze the problem to gain a deeper understanding before involving a larger group of stakeholders. In this work and in the context of the framework, this activity is called pre-workshop activity.

Pre-workshop activity

Phase 2 starts with pre-workshop activity where the participants are managers that are affected by the problem identified in the problem identification phase. If, for example, the CEO and CFO have chosen a problem in a specific part of a production line, the line manager/s responsible for that part of the production are key stakeholders that are needed for input. The pre-workshop activity is an important part of the process of using the framework for several reasons. It helps to narrow down on initially identified problems and set the motivation for what the main workshop should focus on. It also helps gathering the different views of concerned parties in a structured way. In addition, it provides the opportunity to learn about using the elicitation activity of plastic walls and paper notes as suggested by Sandkuhl et al. (2014), potentially for the first time for some, as a preparation for the main workshop if that approach is used. Moreover, the pre-workshop activity helps providing a deeper understanding of the problem. If a company is being aided by external specialists, they will have the chance to get a better understanding of the chosen problem in that particular settings as well. Depending on the nature of the problem (area of core concepts), stakeholders are identified that need to both accept and own the problem from a management perspective as well as identifying other stakeholders that need to participate in the upcoming main workshop. Depending on the nature and impact of the problem, there could be more than one key stakeholders that need to accept and provide resources to solve the problem, but there should only be one problem owner.

Outcomes

There are several outcomes from the pre-workshop activity. There is a deeper understanding of the actual problem and how the problem affects the company. During the problem identification phase, an overarching problem is identified, the pre-workshop activity in phase 2 breaks down that problem and therefore more problems can emerge as the views from key management stakeholders are taken into account. It is therefore important to *establish prioritization* regarding what problem should be the main focus of the main workshop. Furthermore, clear ownership of both the problem and the workshop needs to be instituted. It is important that after the pre-workshop activity that there is a consensus amongst participants on what problem is the starting point

for the main workshop, who the *problem owner* is, where the problem is perceived to originate and what stakeholders need to be involved when analyzing the problem during the main workshop. Finally, *existing KPIs´* related to the chosen problem need to be identified that demonstrate the impact of the problem, if they exist. If there are no existing KPIs´ related to the problem, they should be identified either during the main workshop, or during the solution design (Phase 3).

The main workshop

When the pre-workshop activity is done, the main workshop activity can be started. In the main workshop, the elicitation activity with plastic wall and notes or a digital tool is used to capture the views of a broader group of stakeholders. This can mean stakeholders working on a more operative level within the company. The main workshop should be held by and opened by the problem owner that explains the purpose of the workshop. In addition, when the workshop is run by the problem owner on a management level, it signals clear ownership and authority to spend resources on the solution design and implementation. The point of the main workshop is to get even deeper understanding of the problem from a broader perspective and to understand what roles (personnel, IT etc.) are being affected and how they are affected.

The main workshop aims to get consensus regarding the problem understanding and it is therefore important to focus on current effects of the problem to be able to identify the issues that relate to that specific problem. If the problem is within a process, it is important to have a good description on how the process in being done today, before moving towards designing how the process should be done in the future. Since there are more people involved than during the pre-workshop activity, new issues will arise along with new views of the problem. This helps understanding the problem from a wider perspective. During the workshop, there needs to be a balance between "detailed description" and "good enough" so the focus on the current situation does not drag out for too long. This is particularly important when it comes to analyzing processes. Finding this balance is something that needs to be done in any specific case but a rule of thumb can be that if participants are asked if the descriptions are "at least 80% correct", that should be enough to move forward with according to the participating companies in this research.

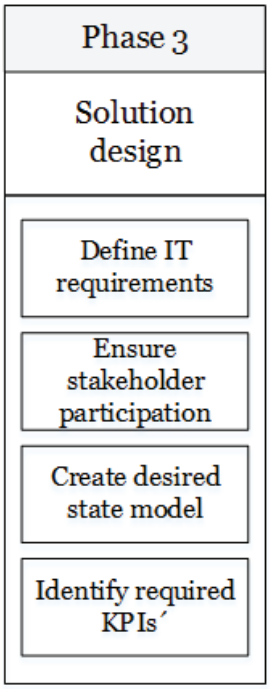
During the main workshop, discussions amongst participants can easily drift towards suggesting solutions to the identified problems. It is therefore important to stay on track, and keep the focus on the problem understanding. However, it is also important to capture the solution ideas being discussed and document them as input for the solution design and future work. We found that people in general are solution orientated and it is easy to lose focus so it is important that the problem owner who runs the workshop guides discussions towards problem understanding, but also to make sure that there are people documenting ideas for the solution design.

Outcomes

The outcome of the main workshop should be an in-depth understanding of the problem from different points of view and a general consensus on how the current state actually is. Existing KPIs identified during the pre-workshop activity should be updated (or identified during the main workshop). Things like how often the problem occurs and potential effects of the problem are key measurements to understand the gravity of the problem and to be able to use as benchmark to analyze the impact of the

solution. If a plastic wall with notes was used, then it should be digitalized for safe keeping and to be able to share the results of the workshop. The plastic wall output is therefore a simple digitalized model that describes *the current state* of how the problem affects the organization from different perspectives. Since there is endless possibilities of potential problems and potential ways to model problems, the focus should be to keep it simple. A simple goal model or a simple process model is better than no model, and then the focus can be on the problem solving, not problem modelling.

6.2.3 PHASE 3: SOLUTION DESIGN



Similar to phase two, phase three has two steps as well. The first step is to start designing the solution during the pre-workshop activity, and the second step is to get input regarding the design and acceptance for the new design (main workshop).

Pre-workshop activity

When the problem understanding has been established and agreed upon, the work towards designing the solution can commence. This step may involve some different people compared to the participants of the problem understanding phase as new perspectives and stakeholders could have been identified during the problem understanding. This should however be minimal and the solution design should preferably be done by the participants of the pre-workshop during the first step of the problem understanding phase. After analyzing the problem during the pre-workshop activities and then with the addition of understanding from the main workshop, those stakeholders should have a good idea on the root cause of the problem and potential solutions.

The solution design process starts the same way as the problem understanding phase, with a pre-workshop activity. This means only the key stakeholders, not everyone that participated in the main workshop of the previous phase, take part in the initial solution design. The starting point is the outcome of the previous main workshop from the problem understanding phase including the suggestions for solutions made during that activity. The solution is designed by creating a new version of the digitalized version of the outcome from the main workshop, or by using the plastic walls approach again. This is a choice that needs to be made in any individual case. This can e.g. depend on the scope of the problem and competence on working with digital tools. When the solution has been developed, it should be digitalized as well if the plastic wall was used.

The main workshop

After designing the solution during the pre-workshop activity, a new main workshop is conducted. During the main workshop, the new solution design from the pre-workshop activity is presented for approval to a larger group of stakeholders. The changes made during this main workshop should be minimal since the problem has been agreed upon and ideas regarding how it should be solved has already been put forward in the previous phase and developed during the pre-workshop activity of the solution design phase. The most important outcome of this main workshop is getting approval

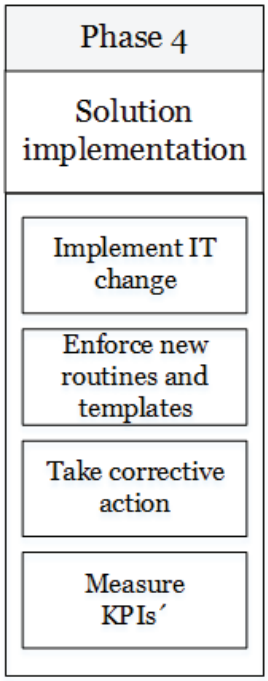
on the solution and ensuring *stakeholder participation* when implementing the solution. Requests for changes should of course be discussed, and noted, but there should not be a need to work with a plastic wall or to do any major changes in the solution design. If the case would be that the proposed solution is rejected and needs major revisions, the group of stakeholders that have been participating in the pre-workshop activities both during this phase and the previous phases need to decide if the revisions are of such a significance that there is a need to go back to phase one or two, or if the presented solution can be adjusted to meet the requirements.

During the solution design, it is important to establish metrics that show the effects of transforming from "current" state to the "desired" state. The metrics identified in previous phases need to be reviewed to see how well they capture this change. If needed, new metrics can be identified to capture the impact of the designed solution. This will help the companies to keep track of the effects of the changes and help documenting the outcome of the project. The metrics should also help with the transformation from "current" to "desired" by setting the frame or boundaries around the transformation process. For example, if you have designed a new process that should go forward according to specific steps, you can count the number of times the process is not going according to the implemented solution. Metrics should also be used to create baseline when possible before implementing the solution. For example, if there is a lack of information for doing a specific task, the number of times the information is missing can be counted during the "current" state before implementing the solution and then counted after the solution implementation to see if the change actually worked according to plan. Other KPIs´ and *IT requirements* need to be acknowledged to support the solution design as well. All the four core concepts of BI that constitute the categories of problems rely on IT support, and that should be accounted for during the solution design.

Outcome

One of the important outcomes of this phase is the consensus and acceptance of the solution design. If acceptance is not achieved, there might be problems implementing the solution. Another important outcome involves identifying *required KPIs´* and what IT support is needed to measure those. Having identified required KPIs´ lay the foundation for defining IT requirements to support solving the problem. In some cases, simple measurements just by using pen and paper can help getting the idea of the impact of the problem but to be able to measure and keep track of performance indicators, the requirements regarding IT support need to be clear. Other outcomes are accepted *model of the desired solution* that is going to be implemented and the KPIs´ that have been identified to help monitor the solution implementation. In addition, the approval from stakeholders after the main workshop needs to be in place to increase the chances that involved personnel actually work according to the new solution design.

6.2.4 PHASE 4: SOLUTION IMPLEMENTATION



This phase is not about how to actually implement the changes or the solution, which is something any individual company does in its own way. There are many theories that support change management and best practices to implement change or solution designs, but that is out of scope for this research. This phase supports monitoring the implementation by utilizing BI, enforcing *new routines* and to take *corrective action*. The different metrics (*KPIs´*) that have been identified both during the problem understanding phase and solution design need to be *measured* so they can be monitored throughout the whole solution implementation. Although these metrics are considered to be KPIs´ for this particular problem, KPIs´ that are identified for the company as a whole should also be implemented. *IT* changes based on the *requirements* from the solution design need therefore to be *implemented*. Depending on the situation, the visualization of the measurements can vary. In some cases, simple Excel graphs or tables are enough, depending on the type of the problem and perhaps technical capabilities. Another way to visualize the designed solution for implementation is to print out the new design and put it on a wall. This can be particularly helpful for managers to enforce new routines and processes. For example if a new process has been designed so that people involved in the process can go to have a look at the flow of the process and what their role is. Even goal models and modeled decision rules can help with the implementation of the new design if made visible for the personnel.

Outcome

There are several possible outcomes from the solution implementation. The process models can highlight documents and templates and visually show where in the process the documents are handled and by whom, giving a more in-depth knowledge on actions and information flow. Carefully monitoring the solution implementation provides the opportunity for managers to take corrective action during the implementation process as well. If a goal is being measured, and the company is not moving in the right direction towards that goal, the indicators give an early warning since it becomes clear that the company is not going towards the designed solution. Another example is, that if managers are still lacking information that has been identified in the problem understanding phase, actions towards implementing the new IT requirements might be needed or further enforcement for following the new routines regarding information sharing. An important outcome is also that a problem deemed important for the organization has been identified, and solved, with the involvement of stakeholders, and explicitly demonstrating how BI can support the problem solution which spawns interest in further adopting BI in the organization.

6.3 REVISITING CHALLENGES AND THE FRAMEWORK

As presented in chapter 2, several challenges with BI adoption have identified in literature. We also demonstrated in Table 6 how these challenges relate to what BI promises to support, relating the core concepts of BI with previous literature. To take re-

search on BI adoption, readiness and CSF one step further, we have converted the factors identified as necessary to successfully implement BI into challenges. Furthermore, the BIFF framework has been designed to both capture what BI promises, and propose actions that can help addressing these challenges. This section revisits the challenges consolidated in Table 6 and discusses how various phases help addressing the challenges. It also discusses how some challenges are related, and how solving one fundamental challenge influences many other challenges. Finally, a discussion is provided on how the framework could potentially support addressing other challenges identified in literature that did not have similarly direct connection with the core concepts of BI as discussed in chapter 2.4. We will now revisit Table 6 from chapter two (here Table 12) and discuss how different phases support addressing the challenges from literature.

Table 12: Challenges revisited

BI support	Challenges from literature
Supporting achieving business goals	Management support and involvement Alignment with business vision and strategy through business cases Business-driven approach with business champions Having resources for adoption Perceived usefulness
Supporting process efficiency	Well defined business process Continuous process improvement culture
Supporting decision making	Knowledge on how BI can support decisions CEO´s innovativeness context – Decision making, willingness to adopt IT to improve business performance Culture for using information and analytical applications for decision support Decision process engineering culture
Supporting data management	Data quality and integrity Up-to-date information
IT support	Integration between BI and other systems Technological context – internal and external Business intelligence and data warehousing technical readiness Effective business/information technology partnership for BI

- Management support and involvement

One of the fundamental challenges in literature when adopting BI is to get management support and involvement. Addressing this challenge, and succeed in getting management support and involvement has a great impact on many other challenges. The BIFF framework supports addressing this challenge in several ways. First, the

framework points out where to start looking for potential support within the company (functional proficiency) by identifying problems within given functions. This helps management to set focus on one part of the company, and guides them where to start. Next the model suggests to break down the identified problem into one of the core concepts of BI support which guides the rest of the work when following the framework. This aligns the identified problem with what BI sets out to support, and helps managers to better understand what kind of BI support is possible as it is based on a business problem identified in their own settings. The manager of the function where the problem has been identified is therefore a key player when continuing working with the framework. That is the first step when addressing the challenge of getting management involvement, and also addresses the challenges expressed by participating companies of this research regarding not knowing where to start and what to do (see Gudfinnsson, K. and Strand, M., 2017). Phases two and three also focus on management involvement. In phase two, establishing prioritization requires managers to agree on what problem to focus on, and then decide who the problem owner is. Achieving this lays all the prerequisites to have management support and involvement. In addition, it will also address the following challenges:

- Alignment with business vision and strategy through business cases
- Business-driven approach with business champions
- Having resources for adoption

When the managers have identified a problem, prioritized and accepted a problem owner, the problem should be a clear business case that needs to be solved following the business vision. No managers would want to spend time and resources solving a problem that would not relate to what the company wants to achieve, or at least, that would be quite inefficient way to use company resources. The problem owner takes on the role of business champion (although it is also both possible and likely that someone other than the managers acts as champion). Having clear management ownership should also support having enough resources for the BI adoption since the chosen problem is deemed important enough to spend time and resources on. Establishing a clear prioritization of what problem to address indicates from a management perspective what problem has high priority from a business point of view.

There are additional challenges in literature that can be argued to be heavily dependent on management involvement. These would be:

- Perceived usefulness
- Knowledge on how BI can support decisions
- CEO´s innovativeness context – Decision making, willingness to adopt IT to improve business performance
- Culture for using information and analytical applications for decision support
- Decision process engineering culture

The foundations for addressing these challenges are laid down in phase one when managers categorize the identified problem into an area that BI supports. That activity connects BI support with the problem and shows potential usefulness and increases the knowledge on how BI can support addressing the problem. However, it becomes even clearer in phase 3 of the framework which focuses on solution design. When designing the solution, managers address the challenge of aligning BI with business strategy as the solution needs to support the business. The solution design has a strong

relation to BI as two of the activities are directly linked to how BI (and IT in general) can be part of the solution both by when defining requirements and when identifying required KPIs´. If BI is designed as part of the solution, the perceived usefulness should be high and it should be quite clear how BI can support decisions as it is part of the solution design. The solution design also requires managers to be innovative and to be willing to incorporate IT to the solution. Although company cultures can be hard to change, the challenge of creating a culture for using information and analytical applications is addressed in the solution phase with its high emphasizes on involving IT/BI in the solution design. Similar can be said regarding creating a decision process engineering culture. This is not something that can be solved over night, but by continuously using the framework and adding BI and IT in general to solve identified problems will certainly support creating that type of culture.

Challenges specifically focus on process issues have been identified as well:

- Well defined business process
- Continuous process improvement culture

If the results of the problem identification phase show problems in some of the business processes, the rest of the framework supports improving those processes in several ways. First, it asks its users to create a current state model of the process to create a common understanding of the problem. It also suggests to identify KPIs´ to measure the extent of the problem identified. During the solution design phase, an updated version of the process is made during the "create desired state model" activity. The framework also requires users to add BI to the solution and KPIs´ so the effects of changing the process can be measured. The challenge of creating continuous process improvement culture is just like most cultural changes something that will not change overnight, but by keeping track of KPIs´ that demonstrate how the new processes become more efficient should support the company to move towards that kind of culture.

Two challenges have a more data and information perspective:

- Data quality and integrity
- Up-to-date information

Improving data quality and providing up-to-date information also starts in phase one and then continues to be addressed throughout the phases of the framework. One of the categories of the framework in phase one addresses the issue of lacking information and it is one of the core concepts of BI to support. Going through the phases with a specific focus on what information is currently missing, and then designing a solution that improves that for example when defining IT requirements helps addressing this issue.

The final four challenges presented in table 12 are:

- Integration between BI and other systems
- Technological context – internal and external
- Business intelligence and data warehousing technical readiness
- Effective business/information technology partnership for BI

These sets of challenges are not as directly addressed in the framework as the previous ones. They are of a more technical nature, and at least when it comes to data warehouse readiness might be a bit out of scope for SMMEs as they might not have a data warehouse. However, the framework does support its users to improve their knowledge that

in turn helps to at least partially address these challenges. For example, during the solution design, the IT requirements activity helps addressing the challenge of integrating BI with other systems in a way that managers have better knowledge on what requirements they have as they have been involved with designing the solution. This can be quite important if a company needs to talk to external vendors to upgrade or add modules to their current systems for example to be able to receive the data needed according to the solution design. The more knowledge they have on what they need, the better chances are that they get their problems solved when communicating with their vendor. Using the framework continuously should also increase the BI readiness as more and more solutions are made including BI. That could also spark a desire to start looking at implementing a data warehouse as managers become more and more accustomed to what BI can do to support their decision making.

The BIFF could possibly also have an impact to address other factors that are not as related to what BI promises. These factors were presented in chapter two, but as a reminder, here is the list that was presented:

- Competent BI project manager
- Organizational context – Size, structure, managerial structure, human resources
- Personal contacts
- Organizational readiness
- User-orientated change management
- Team skills
- User friendly system
- User participation
- Teamwork
- Business intelligence portfolio management
- Environmental context – strategic foresight
- Environmental context – competitors, regulatory environment
- Complexity of implementation
- Competitive pressure
- Vendor selection

Although not directly focused on these factors, the BIFF could potentially support addressing some of these factors as well. For example, when identifying IT requirements in phase three, the managers might have a better idea of what to seek for if they need to look for new vendors. The framework also highlights the importance of involving all relevant stakeholders (user participation) and by that involving users in the organizational change. Teamwork is encouraged by involving all relevant stakeholders as well and the more times the framework is used, the more skilled the team becomes. If the framework is used constantly within an organization, the users gain more and more knowledge on how BI can be used within the organization and become better at expressing requirements. This increase in skills and knowledge can help the organization to address other factors not as explicitly addressed by the framework.

CONTRIBUTIONS AND FUTURE WORK

CHAPTER 7
CONTRIBUTIONS AND FUTURE WORK

The research presented in this thesis builds on both theoretical and empirical work. Previous research has provided insights into what needs to be considered when adopting BI - this work has then converted those insights into challenges to be met to support BI adoption. The principle contribution is a theoretically and empirically based framework aimed at addressing the challenges. Supported by the action design research method, this work contributes to knowledge by providing further insights into how SMMEs are taking advantage of BI, and what challenges they are facing, both with respect to individual challenges for the companies, and from a BI adoption perspective. This work also suggests ways to address the challenges identified in the literature, and in the participating organizations, and thus can be used to facilitate BI adoption within SMMEs. The overall research aim has, in this way, been accomplished.

7.1 CONTRIBUTION TO RESEARCH

This thesis contributes to research in several ways and to various degrees. The BI literature contains many examples of how BI can support companies, and the thesis summarizes these in a model that provides an overview of the core concepts of BI Figure 3), that can be used to guide future work to categorize problems into areas supported by BI. This work also recapitulates previous literature on BI adoption theories in SMEs from various perspectives:

- BI adoption research in SMEs
- BI adoption – assessing readiness
- BI adoption – critical success factors
- BI adoption – maturity as a goal

Furthermore, the adoption theories are consolidated into a table of challenges, where the core concepts of BI are related to these identified factors (Table 6), showing that BI can be used to address these challenges.

The papers also make individual contributions to research. Paper one adds to knowledge on the BI maturity of SMEs, supporting the findings of previous research that SMEs lag behind and can be considered immature. The paper also adds to knowledge on how BI is used, although in a limited way, to give input to the current state of practices of SMEs. Paper two provides additional knowledge on the state of

practice, and demonstrates how badly prepared the participating manufacturing companies are when it comes to facing the fourth industrial revolution (smart factories) - further highlighting the importance of finding a way to support them in BI adoption. Paper three adds to the literature challenges faced by SMEs, both with regard to BI adoption and more general organizational challenges (such as lack of knowledge and interest in how BI can support the organization). Paper four further describes challenges faced by SMEs and demonstrates how the elicitation activity by Sandkuhl et al. (2014) can be used both to analyze the current state of practice, and to create a desired state - something that lays the foundation for the workshops carried out later in the research. Paper five contributes to research by demonstrating how goal modeling can be used to address company problems and to support continuous improvement. Finally, paper six provides examples of problems faced by SMEs from the field, and provides descriptions of how these problems can be addressed – contributing fundamental parts of the BIFF framework.

The main contribution of this work is the BIFF framework. The framework addresses many of the challenges identified in both literature and the empirical data, and therefore builds on understanding the problem environment. No obviously similar frameworks were identified in the literature, making it unique when it comes to supporting SMEs in adopting BI. Problems with BI adoption are well reported in the literature; however the framework suggests a new solution to known problems in the field. Gregor and Hevner (2013) propose a knowledge contribution framework (Figure 25) that can be used to position this contribution. Their framework has two axes on a scale high to low: application domain maturity (X-axis) and solution maturity (Y-axis). If the application domain maturity is high, and the solution maturity is high, the contribution is considered as minor (routine design), as known solutions are applied to known problems. If the application domain maturity is low, and solution maturity is high, it contributes research opportunity and knowledge as known solutions are applied to new problems (exaptation). If the solution maturity is low, but the application domain maturity is high, the research contributes through new solutions for known problems (improvement). When both solution maturity and application domain maturity are low, the research contributes through new inventions constructed to solve new problems.

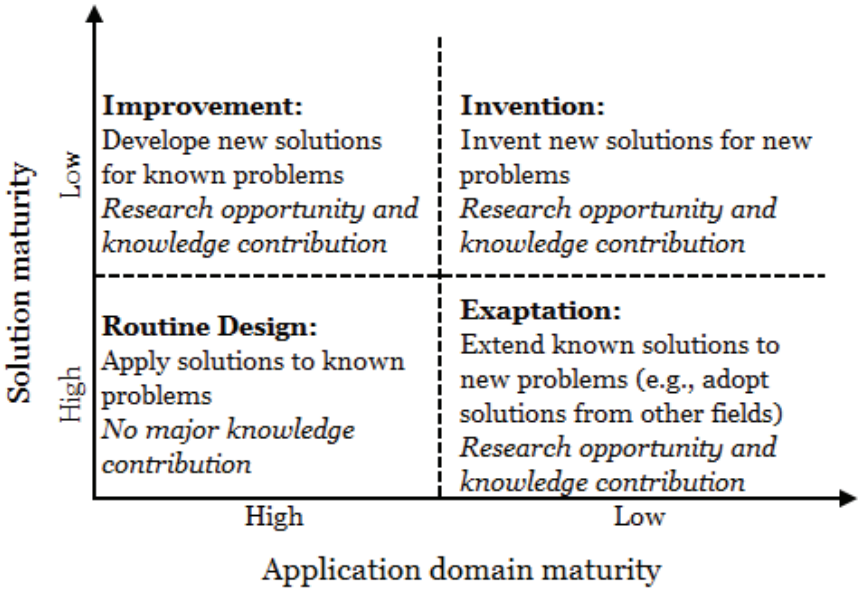


Figure 25: Knowledge contribution framework (from Gregor and Hevner (2013)

In this work, the application domain maturity can be considered to be high since the problems within the field are well documented, but the solution maturity is low as there are few solutions available. This quadrant is the i*mprovement* knowledge contribution quadrant. The BIFF framework can be positioned here, where the key contributions is to build innovative artifacts to solve known problems in the field, and to demonstrate how that solution adds to previous knowledge (Gregor and Hevner, 2013).

7.2 CONTRIBUTION TO PRACTICE

Much was learned through the collaboration with the participating companies that can contribute to practice. For example, previous literature discusses the importance of being able to integrate BI with other systems (Olszak and Ziemba, 2012) and having effective business/IT partnership (Williams and Williams, 2007), but during the work with the participating companies it was evident that their interest for identifying IT requirements varied quite a bit. The companies were initially not highly enthusiastic and a number of interviewees simply explained that they did not know how BI could support their business. Even if they wanted to integrate BI with other systems or make use of BI for decision support, they did not know how or where to start. This problem was described during the initial interviews in all participating companies and the research accordingly turned towards how to support managers in identifying how BI could support them in their particular settings. Even though previous literature had identified what needs to be in place, a supporting framework on how to actually achieve the factors identified was missing. Companies in similar situations can learn from the examples provided by the participating companies and might even identify similar problems within their own settings.

The workshop activities also proved to be very informative. In two companies, there was doubt if the elicitation activity would actually contribute with enough materials to analyze the current state of the identified problem. However, when the problem owner (manager) started putting up notes, others followed. It became evident that it is very important that the problem owner leads the way during this activity. The more involved the problem owner was, the better results we had from the workshops, especially during the problem understanding phase.

One part of the problem understanding phase that is not as explicit in previous BI literature compared to other fields is creating a current state model related to the identified problem. This turned out to be very important when working with the participating companies. At first during the MMC2 project, it was seen as a tool to better understand the problem for us (members of the project group) since we were not very familiar with the core business of the companies and didn´t have the same knowledge as the representatives of the companies. However, while making the simple current state models (in all of the participating companies) we saw how this exercise helped the company representatives themselves to better understand the scope and depth of the problem. It also laid the groundwork for identifying relevant KPIs to further understand the extent of the problem, and worked as a baseline to see the effects of the upcoming changes designed in phase 3 of the framework. Working with the companies also contributed much to the solution discussions as many ideas on how things should be done, and how problems could be solved came up during the current state analysis. When it then came to the actual solution phase, managers and other stakeholders that

had participated in the in-depth problem understanding activities were already invested in the solution discussions and could see potential improvements for the company.

As with contribution to research, the main contribution to practice is the BIFF framework. The suggested activities have been carried out in four manufacturing companies with good results. The framework supports companies that work with continuous improvements and provides a way to link BI to designed solution, making the users better at understanding their needs, perceived usefulness and to be better at communicating requirements. The BIFF framework is not complicated, so it has a short learning curve for both practitioners in SMEs and potentially consultants. Although the framework contains generalized activities and phases, it emphasizes on addressing problems within its users settings, making it highly relatable for SMEs.

7.3 EVALUATING THE RESEARCH

To support good research practice, the ADR method provides seven principles when conducting ADR research. The following table summarizes these principles and provides a short overview of how they were fulfilled (Table 13).

Table 13: Complying with ADR research principles

Principles	**Description**
Principle 1: Practice-inspired research	Both literature survey and close collaboration with participating companies contributed to identifying the knowledge creation opportunity. The problems identified can be applied to a class of problems: adopting BI in SMMEs.
Principle 2: Theory-ingrained artefact	The framework is supported by synthesis of the core concepts of BI and BI adoption theories.
Principle 3: Reciprocal shaping	Each companies all contributed to a mutual shaping of the framework through their contribution to each individual part, including both IT and organizational context.
Principle 4: Mutually influential roles	Close collaboration between researchers and practitioners included dialog meetings, workshops and seminars catering for mutual learning and influence on framework design.
Principle 5: Authentic and concurrent evaluation	Evaluations were done continuously throughout the design and building process.
Principle 6: Guided emergence	Workshops and dialog meetings helped guide the emergence of the framework as parts of the framework were designed and built incrementally.

Principle 7: Generalized outcomes	The specific problems of the participants have been generalized through publications (papers 4, 5 and 6). The framework provides a new solution to known problems in the field and supports addressing these problems. The work that was done with the companies was described in details in chapter 5, and the framework in chapter 6.

In addition to evaluating this work with the principles of the ADR method, the practical work that was done with the companies and an early version of the BIFF framework was presented at a workshop with all participating companies. Before the presentation of the initial artefact idea, representatives from the companies gave a short presentation of what had been done in their company, and the project effects. All companies were positive and indicated that they had elevated their level of BI awareness and usage. The ideas of breaking down a problem into one of the core concepts of BI, and analyzing the current state before designing the future state were presented as building blocks of a future framework (that later became the BIFF framework). The presentation and the idea received positive feedback, and the companies were given the opportunity to provide additional comments on the work that was done in their particular settings.

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KRISTENS GUDFINNSSON

Kristens Gudfinnsson has a background in information systems and business administration. Before pursuing his Ph.D. studies, he held the role as director of service desk and support at Glitnir bank, Iceland. He holds a Bachelor of Science degree in information systems, a Bachelor of Science in business administration and a Master of Science degree in computer science from the University of Skövde. His current research focuses on supporting small and medium sized manufacturing companies to use business intelligence for more data-driven decision making.

In his thesis, Kristens explores challenges that hinder small and medium sized companies to adopt business intelligence. He develops and tests a framework based on both previous literature and experience with several companies. The Business Intelligence Facilitation Framework (BIFF) focuses on business goals, data management, decision support and process efficiency. The framework contains four phases: Problem identification, problem understanding, solution design, and solution implementation. Each phase addresses particular challenges. The framework contributes to the literature a way for inexperienced companies to get started with their BI projects, and provides support for practitioners wishing to adopt BI in their companies and consultants trying to help them.

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