Qualitative Measurement of BI Maturity in a SME ICT Organisation

by

Jelle Keppels

Master of Science Thesis

Supervisors:
dr.ir. A.A.M. Spil
dr. N. Sikkel

in the

Faculty of Electrical Engineering, Mathematics and Computer Science

July 2018

Abstract

In this study we identify the main benefits and challenges involved with Business Intelligence (BI) and gather the main BI maturity models and frameworks from both practice and research. This is done by conducting a literature study. Afterwards, we have chosen the Business Analytics Capability Framework (BACF) by Cosic et al. [2015] to be used in a case study, this framework is well grounded in theory but needs further refinement and operationalisation.

We extend the BACF with operationalisation and transform it into the Business Intelligence Capability Maturity Model (BICMM) that uses qualitative measurement based on interviews. The BICMM is applied in a case study, on a SME ICT organisation from the Netherlands. The case study has two main goals; to test the model in a real world scenario and suggest improvements, and to compare the results of the case study with the found benefits and challenges from the literature study.

The results of the study show that the BICMM is very usable for the measurement of BI maturity. Improvements are suggested for future iterations of the model, such as the transformation to a prescriptive model. Because of the low BI maturity level of the organisation in this case study it was not possible to compare the found benefits, the challenges however show consistency with the findings from the literature study. These comparison can be identified in the challenges regarding governance (e.g. limited funding), culture (e.g. limited cooperation between departments), technology (e.g. no data management strategy) and people (e.g. lack of BI knowledge).

Overall, this study provides practice and research with a new BI maturity model that has solid theoretical grounding, and confirms many of the found challenges from literature.

Contents

List of Figures

List of Tables

Abbreviations

BICMM   **B**usiness **I**ntelligence **C**apability **M**aturity **M**odel

BI   **B**usiness **I**ntelligence

BA   **B**usiness **A**nalytics

BI&A   **B**usiness **I**ntelligence **A**nd **A**nalytics

ERP   **E**nterprise **R**esource **P**lanning

TIS   **T**wente **ICT** **S**pecialists

Chapter 1

Introduction

In this chapter we will make an introduction to the field of Business Intelligence (BI), its benefits and challenges and its maturity models. Furthermore we will describe the reasons for conducting this study and give an overview of the research objectives in the following sections.

1.1 Background information

In this digital era, a large number of ICT tools are available to help increase the effectiveness of decision making. These tools are called Business Intelligence (BI). In this study we use the definition by Negash [2004] to describe BI:

- *"A system that combines data collection, data storage, and knowledge management with analytical tools so that decisions makers can convert complex information into competitive advantage."*

Business analytics (BA) is often seen as the as the analytical component of BI, focused on analysing and predicting future trends and phenomenons. BA is often based on statistical techniques in order to create powerful analysis of the future. In this study we define BI as a broad term and define BA as a subset of BI that is focused on more advanced forms of BI, such as predictive modelling and big data analytics. In recent years, the decrease in the costs of computing power and the emergence of new techniques

has enabled organisations to analyse enormous amounts of data, leading to a new term "Big Data" [Walker, 2014]. In this research we view Big Data Analytics (BDA) as an integral part of BA, and thus as a part of the umbrella term BI.

Data-driven decision making is based on making decisions backed up by data and data analytics instead of making decisions that are based on intuition and 'gut feeling', this is achieved by using BI tools like analysis and decision support. Research conducted by Brynjolfsson et al. [2011] inspected 179 large publicly traded firms, and showed that the data driven organisations have an output and productivity that is 5-6% higher than expected. Research by Ransbotham et al. [2015] suggests that while organisations are increasingly using more sophisticated analytical methods this often leads to a gap between the ability of organisations to produce analytical results on the one hand, and how to apply these results on the other hand.

BI has numerous possible advantages. BI can improve business decision making [Kache and Seuring, 2017]. Organisations can use BI to better understand their customers and customise their sales to maximise profits [Akter and Wamba, 2016, Chen et al., 2012] Organisations can also use the tools the tools of BI to improve the use of the capabilities of their employees, improving their effectiveness and decreasing the headcount.

The are numerous challenges involving BI. An organisation that aims to use analytics in its management style should find the right balance between humans and analytics, in order to avoid a working environment that is purely driven on 'cold' data [Kache and Seuring, 2017]. Organisations wishing to make use of BI should be aware of the many technical challenges involved with implementing BI such as the processing power required to analyse Big Data [Sivarajah et al., 2017]. Members of the organisation often have limited knowledge about BI and are unaware of the potential benefits of BI [Coleman et al., 2016]. Furthermore there are organisational, ethical and legal challenges involved with BI.

The maturity of an organisation in BI is the level of effectiveness of an organisation in using BI. An organisation that has low BI maturity has limited to no standardisation, is unaware about the capabilities and does not have the technical infrastructure in place to support it. In comparison, a high maturity organisation has a high level of standardisation, is fully aware of the capabilities and has a technical infrastructure that fully supports the capabilities of BI. A maturity model is a benchmarking tool

to evaluate an organisations BI capabilities, empirical evidence suggests that achieving higher BI maturity will lead to higher BI success [Chen and Nath, 2017]. Maturity models can thus be used to assess and improve an organisations BI maturity. There are numerous maturity models available for measuring an organisations capabilities in BI, and choosing the right maturity model for the right organisation can be a difficult task. Choosing the right BI maturity model will depend on several factors such as the size of the organisation and the focus areas in which an organisation wants to improve.

1.2 Problem statement

BI is a broad concept, that requires a broad range of skills and requirements for a successful implementation. Many organisations have the feeling that they need more BI, but they often have a limited clue about the benefits and challenges involved. An useful way to asses the BI capabilities of an organisation is by measurement of its BI maturity level, but there are many maturity models available, so which of these models is the most suitable?

Twente ICT Specialists (TIS) is an organisation that wants to make more effective use and improve its BI capabilities. TIS is a business to business small/medium enterprise (SME) ICT service provider that focuses on cloud computing, networking, work-space, security, identity and general ICT consultancy. A past advice report that was conducted at TIS concluded the management of TIS misses crucial information when making decisions. This advice report showed that TIS had to improve its use of BI because the management often had the feeling that they had to make important decisions based solely on gut-feeling, and they had no information to back up or analyse their decisions. Also there was a lack of real-time information as financial reports were only generated on a monthly basis. The advice report concludes with a list of global requirements, such as the need for insight in the performance of certain products in the product portfolio, and the need for more detailed insight in the performance of products and services.

TIS is currently in the process of implementing an enterprise resource planning (ERP) system. One of the reasons for implementing this new ERP system were its presumed BI capabilities. Currently the implementation of the ERP system at TIS has been going on for a while, but certain issues have arisen; the BI capabilities of the ERP system are not

up to the expectations of TIS, only basic reporting modules are available and the amount of available customisation is low. These problems were not anticipated and because of this TIS needs a measurement of its current BI maturity level and capabilities, in order to create a plan on how to improve them.

1.3   Research objectives

In this study we will generate a comprehensive list of both benefits and challenges and BI maturity models. We will develop a new BI maturity model based on an existing framework. This maturity model will be used on the case of TIS and we will generate an advice for TIS on how they can improve their BI capabilities. The findings will be used to analyse the usability of the newly developed model, suggest improvements to the model and to compare the findings with the literature study.

Chapter 2

Research design

In the this chapter we will discuss the research questions, in the following sections we will discuss the research methodology.

2.1   Research questions

In this research we will address the following research questions:

- *RQ1. What are the most important benefits and challenges of business intelligence and is there an overlap with the findings of the case study?*

- *RQ2. What are the business intelligence maturity models that are available from literature and practice, and which one of these models is the best suited for the TIS case?*

- *RQ3. What is the current business intelligence maturity level at TIS, and how can these maturity levels be explained?*

- *RQ4. How did the the maturity model perform in this case study and is it possible to suggest improvements based on the findings?*

2.2 Research methodology

2.2.1 Literature review

A structured literature review was conducted to give a comprehensive overview of all the relevant BI models from both research and practice. In the literature review the outlines set by Wolfswinkel et al. [2013] were used. The queries were entered in Scopus and Google Scholar.

Research queries used:

- "data driven" OR (business AND analytics OR intelligence) AND maturity

- "data driven" OR (business AND analytics OR intelligence) AND (benefits OR profits)

- "data driven" OR (business AND analytics OR intelligence) AND (challenges OR down-falls OR downfalls)

2.2.2 Design science methodology

The design science methodology by Peffers et al. [2007] was used to structure this research.
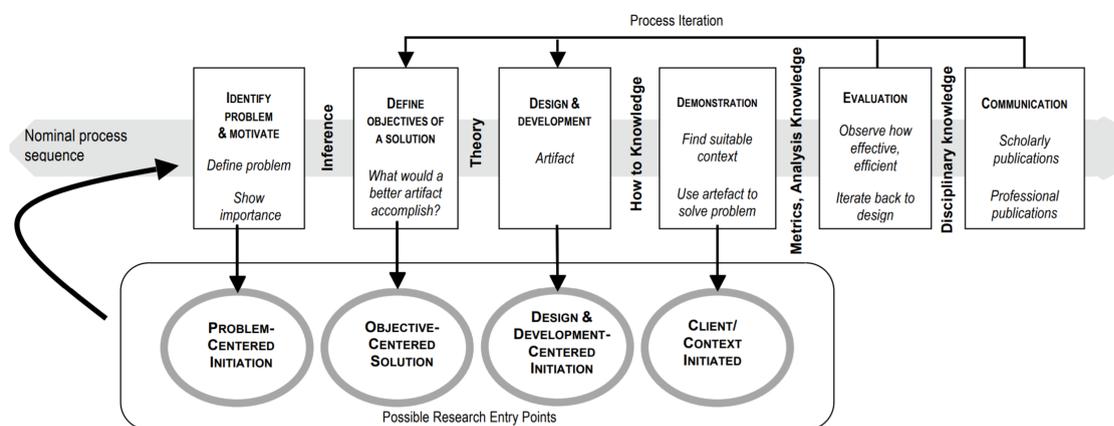
FIGURE 2.1: DSRM model by Peffers et al. [2007]

Identify Problem and Motivate

In the introduction the topics of BI, maturity and benefits and challenges are introduced. Furthermore we identify the problem at TIS.

Define Objectives and Solution

There are numerous BI maturity models, both from practice and research. What are their differences, and which one is the best usable in the TIS case? Which of the benefits and challenges are applicable to the case study?

Design and development

We operationalise an existing framework to a operationalized BI maturity model by using a qualitative interview framework.

Demonstration

The newly created BI maturity model is used in a case study to measure the BI maturity of TIS.

Evaluation

The results of the case study are compared with the findings from literature. Which of the benefits and challenges apply? Furthermore we evaluate the usefulness of the model and suggest improvements. Lastly, we discuss the generalisability and validity of the newly created BI maturity model.

Communication

The results of this study are communicated in two ways; this paper (for research) and in the form of an advice report (for practice) for TIS.
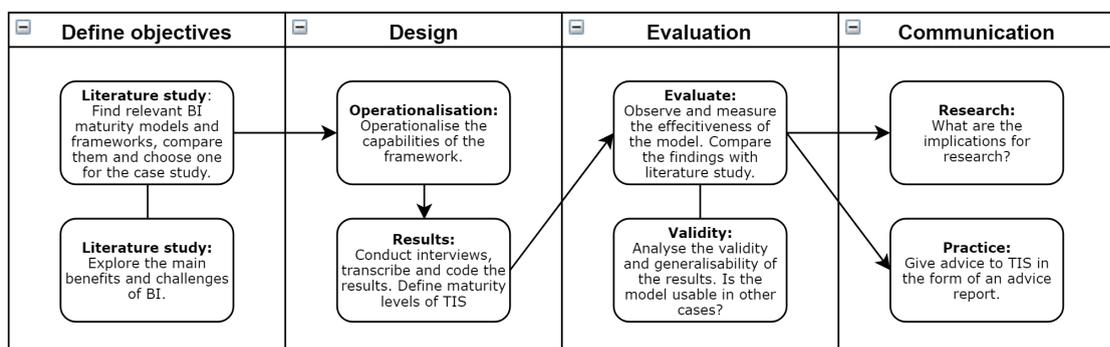
Figure 2.2: Design science methodology in the context of this research

2.2.3   Qualitative research

For the qualitative research semi-structured interviews were used. The interviews were recorded in a silent environment, and were conducted one on one, with no other individuals present. The interviews were recorded using a voice memo application on a phone. After the recording, the interviews were transcribed semi-verbatim, using the online application Otranscribe.com.

Otranscribe allows the transcriber to easily skip forward and backward in the voice memo. Also it allows for quick and easy speed adjustment of the playback, using hotkeys.

Atlas.ti was used to code the transcripts. The coding was done by using open coding followed by axial coding as described by Saldaña [2015]. These codes were then translated to maturity levels.

2.3   Definitions

BI is a term that has different definitions. Olszak [2016] gathered the most widely used BI definitions in their paper. These definitions can be found in tables A.2 and A.3 in the Appendix. As was explained in Chapter 1, we see BI as a broad term, and take the definition of Negash [2004] to define BI as: *"A system that combines data collection, data storage, and knowledge management with analytical tools so that decisions makers can convert complex information into competitive advantage."*

The terms Business Intelligence and Business Analytics are often used interchangeably. An example of this is in the paper by Cosic et al. [2012], which uses the definition of Negash [2004] but than uses it to describe Business Analytics. As explained by Olszak [2016] there are many definitions, and there is not a clear consensus about what is main definition of BI. In this paper we want to keep the definition of BI as encompassing as possible, hence why we use the definition introduced by Negash [2004].

Chapter 3

Benefits and challenges

In the next section the benefits and challenges of BI are discussed. This chapter starts with the benefits and then concludes with the challenges. They bring structure the benefits and challenges are mapped on the dimensions of the BACF; Governance, Culture, Technology and People. These dimensions are discussed in more detail in Chapter 4.3.

3.1   Benefits

The potential benefits of BI are huge. Table 3.1 show the most important benefits of using BI in an organisation, divided across the different dimensions of the BACF.

9

Benefits of BI		
Dimensions	**Benefit**	**Literature support**
Governance	BI gives the ability to the management to allocate resources to the right parts of the organisation, and gives understanding of the costs and benefits within the organisation. The improved use and allocation of resources within the organisation will ultimately lead to reduced costs and improved revenue.	bib, Bose [2009], Brynjolfsson et al. [2011], Kache and Seuring [2017], Seddon et al. [2017]
Culture	BI can assist in the decision-making process, and this can improve the productivity of an organisation. Using BI will give more insight to the decision makers, enabling them to make decisions based on facts instead of gut-feeling. BI can enable managers to have real time control, with the help of dashboarding and real time responsiveness.	bib, Bose [2009], Kache and Seuring [2017], Seddon et al. [2017]
Technology	Improved discovery, understanding and use of information within the organisation. Real time data and visualisation will lead to a higher degree of control within the organisation. BI can be used to analyse customer behaviour. BI can be used to cater to the individual wishes of customers (personification). Customers can be tracked and be given personal recommendations, which will both increase their happiness and the amount of revenue. Emerging market trends can be observed and acted upon a much earlier stage because of this. Predictive analysis can help with identifying future sales trends.	bib, Akter and Wamba [2016], Bose [2009], Chen et al. [2012], Kache and Seuring [2017], Seddon et al. [2017]
People	The ability to cater to the needs of the employees of the organisation. Their productivity can be improved by measuring and analysing their work load, and their happiness can be increased by giving them a more personal approach. BI can lead to a reduction in headcount, by automating simple tasks, thus reducing costs. When used correctly, BI can improve employee satisfaction.	bib, Kache and Seuring [2017]

TABLE 3.1: Benefits of BI

3.2 Challenges

Applying BI can be a daunting task for organisations, there are numerous challenges involved and the most important ones will be discussed in this chapter.

3.2.1 Governance challenges

Governing and managing BI can be a challenging task. the alignment of BI with operational objectives is difficult and requires expertise. BI, and big data in particular can pose big risks to both privacy and security [Sivarajah et al., 2017]. For example location-based data that is being analysed can pose a threat to the privacy of the persons being analysed. Organisations have to find ways to tackle these problems, it is not possible to store and analyse all the data that is available, especially not when people are involved. Creating clear guidelines and rules are essential to tackle the privacy issue. Another issue is the security of the data. The data that is being analysed can contain sensitive information, both for the company and for the individuals involved. It is important to develop regulating political and/or legal mechanisms to cope with these issues [Cao, 2016].

Governance challenges	
Challenge	**Literature support**
Organisations should be aware of the limitations of BI, and that it is not the answer to everything. To ensure this the organisation needs to be critical of its data and have the right persons in place to analyse the available data and analytics. Data governance can ensure good data quality across the whole organisation.	[Cao, 2016, Labrinidis and Jagadish, 2012, Sivarajah et al., 2017]
In order to conduct BI, substantial monetary investments are required. This is needed for the purchase of new tooling, for training and for the hiring of new talent. Analysing vast amounts of data is expensive, and the organisation needs to reserve enough financial resources for this. Also external help with BI, often in the form of consulting, is expensive.	[Coleman et al., 2016, Kache and Seuring, 2017, Sivarajah et al., 2017]
Managers have difficulty with finding the right managerial and organisational models in order to asses the current state of the organisation and the actions they need to take to improve the organisational maturity. Managers also find it difficult to evaluate the business impact of analytical findings. The findings of analytics should not just be about analytical outcomes, rather its goal should be to support decision making, a solid project plan can assist with this.	Cao [2016], Coleman et al. [2016]
Managing and analysing vast amounts of data poses a big security risk. Data security is a big challenge. A potential data leak can prove disastrous to an organisation, especially if the data falls in the wrong hands. Organisations are legally required to have adequate data protection.	[Chen et al., 2012; 2014, Coleman et al., 2016, Sivarajah et al., 2017]
Privacy regulations are becoming increasingly complex and difficult to comply with. Large amounts of data can have huge privacy implications and can contain sensitive information regarding persons. Organisations are legally required to report data leaks.	[Chen et al., 2014, Coleman et al., 2016, Kache and Seuring, 2017, Sivarajah et al., 2017]

TABLE 3.2: Governance challenges

3.2.2 Culture challenges

Getting the right mindset and culture within an organisation willing to make optimal use of BI can be a challenge. There needs to be a certain trust in the outcome of BI in order to make effective changes. It is important to start a cultural change, meaning that everyone in the company needs to have a data-driven mindset, and should be interested in gathering new insights from data [Kache and Seuring, 2017]. Another challenge found by Kache and Seuring [2017] is the challenge is the balance between a human focused and analytical management style. Managers should find the right balance between focusing on the results of the analytics and managing based on the results of the data, and also taking the human factor and instinct of their employees into account. This to ensure that the organisation does not transform into a 'cold-hearted' data focused company that loses the human focus.

Culture challenges	
Challenge	**Literature support**
Departments and different parts of the organisations need to cooperate in order to make BI a success. They need to share data and knowledge. The mindset in the organisation needs to change so that everyone is aware of the capabilities of BI. Data should be available from all parts of the organisation when needed. Often the organisational structure needs to change in order to ensure BI success.	[Kache and Seuring, 2017, Sivarajah et al., 2017]
Organisations are often highly specialised in their own field. Domain specialised organisations often have little confidence and and interest in new trends. This leads to a low confidence in new technologies such as BI.	[Coleman et al., 2016]
The organisation should not lose its focus on humans, and should find the right balance between analytics and humans. This is to ensure that the organisation does not change in a cold analytic driven organisation that does not take human input into consideration.	[Kache and Seuring, 2017]

TABLE 3.3: Culture challenges

3.2.3   Technology challenges

The technological challenges involved with BI are numerous. Data acquisition from different sources can produce an enormous amount of data [Labrinidis and Jagadish, 2012]. It is a challenge to combine and analyse these large amounts of often heterogeneous data. The analysis has to happen in an automated manner. This means that the database design has to be suitable in order to be understood by the computer. Coleman et al. [2016] claims that a lack of intuitive software is also a problem, especially for small and medium-sized enterprises. The software that is used in BI is often difficult to understand for employees that are not domain-experts. Improving the usability of the software used in BI will improve the use and effectiveness of BI as a whole. Cao [2016] argues that data quality is a critical problem in data science and engineering (and thus also in BI). It is important to not make assumptions about the quality of the data, and always assume that the outcome will involve better decision making. Chen et al. [2014] claims that data redundancy en data compression is a challenge. By making good use of redundancy reduction and data compression the whole cost of the system can be limited. Data governance is another management challenge that is involved with BI. It is important to describe which data is warehoused, analysed and accessed [Sivarajah et al., 2017].

Technology challenges	
Challenge	**Literature support**
The technical infrastructure that is in place is often not capable of handling big data and advanced analytics. BI requires specific tools and hardware to make effective use of its capabilities. And the use of these tools is often difficult, meaning that only a small amount of persons in the organisation is capable of using them.	[Chen et al., 2014, Coleman et al., 2016, Kache and Seuring, 2017, Sivarajah et al., 2017]
Gathering data from different sources and linking the existing database systems. The existing database systems are often "silo-ed" meaning that they are not linked and that their access is limited.	[Kache and Seuring, 2017, Labrinidis and Jagadish, 2012, Sivarajah et al., 2017]
Ensuring the quality of the data. Before the data can be used it often needs "cleaning" and parsing so that it can be analysed. Without good quality data there is a risk of "garbage in, garbage out", meaning that bad quality data will also lead to bad quality analytics.	[Cao, 2016, Kache and Seuring, 2017]

TABLE 3.4: Technology challenges

3.2.4 People challenges

Even when an organisation is capable of analysing (big) data, it is important that a decision-maker is capable of analyzing the results [Labrinidis and Jagadish, 2012]. Ransbotham et al. [2015] calls this the "analytics gap". *"In an increasingly data-driven business environment, many executives must make critical decisions based on analyses that use data and statistical methods that they do not fully understand. "* This gap shows a problem with business analytics, that will only grow larger. Because analytical methods become increasingly more complex, the understanding of these methods is reserved for only a small amount of experts. The analytics gap is the difference between an organisations capacity to produce analytical results, and the organisations ability to use these results in business that will lead to success. Without a decision maker that can translate the results of the analysis into business decisions, BI is useless. In their paper Chen et al. [2012] identify a shortage of qualified personnel. The shortage of data-savvy managers and business professionals with (deep) analytical skills. They claim it is important to supplement the current curriculum in IT education in order to cover analytics. This will ensure that there are more data-savvy students available that can fill the enormous demand.

People challenges	
Challenge	**Literature support**
Employees often have limited knowledge of BI. The amount of employees that know how to conduct BI is limited. Organisations need to hire new talent in order to conduct BI, but the pool of talent is very small as there are a limited number of data scientists and data analysts available because they need a large skill set. Having the right talent in house is a major challenge for most organisations.	[Cao, 2016, Chen et al., 2012, Coleman et al., 2016, Kache and Seuring, 2017, Labrinidis and Jagadish, 2012]
Managers have difficulty in understanding advanced analytics. This is called the "analytics gap". Because of this, decision makers often find it difficult to trust data and analytics and use the outcomes of BI to support decision making. This leads to managers being unsure about investing in BI, because they find it difficult to asses its usefulness. Managers should at least get basic understanding of BI and its concepts in order to use its findings in their decision making process.	Chen et al. [2012], Coleman et al. [2016], Ransbotham et al. [2015]

TABLE 3.5: People challenges

3.3   Conclusion on benefits and challenges

In the literature review we gathered the major benefits of BI. Using BI in an organisation can assist in the decision making process, which can lead to decision based on facts instead of 'gut feeling'. This gives management the power to invest in the right projects. BI can also assist sales. By analysing and tracking customer behaviour an organisation can cater to the wishes of individual customers. Market trends can be observed and acted upon quickly. BI can also assist in increasing the happiness and effectiveness of personnel. Overall BI is used to give insight in the whole organisation by improving the use and visualisation of information. Ultimately the use of BI in an organisation will lead to an increase in profits and a decrease in costs.

The challenges regarding BI were also gathered by conducting a literature review. The results of this review show that the amount of potential challenges is numerous, and that an organisation wishing to start or expand their BI capabilities should be aware of these potential challenges. The most important challenges that were found were acting on the results of BI is a challenge, organisations should be careful not to transform into a cold-hearted and purely data-driven organisation, instead organisations should carefully take the human side into consideration when engaging in data-driven decision making resulting from BI. Also the most important technical challenge that was found was that the current technical infrastructure in the organisation is not capable of handling BI. Usually the right tooling is not used or in place, and the data sources within the organisation are not linked and not suitable for analysis, furthermore the data that the organisation wants to analyse should be clean, or they should be capable of cleaning the data. Also there is challenge to find the right persons (data analysts and data engineers for example) for the job, as supply is limited and the demand for talent is huge in the current market. In Chapter 7 the found benefits and challenges in this chapter will be compared and evaluated with the findings from the case study.

Chapter 4

Maturity models

BI maturity models can assist organisations in scoping and assessing their BI initiatives [Cosic et al., 2012]. BI maturity models can be used to asses the current state of the organisation, and the organisational factors that need to to change in order to achieve higher BI maturity. Empirical research conducted by Chen and Nath [2017] suggests that BI maturity positively affects the organisations overall BI success. This means that organisations can improve their use of BI by improving their BI maturity, and in order to measure and improve their maturity, maturity models can be a helpful tool.

4.1   Inclusion criteria for the maturity models

There is a wide variety of BI maturity models and frameworks available, both from research and from practice. Because of the different naming convention we will use the term maturity model for both models and frameworks. Table A.1 on page 51 lists the relevant BI maturity models in the field of BI. This list was derived from different sources that analysed the available business analytics maturity models [Chen and Nath, 2017, Chuah and Wong, 2011, Hribar Rajterič, 2010, Muller and Hart, 2016, Thamir and Theodoulidis, 2013]. The list was than completed with the results of the literature review by adding newer maturity models such Chen and Nath [2017]. The list includes maturity models that are focused on business intelligence, business analytics, big data analytics or a combination of these factors. Some older models were named in literature, but their

documentation was not available anymore. These particular models were omitted from table A.1 to improve readability and usability.

4.2   Comparison of the models

Chen and Nath [2017] identified four categories of maturity models; technology, organisation, capability and impact focused models. The first BI models that emerged were focused on the technical aspects and their associated issues involving data architecture and business intelligence [Chen and Nath, 2017]. An example of one of these earlier technical models is the Data Warehousing Maturity Model by Watson et al. [2001]. The second category of maturity model focus on the business side of BI maturity. What has to change in an organisation in order to achieve BI maturity? An example of the organisational models is the first model by Gartner. Capability models are focused on how organisations can focus and renew resources to invest in BI [Chen and Nath, 2017]. An example of a capability model is the Business Analytics Maturity Model by Cosic et al. [2012]. The last category that was named by Chen and Nath [2017] are the impact oriented maturity models. These models focuses on the (positive) impact of BI on an organisation. The model created by Lahrmann et al. [2011] is an empirically validated impact oriented model that shows that the use of BI can lead to a positive organisational impact.

Maturity models can be either be staged, continuous [Lahrmann et al., 2011], or contextual [De Bruin, 2009]. The staged maturity model consists of a set of discrete stages, often in the range of three to five. Before the next stage, or maturity level, can be reached, first all the prerequisites of the previous stage have to be fulfilled. An example of such a staged model is the TDWI model, with stages named Infant, Child, Teenager, Adult and Sage. The staged maturity models all have their basis in the Stages of Growth maturity model introduced by Nolan [1975]. This model can be seen in figure 4.1. Other staged maturity models have similar structures, as can be observed in the maturity model of 4.2. Continuous models have a score attached to each maturity dimension. The maturity level of a continuous model are either the individual maturity scores across all the dimensions, or the weighted average of the levels across all dimensions [Lahrmann et al., 2011]. A continuous maturity provides more flexibility, as there are several paths

possible to achieve maturity [Cosic et al., 2012]. Contextual models are similar to continuous models [Cosic et al., 2012], the difference according to De Bruin [2009] is that contextual models are depended on the context and can be used in a non-linear fashion, meaning that the maturity levels can increase or decrease. These contextual models are the most flexible and adaptable to the specific situation, but also require more skill and knowledge of the person(s) using them.

De Bruin [2009] identified three purposes for maturity models; descriptive, prescriptive and comparative. Descriptive models are used to asses the current maturity level. Prescriptive models are used to asses the maturity level at an organisation, and also gives recommendations on how to reach the next maturity level. A comparative model is the same as a prescriptive model, but has been applied in a large number of organisations, so that that data can be used for comparison.

Not all models from table A.1 are empirically validated, examples of models that are empirically validated are the models by Lahrmann et al. [2011] and Chen and Nath [2017]. However these models are a minority, and more often than not the theoretical basis of the maturity models is unclear, this is especially the case with the maturity models that originate from practice. The majority of the models, and especially the models that originate from practice are created based on assumptions and the experience in the field of BI by their authors. Companies such as Gartner have created multiple maturity models, in different fields of IS in the course of years. They continuously update existing models to incorporate new techniques or create new models that are based on older models that they created.
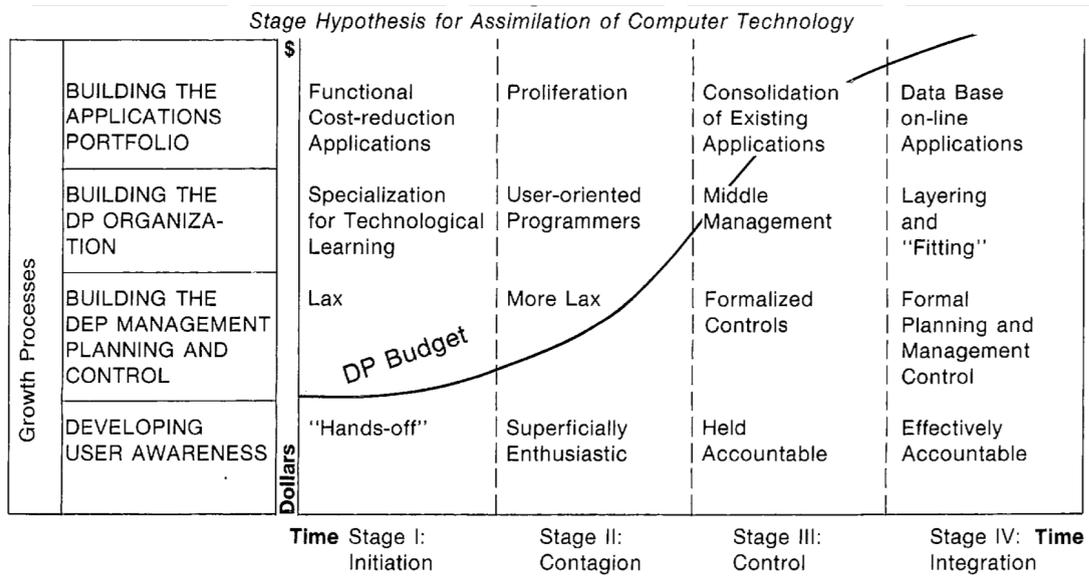
FIGURE 4.1: Stages of maturity by Nolan [1975]
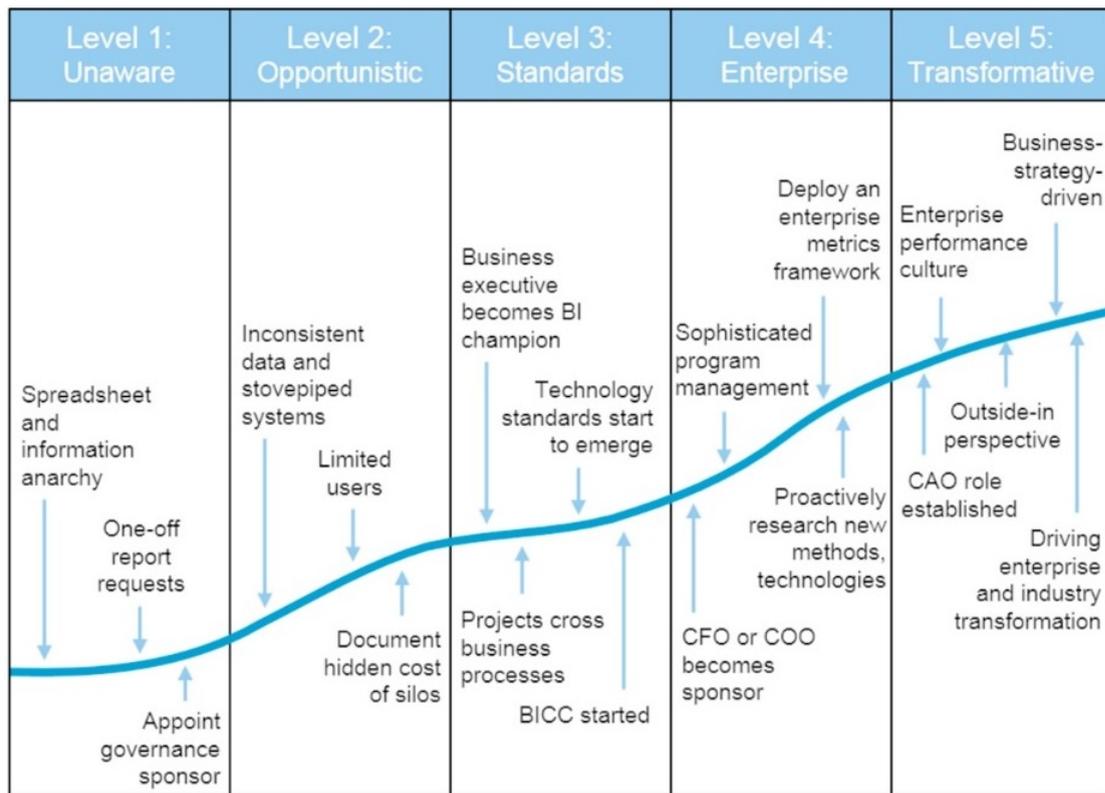
FIGURE 4.2: BI maturity model by Gartner

4.3   The Business Analytics Capability Framework

An analysis of the available BI maturity models identifies two good candidates for BI maturity analysis. The model by Chen and Nath [2017] is a good option for a quantitative measurement of BI maturity. The model by Chen and Nath [2017] is empirically validated by testing the model on more than 100 organisations. However, the main issue in the setting of a case study is that the model gives a quantitative measurement of BI maturity, that is limited in scope. Because of this it is difficult to create a specific advice based on these limited factors.

A good candidate for a qualitative assessment of BI is the Business Analytics Capability Framework (BACF) by Cosic et al. [2015]. The main drawback of the BACF is the fact that is is not operationalized, but this also provides the opportunity to improve the BACF into an useful maturity model, which is a contribution to both practice and research. The BACF was developed in two iterations, the first iteration in Cosic et al. [2012] and the next iteration in Cosic et al. [2015] by conducting a Delhi study to further define the attributes of the framework in more detail. The BACF can be seen in figure 4.3. The BACF provides a strong theoretical basis, based on the combination of the resource-based view by Barney [1991] in combination with the theory of dynamic capabilities by Teece et al. [1997]. The resource-based view proposes that organisational resources are the basis for competitive advantage and improvement to the organisation. These resources should be VRIN:

- Valuable: enable an organisation to implement a value-creating strategy

- Rare: are in short supply

- Inimitable: cannot be perfectly duplicated by rivals

- Non-substitutable: cannot be countered by a competitor with a substitute

Cosic et al. [2012] states that normally IT resources do not fit to all these criteria, due to them becoming increasingly commoditised. Because the resource-based view defines organisational resources as static, the theory of dynamic capabilities was added to the framework. These dynamic capabilities are based on continuous renewal and

re configuring of the resources of an organisation, making them better suitable for IT resources and capabilities.

The BACF consists of the following four dimensions, called capability areas, that were defined by Cosic et al. [2012]. The definitions of the underlying capabilities can be found in tables A.4, A.5, A.6 and A.7 in the Appendix:

- *Governance: is the mechanism for managing the use of BA resources within an organisation and the assignment of decision rights and accountability's to align business analytics initiatives with organisational objectives [Weill and Ross, 2004]. It also involves continuously renewing BA resources and organisational capabilities in order to respond to changes in dynamic business environments [Collis, 1994, Shanks and Sharma, 2011], and mitigating resistance to change [Williams and Williams, 2007].*

- *Culture: is the tacit and explicit organisational norms, values and behavioural patterns that form over time and lead to systematic ways of gathering, analysing and disseminating data [Leidner and Kayworth, 2006]. It influences the way decisions are made (e.g. ad-hoc or fact-based), the proclivity for key performance indicators and quality measurement, the degree to which BA is enmeshed in daily business activities, the level of management support for BA [Davenport and Harris, 2007], and receptivity to change [Hopkins et al., 2010].*

- *Technology: refers to the development and use of hardware, software and data within BA activities. It includes the management of an integrated and high quality data resource [Davenport and Harris, 2007], the seamless integration of BA systems with other organisational information systems [Kohavi et al., 2002], the conversation of data into information through reporting and visualization systems [Watson et al., 2001], and the use of more advanced statistical analysis tools to discover patterns, predict trends and optimise business processes [Negash, 2004].*

- *People: refers to all those individuals within an organisation who use BA as part of their job function. BA initiatives are considered to be knowledge intensive and require technical, business, managerial and entrepreneurial skills and knowledge [Davenport and Patil, 2012].*

The maturity level of the BACF is scored on a five level maturity scale:

- Level 0 – Non-existent: the organisation does not have this capability

- Level 1 – Initial: the capability exists but is poorly developed

- Level 2 – Intermediate: the capability is well developed but there is much room for improvement

- Level 3 – Advanced: the capability is very well developed but there is still a little room for improvement

- Level 4 – Optimised: the capability is so highly developed that it is difficult to envision how it could be further enhanced. At this point the capability is considered to be fully mature

The BACF is a contextual framework, this means that the maturity level is dependent on the context of the organisation. Also the framework is descriptive, meaning that it gives an overview of the current maturity level of the organisation, but does not provide exact guidelines on how to improve this maturity.

In its current form, the BACF serves as a framework but is not yet suitable for the measurement of BI maturity. This is also stated in the conclusion by Cosic et al. [2015], this is because the capabilities of the BACF first need to be operationalised. In Chapter 5 we will operationalise the capabilities of the BACF, and transform the framework into a usable maturity model.

4.4 Conclusion on maturity models

In this chapter the relevant BI maturity models from practice and literature were collected. These can be found in table A.1. The major differences and similarities between the models were analysed. The main difference between the maturity models is their category (technology, organisation, capability and impact focused models) their type (staged, continuous or contextual), their purpose (descriptive, prescriptive or comparative), their origin (practice or research) and the empirical validation of the model. Finally a choice was made for the maturity model to be used in the case study, which is the BACF by Cosic et al. [2015]. This framework has a strong theoretical basis, but lacks operationalisation.
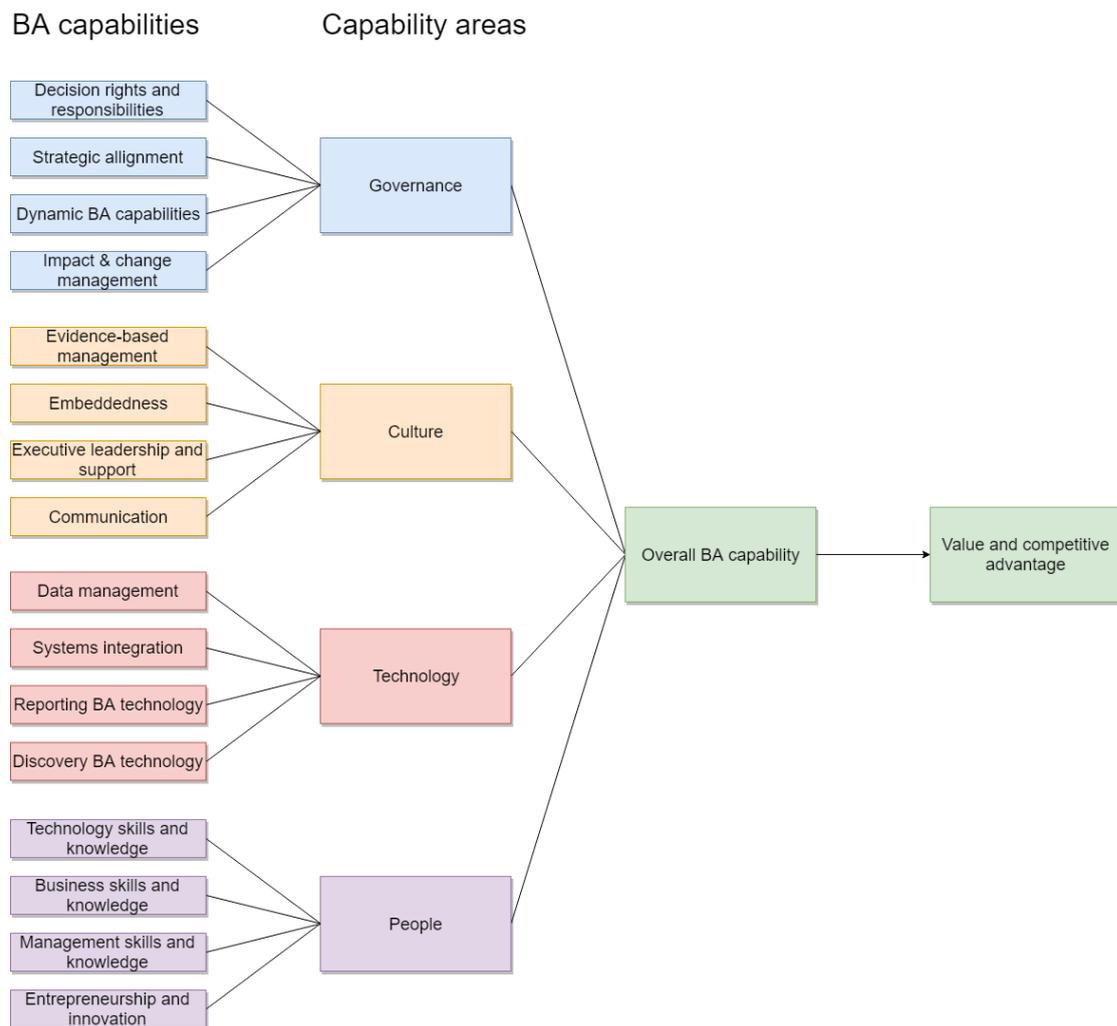
FIGURE 4.3: Business Analytics Capability Framework by Cosic et al. [2015]

Chapter 5

Case study set-up

In this chapter we will give a short recapitulation of the case study situation as described in Section 1.2. Afterwards, we extend the BACF from Section 4.3 with the operationalisation of an interview model to transform it into a usable BI maturity model. In the following sections we describe the capabilities and the interview protocol of the newly developed BI maturity model, the Business Intelligence Capability Maturity Model (BICMM).

5.1   Description of the situation

In this case study we will use the newly developed BICMM on the case of TIS. TIS is an ICT service provider that focuses on the business to business market. TIS is an organisation that has undergone a massive growth in the last few years, but struggles with the implementation and use of BI. In this case study we will use the newly developed BI maturity model to measure the current maturity level of TIS across the dimensions of the model, and we will generate recommendations for TIS on how to improve their use and implementation of BI in Section 8.2.

5.2   Transforming the BACF into the BICMM

In order to transform the BACF into a usable maturity model, the capabilities of the framework have to be operationalised, as in its current form, the BACF is not suitable

for BI maturity measurement. In this study we transform the BACF into the Business Intelligence Capability Maturity Model (BICMM). In Table 5.1 the capabilities of the BICMM, together with their respective codes can be found. The comprehensive definition of these capabilities can be found in the Appendix, in Tables A.4, A.5, A.6 and A.7.

In their study, Olszak [2016] created an interview framework that is capable of measuring BI maturity. The model has been tested on 20 organisations in Poland in two different periods. In this study we have adapted this interview framework to the capabilities of the BICMM.

Not all of the interview questions by Olszak [2016] were suitable for adaption to the capabilities of the BICMM, but were still deemed valuable as they were able to create a context. Because of this an extra category was created, which can be found in table 5.2. These general attributes are not used for the measurement of the maturity level of TIS, but serve to get a better understanding of the context and to analyse the future wishes of the interviewees regarding BI at the case study.

The adapted interview framework, adapted for the BICMM can be found in table 5.3. In this table the questions with their corresponding capabilities can be found. Because all the participants in the case study were Dutch, a Dutch version was created and used in the case study, which can be found in table B.1 in the Appendix.

Attributes		
Area	**Code**	**Capability**
Governance	GOV1	Decision rights
Governance	GOV2	Strategic Alignment
Governance	GOV3	Dynamic BI Capabilities
Governance	GOV4	Change Management
Culture	CUL1	Evidence-based Management
Culture	CUL2	Embeddedness
Culture	CUL3	Executive Leadership and Support
Culture	CUL4	Communication
Technology	TEC1	Data Management
Technology	TEC2	Systems Integration
Technology	TEC3	Reporting and Visualisation BI Technology
Technology	TEC4	Discovery BI Technology
People	PEO1	Technology Skills and Knowledge
People	PEO2	Business Skills and Knowledge
People	PEO3	Management Skills and Knowledge
People	PEO4	Entrepreneurship and Innovation

TABLE 5.1: BICMM capabilities

Attributes		
Dimensions	**Attribute**	**Definition**
General	**GEN1**: BI use	This attribute is used to give a global overview of the BI use in the organisation and of the person in question.
General	**GEN2**: External environment	To see if the BI use is only internally or also externally (to analyse customers, suppliers, competitors and other business partners).
General	**GEN3**: Future wishes	To see what the biggest requirements and wishes are for the short and the long term.

TABLE 5.2: General attributes

Interview questions in English	
Question	**Capability**
1.Do you use BI? What do you use BI for? (dashboarding, reporting, ad-hoc reporting, analysing, alerting, predictive modelling, operationalising, optimisation, activating, etc.)	**GEN1/TEC3-4**
2.Do you use BI for analysing customers, suppliers, competitors and other business partners (external environment)?	**GEN2**
3.Does your organisation have a defined BI strategy and is it aligned with the overall business strategy?	**GOV2**
4.Are decision rights and responsibilities within the organisation clearly defined?	**GOV1**
5.Does the organisation use change and impact management to manage big chances? (For example the implementation of a new ERP system)	**GOV3/GOV4**
6.Are the BI systems (un) limited to the part/department of the organisation?	**CUL2/TEC2**
7.When making decisions, do you use data/predefined metrics/KPIs or do you make the decision based on gut feeling?	**CUL1**
8.Does the (executive) management support the use of BI?	**CUL3**
9.How is the communication of data and results on a departmental level?	**CUL4**
10.Asses the quality of (available) data in the organisation. (complete/correct/consistent; high/medium/poor quality data) Is there a data management strategy in place?	**TEC1/TEC2**
11.Are the systems that you use integrated? Meaning that necessary data is shared, systems are easily interlinked where needed etc.	**TEC2**
12.Do you use reporting BI technology, if so which? (Dashboarding, KPI's, reports?)	**TEC3**
13.Do you use discovery BI technology, if so which? (Data mining, web scraping, machine learning etc.)	**TEC4**
14.Do you think there is enough knowledge available in the organisation to use BI? (Technology, Business)?	**PEO1/PEO2**
15.Do you think you have the necessary knowledge to make (optimum) use of BI?	**PEO3/PEO4**
16.Which BI capabilities would you like to see the most (Do you miss the most)? (Dashboarding/Specific data/Etc.?)	**GEN3**

TABLE 5.3: Interview questions in English

Chapter 6

Case study results

6.1 Interview set-up

The interviews. were conducted at TIS with the following managers:

- Interview 1: Product Development Manager

- Interview 2: Technical manager & Business Unit manager

- Interview 3: Service operations manager

- Interview 4: Sales manager

- Interview 5: Commercial manager & Business Unit manager

The interviews were transcribed semi-verbatim, and the transcriptions were coded to determine the different maturity levels of the attributes.

6.2 Result Matrix

Area	Code	Capability	Int. 1	Int. 2	Int. 3	Int. 4	Int. 5	Total
Governance	GOV1	Decision rights and responsibilities	3	3	2	2	3	3
	GOV2	Strategic alignment	0	0	0	0	0	0
	GOV3	Dynamic BI capabilities	0	0	0	0	0	0
	GOV4	Impact & change management	2	2	2	2	1	2
Culture	CUL1	Evidence-based management	1	0	2	1	1	1
	CUL2	Embeddedness	1	1	2	2	1	1
	CUL3	Executive leadership and support	1	2	0	0	2	1
	CUL4	Communication	0	0	0	0	0	0
Technology	TEC1	Data management	0	0	0	0	0	0
	TEC2	Systems integration	2	1	1	2	1	1
	TEC3	Reporting BI technology	1	2	3	2	1	2
	TEC4	Discovery & analytical BI technology	0	0	0	0	0	0
People	PEO1	Technology skills and knowledge	0	1	2	0	0	1
	PEO2	Business skills and knowledge	0	0	2	1	1	1
	PEO3	Management skills and knowledge	1	0	2	1	1	1
	PEO4	Entrepreneurship and innovation	1	2	0	0	1	1

TABLE 6.1: Maturity level results

In the next section the results of the case study are summarised. These results are the outcome of the transcribed interviews. The analysis and interpretation of these results is done in the chapter on analysis.

6.2.1 Governance

In the **decision rights and responsibilities** the maturity level is at a relatively high level. The interviewees noted that in general, the responsibilities are clearly divided between the different managers and between the different layers of the organisation. There is some overlap between responsibilities, but this was overall not seen as a big problem. However, while most of the time it is clear who is responsible for which decision, the decision making process is sometimes very long.

Strategic alignment was scored as zero. TIS has no specific BI strategy in place. And while there is a business strategy in place, this is not aligned with BI. As described in interview 1:

"There is a wish, but not a specific strategy, there is no plan to let the wish go into fulfilment."

The results show that overall, the need for BI and better use of the available data is known and understood, however the specific steps and strategy taken to reach this point is unclear.

The use of **Dynamic BI capabilities** is also non-existent. Continuous renewal of the organisation's BI resources and capabilities is something that is not in place at the moment.

Change and impact management at TIS is done on a purely operational level. TIS is starting to implement change management for one if its customers. Change management is done on a basic level, and is something that is being developed further. On a higher, organisational level, change management is not used. In interview 3 this is described:

"At this moment we only use it in an ICT environment. It is not used when for example the composition of a department changes"

6.2.2 Culture

Evidence based management is scored on levels ranging from zero to two. There is a discrepancy in the use of data and quantitative analysis over the use of gut-feeling and intuition. Most of the time, a mixture between gut-feeling and information (when available) is used. The lowest score was measured in interview 2, who stated: *"When you make a decision you try to create a picture for yourself, for example by talking to colleagues, but this process is not data-driven"*

A maturity level of two was measured in interview 3, where it was stated:

"The information from Topdesk, like the amount of incidents, is available. So based on that information we can create a good feeling about the current state by using that information"

Embeddedness, or the extent to which BI has permeated the organisation was scored between one and two. Overall information and BI is used where it is available, such as the BI capabilities of the software used at the servicedesk (Topdesk) or the sales dashboard. But the available BI solutions are limited, and are often created by the users themselves.

Executive leadership and support shows maturity levels ranging from zero to to two. The business unit managers have a more positive view on this dimension than the other interviewees. They state that it is supported by the business unit management and the CEO. The other interviewees state that it is supported to gain significant results, but have the feeling that it is not supported by making significant investments in BI.

Communication was scored as zero on all interviews. This specific attribute is aimed at the communication of BI within the organisation, and because of the lack of BI iniatives, this is not done at TIS.

6.2.3 Technology

The maturity level of **Data Management** is consistently non-existent among st all the interviews. It is clear that there is no data management strategy in place. However most of the interviewees state that this is something that has to be done in the near future.

In the **Systems Integration** attribute the scores range from one to two. Some of the systems are integrated, but their integration are usually crude. There are no smart links between the different systems and they do not share a common data warehouse. The links usually only consists of copying a certain data item from one of the particular systems to the other. As stated in interview 2:

"The use of BI is very localised, if you want information you have to gather it from several places"

Reporting BI technology is used on a small scale. The sales department uses a sales dashboard that has some crude metrics that are measured and visualised. The place where the most reporting BI is used is on the service & operations side of the organisation. This department uses Topdesk, that has a lot of build in visualisation and reporting abilities, which are widely used.

Discovery & analytical BI technology is not used. However the wish for it is high. Participants explained the need for models that made it easier for them to predict trends in the future.

6.2.4 People

The **People** capability area was difficult to measure, because there was no hard data available on the capabilities of the personnel of TIS. That is why these maturity levels are based on the assumptions of the interviewees. The BI knowledge is at a low level, as was explained in interview 1:

"For advanced analytics there is no knowledge available, if you want this you should hire new people"

Several of the participants explained that they thought the knowledge was not available at the members of the organisation, and if the knowledge was there it was divided between several of the members of the organisation. It is quite difficult to asses the validity of these claims as the exact knowledge required to implement BI is quite diverse, and the maturity level in this field is just a 'feeling' of the interviewees. It may very well be that the amount of knowledge in reality is much higher, or even lower, than what can be concluded from the results of the interviews. In order to accurately asses the

knowledge within the organisation, one analyse the available (technical) personnel, and test them to see if they have a certain level of knowledge that is required for implementing and using BI.

6.2.5   General attributes

6.2.5.1   BI use

This attribute is used to measure to give a global overview of the BI use of the person and the organisation. The result shows that were BI is available, it is used by the interviewees, however, because of the limited availability and quality of the systems this is done on a limited level. The part of the organisation were BI is used the most and with the most satisfaction is on the service and operations side, where they use the software of Topdesk. Topdesk is available to generate valuable reports and analyses. This was also stated in interview 2:

"I think Topdesk is a good example of a system with valuable and accurate information"

Also in the sales department a sales dashboard is used that is capable of visualising basic strategic information. The results of this attribute confirms the findings of the maturity level results.

6.2.5.2   External environment

Externally BI is used on several fields. For analysing the turnover per supplier, the suppliers own portals and systems a re used. There is not a internal system in place that stores and analyses this information. Customers satisfaction is also measured at TIS, and the customers have the ability to give feedback. In the sales department the competitors of TIS are stored on a basic level.

6.2.5.3   Future wishes

This attribute is used to gather the largest wishes of the interviewees, what sort of solutions would they like to see in the short and in the long term? The main wish on the short term is to get more control and grip on the financial data. At this moment that is

something that is not available, only very crude financial data, such as the total amount of money coming in and the total amount of money going out is available, but this data is not specific to certain products or services, making it impossible to view the profit generated by a single service for example. In the long run, the main wish is to generate accurate predictions. Models are needed that are able to accurately predict the future, so the management can act in time to changing business needs and profit forecasts.

6.2.6 Conclusion on results

Overall the case study shows a low level of maturity. The widespread use of BI within TIS is limited, and most of the BI available is done on an ad-hoc basis, with no central control or strategy involved. The use of more advanced forms of (analytical) BI is non-existent and the overall level of knowledge is low. The main wish of the interviewees on the short term is more grip and control on financial information, and in the long term there is a wish for predictive models that can accurately predict the the future.

Chapter 7

Evaluation

In this study we use the DSRM by Peffers et al. [2007] for structure and guidance. The evaluation phase is used to observe how well an artifact supports a solution to the problem. In this chapter we will first discuss the findings of the case study, and find explanations for them. Afterwards we will compare the found benefits and challenges with the literature study of Chapter 3. Finally we will discuss the usability of the BICMM, suggest improvements, and discuss the validity of the model.

7.1 Analysis of the case study results

In the following section the results of the case study described will be discussed and analysed. The results of the case study will be held in light with the literature study conducted on benefits and challenges and the phenomenons observed will be analysed.

7.1.1 Low maturity level

The results show a low maturity level at almost all attributes at TIS. One could argue that this is a strange, as TIS is an ICT company with 15 years of experience, that has grown fast in the last few years. However, there are some explanations for the cause of the limited amount of knowledge in the field of BI for TIS.

7.1.2 Explanations for low maturity level of TIS

In their paper Coleman et al. [2016] identified the main challenges for applying BI in a SME (small or medium enterprise) context. The following challenges that were found by Coleman et al. [2016] are also applicable to this case study:

Shortage of in-house data analytic expertise: TIS employs a number of specialists (called ICT-specialists). However these are not specialists in the field of BI, instead they are specialists in the expertise fields of TIS; cloud, network, workspace, security, communications and identity. The lack of these in-house data analytic experts makes it difficult for TIS to start new BI initiatives.

Non-transparent software market: A significant portion of the current problems and uncertainty with the implementation of BI at TIS originates from the implementation of the new ERP system. In the process some big mistakes have been made. The expectation of the ERP system was that it would include significant BI capabilities, but after the implementation of the system it seems that this was not the case, and that TIS still has to manually extract the data in order to perform BI, which was not expected beforehand. This process confirms the point made by Coleman et al. [2016], because of the limited BI expertise at TIS, it was very difficult to choose the right software product that was able to meet all the requirements.

Financial barriers: Finding the right persons for data analytics is expensive. Davenport and Patil [2012] explains that finding the right data scientists for the job is a daunting task for organisations, because their availability is limited and their salary high. As an SME, TIS does not have large funds available to invest in BI.

Another possible explanation for the low level of BI maturity within TIS is the high amount of organisational growth that TIS has undergone in the last few years. Organisational growth often is not a linear process. Mostly it consists of years of stable growth (evolution) which are interrupted by periods of turbulence (revolution) [Greiner, 1998]. In their paper Greiner [1998] explain that these periods of revolution consists of large changes in the organisation; management practices that were appropriate for the smaller firm size at the beginning of the evolutionary process are not applicable and effective anymore. The challenge for organisations that are in the phase of a revolution is to find new management practices that are fitting to the larger size of the organisation.

TIS was subject to a rapid growth in the last few years.When analysing the current situation, and the results from the interviews it seems that TIS has entered a revolutionary phase, as described in the paper by Greiner [1998].

This revolutionary phase started with the realisation that old legacy systems, that were mostly build in-house, were not up to the task anymore. Because of this the decision was made to implement an ERP system that would link all the relevant departments. However the implementation of the ERP system has also created new problems, and many of the requirements were not met. Getting grip and control was much easier when TIS was smaller, as the amount of data was much lower and it was easy just to walk to the department for the information that was needed. Now, with the increase in business units, amounts of data and employees this task has become much more difficult and time consuming. The main struggle for TIS is to ensure processes and tooling are put in place to ensure the delivery of information at the right time, to the right people.

7.1.3 Comparison of benefits and challenges

The major benefits and challenges of BI were collected in Chapter 3. In this section we will analyse the found benefits and challenges with the findings of the case study.

The major benefits of BI include using BI for decision support and giving more insight into the business itself, using BI for marketing purposes, making personalised recommendations which lead to an increase in sales and customer satisfaction. And the ability to better use the available employees, by catering to their needs and by putting their skills to more effective use, which will increase their productivity and satisfaction. Overall it is difficult to compare the found benefits with the results of the case study. The main reason for this is the low BI maturity level of TIS. The use of BI is relatively low, and mostly on an ad-hoc basis. However where the use of BI is more prevalent, such as in the service and operations several benefits were found. Such as the ability to monitor calls, and to gather statistics and create visualisations on the performance of the service desk.

Several of the **governance** challenges were observed in the TIS case. The sometimes substantial requirements for resources to implement BI was also observed at the TIS case. An SME such as TIS needs to make difficult decisions in what to do with their

limited resources, and they cannot just invest in every BI opportunity. Also the limited amount of decision support was noted in the TIS case. Managers often had to use gut-feeling instead of using meaningful BI solutions that would help them in their decision making process.

The **culture** challenges that were observed in the case study involve the difficulty of different parts of the organisation working together and sharing data and information. In this case study this was caused by the limited technical capabilities of the system, and the limited amount of integration between the existing systems. When there is a link available to share information, these links are not developed. As explained in interview 1:

"The connections between the application are not smart"

"Every change is just duplicated in all the other applications"

The challenges involved with **technology**, such as the extraction and cleaning of data, the availability of data within the organisation, and the use of a data management strategy were confirmed by the interviews in the case study. These challenges with data were confirmed in the interviews, as was stated in interview 1:

"The available data is of medium quality, however the data is very disorganised, and is not funnelled in the right KPI's. It seems the information is there, however this is so disorganised that this information on itself is not useful."

"Yes that is something that we should do (implementing a data management strategy), because I see that sometimes the same data is entered two times, through a fault in the process of which the employee that entered the data is not aware."

The challenges with finding the right **people**, with the knowledge to implement and use BI, was very prevalent in the results of the literature study in Chapter 3. This was also the case in the case study, where the maturity levels on the People dimension was low. It seems that even for an IT organisation, having the right talent in house that is capable of developing BI is difficult. In interview 5 it was stated:

"I think we need a new type of person, a real data specialist"

7.2 Analysis of the model

In the previous section the results of the case study were analysed and compared with the findings from the literature study. In the next section the maturity model used in the case study will be discussed.

7.2.1 Performance of the BICMM

In Chapter 5 we developed the BICMM, in Chapter 6 we applied the newly developed model in a case study. In the following section we will discuss the usability of the model, suggest improvements, and discuss the validity of the BICMM.

7.2.2 Usability of the BICMM

Most of the attributes of the BACMM model were suitable to be measured via a qualitative semi-structured interview. However not all of the attributes were as easy to measure, and required more context analysis than that they were obtainable directly from the answers of the interviewees.

It seems that the model is better suited, and able to give more rich information and feedback, in a higher maturity level organisation. In this specific case study, the overall BI maturity model was at a low level. Something that was also expressed by several of the interviewees.

Because of this low maturity level of TIS, a lot of the attributes automatically default to zero. For example; Dynamic BI capabilities is aimed at the ability of the organisation to continuously renew and improve BI capabilities and resources within the organisation. However, when an organisation is at such a low maturity level such as TIS, it is quite obvious that this capability is not present, as there first needs to be a basis of BI use before this can be implemented. The same problem persists with the other capabilities that defaulted to zero. In the People capability area this problem was most noticeable. In this capability area the different levels of BI knowledge within the organisation are measured, ranging from a pure operational (technical) level to higher managerial and entrepreneurial levels of BI knowledge within the organisation. Measuring the exact

maturity levels on each of these attributes was difficult to asses, in interview 1 it was stated:

"The whole organisation has 250 employees, but maybe one or two have the knowledge to develop BI"

Which was confirmed in interview 2:

"I think we have knowledge in the organisation, but the resources are scarce"

Overall the results show that the interviewees had the 'feeling' that there may, or may not be, enough knowledge within the organisation to use and implement BI on the different levels of the organisation. However, because of the low maturity level overall, there is no concrete information available on the BI skills of that of the employees and that of the management. While the results of the maturity model probably give a good indication of the level of knowledge within TIS in the area of BI (which is low) it is not concrete. In order to give an exact level of maturity level of the knowledge within TIS, further research is required. For example by analysing the exact skills of the employees in the field of BI. In the opinion of the researcher, this is also a problem that is caused by the low maturity level of TIS. An organisation that is on a higher BI maturity level will have a better idea of their BI capabilities, and most likely will have a special BI team or data analytics team in place to support the BI initiatives, both internally and externally. When this is the case, the managers will probably have a much better understanding of the skills of themselves and their employees in the field of BI, making it much easier to measure the attributes of the People capability area and making the scores more accurate, because then the scores are based on facts instead of gut-feeling.

7.2.3   Improvements to the BICMM

After using the BICMM in the case study described in the previous chapters, several possible improvements have come to light. While not in the scope of this particular study, these improvements can possibly be applied in the following iterations of the model.

The most beneficial improvement to the BICMM is the change to a prescriptive model. The BICMM in its current form is a descriptive model. As was described in Chapter 3, a

descriptive model gives a description of the current maturity level, but lacks guidelines on how to improve the maturity levels. A prescriptive model on the other hand has specific guidelines in place on how to ascend to higher maturity levels. In order to change the BICMM into a prescriptive model, these guidelines have to be developed for each of the capabilities and capability areas. An example of such a guideline for the capability of data management could be instructions on how to implement a data management strategy in an organisation lacks one, with increasing levels of complexity for the higher maturity levels. These guidelines will also enable users with less knowledge of BI to use the model in an effective way.

The BICMM in its current form measures all the capabilities simultaneously. The results and the evaluation in the previous section show that this may not necessarily be a good thing. In the case study it was noticeable that many of the capabilities default to zero in a low BI maturity organisation. A possible improvement to the model may be to change it into a two-staged model. The first stage will be focused on basic BI technology, that focuses on reporting and visualisation BI technology such as reports, dashboards and scorecards with the appropriate capabilities involved. The next and last stage is focused on discovery BI technology that is focused on advanced forms of BI such as statistical analysis and data and text mining. It seems logical that an organisation first has to fulfil the requirements of the first stage, before it can ascend to the second stage. This was also observed in the case-study, where the organisation is still busy with implementing the basic forms of BI, so it is only logical that they have not started with the advanced forms of BI and because of this the capabilities associated with these advanced forms of BI default to zero. Changing the model into a two staged model will solve this problem and will make the model more logical and easy to use.

The last possible improvement to the model is the extension of the operationalisation of the capabilities. In its current form, some of the capabilities are easy to measure by using an interview, but other capabilities are more difficult. Especially in the People capability area, it will be beneficial to set up specific guidelines on how to measure the knowledge level of the members of the organisation.

7.2.4   Validity of the BICMM

According to Golafshani [2003]: *"Engaging multiple methods, such as, observation, interviews and recordings will lead to more valid, reliable and diverse construction of realities.
"* In this study we use triangulation to validate the outcome of the BICMM in the case study. Triangulation is the process of looking at different sources and perspectives to check if consistency between the sources. According to [Golafshani, 2003], construct validity is supported if two different sources are used for identifying propositions.

The main outcome of the case study is that BICMM has a low overall BI maturity level. This outcome was supported by other sources. In the time of the study, the researcher also conducted BI projects himself at the organisation, such as the linking of the ERP system (AFAS) with BI dashboarding tools (PowerBI). The observations that were made during these projects confirmed and validated the outcome of the BICMM. The outcome of the low level of knowledge was validated by checking the competencies of the employees of TIS, to see if there was BI expertise available, with the HR department. The reply of the HR department validated the claim of the low level of BI knowledge within TIS.

Overall it seems that the BICMM has given an accurate overview of the level of BI maturity within TIS, and the outcome is also supported by other sources. The challenges that TIS face are also confirmed by comparing the results of the case study with the literature study.

External validity, also called generalisability or transferability (in qualitative research), is the degree in which results can be repeated in similar cases and receive the same outcome. In this study, many of the challenges that were found in the case study confirmed our findings from the literature study in Chapter 3.

In order to further externally validate the following steps have to be taken:

- The BICMM has to be applied by other persons

- The BICMM has to be applied on other case studies

- Some of these case studies have to be similar to TIS (e.g. SME ICT organisation) and different to TIS (e.g. other sectors, bigger organisations, other countries/regions)

Chapter 8

Conclusion

The section below consists of a recapitulation of the chapters in this research, and provides answers to the research questions. After the research questions have been answered, an overall conclusion will be given. The next sections will consists of the contributions to theory and practice, future research, recommendations and limitations.

- *RQ1. What are the most important benefits and challenges of business intelligence and is there an overlap with the findings of the case study?*

BI can give huge benefits to the organisation. The use of BI will allow the organisation to allocate resources and funds to the right parts of the organisation. It gives the understanding of costs and benefits within the organisation and BI will help decision-makers within the organisation to make better decisions, which are based on factual information instead of gut-feeling. Real time data and visualisation will lead to a higher degree of control. BI can also be used for sales purposes, for example to analyse customers, market trends which will lead to an increase in revenue. BI gives the ability to cater to the specific needs of employees, and enables decision makers to better use their specific skills more effectively. Because of the low BI maturity level at TIS, it was not possible to asses their specific benefits and compare them with the findings from literature.

Several of these challenges found in the literature study were also applicable to the TIS case, and were specifically named in the interviews. Most prevalent were the challenges involved with technology, such as the data quality and the lack of data management.

But also the challenges involved with People, finding the right talent en the lack of knowledge in the area of BI were confirmed in the case study.

- *RQ2. What are the business intelligence maturity models and frameworks that are available from literature and practice, and which one of these models is the best suited for the TIS case?*

In this research we collected the relevant BI maturity models and frameworks. These models and frameworks can be found in A.1. The biggest difference between the models and frameworks are their category (technology, organisation, capability and impact focused models) their type (staged, continuous or contextual), their purpose (descriptive, prescriptive or comparative), their origin (practice or research) and whether the model was empirically validated. The framework that was chosen for the TIS case is the BACF, created by Cosic et al. [2015]. This framework is contextual and descriptive, meaning that it gives a lot of freedom to the user to create an advice that is specifically tailored to the situation at TIS.

- *RQ3. What is the current business intelligence maturity level at TIS, and how can these maturity levels be explained?*

In this study we extend the BACF with operationalisation to create the BICMM. The BICMM was used to measure the maturity level of TIS. The overall BI maturity level at TIS is low, the specific scores can be found in table 6.1. The low BI maturity of TIS was was also mentioned several times during the interviews in the case study. The low maturity level at TIS can be seen as strange, especially because TIS is an ICT company. However, the low maturity level can be explained by several possible factors. The first reason is the fast growth of TIS in the last few years. Organisational growth is often not a linear process, but consists of years of stable growth, interrupted by periods of turbulence. It seems that TIS has entered such a state of turbulence, in which the the old management practices and systems that were in place, and where useful in the smaller organisation, are no longer use-able and need change. Another explanation for the low BI maturity level of TIS is the fact that TIS is a SME. Because of of this, TIS specialised in several ICT fields; cloud, networking and security. However, BI is not one of these specialisations. Furthermore, most SME's and also larger organisations have difficulty with acquiring the right talent to conduct BI.

- *RQ4. How did the the maturity model perform in this case study and is it possible to suggest improvements based on the findings?*

The BICMM was used to give an accurate description of the BI maturity level at TIS. Because of the current state of the model (descriptive) it has served its purpose. Validation by triangulation showed that the outcome of the model gives an accurate representation of the real BI maturity level within TIS.

There are several possible improvements possible to the BICMM. The main improvement will be to change the model into a prescriptive model, that has specific guidelines on what to do to achieve higher levels of maturity. Another improvement will be to change the model into a two stage model, with the first stage havin the basic BI capabilities, and the second stage with the more advanced BI capabilities. This change will increase the usefulness of the model in low maturity cases such as TIS. The last suggested improvement is to extend the amount of operationalisation, to make the capabilities better measurable.

This study gives a comprehensive overview of benefits, challenges and maturity models in the field of BI. Furthermore an existing framework is extended to create a new maturity model, the BICMM, that is able to measure BI maturity by using qualitative methods. The results of the case study show consistency with the findings of the literature study.

8.1   Contributions to theory and future research

In this study we have gathered an comprehensive overview of both benefits and challenges. This overview can be used in other studies that measure the effect of BI within organisations. The list can be extended, or changed according to the findings in following studies.

The list of maturity models that was created in this study can serve as a starting point for BI maturity research. In this study we analysed the models on a high level, but a more in depth analysis of the maturity models is also possible, that for example focus on the underlying theories that support the models. Over the years the list of maturity models can be extended to include newer models that are created.

Overall the main contribution to theory is the extension of the BACF into the BICMM. The BACF has a solid theoretical basis, but was not fit for the measurement of BI because it was not operationalised. In this study the BACF was transformed, making it suitable for BI maturity measurement. The results of the case study show that the BICMM is able to make an useful representation of the level of BI maturity within the context of the case study. The expectation is that the model is also suitable for other organisations that wish to measure their BI maturity, but this claim has to be validated in future research by applying the model on other case studies.

8.2 Recommendations

One of the main goals for conducting this study in the first place was to measure the maturity level of TIS, and to give specific advice on how TIS can improve their maturity level and become more data-driven in the long run. In this section we will summarise our findings, and give advice based on the interpretation of the researcher. This advice is not a part of our empirical investigation but is nonetheless very useful for TIS.

The interviewees expressed their concern with the current state of BI within TIS. The main management goal for this year is to get more control and grip on financial information. The results of the case study show that the BI maturity overall is at a very low level. However, the most important short term goal of TIS is to get back control and grip of their data sources. A large portion of the internal data is stored in the new ERP system by Afas. While this new system does pose benefits in comparison with the old legacy systems, one of the main drawbacks is the lack of transparency in the data structure. Even the consultants of Afas, that were responsible for the implementation of the system could not give insight into the data structure. This means that it is a very daunting and work intensive task to find the right data in the Afas ERP system. The most important short term goal for TIS should be to get back control of their own data. By implementing a data management strategy, and by creating a team of data specialists that is responsible for implementing and upholding this strategy, this can be achieved.

When the first steps of the data management strategy have been implemented, and TIS has regained some control over its own data, the next steps can be taken. The results

of the BI maturity measurement show that there is a low level of knowledge in the field of BI within TIS. In order to get meaningful results, and to start implementing and creating BI systems that create meaningful value for TIS, BI talent has to be acquired or 'created'. These BI talents should be able to create visualisations, and should have a solid understanding of the properties of data and how to extract and combine data in order to create value for TIS in the form of visualisations. When TIS has acquired the required amount of talent, they can proceed with the implementation of BI internally.

TIS as an organisation uses a lot of the tools provided by Microsoft, also for their clients. PowerBI is a strong tool released by Microsoft, that is capable of performing data analysis and visualisation. The researcher has already written a guide for TIS on how to import the data of the of the AFAS ERP system into PowerBI, and how to perform analysis and visualisation. This can be a starting point for the BI experts within TIS to start with implementing the most important KPI's. In the long run, the interviewees expressed that they want TIS to perform more advanced forms of BI, such as predictive modelling. It is obvious from the results of the case study that this is something that is not achievable in the short term, first a solid foundation has to be created by implementing the data management strategy and acquiring the right talent as explained above. In order to implement the more advanced forms of predictive modelling, TIS has to acquire data scientists. These data scientists often have a background in statistics. These data scientists will be able to create models that can predict the future, and are able to spot new trends in the data that can be used for competitive advantage by TIS.

The lessons learned by TIS in this process can be used to offer new services to their customer base. A lot of organisations are expressing their need for more insight into their data. With the lessons learned by improving and implementing BI within TIS, they can offer these services also to their customers, and get even more knowledge and competitive advantage in this process.

8.3   Limitations

This study has several limitations that have to be addressed. Because of the qualitative nature of this study, a lot of the choices made are based on the authors personal insight and views. Because of the large amount of available BI maturity models, a choice had to

be made in which model would be used in the case study. While this choice was based on solid argumentation, this does not mean that the choice for this model is definitely the best choice. Another limitation is the operationalisation of the constructs. An interview scheme that was derived from another study that measured BI maturity was used to operationalise the constructs, but this process also consists of a large portion of insight and creativity from the author, and not so much hard science. The same can be said about the coding of the results, and the interpretation of the interview results. Another researcher may have slightly different results based on the same interviews, as deriving the exact score (in numbers) from qualitative interview transcriptions also has some subjectivity and personal interpretation involved.

The sample size of the interviews is small with $n = 5$, and only with middle and upper management. Because of the small sample size the results should be interpreted with care. The model was tested on one organisation with $n = 1$, as such the results of applying the maturity model should also be met with care. At this moment it is impossible to explain if the discrepancies in the results originate from faults in the model or because this particular case study is an unique situation that is not applicable to similar cases.

Appendix A

Tables

List of maturity models		
Year	**Name**	**Origin**
2001	Data Warehousing Maturity Model [Watson et al., 2001]	Research
2004, 2009	TDWI's Business Intelligence Maturity Model [TDW]	Practice
2005	Ladder of business intelligence [Cates et al., 2005]	Literature
2005	Enterprise Data Management Maturity Model [Fisher, 2005]	Research
2006	Data Warehousing Process Maturity [Sen et al., 2006]	Research
2007	Business intelligence maturity hierarchy [Deng, 2007]	Research
2007	Business information maturity model [Williams and Williams, 2007]	Research
2007	Infrastructure Optimization Maturity Model [Mic]	Practice
2007	Analytical Capability Maturity Model [Davenport and Harris, 2007]	Research
2008	Gartner Maturity Model for Business Intelligence and Performance Management [Gar, ?]	Practice
2009	Hewlett-Packard (HP) Business Intelligence Maturity Model [HP]	Practice
2009	SAS Information Evolution Model [SAS]	Practice
2009	TERADATA's BI and DW Maturity Model [Miller et al., 2009]	Practice
2011	SOBIM [Shaaban et al., 2011]	Research
2011	Impact-Oriented BIMM [Lahrmann et al., 2011]	Research
2011	EBIM [Tan et al., 2011]	Research
2012	Enterprise Business Intelligence Maturity Model (EBIMM) [Chuah and Wong, 2012]	Research
2013	IDC - Big Data and Analytics MM [Vesset et al., 2013]	Research
2013	Pillars for analytics succes [Harriot, 2013]	Practice
2014	TDWI's Big Data Maturity Model [TDW]	Practice
2014	IBM's Big Data Maturity Model [IBM]	Practice
2015 (2012)	BACF [Cosic et al., 2012; 2015]	Research
2015	Maturity model for BI and analytics by Gartner	Practice
2016	DCWMM - The datawarehouse capability maturity model [Spruit and Sacu, 2015]	Research
2017	Maturity Model for Implementation of Enterprise Business Intelligence Systems [Khuen and Rehman, 2017]	Research
2017	Business Analytics Success Maturity Model [Chen and Nath, 2017]	Research

TABLE A.1: Overview of BI maturity models

BI definitions	
Study	**Definition**
Adelman and Terpeluk Moss [2000]	An umbrella term to describe the set of software products for collecting, aggregating, analysing, and accessing information to help organisations make more effective decisions
Alter [2004]	An umbrella term for decision support
Azvine et al. [2005]	BI is all about capturing, accessing, understanding, analysing, and converting one of the fundamental and most precious assets of the company, represented by the raw data, into active information in order to improve business.
Chung et al. [2005]	Results obtained from collecting, analysing, evaluating, and utilising information in the business domain
Power [2007]	An umbrella term to describe the set of concepts and methods to improve business decision-making by using fact-based support systems
Eckerson [2005]	A system that takes data and transforms into various information products
Glancy and Yadav [2011]	BI focuses on supporting a variety of business functions, using the process approach, and advanced analytical techniques
Hannula and Pirttimaki [2003]	Organised and systematic processes that are used to acquire, analyse, and disseminate information to support the operative and strategic decision making
Jordan and Ellen [2009]	BI is seen as a critical solution that will help organisations leverage information to make informed, intelligent business decisions to survive in the business world
Jourdan et al. [2008]	BI is both a process and a product that is used to develop useful information to help organisations survive in the global economy and predict the behaviour of the general business environment
Lönnqvist and Pirttimäki [2006]	A managerial philosophy and tool that helps organisations manage and refine information with the objective of making more effective decisions
Moss and Atre [2003]	An architecture and a collection of integrated operational as well as decision support applications and databases that provide the business community easy access to business data
Negash [2004]	A system that combines data collection, data storage, and knowledge management with analytical tools so that decisions makers can convert complex information into competitive advantage
Olszak and Ziemba [2003]	A set of concepts, methods, and processes that aim at not only improving business decisions but also at supporting realisation of an enterprise' strategy
Reinschmidt and Francoise [2000]	BI is an integrated set of tools, technologies, and programmed products that are used to collect, integrate, analyse, and make data available

TABLE A.2: Part 1: BI definitions gathered by Olszak [2016]

BI definitions	
Study	**Definition**
Watson and Wixom [2007]	BI describes the concepts and methods used to improve decision making using fact based systems
Wixom and Watson [2010]	BI is a broad category of technologies, applications, and processes for gathering, storing, accessing, and analysing data to help its users make better decisions
White [2004]	An umbrella term that encompasses data warehousing, reporting, analytical processing, performance management, and predictive analytics
Williams and Williams [2007]	A combination of products, technology, and methods to organise key information that management needs to improve profit and performance

TABLE A.3: Part 2: BI definitions gathered by Olszak [2016]

Governance Capabilities	
Capability	**Definition**
GOV1: Decision rights	Assignment of decision rights and responsibilities by determining; (i) those responsible for making certain decisions in relation to the planning, implementation and applications of BA, (ii) where appropriate, those who will provide the input for such decisions, and (iii) those who will be held accountable for the resulting actions and outcomes of these decisions. It is important that a person responsible for making a certain decision is held accountable for the resulting actions and outcomes [Weill and Ross, 2004].
GOV2: Strategic Alignment	Alignment of an organisation's BA initiatives with its business strategy. It is a two-way relationship in the sense that BA initiatives can help measure and enforce a business strategy, whilst business strategy necessarily shapes BA initiatives as they evolve. This requires a clearly defined business strategy that is enunciated to all staff and translated into a set of measurable outcomes. It also requires a genuine commitment to the strategy demonstrated by the decisions and actions of senior people [Williams and Williams, 2007].
GOV3: Dynamic BA Capabilities	Ability to reconfigure and leverage an organisation's BA resources and capabilities in order to respond to changes in the business environment in a timely and efficient manner. Such responsiveness requires the ability to identify potential BA opportunities (Search), prioritise those opportunities based on business need, risk and technology maturity (Select) and then funding and implementing the opportunities (Asset Orchestration) resulting in new and unique resource configurations [Shanks and Sharma, 2011].
GOV4: Change Management	Ability to manage human, technological and process impacts across the organisation arising from BA initiatives. This involves managing changes to the systems environment and the provision of training and rewards in order to; (i) demonstrate the value and utility of BA, (ii) encourage the adoption of new BA technologies and work practices, (iii) mitigate potential resistance, and (iv) manage expectations. Furthermore, it is important that all types of BA users, from managers to operational staff, are involved in the initial planning of a BA initiative [Negash, 2004].

TABLE A.4: Definition of governance capabilities by Cosic et al. [2015]

Culture Capabilities	
Capability	**Definition**
CUL1: Evidence-based Management	A culture where (i) formal authority, reputation, intuition and ad-hoc decision-making are preceded by decisions based on data, (ii) BA users, including power users, are encouraged to actively participate in the development of a data-driven environment, (iii) there is trust in data and the BA tools used to analyse data, (iv) whenever possible, assertions are substantiated with data, and (v) although the emphasis is on fact-based decision making, there is still some room for intuition and ad-hoc decision-making, particularly when the required data is not available [Pfeffer and Sutton, 2006].
CUL2: Embedded-ness	Extent to which BA has permeated the fabric of an organisation e.g. business processes and values (e.g. appreciation for BA analysis tools and data-driven insights). It is reflected in the extent to which people routinely use data and BA tools to solve problems and make decisions. It is facilitated by sharing metadata and the use of a collaboration portal. The portal enables work to be shared and intellectual property to be spread throughout the organisation. Where appropriate, models are used to make decisions on an ongoing and pervasive basis [Shanks et al., 2012].
CUL3: Executive Leadership and Support	Ability of senior managers and executives to advocate the use of BA systems and data-driven decision-making throughout the organisation. This requires (i) a clear vision, (ii) first-hand experience and understanding of the benefits and successes of BA and (iii) the promotion of this vision and understanding throughout the organisation, and (iv) the provision of financial and material support for BA initiatives [Laursen and Thorlund, 2016].
CUL4: Communica-tion	BA personnel across the organisation foster a culture of open communication and trust between themselves and other business users. This involves listening carefully to the needs of business users and translating BA concepts into every-day business language. It is facilitated by close and frequent contact via a variety of different communication channels [Davenport and Harris, 2007]

TABLE A.5: Definitions of culture capabilities by Cosic et al. [2015]

Attributes	
Capability	**Definition**
TEC1: Data Management	Mechanism for (i) sourcing data for BA initiatives from multiple channels, including operational/transactional systems and third-party sources, (ii) ensuring its quality e.g. consistency, accessibility, flexibility, integrity, timeliness and availability and (iii) integrating it with existing data in a central repository e.g. enterprise data warehouse. It also includes master data management and metadata management to ensure data definitions are consistent across organisational units to encourage common usage and understanding of the data [Watson and Wixom, 2007].
TEC2: Systems Integration	Seamless integration of BA systems with operational/transactional systems at the process, technology and data levels in order to exploit the capabilities of both. Systems integration is important for leveraging value from BA and is facilitated by the flexible design of technology infrastructure and systems architecture. It also introduces a degree of complexity and therefore should be done with care and careful consideration of the need [Sharma and Shanks, 2011].
TEC3: Reporting and Visualisation BI Technology	Ability to develop and utilise self-service analysis applications e.g. reports, dashboards, scorecards, online analytical processing (OLAP) and data visualisation technologies, which display output in a user-friendly format that is readily understood by non-technical users. These applications are particularly useful for addressing structured problems and facilitate the visual manipulation and exploration of data [Watson and Wixom, 2007].
TEC4: Discovery BI Technology	Ability to develop and utilise quantitative and qualitative analysis tools (e.g. statistical analysis, data mining, text mining and predictive analysis) to facilitate the semi-automated analysis of numerical, semistructured and unstructured data to; (i) discover new actionable insights from patterns in the data, and (ii) extrapolate patterns found in the data to predict what is likely to occur in the future. These tools are particularly useful for addressing less structured problems [Negash, 2004].

TABLE A.6: Definitions of technology capabilities by Cosic et al. [2015]

Attributes	
Capability	**Definition**
PEO1:Technology Skills and Knowledge	Combined skills and knowledge of BA technology specialists across the organisation including; programming, optimisation software, algorithms, database/file management, ETL (Extraction, Transformation and Loading), data warehousing, software development methodologies and high level architectures. Some level of business domain and industry knowledge is necessary to apply these skill sets. Furthermore, teams should consist of specialists whose skills are complementary to other team members [Davenport and Harris, 2007].
PEO2: Business Skills and Knowledge	Combined skills and knowledge of people throughout the organisation that are involved in the business side of BA initiatives including; (i) fundamental business principles, and (ii) depth of domain knowledge of the organisation's key products, services, processes, value chain and industry in general. It also includes the ability to; (i) network, (ii) seek out opportunities and threats, and (iii) develop and drive an agenda. Some level of technical expertise is necessary to understand the data available to them and communicate with BA technical specialists [Anderson-Lehman et al., 2004].
PEO3: Management Skills and Knowledge	Combined skills and knowledge of people in BA related management roles throughout the organisation to (i) prioritise and manage BA projects, (ii) redesign business processes as a result of implementing BA, and (iii) translate, communicate and sell the potential values and benefits of BA to senior executives (e.g. senior executives and general managers). Some level of technical expertise is necessary to understand the data available to them and communicate with BA technical specialists [Davenport and Harris, 2007].
PEO4: Entrepreneurship and Innovation	Combined skills and knowledge of BA managers and other BA users throughout the organisation to (i) continually challenge the status quo, (ii) manage new innovation as a separate activity to continuous improvement, (iii) create and promote a technical innovation team, as well as (iv) an innovation forum made up of innovation teams from other business units. It is characterised by an entrepreneurial mindset and vision and the ability to rationally assess risks and benefits. It is enhanced through the provision of some authoritative autonomy and financial independence, which provides BA managers with a degree of freedom to pursue value-creating actions. [Sharma et al., 2010].

TABLE A.7: Definitions of people capabilities by Cosic et al. [2015]

Appendix B

Interview questions

Semi-structured interview questions in Dutch	
Question	**Dimension**
1.Maakt u gebruik van BI in uw werkzaamheden? Op welke manier? (dashboarding, reporting, ad-hoc reporting, analyzing, alerting, predictive modelling, operationalizing, optimization, activating, etc.)	General
2.Gebruikt u BI om klanten, leveranciers en concurrenten te analyzeren? (externe omgeving)	General
3.Maakt uw organisatie gebruik van een gedefinieerde BI strategie? Is deze strategie gekoppeld/in lijn met de gehele (bedrijfs)strategie?	Governance
4.Is het duidelijk wie verantwoordelijk is voor het nemen van beslissingen en zijn verantwoordelijkheden in de organisatie (op mangement niveau) duidelijk bepaald of onduidelijk/onzeker?	Governance
5.Maakt de organizatie gebruik van change en impact management (verandering en impact) bij het doorvoeren van (grote) veranderingen?	Governance
6.Is het gebruik van BI systemen verspreid over alle afdelingen of gelimiteerd/gefocussed op specifieke afdelingen? (bijv. alleen sales afdeling etc.)	Culture
7. Wanneer u beslissingen neemt, zijn deze dan vooral gestaafd op data/metrics/kpis of maakt u hierbij vooral gebruik van (onderbuik) gevoel?	Culture
8.Word het gebruik van BI aangemoedigd/ondersteund door het (hoger)managment/leidingevend en hoe?	Culture
9.Worden data en resultaten op een effectieve/snelle/goede manier gedeeld tussen de verschillende afdelingen? Zijn hier verbeteringen te behalen?	Culture
10. Wat vindt u van de kwaliteit van de data in de organizatie? Is deze volledig/onvolledig laat/op tijd goed/gemiddeld/slechte kwaliteit? Maakt uw organizatie gebruik van een data management strategie?	Technology
11. Zijn de BI systemen in uw organizatie gekoppeld? Delen ze data waar nodig etc.	Technology
12. Maakt u gebruik van reporting/rapporterende BI technologie? Welke? (Dashboarding, KPI's, rapporten)	Technology
13. Maakt u gebruik van discovery/ontdekkende/analytics BI technologie? Welke? (Data mining, web scraping, machine learning etc.)	Technology
14. Denkt u dat er genoeg kennis(knowledge) in de organizatie aanwezig is om (optimaal) gebruik te kunnen maken van de mogelijkheden van BI?	People
15. Denkt u dat u (als manager) genoeg kennis in huis heeft om optimaal gebruik te maken van BI?	People
16. Welke BI capaciteiten/mogelijkheden zoekt/wilt u het meeste? (Bijvoorbeeld: Dashboarding, specifieke data, rapportage, predictive analyse etc etc.)	General

TABLE B.1: Semi-structured interview questions in Dutch

Bibliography

Maturity Model Overview for Business Intelligence and Performance Management. https://www.gartner.com/doc/842813/maturity-model-overview-business-intelligence.

The HP Business Intelligence Maturity Model: describing the BI journey. http://download.101com.com/pub/tdwi/Files/BI_Maturity_Model_4AA1_5467ENW.pdf.

Big Data Analytics Maturity Model. http://www.ibmbigdatahub.com/blog/big-data-analytics-maturity-model.

What is Infrastructure Optimization and Why do I Care? http://download.microsoft.com/download/c/a/3/ca35ac61-bfea-4ce1-a9c1-33e2a931cda8/WhatisInfrastructureOptimizationandWhydoICare.ppt.

Big data: What is it and why it matters. https://www.sas.com/en_us/insights/big-data/what-is-big-data.html.

TDWI Analytics Maturity Model Guide. https://tdwi.org/whitepapers/2014/10/tdwi-analytics-maturity-model-guide.aspx.

The Benefits of Business Intelligence... Why Do Organizations Need BI? https://bi-survey.com/benefits-business-intelligence.

S. Adelman and L. Terpeluk Moss. *Data warehouse project management*. Addison-Wesley Longman Publishing Co., Inc., 2000.

S. Akter and S. F. Wamba. Big data analytics in e-commerce: a systematic review and agenda for future research. *Electronic Markets*, 26(2):173–194, 2016.

S. Alter. A work system view of dss in its fourth decade. *Decision Support Systems*, 38(3):319–327, 2004.

R. Anderson-Lehman, H. J. Watson, B. H. Wixom, and J. A. Hoffer. Continental airlines flies high with real-time business intelligence. *MIS Quarterly Executive*, 3(4):163–176, 2004.

B. Azvine, Z. Cui, and D. D. Nauck. Towards real-time business intelligence. *BT Technology Journal*, 23(3):214–225, 2005.

J. Barney. Firm resources and sustained competitive advantage. *Journal of management*, 17(1):99–120, 1991.

R. Bose. Advanced analytics: opportunities and challenges. *Industrial Management & Data Systems*, 109(2):155–172, 2009.

E. Brynjolfsson, L. M. Hitt, and H. H. Kim. Strength in numbers: How does data-driven decisionmaking affect firm performance? *Working paper, Sloan School of Management, MIT*, 2011.

L. Cao. Data science: Nature and pitfalls. *IEEE Intelligent Systems*, 31(5):66–75, 2016.

J. E. Cates, S. S. Gill, and N. Zeituny. The ladder of business intelligence (lobi): a framework for enterprise it planning and architecture. *International Journal of Business Information Systems*, 1(1-2):220–238, 2005.

H. Chen, R. H. Chiang, and V. C. Storey. Business intelligence and analytics: from big data to big impact. *MIS quarterly*, pages 1165–1188, 2012.

L. Chen and R. Nath. Business analytics maturity of firms: an examination of the relationships between managerial perception of it, business analytics maturity and success. *Information Systems Management*, (just-accepted), 2017.

M. Chen, S. Mao, and Y. Liu. Big data: A survey. *Mobile networks and applications*, 19(2):171–209, 2014.

M.-H. Chuah and K.-L. Wong. A review of business intelligence and its maturity models. *African journal of business management*, 5(9):3424–3428, 2011.

M.-H. Chuah and K.-L. Wong. Construct an enterprise business intelligence maturity model (ebi2m) using an integration approach: A conceptual framework. In *Business Intelligence-Solution for Business Development*. InTech, 2012.

W. Chung, H. Chen, and J. F. Nunamaker Jr. A visual framework for knowledge discovery on the web: An empirical study of business intelligence exploration. *Journal of Management Information Systems*, 21(4):57–84, 2005.

S. Coleman, R. Göb, G. Manco, A. Pievatolo, X. Tort-Martorell, and M. S. Reis. How can smes benefit from big data? challenges and a path forward. *Quality and Reliability Engineering International*, 32(6):2151–2164, 2016.

D. J. Collis. Research note: how valuable are organizational capabilities? *Strategic management journal*, 15(S1):143–152, 1994.

R. Cosic, G. Shanks, and S. Maynard. Towards a business analytics capability maturity model. In *ACIS 2012: Location, Location, Location: Proceedings of the 23rd Australasian Conference on Information Systems 2012*, pages 1–11. ACIS, 2012.

R. Cosic, G. Shanks, and S. B. Maynard. A business analytics capability framework. *Australasian Journal of Information Systems*, 19, 2015.

T. H. Davenport and J. G. Harris. *Competing on analytics: The new science of winning*. Harvard Business Press, 2007.

T. H. Davenport and D. Patil. Data scientist. *Harvard business review*, 90(10):70–76, 2012.

T. De Bruin. *Business process management: theory on progression and maturity*. PhD thesis, Queensland University of Technology, 2009.

R. Deng. Business intelligence maturity hierarchy: a new perspective from knowledge management. *Information management*, pages 1079089–1, 2007.

W. W. Eckerson. The keys to enterprise business intelligence: Critical success factors. *TDWI Report*, 2005.

T. Fisher. How mature is your data management environment? *Business Intelligence Journal*, 10(3):20, 2005.

F. H. Glancy and S. B. Yadav. Business intelligence conceptual model. *International Journal of Business Intelligence Research (IJBIR)*, 2(2):48–66, 2011.

N. Golafshani. Understanding reliability and validity in qualitative research. *The qualitative report*, 8(4):597–606, 2003.

L. E. Greiner. Organizations grow. 1998.

M. Hannula and V. Pirttimaki. Business intelligence empirical study on the top 50 finnish companies. *Journal of American Academy of Business*, 2(2):593–599, 2003.

J. Harriot. Pillars for successful analytics impementation. *Marketing Insights*, 25(1): 34–41, 2013.

M. S. Hopkins, S. LaValle, and F. Balboni. 10 insights: a first look at the new intelligent enterprise survey. *IT Management Select*, page 14, 2010.

I. Hribar Rajterič. Overview of business intelligence maturity models. *Management: Journal of Contemporary Management Issues*, 15(1):47–67, 2010.

J. Jordan and C. Ellen. Business need, data and business intelligence. *Journal of Digital Asset Management*, 5(1):10–20, 2009.

Z. Jourdan, R. K. Rainer, and T. E. Marshall. Business intelligence: An analysis of the literature. *Information Systems Management*, 25(2):121–131, 2008.

F. Kache and S. Seuring. Challenges and opportunities of digital information at the intersection of big data analytics and supply chain management. *International Journal of Operations & Production Management*, 37(1):10–36, 2017.

C. W. Khuen and M. Rehman. A maturity model for implementation of enterprise business intelligence systems. In *International Conference on Mobile and Wireless Technology*, pages 445–454. Springer, 2017.

R. Kohavi, N. J. Rothleder, and E. Simoudis. Emerging trends in business analytics. *Communications of the ACM*, 45(8):45–48, 2002.

A. Labrinidis and H. V. Jagadish. Challenges and opportunities with big data. *Proceedings of the VLDB Endowment*, 5(12):2032–2033, 2012.

G. Lahrmann, F. Marx, R. Winter, and F. Wortmann. Business intelligence maturity: Development and evaluation of a theoretical model. In *System Sciences (HICSS), 2011 44th Hawaii International Conference on*, pages 1–10. IEEE, 2011.

G. H. Laursen and J. Thorlund. *Business analytics for managers: Taking business intelligence beyond reporting*. John Wiley & Sons, 2016.

D. E. Leidner and T. Kayworth. A review of culture in information systems research: Toward a theory of information technology culture conflict. *MIS quarterly*, 30(2): 357–399, 2006.

A. Lönnqvist and V. Pirttimäki. The measurement of business intelligence. *Information systems management*, 23(1):32, 2006.

L. Miller, D. Schiller, and M. Rhone. Data warehouse maturity assessment service. teradata, 2009.

L. T. Moss and S. Atre. *Business intelligence roadmap: the complete project lifecycle for decision-support applications*. Addison-Wesley Professional, 2003.

L. Muller and M. Hart. Updating business intelligence and analytics maturity models for new developments. In *International Conference on Decision Support System Technology*, pages 137–151. Springer, 2016.

S. Negash. Business intelligence. *The communications of the Association for Information Systems*, 13(1):54, 2004.

R. L. Nolan. Thoughts about the fifth stage. *ACM SIGMIS Database: the DATABASE for Advances in Information Systems*, 7(2):4–10, 1975.

C. M. Olszak. Toward better understanding and use of business intelligence in organizations. *Information Systems Management*, 33(2):105–123, 2016.

C. M. Olszak and E. Ziemba. Business intelligence as a key to management of an enterprise. In *Proceedings of informing science and IT education conference*, pages 855–863, 2003.

K. Peffers, T. Tuunanen, M. A. Rothenberger, and S. Chatterjee. A design science research methodology for information systems research. *Journal of management information systems*, 24(3):45–77, 2007.

J. Pfeffer and R. I. Sutton. Evidence-based management. *Harvard business review*, 84 (1):62, 2006.

D. J. Power. A brief history of decision support systems. *DSSResources. COM, World Wide Web, http://DSSResources. COM/history/dsshistory. html, version*, 4, 2007.

S. Ransbotham, D. Kiron, and P. K. Prentice. Minding the analytics gap. *MIT Sloan Management Review*, 56(3):63, 2015.

J. Reinschmidt and A. Francoise. Business intelligence certification guide. *IBM International Technical Support Organisation*, 2000.

J. Saldaña. *The coding manual for qualitative researchers*. Sage, 2015.

P. B. Seddon, D. Constantinidis, T. Tamm, and H. Dod. How does business analytics contribute to business value? *Information Systems Journal*, 27(3):237–269, 2017.

A. Sen, A. P. Sinha, and K. Ramamurthy. Data warehousing process maturity: An exploratory study of factors influencing user perceptions. *IEEE Transactions on Engineering Management*, 53(3):440–455, 2006.

E. Shaaban, Y. Helmy, A. Khedr, M. Nasr, et al. Business intelligence maturity models toward new integrated model. *ACIT 2011 proceedings*, 2011.

G. Shanks and R. Sharma. Creating value from business analytics systems: the impact of strategy. *Proc. 15th Pacific Asia Conference on Information Systems*, 2011.

G. G. Shanks, N. Bekmamedova, F. Adam, and M. Daly. Embedding business intelligence systems within organisations. In *DSS*, pages 113–124, 2012.

R. Sharma and G. Shanks. The role of dynamic capabilities in creating business value from is assets. 2011.

R. Sharma, P. Reynolds, R. Scheepers, P. B. Seddon, and G. G. Shanks. Business analytics and competitive advantage: A review and a research agenda. In *DSS*, pages 187–198, 2010.

U. Sivarajah, M. M. Kamal, Z. Irani, and V. Weerakkody. Critical analysis of big data challenges and analytical methods. *Journal of Business Research*, 70:263–286, 2017.

M. R. Spruit and C. Sacu. Dwcmm: The data warehouse capability maturity model. *J. UCS*, 21(11):1508–1534, 2015.

C.-S. Tan, Y.-W. Sim, and W. Yeoh. A maturity model of enterprise business intelligence. *Communications of the IBIMA*, 2011.

D. J. Teece, G. Pisano, and A. Shuen. Dynamic capabilities and strategic management. *Strategic management journal*, 18(7):509–533, 1997.

A. Thamir and B. Theodoulidis. Business intelligence maturity models: information management perspective. In *International Conference on Information and Software Technologies*, pages 198–221. Springer, 2013.

D. Vesset, M. Versace, G. Girard, A. O'Brien, C. Burghard, J. Feblowitz, D. Osswald, and S. Ellis. Idc maturityscape: Big data and analytics-a guide to unlocking information assets, 20 p. IDC, 2013.

S. J. Walker. Big data: A revolution that will transform how we live, work, and think. *International Journal of Advertising*, 33(1):181–183, 2014.

H. Watson and B. Wixom. Enterprise agility and mature bi capabilities. *Business Intelligence Journal*, 12(3):4, 2007.

H. Watson, T. Ariyachandra, and R. J. Matyska. Data warehousing stages of growth. *Information Systems Management*, 18(3):42–50, 2001.

P. Weill and J. W. Ross. *IT governance: How top performers manage IT decision rights for superior results*. Harvard Business Press, 2004.

C. White. Now is the right time for real-time bi. *Information Management*, 14(9):47, 2004.

S. Williams and N. Williams. *The profit impact of business intelligence*. Morgan Kaufmann, 2007.

B. Wixom and H. Watson. The bi-based organization. *International Journal of Business Intelligence Research (IJBIR)*, 1(1):13–28, 2010.

J. F. Wolfswinkel, E. Furtmueller, and C. P. Wilderom. Using grounded theory as a method for rigorously reviewing literature. *European journal of information systems*, 22(1):45–55, 2013.