Master Thesis:

Overcoming challenges of Big Data Analytics outsourcing meant to improve Business Intelligence

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ABSTRACT

Due to the increasing growth of computer processing capabilities the amount of data generated is steadily increasing. Due to this increase in data volume, many companies are in the possession of very large amounts of data, often referred to as Big Data. Companies often struggle to perform Big Data Analytics (BDA) efficiently, in order to use this data efficiently. The reason companies struggle is often found to be related to the lack of technological expertise and experience. A potential solution for companies is to outsource BDA implementation, thus seeking BDA expertise outside of the company. BDA outsourcing is, however, scarcely research making it is unclear how BDA outsourcing should be conducted. It is also unclear what challenges occur during BDA outsourcing. During this study it is attempted to gain more clarity on the managerial and organizational challenges that can occur during BDA outsourcing. In doing so the following research question is pursued; *How could Dutch Big Data consultants, and customers better handle the challenges occurring during BDA outsourcing projects meant to improve BI systems?'.* In order to answer this research question a literature study was conducted in order to gain insight in the challenges that potentially occur during BDA outsourcing. The management and organizational challenges found during the literature study were then validated by conducting twelve interviews amongst ten Dutch Big Data consultancy companies. During these interviews various management and organizational challenge categories and subcategories were establish. The challenge categories found during this study consisted of; 'Project Strategy', 'Value of the Project', 'Resources and Costs', 'Contract', 'Governance and Compliance', 'Management during the Project', and 'Customer Resistance and Trust'. During the study relationships were found between these challenge categories were also established. During the literature study very few connections were found between challenge categories. During the interviews, however, multiple unexpected connections between challenge categories were apparent, indicating that certain challenges can influence the occurrence of other challenges throughout a BDA outsourcing project. Especially challenges related to 'Project Strategy' seem to influence other challenge categories. Ultimately the results of this study are used to grant theoretical and practical recommendations. The results of this paper showcase the need for additional BDA outsourcing research, as well as offering practical advice on how to potentially prevent the occurrence of various BDA outsourcing challenges.

1; Introduction

Since the dawn of computer technology a steady increase has been present in computer processing capacity. Where previously computers were expensive machines only owned by a select few, computers have dropped in price and are now attainable for a broad range of people. Gantz, & Reisel (2011) indicate that in 2010 the world generated over 1 ZB of data. In 2014 the amount of data generated worldwide increased to 7 ZB, showing that the amount of data generated is vastly increasing (Gantz, & Reisel, 2011). This increase in data generation is partly due to the increase in activities that can be performed using computer devices (Gantz, & Reisel, 2011). It became possible to perform various activities online, for instance communication, purchasing, gaming. It is thus necessary for computers to process increasingly higher amounts of data, in order to keep up with the amount of data that is being generated. The analysis of these big data files is often referred to as Big Data Analytics (BDA). BDA can potentially be used by companies is to improve Business Intelligence (BI). BI is the ability of companies to make meaningful use of data it collects during its business operations. Despite various articles stating the promise of BDA, it appears that companies often struggle in order to implement BDA (Sanders, 2016). Since BDA is a complex process, companies often struggle to implement BDA due to lacking analytical knowledge. BDA implementation can also be surrounded by various ethical and privacy related issues. For example, a well-known retail chain called Target used BDA in a very controversial manner. Using purchase data, Target was able to make accurate pregnancy predictions. This data was used in order to send pregnant women customized advertisements. This caused a media storm, when target correctly predicted the pregnancy of a teen girl. The girl was hiding her pregnancy, however, her parents found out through the customized pregnancy advertisements.

A potential solution to avert such BDA implementation challenges is to outsource these IT activities. When IT activities are outsourced, an external company is hired that possess more IT experience. In doing so, both companies collaborate in order to implement certain IT capabilities. Various IT activities are often being outsourced, and IT outsourcing is a growing phenomenon (Qi, & Chau, 2012; Gantz, & Reisel, 2011). Despite IT outsourcing being subject to various researches, few articles describe how IT outsourcing can be used as an implementation strategy for BDA implementation. Potentially, BDA is subject to a different set of challenges than other forms of IT outsourcing. For example, since BDA is a relatively new technology it is possible that there is a larger asymmetry in knowledge and experience between vendor and customer organizations than is the case for other IT outsourcing activities. Despite BDA outsourcing seeming quite common in practice, it is scarcely researched. It thus remains unclear what potential challenges of BDA outsourcing are, and how BDA outsourcing should be handled.

During the current study it is attempted to clarify what challenges BDA outsourcing. To establish the challenges that occur during BDA outsourcing, a literature study is conducted. During this literature study challenges relating to IT outsourcing, BDA, and Business Intelligence Systems are sought. Due to the large amount of challenges found during the literature study it was chosen to only validate a portion of the literature study. Since the managerial and organizational challenges were most prevalent during the literature study it was chosen to solely use the managerial and organizational challenges during the interviews. These interviews are conducted with Dutch Big Data consultancy companies, in order to establish what managerial and organizational challenges found during the literature study indeed occurred during BDA projects. The challenges found during the literature study will also be compared to the challenges found in the interviews. A model is made in order to show how the challenges relate to one another. Ultimately the results of this study are used in order to establish what steps can be taken in order to prevent various BDA outsourcing challenges from occurring.

1.1; Research Questions

The research question pursued in this study is; '*How could Dutch Big Data consultants, and customers better handle the challenges occurring during BDA outsourcing projects meant to improve BI systems?'*. In order to answer this research question, three sub questions need to be answered. The first sub question in this research is; '*What challenges related to BDA, BI, and IT outsourcing are described in literature?*'. In order to answer the research question it is assessed what challenges are related to BDA outsourcing. This is done by conducting a literature study. During the literature study, articles will be analyzed that discuss challenges regarding BDA, BI, and IT outsourcing. At the end of the literature study a list is obtained of challenges that occur during BDA, BI, and IT outsourcing. Due to the large amount of challenges found during the literature study it was only possible to use a selection of the challenges during the interviews. Since the managerial and organizational challenges were more prevalent during the literature study, it was chosen to focus on managerial and organizational challenges during the interviews. The second sub question of this paper is; '*What Management and Organizational challenges occur during BDA outsourcing projects performed by Dutch Big Data consultancy companies?'*. In order to answer the research question an interview structure was created using the challenges found during the literature study. During the interviews it is established what BDA, BI, and IT outsourcing challenges found during the literature search, also occur during the interviews. In doing so it will become clear what challenges are prevented when choosing to outsource BDA meant to improve BI. Alternatively, the interviewees were given the opportunity to discuss challenges that were not mentioned during the literature study. Using the interview results a concept matrix is constructed in which all challenges are categorized. The third sub question of this paper is; '*How can customers and consultants handle BDA outsourcing challenges*

more efficiently?'. This sub question is answered by looking at the factors that contribute to the occurrence of various BDA challenges. It is also attempted to construct a model in which challenge relationships are clarified. These results are ultimately used in order to grant theoretical suggestions regarding BDA outsourcing studies and practical suggestions on how consultants and customers can better handle various managerial and organizational challenges.

1.2; Research Contributions

During this study it will be established what challenges occur during BDA outsourcing projects. By comparing the BDA outsourcing challenges found during the literature study, and interviews this study offers various contributions. This study contributes to BDA, BI, and IT outsourcing literature, by granting information on the challenges that occur when using BDA outsourcing as a method to improve BI. By comparing the literature study to the interviews it will become apparent how BDA outsourcing differs from BDA, BI, and IT outsourcing literature. It will become clear what challenges occur during BDA outsourcing, and what factors potentially cause these challenges. The results of this study are used in order to conceive a model in which relationships are made between various BDA outsourcing challenges. In doing so, more understanding is created regarding the influence various challenges can have throughout a BDA outsourcing project. Should the results mentioned in practice differ from those mentioned in the literature study, this could suggest that BDA outsourcing differs from other BDA, BI, and IT outsourcing implementations. In this scenario, the study would highlight the need for more BDA outsourcing studies.

This study also offers various practical contributions. This study will uncover various important factors that companies should be aware of when choosing to outsource BDA in order to improve BI. This study offers implications to both customer and vendor organizations. By researching the challenges that occur during BDA outsourcing, customers are granted more knowledge on how to outsourcing BDA more effectively. When choosing to outsource Big Data a better preparation could reduce risk, which can in turn prevent problems from occurring, and reduce unexpected costs. The outcomes of this study can also be used to aid companies in choosing between BDA outsourcing, and in-house implementation of BDA. This study also benefits Big Data consultancy companies. The results of this study can help Big Data consultancy companies deal more effectively with BDA outsourcing challenges. Since Big Data consultancy companies often possess above average BDA expertise, it might be necessary for various companies to collaborate with Big Data consultancy companies in the future. It is thus important to clarify factors that are important to the BDA outsourcing process.

2; Theory

2.1; Theoretical Background

In this section BDA, BI and IT outsourcing will be explained more thoroughly. In order to establish the BDA, BI, and IT outsourcing challenges, a literature study is conducted. In the first section BDA will be discussed, after which the usage of BDA to improve BI is shown. Then BDA outsourcing is then discussed as a potential implementation strategy, consequently showing the potential of BDA outsourcing to improve BI. Ultimately the literature study is discussed, in which various challenges are found related to BDA, BI, and IT outsourcing.

2.1.1; Big Data Analytics

Addo-Tenkorang, & Helo (2016, p528) 'defined' Big Data as '*a fast-growing amount of data from various sources that increasingly poses a challenge to industrial organizations and also presents them with a complex range of valuable-use, storage and analysis issues*'. In literature, however, there is also no single agreed upon definition of Big Data (Addo-Tenkorang, & Helo, 2016), which shows that different views are taken on Big Data. A common, but contested way to describe Big Data is by using the 4Vs. The 4V definition is used to describe core Big Data characteristics; Volume, Velocity, Variability and Veracity (Bosch, 2016). Volume characterizes Big Data to a certain extent, as the extremely large size of datasets can cause difficulties in loading or applying operations to the data (Shneiderman, & Plaisant, 2015). Velocity is a characteristic of Big Data, as it describes the frequency at which data is created (McAfee, & Brynjolfsson, 2012). For instance, velocity is greater when data is being obtained constantly, for instance online banking data, compared to data that is obtained during a single measurement period, for instance national exams. Variability is characterized as the variance within the dataset. For instance when looking at medical histories diagnoses can include over 90,000 ICD-9 (International Classification of Diseases, 9th revision codes), which makes it difficult to establish global patterns within the dataset (Shneiderman, & Plaisant, 2015). And Veracity is a Big Data characteristic since it explains if the data correctly describes reality. For instance, information on clicking on advertisements might not accurately reflect consumer interest in the product when the advertisement is often clicked on accidentally. One of the points of discussion is that various articles also suggest to add 'Value' as a fifth 'V', in order to highlight the importance of using Big Data to create economic value (Kiron, & Shockley, 2011; Forrester, 2012). Wamba et al. (2015) find it important to not only focus on analytics when defining Big Data, but to also include the development of skills that allow the use of new IT tools to generate valuable insights, and the ability to share these valuable insights with key stakeholders to obtain a competitive advantage. Thus Wamba et al. (2015) defined Big Data as 'a holistic approach to manage, process and analyze 5 Vs (e.g.,

volume, variety, velocity, veracity, and value) in order to create actionable insights for sustained value delivery, measuring performance, and establishing competitive advantages.

2.1.2; The usage of Big Data Analytics to improve Business Intelligence

It is believed that Big Data holds great potential for the future (Wamba et al., 2015). BDA can for instance be used in order to increase Business Intelligence (BI). BI is the ability of a company to make meaningful use of data it collects during its business operations (Kimble, & Milolidakis, 2015). McAfee, & Brynjolfsson (2012) conducted a wide study among 330 North American companies. The results of this study showed that the use of data-driven decision making was accompanied with more productivity and profitability than competitors (McAfee, & Brynjolfsson, 2012). The IT systems designed to enhance the quality of BI can be defined as BI systems (Tunowski, 2015). Currently, it seems that BI systems focus primarily on structured internal business data, ignoring the potential value of unstructured and external data (Ram, Zhang, & Koronios, 2016). Kimble, & Milolidakis (2015) discusses various issues companies might run into when attempting to generate intelligence from data, namely; the volume of data, the speed with which data is produced, the growing variety of formats, the lacking transparency of data collection methods, the complexity of the subsequent data processing, and the complexity of the human element. Kimble, & Milolidakis (2015) also show that Big Data holds great potential in improving BI systems in order to solve these issues.

McAfee, & Brynjolfsson (2012) conducted a wide study among 330 North American companies. The results of this study showed that the use of data-driven decision making was accompanied with more productivity and profitability than competitors (McAfee, & Brynjolfsson, 2012). A great potential use for BDA is to improve supply chain management (Sanders, 2016). The use of BDA during various stages of the supply chain has the potential to increase BI, since BDA allows the company to make better use of the data that is being generated (Kimble, & Milolidakis, 2015). Sanders (2016) shows that BDA can be used during various stages of the supply chain. BDA can be used in order to establish a better sourcing strategy that can ultimately help create a better understanding of suppliers (Sanders, 2016). Analytics are used in operations for years, however, the scale of these analytics becomes increasingly higher as more data is produced. Through the use of BDA large amounts of data can be analyzed, making it possible for managers to gain closer to real time awareness of changes in productivity or quality (Sanders, 2016). BDA can be used in logistics in order to assist in moving goods through the supply chain. For instance, when using BDA in scheduling it becomes possible to respond to delays in a more effective manner (Sanders, 2016). Through the use of Big Data a better real-time understanding can be obtained of human behavior. Better knowledge of consumer behavior can in turn increase the efficiency of the supply chain (Grether, 2016). Big Data can also be used to gain better understanding of employee performance (Doyle, 2015). Companies can also enter into Big Data collaborations. By sharing Big

Data among companies it is possible to decrease investments, whilst giving rise to disruptive innovations (van den Broek, & van Veenstra, 2017).

2.1.3; Big Data outsourcing as an implementation approach

Not all companies might be willing or able to incorporate BDA solutions themselves, since most companies lack the capability to do all the analytical work that is required (Sanders, 2016). An example of typical BDA challenges that can occur due to a lack of analytical capabilities are the four hurdles mentioned by Sanders (2016), namely the; 'Needle in a Haystack', 'Islands of Excellence', 'Measurement Minutiae', and 'Analysis Paralysis problems'. The 'needle in a haystack' problem occurs when companies feel the need to implement Big Data in order to keep up with the hype. Doing so can cause the company to use random analytics in the hope to eventually find relationships or causation. The risk in using this approach is the possibility of uncovering false positive relationships that can waste a lot of time and money. The 'islands of excellence' problem occurs when only a specific process is optimized with low regard for the entire supply chain. For instance, when trying to optimize labor costs without paying regard to customer satisfaction or lost sales can have adverse consequences. The 'Measurement Minutiae' problem occurs when companies measure to many metrics without regarding which metrics to focus on. By cutting the number of metrics down to a smaller customized number, it becomes possible to measure relevant performance. And lastly the analysis paralysis occurs when companies are so overwhelmed with the rapid change of technological capabilities that companies do not know where to even start. This can cause companies to experience a state of paralysis with regards to Big Data implementation.

Since it can be difficult for organization to implement BDA in-house, it might be beneficial for an organization to involve external expertise by outsourcing certain IT activities. Company outsourcing of various IT activities is becoming a growing trend. From 2009 to 2013 the global IT outsourcing market grew around 5%, with extremely rapid growth in China (Qi, & Chau, 2012). Many companies that choose to outsource IT do so primarily in order to mitigate costs (Loh, & Venkatraman, 1992; Liu, & Yuliani, 2016). Other reasons for companies to outsource IT can be increasing efficiency (Khan, Niazi, & Ahmad, 2011) or transferring risk (Willcocks, & Lacity, 1999). Despite IT outsourcing having potential benefits, IT outsourcing can be accompanied with various difficulties. Research by Lacity, & Willcocks (2012) showed that approximately one-third of outsourced IT projects were accompanied with negative outcomes. It also appears that more than 50% of outsourced IT projects were terminated before the contract expired, requiring companies to switch to another vendor or in-house development (Qi, & Chau, 2012; Whitten, & Leidner, 2006). It would thus appear that IT outsourcing is accompanied with its own risks and costs. Sanders (2016) argues that there are two key dimensions with regards to Big Data outsourcing risk, namely scope and criticality. The scope is defined as the degree of responsibility that is outsourced, and criticality is defined as the importance of the outsourced

activities. In Sanders (2016) it is discussed that a greater scope and criticality of BDA consequently causes higher outsourcing risk.

2.1.4; The potential of BDA outsourcing to improve BI

The objective of this study is to assess BDA outsourcing as an implementation strategy meant to increase BI. Various articles discuss the potential of BDA in dealing with various BI challenges (Ram, Zhang, & Koronios, 2016; Kimble, & Milolidakis, 2015; McAfee, & Brynjolfsson, 2012). It appears, however, that companies often struggle to realize this potential, since most companies lack the analytical capabilities to implement BDA in-house (Sanders, 2016; Goes, 2014). Using BDA outsourcing as an implementation strategy may hold various benefits over in-house BDA development, since BDA consultancy companies likely possess a high degree of analytical capabilities. In literature various articles fail to discuss the potential benefit of BDA outsourcing in preventing various common BDA challenges from occurring. Despite Sanders (2016) mentioning BDA outsourcing as an implementation method for BI, the study focusses primarily on the potential risks of BDA outsourcing, Sanders (2016) does not discuss the potential benefits of BDA outsourcing. Especially challenges like the four hurdles mentioned by Sanders (2016) that can be encountered due to a lack of BDA knowledge and experience might not be prevalent during BDA outsourcing. Since BDA consultants possess more knowledge and experience regarding BDA, it is possible that BDA outsourcing can prevent other BDA challenges from occurring as well. In order to better assess the usefulness of BDA outsourcing, it needs to be established how BDA challenges are handled during BDA outsourcing.

Kimble, & Milolidakis (2015) state the potential of BDA to analyze company information to make informed decisions. Kimble, & Milolidakis (2015) focus primarily on the great promise of BDA regarding the generation of BI through social media. The challenges of Big Data mentioned by Kimble, & Milolidakis (2015) are the volume, variety, and velocity of the generated data. These are basic characteristics of Big Data, which Big Data consultancy companies are likely more experienced with than most companies. Another challenge refers to the Big Data quality, as the use of Big Data still necessitates a methodology in generating and analyzing the data (Kimble, & Milolidakis, 2015). Kimble, & Milolidakis (2015) states that neither Big Data nor technological wizardry alone can solve these challenges, and highlights the importance of using human wisdom and technological prowess to solve data-driven challenges. The use of BDA outsourcing could potentially help companies in acquiring the knowledge, and experience required to deal with these Big Data challenges. In order to assess the capability of BDA outsourcing meant to improve BI, it is necessary to establish whether BDA outsourcing is able to solve BI challenges.

Since both BDA and IT outsourcing are growing trends (Qi, & Chau, 2012; Gantz, & Reisel, 2011), it is likely that BDA outsourcing will become a growing trend as well. Companies often lack BDA knowledge

(Goes, 2014), making it more tempting to outsourcing BDA. Qi, & Chau (2012) and Whitten, Leidner (2006) state that IT outsourcing projects are often being terminated, however, in both these articles the authors pay no attention to the activity that is being outsourced. Since IT outsourcing is a collective term for all IT processes that are outsourced. It is possible that the outsourcing of different IT activities is accompanied with similar challenges. It could, however, also be quite possible that the outsourcing of various IT activities is accompanied with its own unique challenges. For instance, outsourcing data storage could come with different challenges than outsourcing BDA. Sanders (2016) discusses various steps that companies should take in order to outsource BDA properly. Sanders (2016), however, does not show the potential of BDA outsourcing to solve various BDA challenges, neither does Sanders (2016) show what challenges can occur during the BDA outsourcing process. It thus remains unclear whether BDA outsourcing is accompanied with IT outsourcing challenges.

2.2; Literature Review and Conceptual Model

In this section the literature study is discussed. In this section it is specified how the literature study is conducted. The results of the literature study are shown, in which it is discussed what challenge categories were found during the literature study. Lastly, it is discussed how the challenges found during the literature study related to one another. During this study it is attempted to gain clarity on the challenges that occur during BDA outsourcing projects. It will also be established how these challenges were dealt with. In doing so it will become clear whether BDA outsourcing can adequately handle various BDA, BI and IT outsourcing challenges.

2.2.1; Conducting the Literature Study

Prior to conducting interviews with consultancy companies and customers, a literature search was conducted. In conducting the literature search, articles were reviewed that contained challenges that occurred during BDA, BI or IT outsourcing. The study was performed using Web of Science, and Scopus as databases. During the literature study articles were sought that were published between 1980 and 2017. On Web of Science the following searches were conducted;

1) ‘Big Data Analytics’ AND ‘(disadvantages OR problems OR issues OR costs OR challenges)’. This search yielded a total of 1.600 articles.
2) ‘Business Intelligence’ AND ‘(disadvantages OR problems OR issues OR costs OR challenges)’. This search yielded a total of 1.273 articles.
3) ,and ‘IT outsourcing’ AND ‘(disadvantages OR problems OR issues OR costs OR challenges)’. This search yielded a total of 1.560 articles.

On Scopus the following searches were conducted;

1) '(Big Data Analytics) AND (disadvantages OR problems OR issues OR costs OR challenges) Not (Healthcare OR Public OR Sports OR Academic OR Epidemiology OR Cities OR Traffic OR Architecture)'. This search yielded a total of 1.628 articles.
2) '(Business Intelligence systems) AND (disadvantages OR problems OR issues OR costs OR challenges) Not (Healthcare OR Health OR Artificial OR Animal OR Culture OR Patient OR Public OR Forest OR Sports OR School OR Environment OR Epidemiology OR Cities OR Traffic OR Architecture)'. This search yielded a total of 1.304 articles.
3) '(Technology outsourcing OR IT-outsourcing) AND (disadvantages OR problems OR issues OR costs OR challenges) Not (Healthcare OR Health OR Artificial OR Animal OR Culture OR Patient OR Public OR Forest OR Sports OR School OR Offshoring OR Environment OR Epidemiology OR Cities OR Traffic OR Architecture OR Crowdsourcing)'. This search yielded a total of 1.743 articles.

These searches yielded a total of 9.108 articles related to BDA, BI, and IT outsourcing challenges. The searches in both the Web of Science, and Scopus databases were conducted in a manner to yield approximately 1.500 hits per search, necessitating the formulation of certain exclusion phrases. These phrases were formulated by assessing the first 50-250 hits for each search. Based on the irrelevant articles found, it was decided to formulate certain exclusion phrases in order to establish a manageable first sample. After formulating the search phrases, it was chosen to refine the sample based on availability, abstract, title, and initial assessment. Various articles were not freely available for students from the University of Twente. These articles were excluded from the literature sample. The abstract, and title of available articles were read, and the article was skimmed in order to assess the article indeed discussed BDA, BI, or IT outsourcing. If an article did not discuss these topics, it was excluded from the literature sample. In doing so, after conducting all searches a total of 624 articles remained in the sample. The remaining sample was then refined based on the full text. During this phase the entire article was read, in order to establish whether the article discussed specific challenges that can occur during BDA outsourcing. The articles that did not mention specific challenges that occur during BDA, BI, or IT outsourcing were discarded from the literature study. A challenge was found to be specific when a concrete aspect of a BDA, BI, or IT outsourcing challenge was discussed. A challenge was found to be unspecific when the article only referred to BDA, BI, or IT outsourcing as challenging without discussing what challenges occur exactly. After this stage 106 articles remained in the sample. Lastly, the sample was refined for duplicate articles after which 102 articles remained to form the final sample. The duplicate articles found in this phase were present due to certain articles discussing both BDA and BI challenges, thus appearing in both the BDA and BI searches.

In order to create clarity on the different types of challenges that might occur during BDA outsourcing to increase BI, it was chosen to combine all the challenges found during the literature study in one table. The

final literature sample was used in order to comprise a concept matrix. It was chosen to organize the final literature sample in a concept-centric manner (Webster, & Watson, 2002). In doing so, first all BDA, BI, and IT outsourcing challenges discussed in the literature sample were listed alphabetically. In this list it was also noted which authors discussed each challenge. A small sample of this list is shown in Table 1.

Table 1; Sample of the Literature Study.

Challenge	**Author**
Analysis paralysis due to increasingly more data sources and technologies becoming accessible	Meleanca (2013)
Balancing the cost of big data management systems with the potential gains in efficiencies and performance	Richey et al (2016); Sivarajah et al (2017)
Clear goals set by leadership regarding big data	Vidgen, Shaw, & Grant (2017)
Defining the scope of analytics projects	Vidgen, Shaw, & Grant (2017)
Difficulty in measuring the actual benefits, opportunities, costs or risks involved during IT outsourcing	Kivijärvi (2015)
Lack of knowledge about the type of development projects best suited for agile and waterfall approaches	O'Donnell, Sipsma, & Watt (2012)
Lack of knowledge in creating, organizing and structuring a BI team	O'Donnell, Sipsma, & Watt (2012)
Lack of management and organizational models especially for SMEs	Coleman et al (2016)
Tuning costs and performance of computation	Choi, Chan, & Yue (2017); Coleman et al (2016)
….	…..

Note: In this table a sample of the literature study is shown, in order to show how challenges found during the literature study were initially listed.

Once the list was completed, each challenge was extracted from the list and grouped with challenges that were found to be similar to one another. In doing so, various challenge sub-categories were created. In Table 2 the subcategories are shown for the challenges mentioned in Table 1.

Table 2; Sample of the Challenge Subcategories made during the Literature Study

Challenge Subcategory	**Challenge**
Difficulty in leadership setting clear goals regarding BDA, and determining the scope of BDA projects	Defining the scope of analytics projects Clear goals set by leadership regarding big data Analysis paralysis due to increasingly more data sources and technologies becoming accessible
Difficulty in measuring and balancing the costs and potential gains of BDA outsourcing	Balancing the cost of big data management systems with the potential gains in efficiencies and performance Difficulty in measuring the actual benefits, opportunities, costs or risks involved during IT outsourcing Tuning costs and performance of computation
Difficulty organizing BDA projects, and teams due to lacking organizational models	Lack of knowledge in creating, organizing and structuring a BI team Lack of management and organizational models especially for SMEs Lack of knowledge about the type of development projects best suited for agile and waterfall approaches
….	….

Note: In this table a sample of the literature study is shown to clarify how the challenges found during the literature study were grouped into different challenge subcategories.

Lastly, it was established during which managerial and organizational activities these challenge subcategories occurred. In doing so, challenge subcategories that occurred during similar managerial or organizational activities were grouped with one another to form challenge categories. The challenge subcategories shown in Table 2 are grouped into categories in Table 3.

Table 3: Sample of the Challenge Categories made during the Literature Study

Challenge Categories	**Challenge Subcategories**
Strategy	Difficulty in leadership setting clear goals regarding BDA, and determining the scope of BDA projects Difficulty organizing BDA projects, and teams due to lacking organizational models
Resources and Costs	Difficulty in measuring and balancing the costs and potential gains of BDA outsourcing
…..	…..

Note: In this table a sample of the literature study is shown to show how the challenge subcategories created during the literature study were used in order to establish the challenge categories.

In Appendix A, an overview is given of all the challenges that are discussed in BDA, BI, and IT outsourcing literature. It is also shown how these challenges are grouped into various challenge categories, and sub-categories. In total 285 different challenges were found during this literature study, ranging from organizational to technical challenges.

2.2.2; Literature Study Findings

During the literature study a large amount of challenges was found, consisting of various technological, managerial, and organizational challenges. Most challenges found during the literature study, however, appeared to be managerial or organizational in nature. Especially managerial and organizational challenges related to the 'Decision Making', 'Managing the project', 'Contract', 'Human Resources', and 'Costs' were apparent. Since the amount and range of the challenges found in the literature study were excessively large, it was chosen to focus solely on the management, and organizational challenges in this study. The management, and organizational challenges noted in Appendix A were used in order to establish the concept matrix found in Appendix B. In this concept matrix all managerial and organizational challenges are grouped in seven challenge categories, namely 'Project Strategy', 'Value of the Project', 'Resources and Costs', 'Contract', 'Governance and Compliance', 'Management during the Project', and 'Customer Resistance and Trust'.

During the literature study twelve percent of articles described challenges related to 'Project Strategy'. The challenges related to project strategy present in the literature study were related to 'strategy determination', 'the project goal', 'defining responsibilities', and 'team formation'. Challenges regarding the determination of a strategy were found in BDA, BI, and IT outsourcing literature. O'Donnell, Sipsma, & Watt (2012) researched the top 20 critical issues that are faced relating BI practices in Australia. During this study meetings were set up

with BI practitioners in order to establish the most important challenges that are being faced. It was determined that strategy determination was in the top 10 of those issues. Various challenges were present relating the establishment of a project goal by leadership. Vidgen, Shaw, & Grant (2017) conducted a study regarding the management challenges present when creating business value from business analytics. A challenge related to an unclear project goal is defining the scope of analytics projects (Vidgen, Shaw, & Grant, 2017). The challenges related to strategy can potentially influence other challenge categories as well. It is for instance possible that having a clear strategy could for instance 'overcoming resistance to change' (Vidgen, Shaw, & Grant, 2017). Challenges related to defining responsibilities are discussed by Anagnostopoulos, Zeadally, & Exposito (2016). In this study various challenges during BDA are discussed, including ethical issues. In this study it was found that ownership determination and accountability during data management, distribution, and analysis can be an issue. Various challenges regarding the organization of BDA projects were also found. These challenges were found to be related to a lack of knowledge, or organizational models (Coleman et al, 2016; O'Donnell, Sipsma, & Watt, 2012).

During the literature study twenty-one percent of the articles described challenges related to the 'Value of the 'Project'. These challenges were either related to a lack of knowledge, determining the relevance of BDA results, difficulty in creating decision making systems, difficulties in creating a BDA model, and difficulty for analysts to grant analytical advice. Challenges regarding a lack of knowledge in creating value from BDA or BI were present during the literature study. These challenges were for instance caused to a lack of knowledge on how to identify valuable data subsets from the original dataset (Zhou et al, 2014; Zeng, Li, & Duan, 2012; Zimmermann, 2006). Another challenge found relating knowledge, is lack of knowledge of how to leverage information to gain a stronger market position (Baesens et al, 2016). Challenges related to determining the relevance of BDA results are discussed by Jorge et al (2016). During this article it is shown that the establishment of data quality is important in order to accurately estimate business value. Various challenges related to creating a decision system were also present in the literature study. These challenges were related to a lack of data decision-support tools (Tien, 2013), and it is challenging to create an automated decision making system (Nielsen, 2016). When this system is in place it is also difficult to take actions based on analysis results (Azvine, Cui, & Nauck, 2005; Lawton, 2006). Difficulties in creating a BDA model are caused due to difficulty for decision based systems to be equipped with all relevant facts needed to make accurate decisions (Kowalczyk, & Buxmann, 2015; Vera-Baquero, Colomo-Palacios, & Molloy, 2016). Challenges related to difficulty for analysts to grant analytical advice, are due to difficulties in making analytics understandable for decision makers (Kowalczyk, & Buxmann, 2015), and doing so in a timely manner (Wang et al, 2016).

The most discussed challenge category during the literature study was the 'Resources and Costs' category. In the literature study thirty-four percent of the articles described challenges related to the 'Resources

and Costs' category. These challenges had diverse causes, namely; a shortage of technical skill, difficulty related to business requirements, difficulties in internal/external resource allocation, difficulties in balancing costs to benefits, difficulties in managing costs, difficulties in securing investments, and the occurrence of hidden costs. Challenges related to a shortage of technical skill are caused due to a shortage of technical or analytical skill, which is especially prevalent for small, or medium enterprises (SME's) (Akter, & Wamba, 2016; Coleman et al, 2016; Richey et al, 2016). The challenges related to business requirement issues are caused by difficulties in the determining and coordinating business requirements (Goldberg et al, 2017; O'Donnell, Sipsma, & Watt, 2012). Difficulties in internal/external resource allocation are present due to management issues related to management issues in directing both internal and external resources (Martinsons, 1993; Yang, Wang, & Douglis, 2009). Challenges related to difficulties in balancing costs to benefits are caused due to difficulties in measuring the actual costs, benefits, opportunities and risks involved during IT outsourcing (Kivijärvi, 2015). Difficulties in managing costs appear due to high costs of analytics and data warehousing (Lawton, 2006; Yeah, & Popovič, 2016). During an analytics project it is also difficult to estimate costs and risks, making it difficult to manage costs efficiently (Wang et al, 2016). Difficulties in securing investments are since various BDA and BI solutions are fairly expensive to develop, implement and maintain, which is especially the case for SME's. Lastly, the occurrence of hidden costs is present throughout various stages of BDA, BI, and IT outsourcing projects (Al-Aqrabi et al, 2013; Bahli, & Rivard, 2003; Barthélemy, 2001; Cong, & Chen, 2015; Hsu, Chiu, & Hsu, 2004; Lacity et al, 1995; Plugge, & Brook, 2012; Martinsons, 1993; Raiborn, Butler, & Massoud, 2009; Susarla, Subramanyam, & Karhade, 2010; Urbach, & Würz, 2012; Willcocks, Lacity, & Fitzgerald, 1995).

During the literature study nineteen percent of the articles described challenges related to the 'Contract' category. Challenges in the contract category were related to difficulties in the following factors; creating a Service Level Agreement, creating an enforceable contract, data ownership and intellectual property rights, monitoring contractual obligations, and providing contractual motivation. Challenges related to creating a Service Level Agreement were discussed by Abushaban (2013). In Abushaban (2013) it is shown that it is difficult to determine Service Level Agreements due to difficulties in communication, different stakeholder backgrounds, and loss of focus when defining and measuring Service Level Agreements. It can be challenging to create an enforceable contract due to difficulties in defining, and measuring performance goals (Christ et al, 2015; Fitoussi, & Gurbaxani, 2012; Goldberg et al, 2017), especially when technological uncertainty is high (Handley, & Benton, 2012; Lee, 1996). Challenges related to intellectual property rights are present due to data ownership issues (Anagnostopoulos, Zeadally, & Exposito, 2016; Sivarajah et al, 2017; Subramaniam et al, 2009; Vidgen, Shaw, & Grant, 2017; Zhou et al, 2014). Data ownership issues can arise due to frequent data migrations between customer and vendor (Bachlechner, Thalmann, & Maier, 2014). Challenges related to

monitoring contractual obligations arise due to difficulty in measuring quality and reliability (Hsu, Chiu, & Hsu, 2004; Wang et al, 2016). It can also be difficult for technical experts to switch between solving IT problems and managing the contract (Lacity et al, 1995). And lastly, in Zhang, & Xu (2017) it is discussed that it is difficult for various customer organizations to provide vendors with contractual incentives to perform well.

In the literature study twelve percent of the studies described challenges regarding the 'Governance and Compliance' challenge category. These challenges were related to issues IT governance, performance indicators, and monitoring performance. The challenges related to IT governance are caused by difficulties in establishing, implementing, and governing IT activities (Ai, & Green, 2009; Bachlechner, Thalmann, & Maier, 2014; Kache, & Suring, 2017; Khan et al, 2014; O'Donnell, Sipsma, & Watt, 2012). During complex IT projects it can be difficult to honor certain security, or legislative arrangements (Bachlechner, Thalmann, & Maier, 2014; Vidgen, Shaw, & Grant, 2017). Performance indicator difficulties are caused due to difficulties in identifying and measuring performance indicators that actually reflect the strategic, economic, and technological objectives (Fitoussi, & Gurbaxani, 2012; Urbach, & Würz, 2012). Performance indicator challenges can also be caused due lacking performance of traditional measurement mechanisms (Demirkan, & Delen, 2013). And finally, difficulties present during performance monitoring were also found (Abushaban, 2013; Raiborn, Butler, & Massoud, 2009). These difficulties can arise due to difficulty in selecting software tools to monitor and report performance (Raiborn, Butler, & Massoud, 2009).

During the literature study it appeared that sixteen percent of the articles described challenges related to the challenge category 'Management during the project'. The challenges connected to managing the project were caused by difficulties in various factors, namely; managing the outsourcing process, managing vendor activities, integrating third parties, changing customer requirements, and staff turnover. Challenges related to managing the outsourcing process could be caused by difficulties in managing data processes, and Service Level Agreements (Abushaban, 2013; Vidgen, Shaw, & Grant, 2017). Managing vendor activities can be difficult when the customer company lacks IT expertise, which allows the vendor to dominate IT management (Park, Im, & Kim, 2011). It can be difficult to integrate third parties during the project, especially when communication between parties is poor (Goldberg et al, 2017; Kern, & Willcocks, 2000). Difficulty for the vendor to adapt to changing customer requirements can also be present during IT outsourcing (Bachlechner, Thalmann, & Maier, 2014). it can consequentially be difficult for vendors to remain flexible (Martinsons, 1993; Urbach, & Würz, 2012). Lastly, staff turnover difficulties can create management difficulties during BDA projects (Goldberg et al, 2017).

In the literature study was established that twenty-seven percent of the articles described challenges related to the 'Customer Resistance and Trust' challenge category. Challenges in the 'Customer Resistance and Trust' category were related to difficulty dealing with organizational resistance, difficulty dealing with cultural

barriers, lacking customer trust, misunderstandings, and low vendor commitment. Challenges related to organizational resistance are caused by lack of customer readiness towards the project (Anjariny, Zeki, & Hussin, 2012; Mohamadina, & Harbawi, 2012). The added difficulty of IT outsourcing can potentially decrease employee morale (Belcourt, 2006). Difficulties caused by cultural barriers were found to create challenges for effective coordination during the project (Christ et al, 2015; Coleman et al, 2016; Vidgen, Shaw, & Grant, 2017; Willcocks, & Choi, 1995). Lacking customer trust was primarily found to be caused due to lack of transparency of the analytical process (Baesens et al, 2016; Coleman et al, 2016; Schroeder, 2016). This lack of analytical transparency can be caused by issues regarding BDA visualization (Anagnostopoulos, Zeadally, & Exposito, 2016; Hoerl et al, 2014; Ishwarappa, & Anaradha, 2015; Khan et al, 2014; Sivarajah et al, 2017; Vidgen, Shaw, & Grant, 2017; Wang et al, 2016). Misunderstandings can arise in different manners, for instance regarding the scope or cost-service (Goldberg et al, 2017). These challenges can occur due to misaligned expectations or conflicting customer and vendor objectives (Goldberg et al, 2017; Urbach, & Würz, 2012). Low vendor commitment also elicit resistance and trust issues, for instance due to degradation of services, lack of vendor commitment, vendor ineffectiveness, and opportunistic vendor behavior (Gorla, & Somers, 2014; Handley, & Benton, 2012; Zhang, & Xu, 2017).

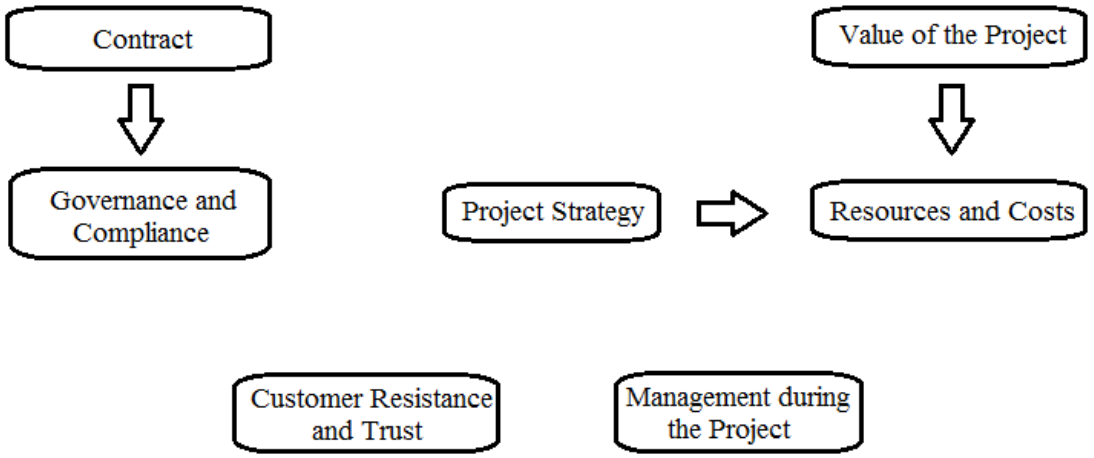

Figure 1; The relationships between challenge categories based on the literature study findings.

In Figure 1 the relationship between challenges is described. It appears that all challenges are related to one another, except for challenges related to ‘Managing the project’. It seems that challenges related to ‘Project Strategy’ influence challenges from the ‘Resources and costs’ category. This influence related to the business requirements. When business requirements set during the strategy determination are unclear, this can cause difficulties in assessing resources and costs. ‘Project Strategy’ challenges also influence challenges from the ‘Resistance and Trust’ category. This influence is present since a clear strategy could potentially prevent resistance and trust issues from arising (Vidgen, Shaw, & Grant, 2017). It appears that challenges from the ‘Value of the project’ category influenced ‘Resources and costs’ challenges. This influence is present due to

difficulty in determining the benefits of the project. When the benefits of the project are unclear, it is difficult to obtain a sense of what the exact value of the project is. 'Contract' challenges influence 'Governance and Compliance' challenges due to difficulty in defining clear performance measures in the contract, thus making it difficult to govern project compliance. Also, when a contract is constructed that is difficult to monitor, it can potentially cause governance and compliance challenges. Lastly, 'Customer resistance and Trust' was found to be influenced by 'Project strategy', since a clear project strategy can potentially prevent various customer resistance issues from arising.

3; Method

During the following sections the development of the interview structure, and analysis of results are discussed. First, it is discussed how the interview was constructed. Then the interview sample, interview materials, and interview procedure is discussed. Lastly, it is discussed how the data is analyzed.

3.1; Instrument Development

The challenge categories found during the literature study, were used in order to establish the interview structure. This first version of the interview structure was tested during a pilot study. During this pilot study an interview was conducted with a CEO of a Dutch Big Data consultancy company. This interview was conducted in a 40 minute time-frame, during which questions were asked about challenge categories found during the literature study. During this pilot study it became apparent that the interview questions were rather generic, since the interview consisted of categories that were far too broad. Consequently, it was decided to construct a new concept matrix, in which the various categories, sub-categories, and challenges were listed in more detail. This final concept matrix can be found in Appendix A. Since this concept matrix consisted of a large number of challenges, it would be far too time-consuming to conduct interviews regarding all the challenges found during the literature study. It was decided thus decided to focus solely on the management and organizational challenges during the interviews. The management and organizational challenges found in Appendix A were used in order to establish the concept matrix found in Appendix B. This concept matrix was then used in order to establish the interview structure found in Appendix C. During the start of the interview first a few introduction questions were asked. These questions were used to get a grasp of the BDA project, and the interviewees' role during the BDA project. The potential challenges were used to formulate open questions. All the challenge categories were used in order to conceive interview questions. The open interview questions that

discuss similar topics were grouped in categories in the interview structure in order to prevent confusion amongst participants (Emans, 2002).

3.2; Sample

Table 4; Specifications of the cases discussed during the interviews.

Case	Project description	Company Size	Project Duration	Interviewee Occupation	Software Development Method
A	Increasing Data Quality of data that is available in multiple countries, and multiple databases to an acceptable level.	10-50	< 1 year	Operations Manager	Scrum
B	The development of automated quality management by using machine data in order to determine the quality of end products.	< 10	<1 year	Project manager	Scrum
C	The development of data driven use-cases in order to generate insights to improve overall production processes.	200-500	1-5 years	(Financial) Manager	Scrum
D	Accurately forecasting revenue based on various available business and environmental data sources.	50-200	1-5 years	Consultant manager	Scrum
E	Using both structured and unstructured report data in order to generate automated	11-50	1-5 years	(Data analytics) Manager	Waterfall followed by Scrum

	predictions.				
F	The development of a central data processing unit for marketing data that is spread throughout the customer organization.	< 10	1-5 years	CPO/ consultant	Scrum
G	The development of fraud identification software able to generate a fraud chance in fraud-sensitive situations using historical data.	> 2.000	<1 year	Project manager/ consultant	A combination of Waterfall and Scrum
H	Using various, available company data sources in order to optimize the entire product purchasing process.	< 10	1-5 years	CEO	Scrum
I	Transitioning from a decentralized to a centralized data processing approach in order to make data analytics more efficient.	10-50	> 5 years	CEO	Scrum
J	Developing software able to automatically grant employees in a sales organization available product photos and information.	50-200	> 5 years	Business developer/ Manager	Scrum
K	The development of a software system able to automatically analyze travel information	50-200	1-5 years	Consultant Manager	A combination of Waterfall and Scrum
L	Creating a software system able to track fuel usage in a	2-10	< 1 year	CEO	Scrum

	real-time manner, based on various available data sources.				

Note: A brief description of the cases discussed during the interviews conducted with managers and CEO's of a BDA consultancy company. This table contains information about the nature of the discussed project, consultant company size, duration of the project, interviewee function, and the software development method used during the project.

In total the sample consisted of twelve Dutch Big Data consultancy companies. The details of each project discussed during the interview are described in Table 4. The interviews were conducted with employees of ten Dutch Big Data consultancy companies. It was chosen to conduct the interview amongst a total of twelve participants. It was chosen to use twelve participants since based on Guest, Bunce, & Johnson (2006) suggest that stable results are reached after interviewing twelve participants. During this study convenience sampling was used in order to search for Dutch Big Data consultancy companies. During convenience sample, the participants were easiest to seek. This sampling method was used since the amount of Dutch Big Data Consultancy companies is fairly limited. These Big Data Consultancy companies were sought using web searches, and are contacted via mail, or phone. Big Data Consultancy companies were also sought after during Big Data events. These Big Data Consultancy companies were persuaded to participate in the study by granting information of the benefits this study might bring. As this study could offer insights into various managerial and organization challenges that occur during BDA outsourcing. The results of this study could offer consultancy companies information on how to better deal with certain challenges that occur during BDA outsourcing projects. In each Big Data Consultancy company one, or two interviews were conducted with either project managers or CEO's.

3.3; Procedure

During the current research semi-structured interviews were conducted. Prior to the study participants are informed about the nature of the interview, and the interview procedure. Participants are also informed that the interview will be recorded, that the interviews processed anonymously, and that interviews are solely used for research purposes. All interviews will be conducted in a 40-60 minute timeframe, during which participants were asked questions concerning various challenges found in the BDA, BI and IT outsourcing literature studies. The interview structure can be found in Appendix C. If possible, interviews were conducted during a face-to-face meeting, and voice-records of the interview were made using a smartphone. When it proved impractical to schedule a face-to-face meeting, it was opted to conduct an interview via phone or using 'google hangouts'. In these scenarios the interviews were recorded using pre-installed software. During face-to-face interviews a

smart phone was used containing pre-installed recording software. The interviews conducted via phone were recorded using the 'Call Recorder' app. The interviews conducted via 'Google Hangouts' were recorded using a laptop and 'Callnote' recording software.

3.4; Data Analysis

After each interview that was conducted, a transcript was made. These transcripts were analyzed in Atlas.ti using the grounded theory. Raymond (1992) discusses the various steps that need to be performed using the grounded theory. The first step includes coding the data. During this study coding was done using open and axial codes. In doing so codes were generated from the transcripts. These codes are essentially parts of the interviews that reflect similar subjects. Coding is used in order to grant meaning to the data, and find relationships in the data (Barton, & Court, 2012; Bernard, & Ryan, 2010). Coding is also necessary in order to ultimately generate a theory from the data (Basit, 2003). During this coding process all statements made related to BDA outsourcing challenges were marked in the interview transcripts. These interview statements could for example consist of information on the factors that caused the challenge to arise. For each different challenge a tag was formulated. In doing so, a list is made of BDA challenges accompanied with interview statements.

The second step was conducted after coding was completed. During this step categories needed to be defined, that could be used to group various codes. In doing so, the content of all interviews could be used in order to summarize the interviews. In Appendix D it is shown how the different challenges found during the interview were grouped into categories and subcategories. Using the challenge tags, interview challenges were initially grouped using the categories and sub-categories found during the literature study. After grouping the interview challenges in this manner it appeared that certain challenges could not be grouped in existing sub-category. For these challenges new sub-categories were constructed. After coding was complete it was established during which challenge categories and sub-categories were present in each case. It also became possible to assess what factors contributed to the occurrence of various challenges.

4; Results

As previously discussed, the managerial and organizational challenges found during the literature study were used in order to establish an interview. In Appendix D it is shown that a great number of managerial, and organizational challenges were discussed during these interviews. It also appeared that the challenges varied greatly between interviewees, since only few challenges were mentioned during multiple interviews. In Appendix D an overview is shown of the challenges mentioned for each category and subcategory. All the

challenges were grouped in seven categories, namely; ‘Project Strategy’, ‘Value of the Project’, ‘Resources and Costs’, ‘Contract’, ‘Governance and Compliance’, ‘Management during the Project’, and ‘Customer Resistance and Trust’. All these categories consisted of multiple subcategories which will be discussed in the following sections.

4.1; Project Strategy

Table 5; The challenge subcategories related to project strategy displayed for each case.

Subcategories	**Cases**												
	A	B	C	D	E	F	G	H	I	J	K	L	
Composing a team		√	√	√	√		√	√		√			
Determining Responsibilities				√		√				√	√	√	
Determining the Project Goal		√	√	√	√		√			√		√	
Project Continuity							√	√			√		
Software development method					√						√		
Strategy Determination	√	√	√	√	√					√	√	√	

The challenges mentioned that are related to project strategy can be categorized in various subcategories, namely; Composing a team, Determining Responsibilities, Determining the Project Goal, Project Continuity, Software development method, and Strategy Determination. In Table 5 an overview is given of which strategic challenges occurred during each case, and it appears that strategic challenges occurred during all cases. It appeared that out of all strategic challenges the most prevalent were challenges related to ‘Composing a team’, ‘Determining the Project Goal’, and ‘Strategy Determination’.

The challenges related to ‘Composing a team’ were caused by low availability of specialized personnel in various instances. This availability issue is either caused by a high demand for BDA outsourcing projects making it difficult to make time available. This challenge occurred in case H, where it was arranged that various people were available for the project. In practice, however, these people are often busy working on other projects causing delays. Availability issues are also caused by a shortage of specialists in the market place. In case D it was argued that there is a scarcity of personnel that are analytically or technically capable. It was challenging to compose a team due to changing customer or project requirements. In case J for instance it was challenging to since changing customer requests meant that certain knowledge was necessary that was not available in the project team. It was challenging to increase knowledge in the customer organization’s team in

case G. In this case the customer organization was intended to eventually administer the project alone. Thus it was necessary to educate the customer in how the project worked.

The challenges grouped as ‘Determining Responsibilities’ were related to making sure all involved parties were well informed of their tasks, and makings sure that all parties took responsibility for the tasks that were assigned to them. In case K it was argued that it is difficult to ascertain that both consultancy, and customer organizations have the same notion of how the responsibilities are distributed. Despite these responsibilities being discussed it was argued that both consultant and customer likely had different views regarding responsibility. Challenges regarding the determination of responsibilities also arise due to a lacking specification of who is responsible when something goes wrong during the project. In case L the project was reliant on ship sensors. Prior to the project it was not specified what should happen when these sensors are defective, which caused some suspense during the project. In this case it was also discussed that challenges arise in determining responsibilities during personnel changeover. Since personnel changes creates a necessity to redefine who is responsible for what.. And lastly, challenges related to determining responsibilities were caused by high customer knowledge. In case D this caused the customer organization to have a strong opinion how the project should be conducted, which was not in line with views from the consultancy company.

Various challenges related to ‘Determining the Project Goal’ were caused by an unclearly formulated customer request. In case G for instance it was argued that it is often difficult to clarify the project goal and specify whether the solutions reached by the project were in line with customer expectations. Another challenge that was present when determining the project goal was defining a clear project scope. In case B it was for instance discussed that it is challenging to specify what sensors should be measured during the project, and what additional security precautions were necessary.

‘Project Continuity’ challenges were related to customer organizations often thinking that at the end of the project the installed product requires no further attention. During case K for instance it was argued that analytics projects are never truly finished, since analytics need to be constantly updated in order to accurately reflect the current state of events.

The challenges related to the ‘Software development method’ were caused by customers finding it difficult to apply the software development method as was planned. During case K it was discussed that it often occurs that prior to the project, the customer organization says it wants to use an agile approach. In practice, however, it appears that various customer organizations do not know how an agile approach is conducted, which often leads to a combination of waterfall and agile approaches being present during the project.

Challenges related to ‘Strategy Determination’ had various causes. Strategy determination challenges were partly caused by a lack of customer experience regarding BDA. In case D it is discussed that customers do not know what is possible using BDA. In turn this creates difficulties in assessing clear customer requirements.

This inexperience makes it necessary for the consultancy company to persuade the customer organization into adopting a certain strategy, or a certain change in order to get on the same page. In case F it was discussed that it is also challenging to make ascertain that a strategy was clearly understood, and clearly communicated in the customer organization. Other 'Strategy Determination' challenges were related to determining if the strategy can be implemented. Another challenge that can arise during the strategy determination is that the lacking data quality can impede BDA strategies. In case C it was discussed that this is especially challenging when data is stored in multiple platform with a varying data quality. This makes it difficult to assess whether the necessary datasets are useful. In case E data restrictions hampered the initial strategy determination, which made it necessary for the consultancy company to change the strategy and implement various work-arounds. Another challenge in strategy determination is the implementation of a standardized process. In case J it was discussed that for larger consultancy companies it is necessary to work with standardized processes during BDA projects. It is often difficult to implement these standardized processes in a non-standard environment. And lastly, in case K it was discussed that when the customer requests a non-existing BDA solution, it is challenging to ascertain whether a certain strategy will also lead a product capable of meeting the customer's requirements.

Overall, various challenges related to 'Project Strategy' were unexpected since far less challenges were found during the literature study. During the interviews 'Project Continuity', and 'Software Development Method' were identified as new sub-categories.

4.2; Value of the project

Table 6; The subcategories related to the value of the project displayed for each case.

Subcategory	**Cases**											
	A	B	C	D	E	F	G	H	I	J	K	L
Applying the project results in the organization		√		√	√		√					
Obtaining value from the project				√		√		√				

The challenges related to the value of the project were categorized in two subcategories, 'Applying the project results in the organization', and 'Obtaining value from the project'. In Table 6 it is shown in which cases these challenges occurred, and it seems that challenges related to the value of the project are prevalent in five out of twelve cases.

The challenges related to ‘Applying the project results in the organization’ were caused by difficulties in implementing project results throughout the entire customer organization. In case D it was discussed that it can be challenging to persuade authorities to approve the implementation of project results. When the further implementation of project results is approved another challenge can arise. In case E it was discussed that it can be challenging to formulate business rules when using project results to make forecasts. This is necessary in order to enable the customer organization to initiate various procedures based on forecast results. It can also be challenging when project outcomes are different than the customer organization had hoped, as was prevalent in case F.

The challenges related to ‘Obtaining value from the project’ were caused by uncertainties in the customer organization on what the possibilities of the project were, and uncertainty what the Return of Investment would be. In case H it was argued that it is very difficult to quantify when the project was deemed a success. Since this project entailed a marketing implementation of BDA, it took a while before the results of the project could be seen. In case F it was discussed that it is also difficult for the customer organization to understand the value of the BDA project when the results are different than expected.

The challenges related to ‘Value of the Project’, were less prevalent than was expected. In the literature study more challenges were found that were related to the value of the project. The challenges that were not present during the interviews were related to lack of knowledge on how to gain value from analytics.

4.3; Resources and Costs

Table 7; The subcategories related to the resources and costs displayed per case.

Subcategory	**Cases**											
	A	B	C	D	E	F	G	H	I	J	K	L
Dealing with unexpected costs										√	√	√
Determining costs and benefits of the project	√		√	√	√	√		√	√		√	√
Internal and External resource allocation	√									√		√
Making funds available		√		√	√			√	√	√	√	√
Obtaining sufficient knowledge and resources			√		√	√			√	√	√	√

The challenges related to resources and costs were grouped in six different subcategories, namely; 'Dealing with unexpected costs', 'Determining costs and benefits of the project', 'Internal and External resource allocation', 'Making funds available', and 'Obtaining sufficient knowledge and resources'. In Table 7 it is shown that challenges related to resources and costs occurred in eleven out of twelve cases.

The challenges related to dealing with unexpected costs were all related to dealing with a set project budget. In case K it was discussed that it is difficult to recover these unexpected costs from the customer organization when dealing with a set budget. In case I the occurrence of unexpected costs would require the consultancy company to make cuts in other essential processes, even though this posed added risks to the project. In case J it was discussed that when unexpected costs arise it is possible that a change request needs to be made. In doing so, it is challenging to explain to the customer organization why an additional investment is needed.

The challenges related to 'Determining costs and benefits of the project' are partly caused by difficulty in assessing what the costs and benefits of the project are exactly. Regarding the costs of the project, it can be difficult to make an accurate estimation. In case D argued that it can be difficult to establish a cost since certain factors are unknown prior to the project. For instance, prior to the project it was unknown what the data quality was, or how long it will take to prepare the data. This in turn makes it is difficult to determine how long the project will last. It is thus possible to make an estimation of the costs, but unexpected costs are likely to occur. In case I it is discussed that for lengthy project it might become necessary to increase the hour-rate that is initially agreed upon, which also poses a challenge. In case K it was discussed that companies are more willing to make additional investments when the project investments were high, and switching is no longer considered an option. Regarding the benefits of the project, in case F it was argued that it is difficult to estimate the benefits of the project, since the benefits are based solely on assumptions. Even though these assumptions are tested throughout the project, it is difficult to manage these benefits.

The challenges related to 'Internal and External resource allocation' differ for both internal and external resources. The challenges related to internal resource allocation were caused due to difficulties in making teams available for the project. In case J it was discussed that there was a standard team present in the organization that installs the software in customer organizations. When this team is unavailable that can cause the installation of software to be more time-intensive. Another challenge related to internal resource allocation is discussed in case J. In case J it is discussed that the customer organization's budget restrains how much internal resources can be allocated to the customer organization. The challenges related to external resource allocation were caused by data generation challenges, or the delivery of incomplete data from external parties. In case L the project relied upon data generated from ship sensors. When these sensors were defective, data could not be generated. In case A it is discussed that it can be challenging to communicate to the customer organization

which additional data is necessary for the project. Since certain data can be quite technical it can be difficult for the consultant to clarify to the customer what data is needed and why.

Challenges related to ‘Making funds available for the project’ occur during the project due to restrictions from the budget. In case E it was discussed that budgets are appointed on a yearly basis in the customer organization, which left no room for creative opportunities to make funds available. In case F it was argued that it is also challenging to make funds available when the benefits of the project are hard to estimate. And in cases D, I, and L it was discussed that it is challenging for customer organizations to obtain sufficient funds available when the scope of the project grows. In case I it is argued that a failure of customer organizations to make funds available to implement the project throughout the entire organization can cause various processes to perform inefficiently. This can in turn leads to business lines operating independently, and look for different solutions thus hampering the integration of the project.

The challenges grouped as ‘Obtaining sufficient knowledge and resources’ partly consist of obtaining usable data in a timely manner. In cases I and L it proved difficult to obtain data in the correct form, where the customer organization needed to be educated in how to send data correctly. In cases F, and J the challenges faced when attempting to obtain sufficient knowledge and resources are also caused due to difficulty in making people available in the organization, or finding expertise in the market place. In case F it was argued that the there is a great shortage in the market place for people that have both business and statistical knowledge. In case E and K it is discussed that it is difficult to obtaining the necessary resources can be difficult when unexpected requirements arise in the customer organization. In case E the new customer requirements necessitated a new data collection method to be implemented, which was difficult to realize due to customer budget restraints. In case J it is argued that it can be challenging for the consultancy company to obtain resources at the beginning of the project. In this case it was necessary for the consultancy company to make a large upfront investment in order to get the project started.

Ultimately the challenges found during the interviews were in line with expectations. The challenges discussed during the interviews were closely related to the challenges discussed in the literature study.

4.4; Contract

Table 8; The subcategories related to the contract described for each case.

Subcategory	**Cases**											
	A	B	C	D	E	F	G	H	I	J	K	L
Constructing a Service			√				√			√	√	

Agreement												
Data/Intellectual Property							√					
Monitoring the Contract		√							√			

The challenges related to the contract were categorized using three subcategories, namely; 'Constructing a Service Agreement', 'Data/Intellectual Property', and 'Monitoring the Contract'. In Table 8 it is shown that challenges related to the contract were prevalent in five out of twelve cases.

The challenges related to 'Constructing a Service Agreement' had diverse causes. For instance it could be challenging to construct a service agreement when working with governmental contracts. In case K it was discussed that these governmental contracts can be very unfavorable for a market party. In case C it was difficult to describe concrete deliverables, which was solved by working with a commitment obligation instead of a result obligation. And lastly, the construction of a service agreement could be time consuming, as was the case during case J.

Challenges that were related to 'Data/Intellectual Property' were present only when working with a governmental customer, since it is not allowed for governmental entities to be in possession of data belonging to another governmental entity. In case G this made it fairly time consuming to obtain the required datasets.

Challenges related to 'Monitoring the Contract' were partly caused by a lack of technical knowledge in the customer organization making it difficult to understand whether the consultant honored contractual agreements. In case I it was argued that this could cause an imbalance in communication, which leads to pointless discussions since the recipient does not understand what activities are being done. In case D it was found to be challenging to concretely articulate what should be delivered during the project. When this is not done properly it can become difficult to assess whether the delivered product is up to par.

It appears that the challenges related to the Contract were less prevalent than was initially expected. During the literature study more challenges were present related to the contract. The challenges that were not discussed during the interviews were related to the construction of an enforceable contract, and providing contractual incentives.

4.5; Governance and Compliance

Table 9; The challenges related to governance and compliance described for each case.

Subcategories	**Cases**											
	A	B	C	D	E	F	G	H	I	J	K	L

Composing Performance Indicators	*Performance*			√					√	√	
Governing IT activities		√		√		√					√

The governance and compliance challenges were divided into two subcategories, namely; 'Composing Performance Indicators', and 'Governing IT activities'. In Table 9 it is shown that governance and compliance challenges were present in six out of twelve cases.

The challenges related to 'Composing Performance Indicators' were challenges that arose during the construction of a performance model. A challenge that occurs prior to construction of a performance model is obtaining clear customer requirements of the project. In case I it is argued that difficulties arise when something is built based on incomplete customer requirements. In this case the customer organization expects various changes to be made which were not specified in the original requirements, which can lead to discussions. Challenges related to composing performance indicators also arose when determining in what timeframe these performance indicators should be improved upon. In case J for instance argued that it is not difficult to construct performance indicators. It is, however, difficult to specify in what timeframe these indicators should be acted upon, since it is unknown what the occupancy of the project teams is at the moment that performance needs to be improved.

Challenges related to 'Governing IT activities' were partly related to the scope of the project. In case K it was argued that for large projects it can become difficult to remain in control of the project goal, since the customer organization can expect extra functionalities that were not previously discussed. In this case it was also argued that it becomes difficult to monitor what is being done in a large scale project. Keeping track of all the activities performed during the project can cause managers to lose control of the overall project, whilst also costing a lot of time and energy. When giving to much control to the project team, however, there is a risk of mistakes being made, that can also be time consuming to fix. Challenges related to governing IT activities were also related to third parties. In case F for instance it was discussed that it can be difficult, and time consuming to govern the IT activities performed by external parties. In case F it was also discussed that it was difficult to convey the context of the project to third parties, especially when contact persons switch frequently within the third party organization. When the context of the project is misunderstood it can lead to a lot of questions arising, and the delivery of incomplete documents or feedback. Another issue that can occur when governing IT activities is related to planning IT activities. In case B it is argued that IT activities are usually performed well, however, it is difficult to state when these activities will be performed. In case D it was discussed that it can be challenging to frequently discuss with the customer organization about the IT activities that are being

performed. This was quite important in order to make project results more satisfactory for the customer organization.

Overall, these challenges were in line with initial expectations, since the challenges found were closely related to the challenges found during the literature study.

4.6; Management during the project

Table 10; The challenges related to management during the project described for each case.

Subcategories	**Cases**											
	A	B	C	D	E	F	G	H	I	J	K	L
Cooperation with the customer organization		√									√	
Customer satisfaction				√								√
Dealing with changing customer requirements	√				√	√			√		√	
Employee turnover during the project	√								√			√
Integrating third parties			√			√			√		√	√
Managing consultant activities	√			√	√				√	√	√	√

The challenges related to management during the project were divided into six subcategories, namely; 'Cooperation with the customer organization', 'Customer satisfaction', 'Dealing with changing customer requirements', 'Employee turnover during the project', 'Integrating third parties', and 'Managing consultant activities'. Challenges related to management during the project occurred during eleven out of twelve cases (Table 10).

Challenges grouped as 'Cooperation with the customer organization' were caused by issues in the relationship between customer and consultant. In case B these challenges were present since collaboration with the customer meant that various novel activities needed to be performed in collaboration with other suppliers. In this case there was a necessity to collaborate with a robot supplier about different types of hardware, which is an activity the consultancy company was not used to. Another challenge that can occur when cooperating with the customer organization, is a lack of customer commitment to the project. In case K for instance, the customer retained a customer/supplier relationship in which all responsibility was given to the consultancy company. In

doing so, it became difficult for the consultancy company to persuade the customer organization to take responsibility for various activities.

Challenges in the subcategory ‘Customer satisfaction’ were related to customer expectations. In cases D, and L it was discussed that it can be difficult to manage customer expectations, since customers often have expectations for BDA projects will provide them with various renewing insights. When the results are less renewing than expected it is possible that customers are underwhelmed with the results. In case L this caused some disappointment from the customer organization, which in turn caused them to doubt the overall value of the project.

Challenges related to ‘Dealing with changing customer requirements’ can have various causes. In case E it was discussed that these challenges can occur during the transition period, where unexpected issues can come to light that also have to be addressed during the course of the project. In case K it is argued that as project progresses the scope of the project can increase, which can in turn trigger a change in customer requirements. As the project progresses it is also possible that the customer organization gains increased understand of the potential value of the project, which in turn can cause the customer request to alter as happened in case F. It is possible that challenges arise due to the customer disregarded the advice given by the consultant. This happened in case C where the consultant suggested the installation of an ERP system, which was initially denied. During the project, however, a sudden necessity for the ERP system arose, which stalled the project. And lastly, in case I it was discussed that customer requirement changes can also occur due to executive changes in the customer organization. In this case there were four executive changes during the project, which caused various changes in customer requirements as well as uncertainty whether the project would continue.

Challenges caused by ‘Employee turnover during the project’ were related with employee switches in either the project team or executive changes in the customer organization. In both cases I, and L this employee turnover caused the project do be delayed. In case A it was also argued that availability issues due to holidays can also lead to project delays, which creates a necessity to take holidays into account prior to the project.

Various challenges can arise when ‘Integrating third parties’. In case F it was challenging to manage the activities of third parties, since the consultant did not have direct communication with these parties. It could also be challenging to cooperate with third parties. In case K for instance it was challenging to cooperate with third parties due to their lack of knowledge from. The lacking knowledge possessed by the parties expressed itself in an inability to understanding the underlying thought behind certain activities during the project. In case K it was also discussed that it could be difficult for third organizations to change processes when requested to. This often caused resistance from the third party organization.

The challenges related to ‘managing consultant activities’ consisted of challenges that arose due to the customer’s method in managing the activities performed by the consultant. In cases E, I, K, and L it was

difficult for the customer organization to manage consultant activities due to a lack of knowledge. In case J the customer organization had difficulty managing the consultant due to a lack of interest in doing so. During this case the customer organization was solely interested in the project results, without being interested in the process. In both cases A, and D there were challenges caused by customer organizations possessing high knowledge. In case A this was challenging because the customer organization was fairly skeptical of the capabilities that the consultancy company claimed possible. In this case it was necessary for the consultant to prove that certain capabilities were indeed possible. In case D the high knowledge in the customer organization caused them to tightly manage the collaboration, making it challenging to utilize the knowledge possessed by the consultant.

The challenges discussed during the interview were fairly expected, since a large number of managerial challenges was also present during the literature study. Most challenges discussed during the interviews were also discussed during the literature study. The only unique challenge category found during the interviews was ‘cooperation with the client organization’.

4.7; Customer Resistance and Trust

Table 11; The challenges related to customer resistance and trust described per case.

Subcategories	**Cases**											
	A	B	C	D	E	F	G	H	I	J	K	L
Customer trust in the project	√			√		√	√		√	√	√	
Internal conflict in the customer organization									√	√		
Differences in corporate culture	√	√						√	√		√	√
Misunderstandings during the project	√	√		√		√		√	√	√		
Resistance against the project		√			√						√	√

The customer resistance and trust challenges were used to create five challenge subcategories, namely; ‘Customer satisfaction’, ‘Customer trust in the project’, ‘Internal conflict in the customer organization’, ‘Differences in corporate culture’, ‘Misunderstandings during the project’, and ‘Resistance against the project’. As can be seen in Table 11, the challenges related to customer resistance and trust were present in eleven out of twelve cases.

The challenges related to ‘Customer trust in the project’ seem to all be related to a lack of understanding about the project itself, or how the project is performing. This lacking understanding can arise due to lacking technical knowledge in the customer organization. Lacking technical knowledge in the customer organization can cause customers to set unrealistic requirements. In case A for instance, challenges arose because the direction of the customer organization was incorrectly informed about the project by the project team. Another cause for low customer understanding is that the customer organization was inadequately informed about the project. This was discussed in case I, where the customer organization doubted the competencies of the consultancy organization because a lack of technical understanding caused them to have unrealistic expectations of the project. Another challenge that can arise is that the customer organization does not trust that the BDA product functions as is promised. In case G for it was discussed that since it was impossible to explain to the customer organization how the product functioned exactly, it was difficult for the customer organization to trust in the BDA project completely.

The challenges related to ‘Internal conflict in the customer organization’ can be caused by diverse priorities set within different departments of the customer organization. In case I for instance, there were often internal discussions in the customer organization about whether the business or IT department should lead which direction the project should go in. These discussions were also about which department could ultimately ‘claim’ the project benefits.

Challenges caused due to ‘Differences in corporate culture’ were could arise due to working with a large customer organization. In cases A, and B working with a large customer organization caused longer waiting periods since often multiple departments needed to be contacted when making certain requests. Another challenge that arose in these cases is that the customer organization has lower knowledge of its own IT systems and needs to bring in external expertise. In case K it was challenging for the consultancy organization to communicate properly with the IT personnel in a technically capable customer organization.

Challenges related to ‘Misunderstandings during the project’ had various different causes. These misunderstandings could arise when customer expectations were inadequately managed. In case D this caused customers to initially be unsatisfied with the results of the project. In this case another evaluation was needed in order to raise customer satisfaction. Misunderstands can also arise when the consultancy organization deems certain activities to be necessary whilst the customer organization disagrees. In case A for instance the customer organization did not want to install certain systems, which eventually caused various problems to arise. Ultimately the systems were placed, however, if the systems were placed initially a lot of time would have been saved. Lastly, challenges can be caused due to different perceptions of the data quality. In case F this caused the customer organization had certain expectations of the project, which the data turned out to be unfit for causing customer disappointment.

The challenges related to ‘Resistance against the project’ were caused due to unfamiliarity with the project. In case L for instance, it was especially difficult for the senior employees to accept that an outside company could help them improve the activities that have been performed for dozens of years. In case E it was difficult for the customer organization to get used to the consultancy company since the customer organization previously collaborated with a different consultant.

The challenges related to customer resistance and trust were fairly expected. Most of the challenges mentioned during the interviews were also present during the literature study. The only unique challenge subcategory present during the interviews was ‘Internal conflict in the customer organization’.

4.8; Relationships between Challenge Categories

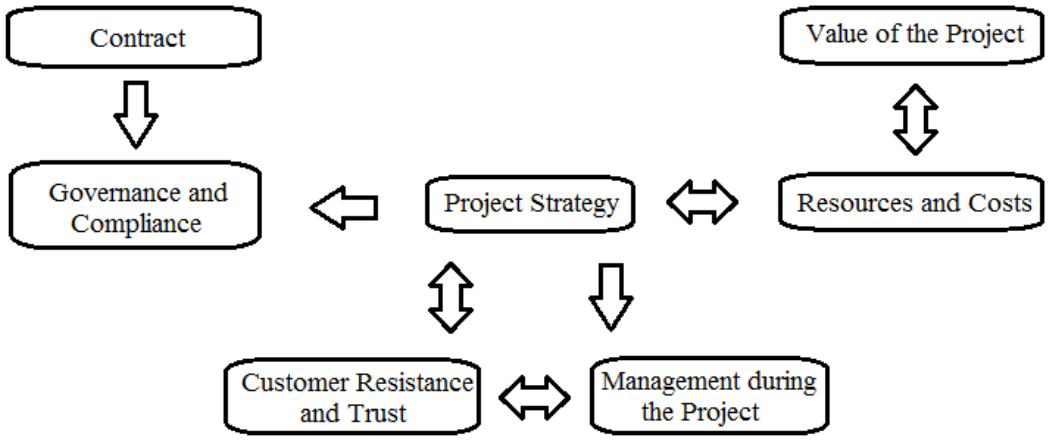

Figure 2; The relationships between the challenge categories found during the interviews.

During the interviews it appears that the challenges mentioned in each category are influenced by one another to some extent. The relationship between challenge categories is displayed in Figure 2. It appears that ‘Project Strategy’ seems to be related to various other challenge categories, namely ‘Customer Resistance and Trust’, ‘Governance and Compliance’, ‘Management during the project’, and ‘Resources and Costs’. The relationship between ‘Project Strategy’, and ‘Customer Resistance and Trust’ is evident since certain customer resistance and trust issues arise due to unrealistic expectations set by the customer organization. These expectations can cause the customer organization to resist the strategy that is determined during the project. Also, if the customer organization distrust could create a necessity for certain strategical changes to be made in the project. The relationship between ‘Project Strategy’, and ‘Governance and Compliance’ is indicated due to the fact that governance, and compliance challenges could arise due to the scope of the project. The scope that was chosen during the strategy determination can thus amount to certain governance and compliance issues. This relationship is also present since certain governance and compliance issues arise when the customer

requirements set at the start of the project are unclear, making it difficult to create a clear strategy which is in turn difficult to govern. 'Project Strategy' is related to 'Management during the project' since certain management challenges are caused by changing customer requirements during the project. These changing customer requirements can potentially necessitate changes to be made to the initial project strategy. The 'Project Strategy' category is linked to 'Resources and Costs' since unprecedented changes to the project strategy can cause various unexpected costs to arise during the project. Also, challenges concerning the available budget can cause restrictions to arise regarding the project strategy.

'Customer Resistance and Trust' is linked to 'Management during the Project' due to the fact that various challenges regarding customer resistance and trust challenges can be caused by customers being incorrectly informed about the project. This relationship is also indicated since customer resistance and trust issues can arise due to customers having unrealistic expectations of the project. This indicates that informing the customer about the project, and customer expectations should be well managed by the consultancy company, in order to avert certain customer resistance and trust issues. The 'Governance and Compliance' and 'Contract' challenge categories are related since lack of customer technological capabilities can make it difficult for the customer to govern whether the consultant is honoring contractual obligations. The relationship between 'Resources and Costs' and Value of the Project' was present since uncertainties in Return of Investment of the project can hamper the customer organizations from further investing in the project, which can stand in the way of achieving value from the project.

4.9; Comparing the Literature Study to the Interviews

Table 12; The amount of challenges categories and subcategories discussed in both literature study and interviews.

	Percentage of literature study articles	**Percentage of interview challenges**
Strategical Management		
Project Strategy	12%	27%
Composing a team	2%	5%
Determining Responsibilities	1%	6%
Determining the Project Goal	3%	4%
Project Continuity	0%	2%
Software development method	0%	2%

Strategy Determination	6%	9%
Value of the Project	21%	5%
Applying the project results in the organization	9%	3%
Obtaining value from the project	13%	2%
Tactical Management		
Resources and Costs	34%	22%
Dealing with unexpected costs	12%	3%
Determining costs and benefits	10%	5%
Internal and External resource allocation	3%	4%
Making funds available	4%	3%
Obtaining sufficient knowledge and resources	6%	7%
Contract	19%	5%
Constructing a Service Agreement	1%	2%
Contract Enforceability	9%	0%
Contractual Motivation	1%	0%
Data/Intellectual Property	7%	1%
Monitoring the Contract	2%	2%
Governance and Compliance	12%	8%
Composing Performance Indicators	6%	2%
Governing IT activities	6%	5%
Operational Management		
Management during the project	16%	15%
Cooperation with the client organization	0%	2%
Customer satisfaction	3%	2%
Dealing with changing customer requirements	3%	4%
Employee turnover during the project	1%	2%
Integrating third parties	2%	4%
Managing consultant activities	2%	3%

Managing project activities	5%	0%
Customer Resistance and Trust	27%	18%
Internal conflict in the customer organization	0%	2%
Misunderstandings during the project	3%	5%
Differences in corporate culture	4%	4%
Customer trust in the project	14%	5%
Resistance against the project	7%	3%

Note: In this table an overview is given of the percentage of articles in the literature study compared to the percentage of challenges discussed during the interviews.

During this study it became apparent that various challenges discussed during the literature study were also present during the interviews. It did appear, however, that certain challenges discussed during the literature study differed from challenges discussed during the interviews. In Table 12 an overview is given of the amount of challenges per category discussed during the literature study and interviews. Overall, various challenges found in literature were also present during the interviews. It appeared that the difference between literature study and interview outcomes is mostly apparent in the 'Project Strategy', 'Value of the Project', 'Contract', and 'Customer Resistance and Trust' categories.

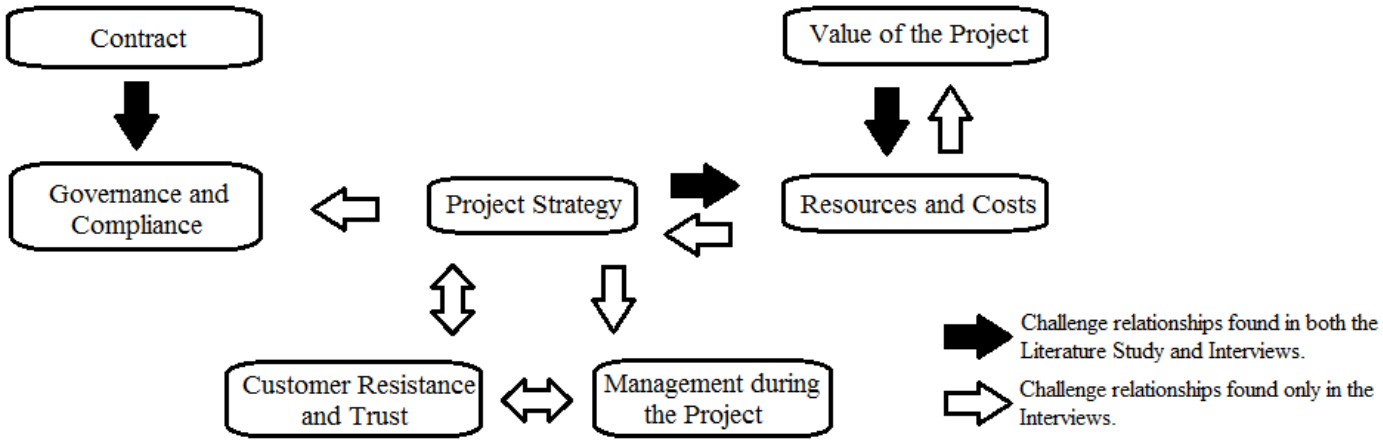

Figure 3; The relationships between challenges categories for both literature study and interviews.

The relationships found between challenge categories were found to differ greatly for the literature study, and interviews (Figure 3). During the interviews it appeared that challenge categories were more related to one another than was apparent during the literature study. The most striking difference between the interview and the literature study outcomes is apparent in the relationship between 'Project Strategy' challenges and other challenge categories. In literature study it seems that challenges related to project strategy solely influence

resource, and costs challenges. No other relationships are apparent regarding the project strategy. The influence of ‘Resources and Costs’ on ‘Project Strategy’ was not present in the literature study. During the literature study it was solely found that the strategy pursued during the project influenced certain resources and costs challenges. During the literature study it was not found that resource and cost challenges could place constraints on the project strategy. The relationship between ‘Customer Resistance and Trust’ and ‘Project Strategy’ was also not present during the literature study. During the literature study various customer resistance and trust challenges were found, however, it was not discussed how these challenges can possibly be prevented by establishing an adequate project strategy. In the literature study it was also not discussed how the occurrence of customer resistance and trust issues can create a necessity to alter the project strategy. The influence of ‘Project Strategy’ on ‘Governance and Compliance’ was not found during the literature study. During the interviews it became apparent that this influence is present when the project scope is unclearly formulated. Defining a clear project scope was found to be challenging in the literature study. Challenges related to the project scope, however, were not connected to other challenges occurring in other challenge categories. The influence of ‘Project Strategy’ on ‘Managing the project’ was not present during the literature study. During the interviews this influence was found to be caused by changing customer requirements. In the literature study, changing customer requirements were perceived as a project management challenge. It was, however, not established during the literature study that changing customer requirements can cause challenges to arise in other challenge categories as well.

Aside from the ‘Project Strategy’ challenge category, various other relationships between challenge categories were found during the interviews. Several of these relationships were not present during the literature study. The relationship between ‘Customer Resistance and Trust’, and ‘Managing the Project’ was not present during the literature study. During the interviews it became apparent that unrealistic customer expectations could cause project management challenges. During the literature study unrealistic customer expectations were considered to be a challenging resistance and trust issue. The project management implications of unrealistic customer expectations were not discussed in the literature study. Also, during the literature study it was not mentioned how managing customer expectations can potentially prevent certain resistance and trust issues. The influence of ‘Resources and Costs’ on ‘Value of the Project’ was also not found in the literature study. The literature study indicating that uncertainty of the project benefits can make it difficult to determine the necessary resources and costs. In the literature study it was not determined that this can in turn cause restrictions to be made to the project budget, thus making it difficult to realize the full potential of the project.

5; Discussion

In the following sections the results will be discussed in detail. In the conclusion section it is shown how this study can be used to answer the research questions. In the findings section the results found during this study will be discussed in greater detail. The challenge implications will be drawn, and the relationship between challenges is discussed. In the theoretical and practical implementation section recommendations are made to both theory and practice in order to answer the final research question. This section is concluded with a limitations and future research section where various limitations to this study are discussed, as well as opportunities for future research.

5.1; Conclusion

During this study a literature study was performed in order to gain some insights into what challenges potentially occur during BDA outsourcing. The results to this literature study are shown in Appendix B. During this literature study various challenge categories became apparent, namely; Project Strategy, Value of the Project, Resources and Costs, Contract, Governance and Compliance, Management during the Project, and Customer Resistance and Trust. In doing so it became possible to answer the first sub question; '*What challenges related to BDA, BI, and IT outsourcing are described in literature?'*.

The managerial and organizational challenges found during this literature study were then validated by conducting interviews. During the interviews it was established whether the challenges found in literature were indeed present during BDA projects meant to increase BI. The results to the interviews can be found in Appendix D. During this study multiple managerial and organizational challenges were found to be present during various BDA outsourcing projects meant. These challenges could be grouped in the following categories; Project Strategy, Value of the Project, Resources and Costs, Contract, Governance and Compliance, Management during the Project, and Customer Resistance and Trust. The challenges related to 'Project Strategy' had a variety of causes, namely 'Composing a team', 'Determining Responsibilities', 'Determining the Project Goal', 'Software development method', 'Strategy Determination', and 'Project Continuity'. Challenges regarding the 'Value of the project' were 'Applying the project results in the organization', and 'Obtaining value from the project'. The challenges that were related to 'Resources and Costs' were influenced by 'Dealing with unexpected costs', 'Determining costs and benefits of the project', 'Internal and External resource allocation', 'Making funds available', and 'Obtaining sufficient knowledge and resources'. Challenges related to the 'Contract' were related to 'Constructing a Service Agreement', 'Data/Intellectual Property', and 'Monitoring the Contract'. The challenges regarding 'Governance and Compliance' were present when 'Composing Performance Indicators', and when 'Governing IT activities'. The challenges related to 'Management during the project' involved 'Cooperation with the customer organization', 'Customer

satisfaction', 'Dealing with changing customer requirements', 'Employee turnover during the project', 'Integrating third parties', and 'Managing consultant activities'. And lastly, the challenges related to 'Customer Resistance and Trust' were influenced by issues regarding 'Customer satisfaction', 'Customer trust in the project', 'Internal conflict in the customer organization', 'Differences in corporate culture', 'Misunderstandings during the project', and 'Resistance against the project'. The results of the interviews could then be used in order to answer the second research question, namely *'What Management and Organizational challenges occur during BDA outsourcing projects meant to improve BI performed by Dutch Big Data consultancy companies?'*.

Relationships between challenges were modeled in order to establish how various BDA challenges influence one another. By gaining understanding of how BDA challenges influence one another it becomes possible to grant advice on how BDA challenges are best handled. In doing so, it becomes possible to answer the third sub question of this study; *'How can customers and consultants handle BDA outsourcing challenges more efficiently?'*. During the following sections the results of the literature study and interviews will be discussed in more detail, and solutions will be offered to various challenge categories found during this study, in order to answer the main research question pursued during this study; '*How could Dutch Big Data consultants, and customers better handle the challenges related to BDA, BI Systems, and IT outsourcing occurring during BDA outsourcing projects meant to improve BI systems?*'.

5.2; Findings

Overall, it appears that the challenges related to 'Project Strategy', 'Resources and Costs', 'Management during the Project', and 'Customer Resistance and Trust' were most prominently present during the current research. Nearly all the cases were confronted with challenges from each of these categories. The challenges related to 'Value of the Project', 'Contract', and 'Governance and Compliance' were less prevalent. For challenges related to the 'Contract', it was unexpected that only few challenges were present, since the literature study indicated otherwise.

The challenges found during the project were also related to one another, as was displayed in Figure 1. It appeared that various challenges categories were connected to 'Project Strategy' to a certain degree, namely 'Customer Resistance and Trust', 'Governance and Compliance', 'Management during the Project', and 'Resources and Costs'. It appeared that less challenges occurred for categories unconnected to the project strategy, namely 'Contract' and 'Value of the Project'. This indicates that challenges related to project strategy influence the occurrence of challenges in other categories. Challenges belonging in the 'Resources and Costs', and 'Customer Resistance and Trust' categories also appear to influence the project strategy. It appears that the project strategy potentially needs to be revised when customer trust or resources are lacking. It also appeared that challenges related to 'Management during the Project' influenced challenges related to 'Customer

Resistance and Trust'. This relationship was present since customer expectations and knowledge influenced customer resistance and trust challenges apparent in the project. Both customer expectations and knowledge can be managed to a certain extent, thus indicating the importance of expectation and knowledge management in preventing various challenges related to customer resistance and trust. Challenges belonging to both the 'Resources and Costs' and 'Value of the Project' categories also influenced one another. This was present in the fact that an unclear Return of Investments made it difficult for the customer organization to invest in the project. This could in turn make it more challenging to gain value from the project. Certain 'Contract' challenges also influenced 'Governance and Compliance' challenges, since difficulty in monitoring contractual obligations can cause difficulty in governing compliance to these obligations.

During this study the causes for various challenges were also discussed. Most challenges had diverse causes, however, there were certain factors that caused challenges to arise in multiple categories. These factors consist of; 'Availability of specialized personnel', 'Customer Knowledge/Experience', 'Unclear project goal or customer requirements', 'Unclear Return of Investment of the project', 'The scope of the project'. The availability of specialized personnel was the cause of certain challenges related to 'Management during the Project', 'Project Strategy', and 'Resources and Costs'. The customer knowledge and experience seemed to influence various challenge categories, namely 'Contract', 'Customer Resistance and Trust', 'Management during the Project', and 'Project Strategy'. Contrary to expectations it was found that both low and high customer knowledge and experience were at the heart of various challenges. This highlights the diverse influence of customer knowledge and experience has on the occurrence of various BDA outsourcing challenges. Unclear project goal or customer requirements were the cause of challenges in the 'Contract', 'Governance and Compliance', 'Project Strategy', and 'Management during the Project'. Unclear Return of Investment of the project caused challenges to arise in the 'Resources and costs', and 'Value of the project' categories. Lastly, challenge categories influenced by the scope of the project were 'Governance and Compliance', 'Management during the project', 'Project Strategy', and 'Resources and costs'. It appears that out of these influencing factors, 'Customer Knowledge/Experience', 'Unclear project goal or customer requirements', and 'The scope of the project' can be addressed when formulating a project strategy. This highlights the importance of establishing a complete project strategy in order to prevent various challenges from occurring.

5.3; Theoretical Implications

This study offers various theoretical implementations. When looking at Table 12 for instance, an overview is given of the amount of challenges per category discussed during the literature study and interviews. It appears that most challenges found in literature were also present during the interviews. In certain challenge categories,

however, there were differences between literature study and interview outcomes. These challenge categories consisted of ‘Project Strategy’, ‘Value of the Project’, and ‘Contract’ categories.

During the literature study fewer challenges were discussed regarding the ‘Project Strategy’. The only strategical challenges that arose during the literature study were related to team composition (Coleman et al, 2016; O’Donnell, Sipsma, & Watt, 2012), the determination of responsibilities (Anagnostopoulos, Zeadally, & Exposito, 2016), strategy (Goldberg et al, 2017; Hoerl et al, 2014; O’Donnell, Sipsma, & Watt, 2012; Vidgen, Shaw, & Grant, 2017), and the project goal (Meleanca, 2013; Vidgen, Shaw, & Grant, 2017). In the interviews additional ‘Project Strategy’ challenges were found, namely challenges regarding project continuity, and software development methods. This indicates that additional research is needed in order to address the continuity aspect in BDA outsourcing projects. Since during multiple cases it was discussed that an analytical project is never truly finished, it is important to establish whether the prosperity of BDA outsourcing is increased when continuity is taken into account during strategy determination. The challenges related to software development methods were apparent due to customer organizations potentially possessing less knowledge of the different approaches.

During the literature study more challenges were discussed regarding ‘Value of the Project’. In the literature study it was discussed that these challenges occur due to lack of knowledge (Aalst, Zhao, & Wang, 2015; Baesens et al, 2016; Duan, & Xu, 2012; Heindrich, Trendowicz & Ebert, 2016; O’Donnell, Sipsma, & Watt, 2012; Sivarajah et al, 2017; Vidgen, Shaw, & Grant, 2017; Wang et al, 2016; Xu et al, 2007; Zhou et al, 2014; Zeng, Li, & Duan, 2012; Zimmerman, 2006), determining the relevance of results (Jorge et al, 2016), creating decision making systems able to change business processes (Azvine, Cui, & Nauck, 2005; Lawton, 2006; McNeely et al, 2014; Nielsen, 2016; Tien, 2013; Vidgen, Shaw, & Grant, 2017), creating a holistic BDA model (Kowalczyk, & Buxmann, 2015; Vera-Baquero, Colomo-Palacios, & Molloy, 2016), and granting transparent advice (Kowalczyk, & Buxmann, 2015; Wang et al, 2015). Many of these challenges, however, were not present during the interviews. The challenges related to ‘Value of the Project’ found in during the interviews were related to implementing project results, dealing with unexpected results, an uncertain return on investment, and clarifying the potential of the results to the customer. It is especially worthy to note that challenges related to the value of the project were not influenced by knowledge during the interviews. This can potentially be explained since more knowledge of BDA value creation is available in the consultancy company, thus making up for lacking customer knowledge.

During the literature study multiple challenges were discussed regarding the project contract. It was found that it was difficult to define, measure and enforce performance goals (Christ et al, 2015; Fitoussi, & Gurbaxani, 2012; Goldberg et al, 2017; Handley, & Benton, 2012; Lee, 1996). In the interviews, however, fewer challenges were mentioned regarding the contract. No challenges were found related to the formulation of

an enforceable contract or contractual motivation. The only challenge regarding data and intellectual property were present due to working with a governmental customer. The challenges related to the Contract were potentially less prevalent due to most projects using an Agile approach during the project. When using an Agile approach, deliverables and project progression are discussed biweekly. In various cases the customer organization also had the option of terminating the project at any point, should the project not progress in a desirable manner. This eliminates various challenges related to contract enforceability, and contractual motivation for consultants to deliver good project results.

This study offers implications on how various challenge categories influence one another. This grants information on the importance of certain processes during a BDA outsourcing project. When comparing the literature study to the interviews it became apparent that various relationships between challenge categories that were discussed in the interviews were not apparent in the literature study results. This indicates that more focus should be given to how various challenges correlate to one another. During the interviews it became apparent that the 'Project Strategy' category is important regarding the prevalence of challenges throughout the project. When comparing the literature study results to the interview results it appears that project strategy challenges were far less prevalent during the literature study than during the interviews. This highlights the importance of additional research in strategy determination during BDA outsourcing projects. The importance of project strategy is also discussed by Vidgen, Shaw, & Grant (2017). It is discussed that various challenges that occur during BDA projects can be prevented during the strategy determination phase (Vidgen, Shaw, & Grant, 2017). In Vidgen, Shaw, & Grant (2017) it was, however, not discussed what exact challenges were influenced by strategy determination. An example was made that a clear strategy could overcome resistance to change, however, other influences of project strategy were not named. The outcomes of this study elaborate on Vidgen, Shaw, & Grant (2017) by showing various managerial and organizational challenges that are connected to project strategy. It is also discussed what can be done in order to improve upon various strategical challenges. It was also found between 'Customer Resistance and Trust', and 'Management during the Project' challenge categories influenced each other, which can be present when project understanding or expectation management are lacking during the project. The results of the literatures study showed that there were no studies describing this relationship, thus indicating a need for additional research. Lastly, a relationship was found between 'Resources and Costs' and 'Value of the Project' due to an unclear Return of Investments. During the literature study the influence of 'Value of the project' on 'Resources and costs' was described by Kivijärvi (2015). Kivijärvi (2015), however, solely described the difficulty in measuring project value. It was not discussed how uncertainty of the project benefits can cause companies to be hesitant in investing in the project, hampering the value of the project. Additional research can focus on how unclear project benefits influences investments made in the project.

In literature negative aspects of IT outsourcing are often highlighted, since a large portion of IT outsourcing projects are terminated (Qi, & Chau, 2012; Whitten, Leidner, 2006). For BDA outsourcing research is rather limited. The research that is present often puts focus on the negative aspects of BDA outsourcing, without discussing how BDA outsourcing can be improved. For instance, Sanders (2016) is quite negative of BDA outsourcing as an implementation strategy and discusses various risks associated with BDA consultancy. Sanders (2016) states that BDA outsourcing is associated with various risks, which are found to be influenced by the project scope, and project criticality. The outcomes of Sanders (2016) concerning BDA outsourcing seem rather limited related to the outcomes of this current study. This study also found project scope to be an important factor in the occurrence of certain BDA outsourcing challenges. During this study, however, project criticality was not found to cause BDA outsourcing challenges. Aside from these two factors the results of this study show a large amount of managerial and organizational challenges to be present during BDA outsourcing. This study shows that these challenges are heavily influenced by project strategy. Sanders (2016) also does not offer recommendations on how to mitigate BDA outsourcing risk. In Sanders (2016) it is simply shown that customers should be mindful of the project scope and criticality when deciding to outsource BDA, as opposed to implementing BDA in-house. The current study, however, offers various recommendations to both customer organizations and consultancy companies in making BDA outsourcing more efficient. By being mindful of the various challenges that can occur, and the relationships between challenges can prevent various challenges from occurring. Both IT and BDA outsourcing are growing trends (Qi, & Chau, 2012; Gantz, & Reisel, 2011). Thus, authors should not solely focus on the negative aspects of BDA outsourcing, but strive to improve the efficiency of BDA outsourcing as an implementation strategy.

5.4; Practical Implications

The outcomes of this study have multiple practical implementations. First of all, the challenges found during this study can grant both consultancy and customer organizations clarity on various managerial and organizational challenges that occur during BDA outsourcing meant to improve BI. These challenges are related to ‘Project Strategy’, ‘Value of the Project’, ‘Resources and Costs’, ‘Contract’, ‘Governance and Compliance’, ‘Management during the Project’, and ‘Customer Resistance and Trust’. Knowledge of the various challenges that can occur during BDA outsourcing is an important step in helping both consultants and customer organizations deal with these challenges. In order to improve the efficiency with which BDA outsourcing is conducted it is advised for both consultants and customer organizations to be informed of the potential challenges that can arise. Awareness of the challenges that can occur during BDA outsourcing can also aid customer organizations in deciding whether to outsource BDA implementation or to develop BDA solutions in-house.

Another practical contribution of this study is the knowledge of how various challenge categories interact with one another. During this study it became apparent that various challenges in the 'Project Strategy' are related to various other challenges that can arise during the project. The determination and implementation of a clear project strategy could, thus be detrimental in order for BDA implementation to proceed smoothly. Challenges related to the 'Value of the project' were also influence by challenges related to 'Resources and Costs'. It is thus important for customers to know that during BDA outsourcing there can also be a high degree of uncertainty of the costs and benefits of the project. This could also make it unclear what steps should be taken in order to gain value from the project. When both consultant and customer organizations are aware of these challenges it can be opted to first conduct a pilot project, during which it is attempted to gain clarity on the value of BDA outsourcing. It also became apparent that challenges related to 'Customer Resistance and Trust', and challenges related to 'Management during the project' are connected to one another. Challenges related to customer resistance and trust arise due to lacking customer understanding of the project, or unrealistic customer expectations. This could potentially make it difficult to manage the project, as the customer can resist various project activities. When the consultancy company is aware of these challenges it is possible for the consultant to emphasize customer expectation management, in order to minimize unrealistic customer expectations. It is also possible for the consultant company to increase customer understanding by either training employees, sending consultants over to the customer organization or getting the customer in touch with a third party. By increasing customer understanding of the project and the technology it is possible to prevent various trust issues from arising.

The outcomes of this research also show that there are various challenges present regarding BDA outsourcing meant to improve BI. Various factors were identified that influenced these challenges, namely 'Availability of specialized personnel', 'Customer Knowledge or Experience', 'Unclear project goal or customer requirements', 'Unclear Return of Investment of the project', 'The scope of the project'. During various projects there can be a shortage of specialized personnel in both customer or consultancy company. When the customer organization lacks specialized skill, it could be opted to send a consultant to the customer organization in order to train customer personnel (Xu et al, 2007). It could also be opted to hire temporary labor force from a third party, however, in this instance companies should be mindful of certain additional challenges potentially arising. Challenges related to 'Customer Knowledge or Experience' can potentially be tackled by involving outside expertise from a third party. By integrating an external party to raise customer knowledge, the customer could potentially gain increased understanding of the project, potentially preventing various challenges. Challenges related to an unclear project goal could potentially be prevented by starting the project in a trial period. During this trial period the project can be performed on a smaller scale, in order for the customer to get accustomed with the new technology. This could potentially help the customer craft more clear customer

requirements as the project continues. Regarding challenges that occur due to unclear Return on Investments, it might be beneficial to conduct a small scale project. During this project it should be aimed to show quick results in order to gain leverage in the customer organization to build further on project results. Challenges related to the scope of the project can also cause various challenges to arise. It could thus be opted to start the project with a smaller scale, in order to limit various managerial and organizational challenges from occurring. Should it not be possible to conduct the project in a smaller scale, various challenges could potentially occur. This could be a reason for customer organizations to opt for in-house implementation of BDA solutions as opposed to BDA outsourcing. In order to prevent the occurrence of various challenges during the project these causes should be addressed during a BDA project.

5.5; Limitations and Future Research

During this study it was attempted to gain clarity on the challenges that occur during BDA outsourcing meant to improve BI. In order to establish BDA outsourcing challenges in a reliable fashion, it was chosen to do so by conducting both a literature study and interviews. During the literature study various challenges were found related to BDA, BI, and IT outsourcing. The results of the literature study were used in order to establish an interview structure, after which interviews were conducted with managers and CEO's of BDA consultancy companies. This approach, however, also caused certain limitations to arise. Since the literature study was used as a guideline for the construction of interview questions, it is possible that the interview structure steered interviewees into discussing various known challenges. This could potentially explain why most challenges found during the interviews were in line with the challenges found during the literature study, and few unique challenges categories were found. For the challenge categories that were discussed various different challenges were found, indicating that the sample size might have been too small to identify all management and organizational challenges that arise during BDA outsourcing. Since the interviews were solely conducting with consultancy companies without regarding customer organizations, it is possible that various challenges were not discussed. This could for instance explain why various contract related challenges were less prevalent during the interviews, since contractual challenges could primarily be challenging for customer organizations. Also the literature study was conducted on a larger scale than the interviews. During the literature study a total of 103 articles was used, whereas for the interviews a total of twelve cases were used. It is quite possible that the difference between the literature study and interviews was exaggerated due to the difference in sample size.

Since only a literature study, and interviews were conducted, various characteristics of the BDA outsourcing challenges found are unclear. For instance, based on this study it is still unclear what the consequences of these challenges are in practice. It is thus unclear what challenges should have priority during BDA outsourcing. It is unclear if the causes for challenges discussed in the interview are indeed the causes for

these challenges. It could very well be possible that various challenge causes are unknown to the interviewees used in this study. This is also the case regarding the relationships between challenges. It is quite possible that various connections between challenge categories are unknown by the interviewees used in this study Despite it being indicated that certain challenge categories influence one another, it is unclear if this is indeed the case. The results of the current study should thus only be used as an indication of the potential relationships that occur between different challenge categories.

This current research can be used as a stepping stone towards gaining more knowledge on the challenges that occur during BDA outsourcing. For future research it would be interesting to expand on the literature study performed in this study. In doing so, it would become clear what other challenge types occur during BDA outsourcing. Additional research on the customer perspective is also needed to expand on the BDA outsourcing challenges found in the current study. During this study various BDA challenges and challenge categories were established. By conducting additional research into specific challenge categories or subcategories, it should be attempted to establish the causes and consequences are of these challenges. It is also important to research the relationships between challenge categories in order to establish what the consequences of these challenge relationships are in practice. In doing so, more clarity can be obtained on the relationship between challenge categories, and the seemingly central role of project strategy in the occurrence of other challenges throughout BDA outsourcing projects. By continuing to strive towards more clarity regarding BDA outsourcing challenges, it is possible to make BDA outsourcing less challenging in the future.

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7; Appendices

7.1; Appendix A

Challenge Categories	Challenge sub-categories	Challenges	Authors
Privacy	Preserving privacy and anonymization of data	Preserving privacy when using big data	Basso et al (2016); Coleman et al (2016); Ishwarappa, & Anaradha (2015); Khan et al (2014); Mantelero (2016); McNeely et al (2014); Rongxing et al (2014); Shuijing (2016); Siddiqa et al (2016); Sivarajah et al (2017); Tien (2013); Vidgen, Shaw, & Grant (2017); Zezula (2015); Zhou et al (2014)
		Preserving privacy when using big data (with highly distributed data)	Zhou et al (2014)
		Preserving privacy during IT outsourcing	Fu, & Cao (2016); Gritzalis et al (2007)
		Adequately anonymization to avoiding privacy attacks (when somebody maliciously tries to bypass data anonymization)	Basso et al (2016); McBride (2014)
		Lack of understanding of requirements of the data protection and privacy legislation (especially for SMEs)	Coleman et al (2016);
		Privacy preserving outsourced storage	Zezula (2015)
Security	Difficulty to keep systems secure, for instance due to outdated systems	Keeping big data secure	Choi, Chan, & Yue (2017); Coleman et al (2016); Hurlburt, & Voas (2014); Kache, & Suring (2017); Kambatle et al (2014); Khan et al (2014); Mantelero (2016); McNeely et al (2014); Richey et al (2016); Rongxing et al (2014); Schroeder (2016); Siddiqa et al (2016); Sivarajah et al (2017); Tien (2013); Vidgen, Shaw, & Grant (2017)
		Staying aware of the data security during	Bachlechner, Thalmann, & Maier (2014)

		complex IT outsourcing	
		Managing data security during (complex) IT outsourcing (in order to avoid information leakage)	Bachlechner, Thalmann, & Maier (2014); Fu, & Cao (2016); Gritzalis et al (2007); Hsu, Chiu, & Hsu (2004); Khidzir, Mohamed, & Arshad (2012); Martinsons (1993); Yang, Luo, & Bigang (2008)
		Restricted control of outsourced IT services makes it difficult to assess whether security and compliance requirements are met	Bachlechner, Thalmann, & Maier (2014)
		Dealing with sophisticated BI security issues, due to its strategic importance for higher management of businesses	Al-Aqrabi et al (2013); O'Donnell, Sipsma, & Watt (2012)
		Avoiding data leakage	Basso et al (2016)
		Higher security risk due to outdated systems (especially for SMEs)	Coleman et al (2016); McNeely et al (2014); Wang et al (2016)
	Difficulty implementing technical controls in order to identify misanalysis or misuse of data	Implementing technical controls at various stages of the BI process in order to create a secure architecture	Al-Aqrabi et al (2013)
		Identifying misanalysis or misuse of big data	Power (2014)
Ethics	Difficulty dealing with ethical issues, for instance keeping data usage transparent or using sensitive data for predictive analyses	Addressing ethical issues regarding big data	Bradlow et al (2017); McNeely et al (2014); Vidgen, Shaw, & Grant (2017)
		Addressing ethical issues regarding the use of BI data (e.g. keeping data transparent, or not selecting a single version of the truth)	McBride (2014)
		Basing predictive analysis on sensitive categories of data	Shuijing (2016)
Strategy	Difficulty determining	Determining a big data (analytics) strategy	Hoerl et al (2014); Vidgen, Shaw, &

	BDA outsourcing strategy and integrating that strategy into the corporate business strategy		Grant (2017)
		Determining a (long-term) BI strategy	O'Donnell, Sipsma, & Watt (2012)
		Determining a (long-term) IT outsourcing strategy	Goldberg et al (2017)
		Integration of big data analytics into the corporate business strategy	Kache, & Suring (2017); Vidgen, Shaw, & Grant (2017)
		Determining a big data objective	Kache, & Suring (2017)
		Difficulties in modeling and analyzing business objectives and specifications	Zoumpatianos, Palpanas, & Mylopoulos (2013)
	Difficulty in leadership setting clear goals regarding BDA, and determining the scope of BDA projects	Defining the scope of analytics projects	Vidgen, Shaw, & Grant (2017)
		Clear goals set by leadership regarding big data	Vidgen, Shaw, & Grant (2017)
		Analysis paralysis due to increasingly more data sources and technologies becoming accessible	Meleanca (2013)
Decision Making	Difficulty creating decision making systems based on BDA, and using BDA to change business processes	Using big data in decision making and analysis	McNeely et al (2014); Vidgen, Shaw, & Grant (2017)
		Lack of big data decision-support tools	Tien (2013)
		Creating automated decision making systems exploiting the models created from big data analytics	Nielsen (2016)
		Changing business processes based on (real-time) BI results	Azvine, Cui, & Nauck (2005)
		Taking actions based on BI analysis results	Lawton (2006)

		Using big data to advance discovery and innovation	McNeely et al (2014)
	Difficulty in creating a holistic BDA model, in order to base decisions on all available facts	Obtaining a holistic model of relevant aspects, in order to make decisions based on all available facts	Kowalczyk, & Buxmann (2015)
		Inability of current BI systems to be integrated with Process Aware Information Systems to improve decision making	Vera-Baquero, Colomo-Palacios, & Molloy (2016)
	Difficulty for analysts to grant transparent analytical advice in a timely manner, especially during uncertain situations	Difficulty for analysts to be adaptable in order to advise decision makers in uncertain or ambiguous decision situations	Kowalczyk, & Buxmann (2015)
		Transparent BI analytics in order to grant decision makers with sound advice	Kowalczyk, & Buxmann (2015)
		Supporting big data analysts to make quicker decisions	Wang et al (2016)
		Supporting big data managers to make quicker decisions	Wang et al (2016)
Value	Difficulty in obtaining value from BDA, for instance due to lack of knowledge or BDA skills	Using big data and data analytics to obtain real value	Aalst, Zhao, & Wang (2015); Baesens et al (2016); Duan, & Xu (2012); Heindrich, Trendowicz & Ebert (2016); Sivarajah et al (2017); Vidgen, Shaw, & Grant (2017); Zeng, Li, & Duan (2012)
		Lack of company knowledge on how to obtain value from big data	Wang et al (2016)
		Identifying valuable or important data subsets from the original big dataset	Zhou et al (2014); Zeng, Li, & Duan (2012); Zimmermann (2006)
		Lack of company knowledge on how to obtain profits from large amounts of data	Xu et al (2007)
		Using big data to leverage information to gain a stronger market position	Baesens et al (2016)

		Developing even better big data engineering and analytics to manage and leverage big data to deliver business value	Baesens et al (2016)
		Practitioners lack of understanding the best strategies and tools necessary for predictive analytics	O'Donnell, Sipsma, & Watt (2012)
	Difficulty in determining the relevance of BDA project results	Determining the relevance of results of big data projects	Jorge et al (2016)
Customer Understanding	Difficulty to use BDA to increase customer understanding, and provide customers with better service	The analysis of massive amounts of data to return useful results back to consumers	Anagnostopoulos, Zeadally, & Exposito (2016)
		Measuring customer value impact	Vidgen, Shaw, & Grant (2017)
		Using big data to know its customers better	Baesens et al (2016)
		Getting a complete view on customers due to the unstructured nature of many relevant Customer Relationship Management data sources	Baars, & Kember (2008); Chung, & Tseng (2012); Subramaniam et al (2009)
		Using big data to identify its most valuable customers and enhance profits through providing these customers with more personalized customer relationships or better customer services	Baesens et al (2016)
		It is difficult to assess the relationship between our real and online identity	Anagnostopoulos, Zeadally, & Exposito (2016)
		Relating rich review expressions to customer ratings to increase customer understanding	Chung, & Tseng (2012)
Real-time	Difficulty obtaining a real-time view of BDA, due to for instance data integration, warehousing,	Real-time view of big data	Jorge et al (2016)

	modeling or analytical issues		
		Real-time view of BI	Azvine, Cui, & Nauck (2005)
		Ensuring data integration in order to achieve real-time BI	Azvine, Cui, & Nauck (2005)
		Enabling efficient data integration to achieve real-time BI	Azvine, Cui, & Nauck (2005)
		On-demand data warehousing to enable real-time BI	Azvine, Cui, & Nauck (2005); Zoumpatianos, Palpanas, & Mylopoulos (2013)
		Developing infrastructure configurations to enable real-time BI	Azvine, Cui, & Nauck (2005)
		Analytical time lag constraining real-time BI	Azvine, Cui, & Nauck (2005)
		Designing BI systems for real-time accessibility	Choi, Chan, & Yue (2017)
		Building models in order to achieve real-time BI	Azvine, Cui, & Nauck (2005)
Time-intensiveness of data processing	Difficulty caused by time-intensiveness of data integration, cleansing, searching and analytics	Time-intensiveness of data integration	Chen (2016)
		Time-intensiveness of data cleansing	Chen (2016); Hoerl et al (2014); Nielsen (2016)
		Inefficiency of searches in big data files	Al-Aqrabi et al (2013); Ishwarappa, & Anaradha (2015)
		Time-intensiveness of outlier identification and removal	Nielsen (2016)
		Making time available for analytics	Vidgen, Shaw, & Grant (2017)
Latency	Difficulty avoiding latency issues during big data acquisition, transference,	Latency issues in data acquisition and capture	Anagnostopoulos, Zeadally, & Exposito (2016)

	and implementation		
		Avoiding increased latency during data migration due to the rapid growth rate of big data volume	Choi, Chan, & Yue (2017)
		Avoiding increased latency while handling high-volume data acquisitions	Anagnostopoulos, Zeadally, & Exposito (2016)
		Avoiding increased latency while supporting a variety of mixed data structures	Anagnostopoulos, Zeadally, & Exposito (2016); Khan et al (2014)
		Decreasing transfer speed due to big data volume increases	Khan et al (2014)
		Dealing with the delayed deliveries of data, and the slow implementation during IT outsourcing	Gorla, & Somers (2014)
Development Process	Difficulty in developing IT systems that are appropriately scalable	High time-intensiveness of business intelligence systems development processes	Khan et al (2014)
		Developing specialized analytical tools	McNeely et al (2014)
		Developing appropriate scalable and incremental algorithms	McNeely et al (2014)
BDA relationships	Difficulty identifying, interpreting and evaluating relationships found during BDA	Deciphering interrelationships in Big Data	Baesens et al (2016) Chen (2016)
		Difficulties selecting BI measures for evaluating correlation, due to multiple measures providing conflicting information	Duan, & Xu (2012)
		Lack of theory that can directly guide the interpretation of ambiguous weak signs in BI data	Rouibah, & Ould-ali (2002)
Aligning Data to Reality	Difficulty to align big data with the reality of the organization, for instance by using semantic	Aligning big data to the reality of the organization	Jorge et al (2016)

	processing		
		Semantic processing using big data	Esposito et al (2015)
		Using big data to accurately monitor current events	Brynjolfsson et al (2016)
Metadata	Difficulty in ensuring big data longevity and readability using metadata	Ensuring data longevity or timelessness (by ensuring data readability using metadata)	Schroeder (2016); Zezula (2015); Zhou et al (2014)
		Keeping track of manipulation made to big data sets	Hoerl et al (2014)
		Loss of big data context (due to lacking or non-existent metadata)	Schroeder (2016)
		Interpreting big data correctly (due to lacking or non-existent metadata)	Jorge et al (2016); Sivarajah et al (2017)
		Adequately characterizing big data	Jorge et al (2016)
		Creating a systemic information collection method to describe information and provide an information cube for collecting integrated information	Khan et al (2014)
	Difficulty to extract, and integrate big data along with metadata	Integration of the results found of metasearch systems	Marshall et al (2004)
		Efficiently extracting metadata from content and document management systems	Baars, & Kember (2008)
		Automatically extracting metadata semantic metadata	Baars, & Kember (2008)
		When developing metasearch tools it is difficult to access and merge information from disparate sources	Marshall et al (2004)
Big Data characteristics	Difficulty dealing with the 5Vs of big data, namely volume, variety, velocity,	Dealing with the 3Vs of big data	Choi, Chan, & Yue (2017); Rongxing et al (2014); Sivarajah et al (2017)

	veracity and value		
		Dealing with the 4Vs of big data	Zhou et al (2014)
		Dealing with the 5Vs of big data	Sivarajah et al (2017)
		Managing the large data volume	Demirkan, & Delen (2013); Uçaktürk, Uçaktürk, & Yavuz (2015)
		Dealing with the rapid growth rate of big data volume	Khan et al (2014); Vidgen, Shaw, & Grant (2017); Zezula (2015)
		Gathering BI from a vast set of available resources	Marshall et al (2004)
Data Volume	Difficulty organizing a parallel, distributed infrastructure capable of processing rapidly growing big data volume	Lack of relevant IT capabilities and infrastructures required to process large amounts of data	Kache, & Suring (2017); Khan et al (2014); Tien (2013)
		Parallel and distributed computing platforms due to rapidly growing data volume	Kambatla et al (2014)
		Running a diverse set of computations on large datasets	Kambatla et al (2014)
		Ensuring big data scalability for growing volume of data	Khan et al (2014); Tien (2013); Zezula (2015)
Storage	Difficulty storing and integrating data in a standardized fashion, for instance due to storage capacity issues	Choosing where to store big data	Anagnostopoulos, Zeadally, & Exposito (2016)
		Storing and processing large volumes of data (big data)	Ishwarappa, & Anaradha (2015); Richey et al (2016); Sivarajah et al (2017); Subramaniam et al (2009); Zeng, Li, & Duan (2012)
		Developing storage systems that can accommodate large datasets	Kambatla et al (2014); Wang et al (2016)
		Managing vast amounts of data using	Vera-Baquero, Colomo-Palacios, &

		traditional storage systems that are not designed for big data management	Molloy (2016)
		Storage capacity and system retain-ability (deciding which data to keep)	Richey et al (2016)
		Standardizing big data storage and processing (across industries)	Schroeder (2016)
		Difficulty in data integration can cause challenges when building data-warehouses	Ramesh, Rao, & Shashi (2011)
	Difficulty capturing, storing, and mapping data reliably along with search enabled meta-data	Capturing big data effectively	Anagnostopoulos, Zeadally, & Exposito (2016); Ishwarappa, & Anuradha (2015)
		Storing big data reliably along with proper search enabling meta-data	Khan et al (2014); Zezula (2015)
		Obtaining descriptive knowledge or content of raw data to increase findability of complex (unstructured) digital data	Zezula (2015)
		Governing big data in categorizing, modeling and mapping the data as it is captured and stored (due to unstructured and complex nature of big data)	Sivarajah et al (2017)
Integration	Difficulty in aggregating and integrating heterogeneous big data from multiple sources	Ensuring data integration of large volumes and diverse types of big data	McNeely et al (2014); Sivarajah et al (2017); Vidgen, Shaw, & Grant (2017)
		Integrating BIS with other management information systems	Mohamadina, & Harbawi (2012)
		Difficulty aggregating big data	Sivarajah et al (2017)
		Difficult data integration due to data heterogeneity	Esposito et al (2015); Kache, & Suring (2017); Khan et al (2014); McNeely et al (2014); Sivarajah et al (2017); Zezula (2015)

		Integrating BI data with other enterprise structured and unstructured data	Subramaniam et al (2009)
		Working with variably formatted and structured data	Coleman et al (2016); McNeely et al (2014)
	Difficulty in integrating systems during BDA outsourcing	Lack of integrated systems across supply chain partners	Richey et al (2016)
		Introducing an integrated data operation into an organization with multiple incompatible systems	Schroeder (2016)
		Difficulty integrating IT services provided by multiple service vendors due to heterogeneity among IT services	Bachlechner, Thalmann, & Maier (2014)
Unstructured Data	Difficulty in managing and processing unstructured big data	Data mining and cleansing from a collected pool of large scale unstructured data	Choi, Chan, & Yue (2017); Sivarajah et al (2017); Subramaniam et al (2009)
		Difficulty in linking unstructured information with structured data	Subramaniam et al (2009)
		Managing and processing unstructured BI data	Baars, & Kember (2008); Marshall et al (2004); Subramaniam et al (2009)
Relevance	Difficulty to create an effective method to select relevant information for BDA	Creating an effective method for selecting relevant data needed to predict a phenomenon of interest	Brynjolfsson et al (2016)
		Difficulties in distinguishing relevant and irrelevant information resources	Schulz, Winter, & Choi (2015)
Modeling	Difficulty in building a big data model with the right model complexity	Building models based on big data	Zhou et al (2014)
		Risk of overfitting models to a particular data set, making it less accurate in new data	Duan, & Xu (2012)
		Achieving the right model complexity (with	Nielsen (2016); Wang et al (2016)

		the available quality of data)	
Extraction of BI from the web	Difficulty extracting data from the web, for instance due to changing page structure, data variety, or scarcity of relevant web pages	Extracting BI from the web	Gregg, & Walczak (2007)
		Ever-changing page structure unexpectedly invalidate information extraction systems making web extraction of BI more difficult	Gregg, & Walczak (2007)
		Widely divergent user communities served by a wide variety of data sources on the web increase the difficulty of web extraction of BI	Gregg, & Walczak (2007)
		Scarcity of web pages with relevant data on the web increase the difficulty of web extraction of BI	Gregg, & Walczak (2007)
Distribution	Difficulty dealing with the distribution of big data sources as it can lead to different access rights, label quality, and data noise	Dealing with highly distributed data sources	McNeely et al (2014)
		Difficulty processing BI data since it often distributed over many enterprise departments or locked in sluggish enterprise departments	Xu et al (2007)
		The distributed existence of big data leading to different access rights, label quality and noise, due to crowd-sourcing	Zhou et al (2014)
Accessibility/ availability	Difficulty defining which people had access to what information?	Protecting data, and restrict accessibility	Coleman et al (2016); Hurlburt, & Voas (2014)
		Defining actions and rules that determine who has access to what information	Anagnostopoulos, Zeadally, & Exposito (2016); Kambatla et al (2014);

			Subramaniam et al (2009)
	Difficulty in gaining access to the required data?	Getting access to data sources	Vidgen, Shaw, & Grant (2017); Wang et al (2016)
		The availability of data, since not all data may be owned by the company	Coleman et al (2016); Vidgen, Shaw, & Grant (2017)
Quality	Difficulty in dealing with a questionable quality of big data	Dealing with the lacking quality of data	Subramaniam et al (2009); Tien (2013)
		Working with low quality big data	Schroeder (2016)
		Dealing with the questionable quality of many resources available on the web	Marshall et al (2004)
	Difficulty in assessing, managing, and evaluating the quality of big data and BDA	Assessing big data quality	Hazen et al (2014); Hoerl et al (2014); Jorge et al (2016); Siddiqa et al (2016)
		Decision makers difficulty to assess the quality of analytics advice, due to their lack of analytical knowledge	Kowalczyk, & Buxmann (2015)
		Difficulty in accurately measuring the quality or performance IT outsourcing services (due to the relationship between input and output variables being more ambiguous)	Christ et al (2015); Goldberg et al (2017); Ramachandran, & Gopal (2010)
		Optimization of complex systems in the expensive processes of evaluating the quality of big data solutions	Zhou et al (2014)
		Managing big data quality (assuring that data files fit the purpose for which they were intended)	Hazen et al (2014); Jorge et al (2016); Kambatle et al (2014); Vidgen, Shaw, & Grant (2017)
		Difficulty providing quality information due to generally low information content quality	Coelho, Popovič, & Jaklič (2010)
		The dispersion of error that occurs in each separate analysis among mixed data	Anagnostopoulos, Zeadally, & Exposito

		structures	(2016)
Reliability	Difficulty in evaluating and managing data reliability, validity and credibility	Creating an evaluation system based on the system reliability data provided by big data technologies	Choi, Chan, & Yue (2017)
		Establishing a forecasting and warning mechanism to process the information of the system reliability	Choi, Chan, & Yue (2017)
		Producing credible analytics	Vidgen, Shaw, & Grant (2017)
		Tracking and validating data	McNeely et al (2014)
		Coping with sampling biases	McNeely et al (2014)
		Ensuring big data integrity (especially when using cloud computing)	Khan et al (2014); McNeely et al (2014)
		Ensuring big data consistency and completeness	Khan et al (2014)
Data collaboration	Difficulty sharing and transferring big data during collaboration	Sharing big data	Ishwarappa, & Anaradha (2015); McNeely et al (2014); Sivarajah et al (2017)
		Transferring big data	Ishwarappa, & Anaradha (2015); Zezula (2015)
	Duplicate work due to multiple role players imputing the same information multiple times	Duplicate work due to multiple role players imputing the same information multiple times during the outsourcing lifecycle	Liu et al (2007)
Managing the project	Difficulty managing BDA outsourcing especially when managers are only waiting to penalize the vendor	Difficulty in effectively managing the IT outsourcing process	Swar, & Kham (2013)
		Managing data processes	Vidgen, Shaw, & Grant (2017)
		Difficulty in managing SLAs when the service level manager is only waiting to penalize the service provider instead of	Abushaban (2013)

	implementing risk management plans and mitigation steps to maintain an acceptable level of service	
	Difficulty in the day-to-day steering of large outsourcing programs (especially in the phase after the transfer of services to the outsourced vendor)	Urbach, & Würz (2012)
Difficulty for managers to direct both internal and external resources especially when managers are granted insufficient authority	IT service management difficulties in selecting, implementing, and integrating the right resources quickly	Yang, Wang, & Douglis (2009)
	Difficulty for managers to direct and coordinate both internal and external IS resources	Martinsons (1993)
	Insufficient authority and resources given to service level manager that might cause issues in the agreement and the provided services	Abushaban (2013)
Difficulty ensuring a successful integration of service providers, staff, and other stakeholders in the BDA outsourcing process	Difficulty ensuring a successful relationship between customer, and vendor during IT outsourcing	Kern, & Willcocks (2000)
	Managing the poor communication with service providers, staff and other stakeholders	Goldberg et al (2017)
	Difficulty integrating sub-contractors and suppliers	Goldberg et al (2017)
Difficulty managing vendor activities due to lack of knowledge	Difficulty managing the vendors activities during IT outsourcing	Hsu, Chiu, & Hsu (2004)
	Lack of IT expertise in customer companies	Park, Im, & Kim (2011)

		allows vendors to dominate IT-management	
	Difficulty organizing BDA projects, and teams due to lacking organizational models	Lack of knowledge in creating, organizing and structuring a BI team	O'Donnell, Sipsma, & Watt (2012)
		Lack of management and organizational models especially for SMEs	Coleman et al (2016)
		Lack of knowledge about the type of development projects best suited for agile and waterfall approaches	O'Donnell, Sipsma, & Watt (2012)
Stakeholders	Difficulty in defining what stakeholder responsibilities were?	Defining who is the stakeholder responsible for data management	Anagnostopoulos, Zeadally, & Exposito (2016)
		Defining who is the stakeholder responsible for data distribution	Anagnostopoulos, Zeadally, & Exposito (2016)
		Defining who is the stakeholder responsible for data analysis	Anagnostopoulos, Zeadally, & Exposito (2016)
	Difficulty keeping track of data ownership and intellectual property rights?	Determining intellectual property rights	Baesens et al (2016)
		Defining who owns the data	Anagnostopoulos, Zeadally, & Exposito (2016); Sivarajah et al (2017); Subramaniam et al (2009); Vidgen, Shaw, & Grant (2017); Zhou et al (2014)
		Difficulty for the customer company to keep track of data they own, due to frequent migration among service vendors and subcontractors	Bachlechner, Thalmann, & Maier (2014)
Knowledge	Difficulty keeping track of different BDA or BI technologies due to a lack of organizational knowledge	Dominance of domain specific knowledge in SMEs reducing awareness of big data analytics	Coleman et al (2016)

		Difficulty managing IT outsourcing regarding an unfamiliar or emerging technology, due to company lack of knowledge	Lacity et al (1995); Pei, Zhen-xiang, & Chung-ping (2007)
		Difficulty for practitioners to keep track of the different technologies used for BI data management	O'Donnell, Sipsma, & Watt (2012)
		Lack of big data understanding and experience (especially for SMEs)	Coleman et al (2016); Kwon, Lee, & Shin (2014)
(Human) Resources	Difficulty finding and managing the necessary skills in order to operationalize BDA	Finding skills necessary to operationalize big data	Akter, & Wamba (2016)
		Bottlenecks in the labor market (for example shortage of qualified data analysts)	Coleman et al (2016)
		Shortage of useful and affordable consulting and business analytics services	Coleman et al (2016)
		Shortage of analytical expertise (especially in SMEs)	Coleman et al (2016); Richey et al (2016)
		Finding networked relationships needed to operationalize big data	Akter, & Wamba (2016)
		The development of appropriate big data analytics skills (especially for SMEs)	Coleman et al (2016); Vidgen, Shaw, & Grant (2017)
		The development of appropriate big data technical skills	Vidgen, Shaw, & Grant (2017)
		Talent management for the new generation of data and computer scientists	Vidgen, Shaw, & Grant (2017)
		Applying new data management techniques in order to deal with big data	Sivarajah et al (2017)
	Difficulty determining, obtaining, and coordinating the business requirements	Difficulty determining business requirements	Goldberg et al (2017)

	necessary to exploit BDA		
		Difficulty coordinating requirements (between business units)	Goldberg et al (2017)
		Difficulty gathering and documenting requirements for BI systems	O'Donnell, Sipsma, & Watt (2012)
		Obtaining the technology that is necessary to exploit big data	Vidgen, Shaw, & Grant (2017)
Service Level Agreements	Difficulty in agreeing on Service Level Agreements due to lacking communication or knowledge	Difficulty in communicating Service Level Indicators, in order to assess Service Level Agreements	Abushaban (2013)
		Different backgrounds of stakeholders may create conflicts in agreeing on Service Level Indicators for certain services	Abushaban (2013)
		Loss of focus when defining and measuring Service Level Indicators and parameters due to lacking specialist knowledge	Abushaban (2013)
Contract	Difficulty in creating a complete enforceable contract in which obligations are clearly defined	Difficulty in crafting complete contracts during IT outsourcing	Susarla, Subramanyam, & Karhade (2010)
		The creation of (mega-)contracts causing problems during (large-scale) IT outsourcing (including, excess fees, declining services, inability to adapt to changing business and technology needs, loss of power to monopoly suppliers, and inability of the customers to manage the interface with the suppliers)	Miozzo, & Grimshaw (2005)
		Difficulty in defining performance goals and translating these goals into appropriate contractual obligations	Christ et al (2015); Goldberg et al (2017)

		Difficulty in defining a detailed contract due to difficulty in measuring certain objectives	Fitoussi, & Gurbaxani (2012)
		Difficulty to develop enforceable contractual provisions (especially when technological uncertainty is high)	Handley, & Benton (2012); Lee (1996)
	Difficulty in measuring, monitoring and managing contractual obligations	Lack of well-defined big data contracts because of the difficulty of measuring quality and reliability of input data and output results	Hsu, Chiu, & Hsu (2004); Wang et al (2016)
		The challenge of adequate contractual monitoring	Christ et al (2015)
		Difficulty for technical experts to switch between solving IT problems to managing contracts	Lacity et al (1995)
	Difficulty in providing contractual incentives for service providers to encourage performance	Difficulty to design an incentive contract to encourage performance of the service provider (especially in the presence of information asymmetry and incentive divergence)	Zhang, & Xu (2017)
Governance/ Compliance	Difficulty establishing, implementing, and adopting IT governance, whilst keeping track of compliance	Difficulties in effective establishment and implementation of IT governance	Ai, & Green (2009);
		Difficulties in governing BI systems (since too much user control leads to duplication or inconsistency, while centralized system control can lead to user disengagement)	O'Donnell, Sipsma, & Watt (2012)
		Governance and compliance to big data analytics adoption across the supply chain	Kache, & Suring (2017); Khan et al (2014)
		Compliance in honoring certain security arrangements during complex IT outsourcing	Bachlechner, Thalmann, & Maier (2014)

		Legislative and regulatory compliance	Vidgen, Shaw, & Grant (2017);
		Difficulty for customer organizations to monitor compliance to Service Level Agreements	Bachlechner, Thalmann, & Maier (2014)
Monitoring IT activities	Difficulty in identifying, and measuring performance indicators in order to effectively manage performance of big data analytics	The lack of performance from traditional measurement mechanisms	Demirkan, & Delen (2013)
		Managing performance of big data analytics	Vidgen, Shaw, & Grant (2017)
		Difficulty in identifying performance indicators that actually depict the outsourcing endeavor's strategic, economic, and technological objectives	Urbach, & Würz (2012)
		Difficulty in measuring performance due to the outsourcing arrangement having a mix of objectives	Fitoussi, & Gurbaxani (2012)
	Difficulty in accurately monitoring performance and productivity	Difficulty choosing IT and software tools to monitor and report aspects of ongoing service parameters	Abushaban (2013)
		Difficulty for customer organizations to monitor vendor performance and productivity	Raiborn, Butler, & Massoud (2009)
Costs	Difficulty in measuring and balancing the costs and potential gains of BDA outsourcing	Balancing the cost of big data management systems with the potential gains in efficiencies and performance	Richey et al (2016); Sivarajah et al (2017)
		Difficulty in measuring the actual benefits, opportunities, costs or risks involved during IT outsourcing (due to difficulty measuring hidden costs, insufficient base for comparison, contradictory criteria, absence of standardized processes)	Kivijärvi (2015)

	Tuning costs and performance of computation (especially for SMEs)	Choi, Chan, & Yue (2017); Coleman et al (2016)
Difficulty assessing and managing costs of BDA solutions	Managing costs of analytics	Vidgen, Shaw, & Grant (2017)
	High costs, resource-intensity, and complexity of BI systems complementation	Yeah, & Popovič (2016)
	The high costs of deploying a large data warehouse to support BI systems	Lawton (2006);
	Increased search costs by knowledge workers due to the steadily increasing number of BI data	Schulz, Winter, & Choi (2015)
	Estimating costs and risks of performing big data analytics for users and suppliers	Wang et al (2016)
Difficulty in securing BDA investments due to high costs of technology, and maintenance	Securing big data investments	Vidgen, Shaw, & Grant (2017)
	High cost of BI solutions restricting the use of BI solutions (especially for SMEs)	Khan et al (2014)
	Complexity of BI technology makes it expensive and usable only by specialists	Lawton (2006)
	Financial barriers to invest in big data (especially for SMEs)	Coleman et al (2016)
	Massive scale of BI software development and long costly maintenance cycles create BI system development difficulties (especially for SMEs)	Khan et al (2014)
The occurrence of hidden or unexpected costs during any phase of the IT outsourcing process	The potential of the occurrence of hidden costs (due to weaknesses in contracting)	Martinsons (1993); Willcocks, Lacity, & Fitzgerald (1995)
	The occurrence of hidden costs due to	Bahli, & Rivard (2003); Cong, & Chen

litigations and disputes (that could potentially result in a lawsuit)	(2015)
Costly contractual amendments (e.g. alterations, redrafting, changes made to the contract)	Bahli, & Rivard (2003); Cong, & Chen (2015)
Cost escalation during the ex-post stage of contracting of the IT outsourcing process (e.g. holdup problems, or disputes between contracting parties)	Bahli, & Rivard (2013)
Indirect costs due to keeping BI environments secure	Al-Aqrabi et al (2013)
The occurrence of hidden costs during vendor search and contracting phase of IT outsourcing	Barthélemy (2001)
The occurrence of hidden costs during the transition phase of IT outsourcing	Barthélemy (2001); Plugge, & Brook (2012)
Hidden or underestimated transition and management costs (e.g. set-up, redeployment or relocation costs, human resources devoted to managing an outsourcing contract, handover, reimplementation costs)	Bahli, & Rivard (2003); Cong, & Chen (2015); Hsu, Chiu, & Hsu (2004); Lacity et al (1995)
The occurrence of hidden (or higher-than-expected) transaction costs during IT outsourcing	Raiborn, Butler, & Massoud (2009); Urbach, & Würz (2012)
The occurrence of hidden costs due to managing the vendor (e.g. includes monitoring, bargaining and negotiating contractual changes)	Barthélemy (2001)
The occurrence of holdup problems due to contractual incompleteness (e.g. one party taking advantage of contractual incompletes which leads to potential underinvestment or inefficient bargaining)	Susarla, Subramanyam, & Karhade (2010)

	The occurrence of a lock-in due to high investments in the IT outsourcing relationship	Lock-in with a certain supplier due to high investments in the IT outsourcing relationship	Bahli, & Rivard (2003); Cong, & Chen (2015); Martinsons (1993)
Adaptability	Difficulty for vendors to adapt to customer's changing requirements	Difficulty for service vendors to adapt to customer's changing security and compliance requirements	Bachlechner, Thalmann, & Maier (2014)
		Difficulty for the vendor to deliver the flexibility and range of options required for business success	Martinsons (1993); Urbach, & Würz (2012)
Trust	Lacking trust in the IT outsourcing relationship and BDA due to lack of transparency	Dealing with a lack of partnership and trust during IT outsourcing	Goldberg et al (2017); Hsu, Chiu, & Hsu (2004)
		Loss of organizational trust in the IT outsourcing relationship	Raiborn, Butler, & Massoud (2009)
		Making analytical models understandable for end-users or non-experts to generate trust	Baesens et al (2016)
		Trusting in data and analytics as a key factor in implementing decision-linked inferences from data	Baesens et al (2016); Zhou et al (2014)
		Transparent big data analytics	Schroeder (2016)
		Non-transparency of the big data analytics software creates difficulties during vendor selection	Coleman et al (2016)
		Visualizing big data effectively	Anagnostopoulos, Zeadally, & Exposito (2016); Hoerl et al (2014); Ishwarappa, & Anaradha (2015); Khan et al (2014); Sivarajah et al (2017); Vidgen, Shaw, & Grant (2017); Wang et al (2016)
Organizational change	Difficulty dealing with organizational resistance to change during BDA	Difficulties implementing BI systems due to employee resistance to change	Seah, Hsieh, & Weng (2010)

	outsourcing		
		Overcoming organizational resistance to change (for instance during the transition phase)	Plugge, & Brook (2012); Vidgen, Shaw, & Grant (2017)
		Lack of organizational readiness towards BI systems making it difficult to implement BI systems	Anjariny, Zeki, & Hussin, (2012); Mohamadina, & Harbawi (2012)
		Lack of successful big data business cases creating difficulty in big data propagation	Coleman et al (2016); Vidgen, Shaw, & Grant (2017)
		Difficulty of IT outsourcing potentially decreasing employee morale	Belcourt (2006)
		Building a corporate data culture due to resistance to change	Vidgen, Shaw, & Grant (2017)
	Difficulty dealing with cultural barriers during the coordination of BDA outsourcing	Cultural barriers and intrinsic conservatism present in companies (especially for SMEs)	Coleman et al (2016); Vidgen, Shaw, & Grant (2017)
		Cultural differences of the workforce create challenges for effective coordination during IT outsourcing (e.g. professional, organizational, corporate, or national conflicts may arise)	Christ et al (2015); Willcocks, & Choi (1995)
Lack of Control	Difficulty staying aware of how data was used?	Unawareness of how data is used	Akter, & Wamba (2016)
		Loss of control over data due to outsourcing analytical services (caused by information asymmetry between customer and vendor)	Coleman et al (2016); Hsu, Chiu, & Hsu (2004); Martinsons (1993); Park, Im, & Kim (2011); Raiborn, Butler, & Massoud (2009); Zhang, & Xu (2017)
Misunderstandings	Misunderstandings, misaligned expectations and cost-service debates causing conflict between vendor and customer	(Service) scope misunderstandings arising during IT outsourcing	Goldberg et al (2017)

		Misaligned expectations of the IT outsourcing project	Goldberg et al (2017); Lacity et al (1995)
		(Continuous) cost-service debates during IT outsourcing	Goldberg et al (2017)
		Difficulty dealing with the conflicting customer and vendor objectives	Urbach, & Würz (2012)
Staff turnover difficulties	Difficulty caused by too high staff turnover during BDA outsourcing	Difficulties caused by too high staff turnover during outsourcing	Goldberg et al (2017)
Service Quality	Degradation of BDA outsourcing due to vendor's lacking commitment, lacking effectiveness, or opportunistic behavior	Dealing with the degradation of IT outsourcing service	Gorla, & Somers (2014)
		Dealing with the lack of vendor commitment to the IT outsourcing project	Gorla, & Somers (2014)
		Dealing with the ineffectiveness of the vendor	Gorla, & Somers (2014)
		Dealing with opportunistic vendor behavior during IT outsourcing services (due to information asymmetry between customer and vendor)	Handley, & Benton (2012); Zhang, & Xu (2017)
Loss of Knowledge	Difficulty for customer companies to retain insider knowledge and technical capabilities during BDA outsourcing	The risk of transferring expertise and insider knowledge to the vendor during outsourcing	Belcourt (2006)
		The risk of the customer company losing certain technological capabilities due to IT outsourcing	Cong, & Chen (2015)
	Customer companies missing major shifts and new trends during BDA	Missing major shifts and new trends (in the company) during IT outsourcing	Goldberg et al (2017)

	outsourcing		
IT system difficulties	Difficulty in training users to engage with often complex IT software	Difficulty in using BI system applications	Xu et al (2007); Zeng, Li, & Duan (2012)
		Engaging and training users with (new) BI systems	O'Donnell, Sipsma, & Watt (2012)
		Lack of intuitive software creates longer learning curves	Coleman et al (2016)
	Difficulty in implementing IT systems due to long install, build, and deploy time	Difficulty implementing BI systems due to the long install, build and deploy time	Xu et al (2007); Zeng, Li, & Duan (2012)
	Difficulty evaluating IT systems prior to purchase	Evaluating business intelligence systems prior to buying	Chuantao, Xiaofei, & Baowen (2016); Rouhani, Ghazangari, & Jafari (2012)

7.2; Appendix B

Strategical Management		
Strategy		
Difficulty determining BDA outsourcing strategy and integrating that strategy into the corporate business strategy	Determining a big data (analytics) strategy	Hoerl et al (2014); Vidgen, Shaw, & Grant (2017)
	Determining a (long-term) BI strategy	O'Donnell, Sipsma, & Watt (2012)
	Determining a (long-term) IT outsourcing strategy	Goldberg et al (2017)
	Integration of big data analytics into the corporate business strategy	Kache, & Suring (2017); Vidgen, Shaw, & Grant (2017)
	Determining a big data objective	Kache, & Suring (2017)
	Difficulties in modeling and analyzing business objectives and specifications	Zoumpatianos, Palpanas, & Mylopoulos (2013)
Difficulty in leadership setting clear goals regarding BDA, and determining the scope of BDA projects	Defining the scope of analytics projects	Vidgen, Shaw, & Grant (2017)
	Clear goals set by leadership regarding big data	Vidgen, Shaw, & Grant (2017)
	Analysis paralysis due to increasingly more data sources and technologies becoming accessible	Meleanca (2013)
Difficulty in defining what stakeholder responsibilities were?	Defining who is the stakeholder responsible for data management	Anagnostopoulos, Zeadally, & Exposito (2016)
	Defining who is the stakeholder responsible for data distribution	Anagnostopoulos, Zeadally, & Exposito (2016)
	Defining who is the stakeholder responsible for data analysis	Anagnostopoulos, Zeadally, & Exposito (2016)
Difficulty organizing BDA projects,	Lack of knowledge in creating, organizing and structuring	O'Donnell, Sipsma, & Watt

and teams due to lacking organizational models	a BI team	(2012)
	Lack of management and organizational models especially for SMEs	Coleman et al (2016)
	Lack of knowledge about the type of development projects best suited for agile and waterfall approaches	O'Donnell, Sipsma, & Watt (2012)
Value		
Difficulty in obtaining value from BDA, for instance due to lack of knowledge or BDA skills	Using big data and data analytics to obtain real value	Aalst, Zhao, & Wang (2015); Baesens et al (2016); Duan, & Xu (2012); Heindrich, Trendowicz & Ebert (2016); Sivarajah et al (2017); Vidgen, Shaw, & Grant (2017); Zeng, Li, & Duan (2012)
	Lack of company knowledge on how to obtain value from big data	Wang et al (2016)
	Identifying valuable or important data subsets from the original big dataset	Zhou et al (2014); Zeng, Li, & Duan (2012); Zimmermann (2006)
	Lack of company knowledge on how to obtain profits from large amounts of data	Xu et al (2007)
	Using big data to leverage information to gain a stronger market position	Baesens et al (2016)
	Developing even better big data engineering and analytics to manage and leverage big data to deliver business value	Baesens et al (2016)
	Practitioners lack of understanding the best strategies and tools necessary for predictive analytics	O'Donnell, Sipsma, & Watt (2012)
Difficulty in determining the relevance of BDA project results	Determining the relevance of results of big data projects	Jorge et al (2016)
Difficulty creating decision making systems based on BDA, and using	Using big data in decision making and analysis	McNeely et al (2014); Vidgen, Shaw, & Grant

BDA to change business processes		(2017)
	Lack of big data decision-support tools	Tien (2013)
	Creating automated decision making systems exploiting the models created from big data analytics	Nielsen (2016)
	Changing business processes based on (real-time) BI results	Azvine, Cui, & Nauck (2005)
	Taking actions based on BI analysis results	Lawton (2006)
	Using big data to advance discovery and innovation	McNeely et al (2014)
Difficulty in creating a holistic BDA model, in order to base decisions on all available facts	Obtaining a holistic model of relevant aspects, in order to make decisions based on all available facts	Kowalczyk, & Buxmann (2015)
	Inability of current BI systems to be integrated with Process Aware Information Systems to improve decision making	Vera-Baquero, Colomo-Palacios, & Molloy (2016)
Difficulty for analysts to grant transparent analytical advice in a timely manner, especially during uncertain situations	Difficulty for analysts to be adaptable in order to advise decision makers in uncertain or ambiguous decision situations	Kowalczyk, & Buxmann (2015)
	Transparent BI analytics in order to grant decision makers with sound advice	Kowalczyk, & Buxmann (2015)
	Supporting big data analysts to make quicker decisions	Wang et al (2016)
	Supporting big data managers to make quicker decisions	Wang et al (2016)
Tactical Management		
Costs		
Difficulty finding and managing the necessary skills in order to operationalize BDA	Finding skills necessary to operationalize big data	Akter, & Wamba (2016)
	Bottlenecks in the labor market (for example shortage of qualified data analysts)	Coleman et al (2016)

	Shortage of useful and affordable consulting and business analytics services	Coleman et al (2016)
	Shortage of analytical expertise (especially in SMEs)	Coleman et al (2016); Richey et al (2016)
	Finding networked relationships needed to operationalize big data	Akter, & Wamba (2016)
	The development of appropriate big data analytics skills (especially for SMEs)	Coleman et al (2016); Vidgen, Shaw, & Grant (2017)
	The development of appropriate big data technical skills	Vidgen, Shaw, & Grant (2017)
	Talent management for the new generation of data and computer scientists	Vidgen, Shaw, & Grant (2017)
	Applying new data management techniques in order to deal with big data	Sivarajah et al (2017)
Difficulty determining, obtaining, and coordinating the business requirements necessary to exploit BDA	Difficulty determining business requirements	Goldberg et al (2017)
	Difficulty coordinating requirements (between business units)	Goldberg et al (2017)
	Difficulty gathering and documenting requirements for BI systems	O'Donnell, Sipsma, & Watt (2012)
	Obtaining the technology that is necessary to exploit big data	Vidgen, Shaw, & Grant (2017)
Difficulty for managers to direct both internal and external resources especially when managers are granted insufficient authority	IT service management difficulties in selecting, implementing, and integrating the right resources quickly	Yang, Wang, & Douglis (2009)
	Difficulty for managers to direct and coordinate both internal and external IS resources	Martinsons (1993)

	Insufficient authority and resources given to service level manager that might cause issues in the agreement and the provided services	Abushaban (2013)
Difficulty in measuring and balancing the costs and potential gains of BDA outsourcing	Balancing the cost of big data management systems with the potential gains in efficiencies and performance	Richey et al (2016); Sivarajah et al (2017)
	Difficulty in measuring the actual benefits, opportunities, costs or risks involved during IT outsourcing (due to difficulty measuring hidden costs, insufficient base for comparison, contradictory criteria, absence of standardized processes)	Kivijärvi (2015)
	Tuning costs and performance of computation (especially for SMEs)	Choi, Chan, & Yue (2017); Coleman et al (2016)
Difficulty assessing and managing costs of BDA solutions	Managing costs of analytics	Vidgen, Shaw, & Grant (2017)
	High costs, resource-intensity, and complexity of BI systems complementation	Yeah, & Popovič (2016)
	The high costs of deploying a large data warehouse to support BI systems	Lawton (2006);
	Increased search costs by knowledge workers due to the steadily increasing number of BI data	Schulz, Winter, & Choi (2015)
	Estimating costs and risks of performing big data analytics for users and suppliers	Wang et al (2016)
Difficulty in securing BDA investments due to high costs of technology, and maintenance	Securing big data investments	Vidgen, Shaw, & Grant (2017)
	High cost of BI solutions restricting the use of BI solutions (especially for SMEs)	Khan et al (2014)
	Complexity of BI technology makes it expensive and usable only by specialists	Lawton (2006)
	Financial barriers to invest in big data (especially for SMEs)	Coleman et al (2016)

	Massive scale of BI software development and long costly maintenance cycles create BI system development difficulties (especially for SMEs)	Khan et al (2014)
The occurrence of hidden or unexpected costs during any phase of the IT outsourcing process	The potential of the occurrence of hidden costs (due to weaknesses in contracting)	Martinsons (1993); Willcocks, Lacity, & Fitzgerald (1995)
	The occurrence of hidden costs due to litigations and disputes (that could potentially result in a lawsuit)	Bahli, & Rivard (2003); Cong, & Chen (2015)
	Costly contractual amendments (e.g. alterations, redrafting, changes made to the contract)	Bahli, & Rivard (2003); Cong, & Chen (2015)
	Cost escalation during the ex-post stage of contracting of the IT outsourcing process (e.g. holdup problems, or disputes between contracting parties)	Bahli, & Rivard (2013)
	Indirect costs due to keeping BI environments secure	Al-Aqrabi et al (2013)
	The occurrence of hidden costs during vendor search and contracting phase of IT outsourcing	Barthélemy (2001)
	The occurrence of hidden costs during the transition phase of IT outsourcing	Barthélemy (2001); Plugge, & Brook (2012)
	Hidden or underestimated transition and management costs (e.g. set-up, redeployment or relocation costs, human resources devoted to managing an outsourcing contract, handover, reimplementation costs)	Bahli, & Rivard (2003); Cong, & Chen (2015); Hsu, Chiu, & Hsu (2004); Lacity et al (1995)
	The occurrence of hidden (or higher-than-expected) transaction costs during IT outsourcing	Raiborn, Butler, & Massoud (2009); Urbach, & Würz (2012)
	The occurrence of hidden costs due to managing the vendor (e.g. includes monitoring, bargaining and negotiating contractual changes)	Barthélemy (2001)
	The occurrence of holdup problems due to contractual incompleteness (e.g. one party taking advantage of contractual incompletes which leads to potential underinvestment or inefficient bargaining)	Susarla, Subramanyam, & Karhade (2010)

Contract

Difficulty in agreeing on Service Level Agreements due to lacking communication or knowledge	Difficulty in communicating Service Level Indicators, in order to assess Service Level Agreements	Abushaban (2013)
	Different backgrounds of stakeholders may create conflicts in agreeing on Service Level Indicators for certain services	Abushaban (2013)
	Loss of focus when defining and measuring Service Level Indicators and parameters due to lacking specialist knowledge	Abushaban (2013)
Difficulty in creating a complete enforceable contract in which obligations are clearly defined	Difficulty in crafting complete contracts during IT outsourcing	Susarla, Subramanyam, & Karhade (2010)
	The creation of (mega-)contracts causing problems during (large-scale) IT outsourcing (including, excess fees, declining services, inability to adapt to changing business and technology needs, loss of power to monopoly suppliers, and inability of the customers to manage the interface with the suppliers)	Miozzo, & Grimshaw (2005)
	Difficulty in defining performance goals and translating these goals into appropriate contractual obligations	Christ et al (2015); Goldberg et al (2017)
	Difficulty in defining a detailed contract due to difficulty in measuring certain objectives	Fitoussi, & Gurbaxani (2012)
	Difficulty to develop enforceable contractual provisions (especially when technological uncertainty is high)	Handley, & Benton (2012); Lee (1996)
Difficulty keeping track of data ownership and intellectual property rights?	Determining intellectual property rights	Baesens et al (2016)
	Defining who owns the data	Anagnostopoulos, Zeadally, & Exposito (2016); Sivarajah et al (2017); Subramaniam et al (2009); Vidgen, Shaw, & Grant (2017); Zhou et al (2014)

	Difficulty for the customer company to keep track of data they own, due to frequent migration among service vendors and subcontractors	Bachlechner, Thalmann, & Maier (2014)
Difficulty in measuring, monitoring and managing contractual obligations	Lack of well-defined big data contracts because of the difficulty of measuring quality and reliability of input data and output results	Hsu, Chiu, & Hsu (2004); Wang et al (2016)
	The challenge of adequate contractual monitoring	Christ et al (2015)
	Difficulty for technical experts to switch between solving IT problems to managing contracts	Lacity et al (1995)
Difficulty in providing contractual incentives for service providers to encourage performance	Difficulty to design an incentive contract to encourage performance of the service provider (especially in the presence of information asymmetry and incentive divergence)	Zhang, & Xu (2017)
Governance/Compliance		
Difficulty establishing, implementing, and adopting IT governance, whilst keeping track of compliance	Difficulties in effective establishment and implementation of IT governance	Ai, & Green (2009);
	Difficulties in governing BI systems (since too much user control leads to duplication or inconsistency, while centralized system control can lead to user disengagement)	O'Donnell, Sipsma, & Watt (2012)
	Governance and compliance to big data analytics adoption across the supply chain	Kache, & Suring (2017); Khan et al (2014)
	Compliance in honoring certain security arrangements during complex IT outsourcing	Bachlechner, Thalmann, & Maier (2014)
	Legislative and regulatory compliance	Vidgen, Shaw, & Grant (2017);
	Difficulty for customer organizations to monitor compliance to Service Level Agreements	Bachlechner, Thalmann, & Maier (2014)
Difficulty in identifying, and measuring performance indicators in order to effectively manage	The lack of performance from traditional measurement mechanisms	Demirkan, & Delen (2013)

performance of big data analytics		
	Managing performance of big data analytics	Vidgen, Shaw, & Grant (2017)
	Difficulty in identifying performance indicators that actually depict the outsourcing endeavor's strategic, economic, and technological objectives	Urbach, & Würz (2012)
	Difficulty in measuring performance due to the outsourcing arrangement having a mix of objectives	Fitoussi, & Gurbaxani (2012)
Difficulty in accurately monitoring performance and productivity	Difficulty choosing IT and software tools to monitor and report aspects of ongoing service parameters	Abushaban (2013)
	Difficulty for customer organizations to monitor vendor performance and productivity	Raiborn, Butler, & Massoud (2009)
Operational Management		
Managing the project		
Difficulty managing BDA outsourcing especially when managers are only waiting to penalize the vendor	Difficulty in effectively managing the IT outsourcing process	Swar, & Kham (2013)
	Managing data processes	Vidgen, Shaw, & Grant (2017)
	Difficulty in managing SLAs when the service level manager is only waiting to penalize the service provider instead of implementing risk management plans and mitigation steps to maintain an acceptable level of service	Abushaban (2013)
	Difficulty in the day-to-day steering of large outsourcing programs (especially in the phase after the transfer of services to the outsourced vendor)	Urbach, & Würz (2012)
Difficulty managing vendor activities due to lack of knowledge	Difficulty managing the vendors activities during IT outsourcing	Hsu, Chiu, & Hsu (2004)
	Lack of IT expertise in customer companies allows vendors to dominate IT-management	Park, Im, & Kim (2011)

Difficulty ensuring a successful integration of service providers, staff, and other stakeholders in the BDA outsourcing process	Difficulty ensuring a successful relationship between customer, and vendor during IT outsourcing	Kern, & Willcocks (2000)
	Managing the poor communication with service providers, staff and other stakeholders	Goldberg et al (2017)
	Difficulty integrating sub-contractors and suppliers	Goldberg et al (2017)
Difficulty for vendors to adapt to customer's changing requirements	Difficulty for service vendors to adapt to customer's changing security and compliance requirements	Bachlechner, Thalmann, & Maier (2014)
	Difficulty for the vendor to deliver the flexibility and range of options required for business success	Martinsons (1993); Urbach, & Würz (2012)
Difficulty caused by too high staff turnover during BDA outsourcing	Difficulties caused by too high staff turnover during outsourcing	Goldberg et al (2017)

Resistance and Trust

Difficulty dealing with organizational resistance to change during BDA outsourcing	Difficulties implementing BI systems due to employee resistance to change	Seah, Hsieh, & Weng (2010)
	Overcoming organizational resistance to change (for instance during the transition phase)	Plugge, & Brook (2012); Vidgen, Shaw, & Grant (2017)
	Lack of organizational readiness towards BI systems making it difficult to implement BI systems	Anjariny, Zeki, & Hussin, (2012); Mohamadina, & Harbawi (2012)
	Lack of successful big data business cases creating difficulty in big data propagation	Coleman et al (2016); Vidgen, Shaw, & Grant (2017)
	Difficulty of IT outsourcing potentially decreasing employee morale	Belcourt (2006)
	Building a corporate data culture due to resistance to change	Vidgen, Shaw, & Grant (2017)
Difficulty dealing with cultural	Cultural barriers and intrinsic conservatism present in	Coleman et al (2016);

barriers during the coordination of BDA outsourcing	companies (especially for SMEs)	Vidgen, Shaw, & Grant (2017)
	Cultural differences of the workforce create challenges for effective coordination during IT outsourcing (e.g. professional, organizational, corporate, or national conflicts may arise)	Christ et al (2015); Willcocks, & Choi (1995)
Lacking trust in the IT outsourcing relationship and BDA due to lack of transparency	Dealing with a lack of partnership and trust during IT outsourcing	Goldberg et al (2017); Hsu, Chiu, & Hsu (2004)
	Loss of organizational trust in the IT outsourcing relationship	Raiborn, Butler, & Massoud (2009)
	Making analytical models understandable for end-users or non-experts to generate trust	Baesens et al (2016)
	Trusting in data and analytics as a key factor in implementing decision-linked inferences from data	Baesens et al (2016); Zhou et al (2014)
	Transparent big data analytics	Schroeder (2016)
	Non-transparency of the big data analytics software creates difficulties during vendor selection	Coleman et al (2016)
	Visualizing big data effectively	Anagnostopoulos, Zeadally, & Exposito (2016); Hoerl et al (2014); Ishwarappa, & Anaradha (2015); Khan et al (2014); Sivarajah et al (2017); Vidgen, Shaw, & Grant (2017); Wang et al (2016)
Misunderstandings, misaligned expectations and cost-service debates causing conflict between vendor and customer	(Service) scope misunderstandings arising during IT outsourcing	Goldberg et al (2017)
	Misaligned expectations of the IT outsourcing project	Goldberg et al (2017); Lacity et al (1995)
	(Continuous) cost-service debates during IT outsourcing	Goldberg et al (2017)

	Difficulty dealing with the conflicting customer and vendor objectives	Urbach, & Würz (2012)
Degredation of BDA outsourcing due to vendor's lacking commitment, lacking effectiveness, or opportunistic behavior	Dealing with the degradation of IT outsourcing service	Gorla, & Somers (2014)
	Dealing with the lack of vendor commitment to the IT outsourcing project	Gorla, & Somers (2014)
	Dealing with the ineffectiveness of the vendor	Gorla, & Somers (2014)
	Dealing with opportunistic vendor behavior during IT outsourcing services (due to information asymmetry between customer and vendor)	Handley, & Benton (2012); Zhang, & Xu (2017)

7.3; Appendix C

Interview Big Data Analytics Consultants

Interviewee: …..

Interviewer: Quincy Boom

Plaats: …..

Datum: ….

Tijd: ….

Opening Interview

Persoonlijke introductie

Introductie onderzoek

Big Data Analytics is een zeer veelbelovende stroming binnen de statistiek, wat zowel in het bedrijfsleven als in wetenschappelijke literatuur wordt erkend. Big Data Analytics heeft de potentie om bedrijven meer inzicht te geven in bedrijfsprocessen. Big Data Analytics is echter een nieuw fenomeen, en het is daardoor uitdagend voor bedrijven om de techniek goed toe te passen. Big Data Analytics outsourcing kan hier mogelijk de oplossing voor zijn, aangezien bedrijven dan externe hulp krijgen bij het invoeren ban Big Data Analytics. Tijdens mijn onderzoek heb ik een literatuurstudie gedaan om erachter te komen welke uitdagingen er bekend zijn m.b.t. Big Data Analytics, Business Intelligence en IT outsourcing. Tijdens mijn afstudeeronderzoek wil ik graag kijken of deze uitdagingen zich ook voordoen tijdens Big Data Analytics outsourcing om bedrijfsintelligentie te verhogen. Hiervoor neem in interviews af bij mensen die op verschillende manieren betrokken zijn/waren tijdens een Big Data Analytics outsourcing project.

Interview introductie:

Het interview zal ongeveer een uur duren. Tijdens dit interview stel ik vragen over verschillende facetten van het project. Van de interviews worden ook opnames gemaakt, die alleen gebruikt worden voor onderzoeksdoeleinden. De gegevens van de interviews worden uitsluitend anoniem verwerkt.

Introductie vragen

Wat is uw huidige functie binnen …..? Wat is uw achtergrond?

Kunt u mij globaal vertellen welke ontwikkelingen zich hebben voorgedaan tijdens het project?

Wanneer bent u betrokken geraakt bij het project?

Wat is uw rol geweest tijdens het project?

Welke werkzaamheden heeft u tijdens dit project voltrokken?

Wat was het uiteindelijke doel van het project?

Interview vragen

Data

Hebben zich uitdagingen voorgedaan bij het managen van de data? (zo ja, welke uitdagingen?)

Hebben zich uitdagingen voorgedaan bij de data analyse? (zo ja, welke uitdagingen?)

IT Strategie

Was het uitdagend om nieuwe systemen te implementeren bij de klant? (zo ja, welke uitdagingen hebben zich voorgedaan?)

Zijn er tijdens dit project meetinstrumenten ingezet om de prestatie te meten? (zo ja, kwamen hier uitdagingen bij kijken?)

Deden zich uitdagingen voor met de beveiliging van de systemen? (zo ja, welke uitdagingen deden zich voor?)

Management uitdagingen

Was het uitdagend voor de managers om een efficiënte beslissingen te maken gedurende het project? (zo ja, welke uitdagingen hebben zich voorgedaan?)

Hebben zich uitdagingen voorgedaan die te wijten waren aan een kennisgebrek bij managers in het klantbedrijf? (zo ja, welke uitdagingen hebben zich voorgedaan?)

Heeft u het idee dat het project effectief gemanaged was? (zo nee, welke uitdagingen hebben zich voorgedaan m.b.t. management?)

Organisatie

Heeft u het idee dat er een gebrek aan Big Data Analytics kennis of middelen was in het klantbedrijf? (zo ja, aan welke kennis of middelen was er een tekort?)

Was er binnen het klantbedrijf sprake van verzet tegen het project? (zo ja, waaraan was dit te merken?)

Was het uitdagend voor het bedrijf om waarde te halen uit het project? (zo ja, welke uitdaging deed zich hierin voor?)

IT Outsourcing

Was het uitdagend om samen te werken tijdens dit project? (zo ja, welke uitdagingen deden zich voor?)

Deden zich uitdagingen voor bij het opstellen van het contract? (zo ja, welke uitdagingen deden zich voor?)

7.4; Appendix D

Strategisch Management	
Strategie	
Interviewvraag	*Uitdagingen*
Productiemodel/Software ontwikkelings methode	Lastig voor klanten om de techniek toe te passen zoals bedoeld was
	Wisseling van productiemodel gedurende het project zorgt voor veel tijdsverlies
Toekomst/Continuïteit	Continuïteit van het geleverde product
	Bedrijven onderschatten dat een analytics project nooit echt klaar is, in tegenstelling tot andere IT projecten
Doel Project	Bepalen Scope
	Lastig om klantvraag concreet te maken
	Onduidelijke vraag
	Predictive Analytics omzetten in actie
	Spanning binnen organisatie of het project door de IT of Business afdeling gedragen moet worden
	Uitvoeren van een ruim doel
Strategie Bepalen	Gebrek aan Data Kwaliteit
	Onwetendheid vanuit de klant
	Een gestandaardiseerd proces invoeren
	Bepalen of de dienstverlening uitgevoerd kan worden
	Certificeren product
	De strategie helder overbrengen
	Onduidelijke klantvraag
	Onduidelijkheid of het product in staat is het doel te realiseren
	Onervarenheid vanuit de klant
	Op één lijn zitten met de klant

	Overtuigen klant
	Restricties door data toegankelijkheid
	Verandering doorvoeren binnen klantbedrijf
Teams vormen	Beperkte beschikbaarheid arbeidsmarkt
	Beperkte beschikbaarheid binnen bedrijf
	Het ondergaan van screenings in geval van een vertrouwelijk project
	Kennis vergroten bij de klant
	Lastig rollen verdelen bij verandering aanbesteding
	Omgaan met veranderende klantbehoeften
	Alle partijen dezelfde richting op krijgen
Verantwoordelijkheden definiëren	Acceptatie vanuit de klant, dat de klant ook bepaalde verantwoordelijkheden heeft
	Ervoor zorgen dat partijen hun verantwoordelijkheid ook nemen
	Specificeren wat te doen als iets niet werkt
	Veel kennis klantbedrijf
	Veranderende verantwoordelijkheden bij personeelswisselingen
	Verschil in opvattingen tussen klant/consultant over wie welke verantwoordelijkheden zou moeten hebben
	Werken met derde partijen
Waarde van het project	
Interviewvraag	*Uitdagingen*
Uitkomsten doorvoeren in het bedrijf	Doorvoering binnen het bedrijf
	Besluitregels formuleren
	Uitkomsten gebruiken
	Onverwachte uitkomsten
Waarde halen uit het project	Mogelijkheden aan de klant verduidelijken

	Lastig over te brengen door onzekere ROI
	Lastig waarde project inzien bij onverwachte resultaten
Tactisch Management	
Kosten en Middelen	
Interviewvraag	*Uitdagingen*
Expertise/Middelen	Binnen de organisatie mensen beschikbaar maken
	Accurate data verzamelen
	Data beschikbaar krijgen
	Data in de juiste format ontvangen
	De juiste expertise vinden in de markt
	Investering consultant om het project te starten
	Ontvangen van data
	Toereikendheid van het budget bij een overheidsklant
	Juiste middelen verzamelen wanneer wensen veranderen
Geld vrij maken	Geld vrij maken
	Moeilijk wanneer baten onduidelijk zijn
	Omgaan met groeiende schaal van het project
	Restricties van het budget
Interne/Externe middelen alloceren	Lastig externe data generatie te garanderen
	Tijdig ontvangen van middelen
	Zorgen dat benodigde teams beschikbaar zijn
	Klantbudget bepaald hoeveel middelen de consultant in kan zetten
	Vertraging door incomplete data
Kosten/Baten bepalen	Kosten/Baten
	Baten onduidelijk
	Kosten onduidelijk

	Lastig bepalen wanneer sommige kosten afgeschreven moeten worden
	Lastig om de duur van een project te begroten
	Lock-in met het consultancy bedrijf
	Prijzen verhogen wanneer het project langer loopt
Onverwachte kosten	Onverwachte kosten
	De kosten verhalen bij de klant
	Indienen van een change request
	Omgaan met een budget

Contract	
Interviewvraag	*Uitdagingen*
Contract Monitoren	Gebrek aan kennis bij de klant
	Achteraf bepalen of product aan de verwachtingen voldoet
Data/Intellectueel eigendom	Overheidsinstanties mogen niet over elkaars data beschikken
Dienstenovereenkomst	Veel tijd in formuleren contract
	Centrale overheidscontracten
	Concrete deliverables innovatieproject

Toezicht	
Interviewvraag	*Uitdagingen*
Prestatie Indicatoren	Bepalen in welke termijn problemen opgepakt worden
	Juiste prestatiemodel ontwikkelen
	Verkrijgen van duidelijke requirements vanuit de klant
Toezicht IT activiteiten	Bij grote scope kost het erg veel tijd/energie
	Bij grote scope lastig om op de details te letten
	De planning
	Lastig wanneer de scope vergroot (tijdens een langdurig project)

	Moeilijk om de context over te dragen aan wisselende contactpersonen
	Regelmatig contact hebben over wat je oplevert
	Verkrijgen van de juiste feedback van derde partijen
	Werkzaamheden derde partijen bijhouden
Operationeel Management	
Managen van het Project	
Interviewvraag	*Uitdagingen*
Integreren van derde partijen	Het managen van derde partijen
	Integreren van derde partijen
	Lastig door gebrek aan kennis bij derde partijen
	Lastig voor derde partijen om zich aan te passen
	Samenwerking externe partijen
	Invoeren van nieuwe technologie binnen een organisatie
	Klant wil processen vaak sneller voltooid hebben
Managen van het consultancy bedrijf	Ongeloof/Overtuiging
	Geen interesse in het proces vanuit de klant
	Restricties vanuit de klant
	Beperkte kennis vanuit de klant
Personeelsverloop	Personeelsverloop
	Personeelsverzuim door vakanties
Klanttevredenheid	Lastig om klantverwachting te managen
	Te makkelijk denken over resultaten van het project
Samenwerking met de klant	In samenwerking nieuwe activiteiten uitvoeren
	Wanneer klanten vasthouden aan een klant/leverancier relatie is er weinig ruimte voor samenwerking
Veranderende benodigdheden	Onverwachte zaken in de transitieperiode

	Veranderingen in het bestuur van de klant
	Vergrotende scope
	Veroorzaakt door een steeds concretere klantvraag
	Verschillende meningen

Weerstand en vertrouwen	
Interviewvraag	*Uitdagingen*
Verschillen in bedrijfscultuur	Klant die alles het liefst zelf doet
	Lange wachttijd
	Communiceren met technici
	Verschillende bedrijfscultuur
	Beperkte transparantie vanuit andere partijen
Misverstanden tijdens het project	Misverstanden
	Lastig om verwachtingen te managen
	Over geschiktheid van de data
	Verschil in noodzaak implementatie
	Vooruitlopen op de klant
	Tevredenheid kwaliteit vanuit de klant: Ander resultaat dan verwacht
Vertrouwen Klant	Correct informeren van de directie
	Laag klant begrip door verschil in kennisniveau
	Zorgen dat de klant vertrouwd in het functioneren van het project
	Twijfel vanuit de klant over competenties van de consultant
	Adequaat communiceren over het project
	Gebrek aan kennis van het project
	Laag wanneer de resultaten pas laat zichtbaar zijn
Weerstand vanuit de Klant	Weerstand
	Onbekendheid bij de klant

	Veel sceptie binnen het klantbedrijf dat de consultant werkzaamheden kan verbeteren Wennen aan een nieuwe leverancier
Intern Conflict	Binnen het consultancy bedrijf omgaan met verschillende prioriteiten vanuit verschillende afdelingen Interne strijd binnen het klantbedrijf over wie de uitkomsten van het project kan claimen