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Evolution of Management Accountants

An exploratory case study on the role of management accountant in the context of implementing big data analytics in a production environment

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Abstract

In this paper, I explore the changes to the role of management accountants in a large energy company following the adoption of big data analytics in the production environment. The theoretical framework, technology power loop by Scarbrough and Corbett (1992), is utilized as a tool for analyzing how the adoption of big data analytics influences the role of management accountants in the production environment. This thesis was an exploratory single case study; therefore, with the opportunity to have a participative observation approach for three-week as an intern in the case company to both interview key employees and gain valuable insight by my mere presence, was essential for my research.

This study contributes to the existing literature by filling some of the gaps regarding the importance of management accountants in production settings, while also adding insight on how the role of management accountants may change in the production environment when adopting big data analytics. The changes are mainly a result of a complex production-world and the management accountants' increasing ability to adapt to their current context. The prominent view of management accountants having a binary role of being either "bean counter" or "business partner", and in some case switching between these two, is ignoring the possibility of incoherent role development within different contextual context. My findings show that the management accountants in production environments are evolving; they have a different background, skill and mindset. I labeled this new form as an *adaptive form*, because they are no longer belonging into either of the role labels, but rather just adapting to their contextual context. Thus, the role of MAs will evidently look differently based on the production environment. This paper also highlights some issues that might provide insight into why management accountant information is perceived as redundant in production environment by operations managers.

The purpose of this thesis is to provide a better understanding of the management accountant role so managers and companies can better accommodate new implementations of technological solutions while minimizing the risk of failure.

Keywords: Role of Management Accountants, *Adaptive form,* Big data analytics, Maintenances, Production environment, Technology Power Loop

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List of Abbreviations

EnergyCo	=	The focal company under study
RA	=	The focal function at EnergyCo where all the MAs work
MAs	=	Management accountants
OM	=	Operations managers
PE	=	Production environment
PM	=	Preventive maintenances
PDM	=	Predictive Maintenances
CBM	=	Condition based maintenances
CM	=	Corrective maintenances
TPL	=	Technology power loop
Big Data	=	myriad of raw unstructured information (sensor data, e-post, etc.)
BDA	=	Big Data Analytics
PowerBI	=	Sophisticated visualization tool
SAP Lumira	=	Sophisticated visualization tool
IIoT	=	Industrial Internet of Things
ML	=	Machine Learning
AI	=	Artificial Intelligence
“Push”	=	Products are pushed through the channel on the end-users.
“Pull”	=	Development of dashboards are driven by actual customer demand

1. Introduction

"Technology is leaping faster than the organization's ability to use it"
[Other, Strategy Advisor – 05]

This quote from one of the interviewees describes one focal obstacle's legacy companies struggle with these days. The recent trend amongst organizations reveals the potential of untapped Big Data (myriad of raw unstructured information). Thus, leading to a heavy focus and investment into technology that can grasp and utilize the underlying potential — resulting in increasing popularity due to the indication of cost decrease, increased flexibility and more fact-based (data-driven) decisions. Big Data Analytics (BDA) technology enables organizations to take more accurate decision based on analyses, offering new work processes, a shift in decision-making, hierarchies and structural change.

This study explores the role of management accountants (MAs) and how it is influenced in a production environment (PE) with the adoption of BDA. Notably, with the intentions of optimizing maintenance activities and minimizing costs.

MAs has one crucial indicator of importance, that the information they generate leads to action (Bruns Jr. & McKinnon, 1993). There is an ongoing debate regarding management accountants providing information in an organization, and how the role of MAs has had different forms and shapes throughout the last decades. In the early 20th century MAs were associated with "bean counter "/ "number cruncher" activities but later became more similar to "internal consultant" that provides information and a proactive business views for managers decision making (Malmi 2001, Windeck et al. 2015).

In this study, MAs are classified as analysts working towards achieving effective processes that lead to noticeably cost savings in PE and helping operations managers (OMs) take better decisions. However, the focus will be directed on the relation between MAs and operational work. In this new and complex production-oriented world, actors demand higher information quality from the MAs. This has led to much criticism for the perceived irrelevance of information MAs contributed to operational work in the last three decades, because of its lack of adaptation to practicality and local settings. As a result, this type of information faces the obstacle of being perceived as less relevant to operational work than other sources of corporate information (Curry, Hersinger, & Nilsson, 2019).

Previous studies have been mostly focusing on MAs in the traditional business analyst environment from a theoretical research perspective (Bruns Jr. & McKinnon, 1993; Malmi 2001; Windeck et al. 2015). Meaning the MAs conducted an analysis based on financial data to lay a solid foundation for decisions. In the digital era, with the increasing availability of Big Data, this study argues that a different type of management accountants has been evolving than formerly in the PE. The new generation has different attributes, competence and background to meet the requirements of various production settings. In this case, none of the MAs had business education, but they were instead engineers with respective masters and PhD degrees, which could lead to a lack of understanding of business and cost-saving optimization fundamentals. A skillset some may argue is necessary to have when trying to minimize costs.

However, there are too little studies to my knowledge that provides enough insight about management accountants in a PE, and their relationship with operations managers (OMs). Curry et al. (2019) argues that OMs fancy information that is contextually anchored in the local operational setting rather than the MA information. Therefore, the traditional MA role can be perceived as inadequate when it comes to flexibility which is required and vital for operational work in a local setting.

A consequence of utilizing the enormous amount of untapped data in analytical data-driven decisions is the need to trust the numbers. This entails making several changes in the organization to accommodate this technology. Firstly, OMs need to feel safe and trust the numbers and analysis, which is essential because most of them are used to make decisions based on their experiences, making decisions highly subjective. Secondly, structural change is needed, because now OMs are required to take risks based on analytical information that they know little about, which is very challenging. Therefore, the risk that previously fell on the OMs should be divided onto the MAs too, so the OMs can be assured that the potential downsides are carefully assessed. Finally, every individual throughout the maintenance process should know precisely how the data they are providing is used in the data-driven decisions, and why it is vital to achieving high data quality.

More research is needed in this field to fully grasp the underlying factors and variables for optimal technological utilization. Although previous studies show a profound effect on the role of MAs when introducing new technology (Hofstedt & Nilsson, 2018), the new era of digitalization has led to an imperative need for more practical and diverse study approaches towards the modern evolution of the MA role. Notably, to understand the emerging complexity regarding PE. In other words, there is a need for more in-depth study of the impact and change to the role of MAs when introducing new technology, i.e. analytical data-driven decisions. Thus, the research question is:

How does Big Data Analytics influence the role of management accountant in a production environment?

To answer this research question, an exploratory single case study was conducted in a large energy company (EnergyCo) that had just started an extensive digital initiative with the use of big data for analytical purposes. To investigate the role of MAs in this specific setting a conceptual framework from Scarbrough & Corbett (1992) was used to shed light onto the inter-relationship between different actors in the studied production setting (maintenance process). With a particular focus on the implementation of BDA technology and the recursive relation amongst expertise, control of technology and development of technology. More specifically, these aspects and the Technology Power Loop were used to research the effect of adopting analytical data-driven decision technology and the ramification it has on the role of MAs in a PE.

The findings of this study contribute to the existing works of literatures on the MAs role in a PE (maintenances process). It contributes to the current research on the MAs role when exposed to new technological implementation (analytics). Firstly, we illuminate the changes in the MA role experience in this setting. Which is distinguished from an academic perspective considering hitherto literature focuses mostly on the traditional MA role in a business setting.

Secondly, there is no previous study to my knowledge that has analytical data-driven decisions and the MAs role in a PE as the focal point of their research. The findings suggest that there is a shift in how MAs are organized, their educational background and their competence when working towards PE; an evolution. Primarily, because production processes are so complex that the individuals conducting analytical work need a significant understanding of several underlying factors. Resulting in a new form of MA functions, an *adaptive form*, where the only one with business education and financial knowledge is the manager — raising concerns whether the MAs have the necessary understanding of business and financials to optimize cost savings. These findings have led to the discovery of this new function, that does no longer include MAs with a business background, but rather engineers and tech-heavy experienced individuals. We could argue that the driving force behind this change was that the traditional

MAs lack the flexibility which is required for operational work in a local setting (Curry et al. 2019) and the increased availability of technological solutions.

Adding to the study of Curry (2018) and Curry et al. (2019), the findings display a transition in the role of MAs and the importance of a mutual understanding relationship between the OMs and the MAs. Hence, suggesting that we should look at the role of MAs as situational in PE. It is no longer just business individuals that conduct the necessary analysis, but rather someone that understands the holistic and complex part of the processes and work closely with the end-users. OMs have done things in their way for years. Therefore, to convince them to base their decisions upon MA-information requires: 1) assuring them that the solution reflects the full landscape of the problem under the scope, 2) be assured that there is an evident cost saving without sacrificing safety.

Lastly, this dissertation adds to the literature on Technology Power Loop when used to assess technology in PE, appealing that in the development of technology, end-users should be included. In this way, the users will trust the information that is presented, and MAs will still have the control of technology, which will affect expertise, and result in parity of power throughout the loop. Resulting in shaping, influencing and defining the role of MAs in PE.

This paper is structured as follows. The literature review is presented in chapter two explaining, firstly, the background, transformation and how the role of MAs are in PE. Secondly, the theoretical perspective explains what the fundaments of Big Data Analytics (BDA) and how this is connected to digitalization in maintenances. Thirdly, presentation of the theoretical framework (Technology Power Loop) is displayed in unison with the role of MAs and BDA.

Chapter three contains the methodology of my thesis: The research design, Data collection, Data analyses and Limitations of the research. Followed by Empirics in chapter four, where I present all my findings by using the theoretical framework as pegs to categorize the data. Shortly after, the discussion about the findings and its implications for the role of MA takes places in chapter five. Lastly, chapter six will present the main findings of this thesis. Followed by practical implications for EnergyCo in chapter seven, and research implications and recommendations for future research in chapter eight.

2. Literature review

The theoretical base for this study is reviewed in the following sections. In 2.1 the role of management accountant is discussed and presented. Further, in 2.2, theoretical perspective for each subsection regarding *Maintenances*, *big data* and *analytics* is introduced. Finally, section 2.3 will lay the foundation for the theorical framework in order to guide the findings afterwards.

2.1 The role of management accountant

2.1.1 Background

MAs have long been conducting multiple tasks and was previously associated with the characteristics as *attention directing, record keeping and problem-solving* (Simon et al. 1954). These three points comply with different parts of organizational work (e.g. compliance, control-type issue and problem-solving information) that helps managers take better-qualified decisions (Emsley, 2005). MAs were earlier identified as someone crunching numbers, providing temporary reports and aggregated analysis, labeled the "Bean counter".

> «An accountant who produces financial information which is regarded as of little use in efficiently running the business and, as a result, its production has become an end in itself» (Friedman & Lynne, 1997)

Forming a standardized and static view of the accountant, leads organizations to develop a consensus that the role of MAs was to conduct financial analysis, reports and gather information, but lacking real influence over business decisions and strategy (Windeck et al. 2015).

Johnson & Kaplan (1987) criticized this form of MA for having too much focus on the past and that they were working in a reactive way. Meaning, what they measured was aggregated historical data, and too late to have an influence in present decision making. He further argued that the "bean counter" could easily lose sight on reality and focus only on the numbers. In other words, the traditional role of MAs, the "bean counter", could not provide managers with any tangible, value-adding business synergies.

2.1.2 Transformation of the management accountant role from Bean counter to Business partner

During recent years, we have had extensive academic discussions regarding the shift in the role of MA. Arguably, the evolution of MAs has been the result of their adaptation to technological advancement. Thus, the traditional view of MAs faded with time and companies started to see the full potential of utilizing MA-information. Study in this field shows that MAs have gone from being scorekeeper and watchdog (bean counter) to taking part in advising management and have increased participation in decision-making (business partner) (Granlund & Lukka, 1998; Siegel and Sorensen, 1999; Burns and vaivio, 2001; Holtzman, 2004; Burns and Baldsvinsdottir, 2005). The previous litterateur also describes the new MA role in various ways, such as business partner, modern business-oriented accountant, internal business consultant, strategic management consultant and hybrid accountant (ibid.). Nevertheless, all of them have still the same characteristics of influencing the decision making and supporting the management.

However, some part of researchers argues that the stereotype of MA labelling in a binary fashion (bean counter or business partner) is too simplistic (El-Sayed & El-Aziz Youssef, 2015; Hofstedt & Nilsson, 2018). El-Sayed & El-Aziz Youssef (2015) further explain that MAs are adaptive to *modes of mediation* (configurations of technologies, artefacts, entities and spatial settings) and that MAs are adjusting to fit their current context. Building on this litterateur, Hofstedt & Nilsson (2018) suggest a new typology for labelling the MA role: Hybridization, applying even more pressure on the MA-paradigm that views this role as binary. Some even claims that MAs are switching between the stereotypes rather than belonging to one of them (Mack and Goretzki, 2017). These studies give us a clear awareness of the complexity regarding the role of MA and lays the foundation for future research within this field.

2.1.3 The role of management accountant in production environment

As aforementioned, MAs have shown the ability to adjust to their environment and settings. Some findings suggest that MAs play a crucial part in shaping of their role (Byrne & Pierce, 2007), thus raising the question if we need to study this function and role at a more detailed (micro) manner, rather than from a bird view (macro), to fully grasp the underlying factors.

One area where researchers have been aiming their discussing for in recent times is MAs capability to provide the necessary information in the production environment (PE). There is an ongoing discussion where operational managers (OM)-, and MA researchers argue regarding the level of relevance MA has in PE. Some critics even claim that MA is redundant in PE (Hansen & Mouritsen, 2006). Most of these opinions have emerged as an outcome of weak results from the work MAs have done in PE. It is even claimed that MAs attempts to decrease costs instead would increase them. However, Curry (2018) argues that there is a need for a nuanced portrayal of management accounting in PE. Furthermore, she calls for a challenge against the research expectation and to accept unconventional research methods by adding more knowledge to studies about MA in PE to fully understand the complexity.

Hansen and Mouritsen (2007) point out some central issues with MAs - the historical connotation of MAs managing operations from a distance leads to an impediment when searching for answers of what to do, and how. Therefore, MAs are looked as unsuitable in PE, and potentially having a negative effect on the desired outcome. However, some acknowledge that the field of MA and OMs are interrelated since they can gain knowledge from each other (ibid.). Curry et al. (2019) shed light on the importance of understanding the behavior of OMs. They seem to prefer information with a contextual anchor in local operational settings. Hence, traditional MAs may be categorized as having inadequate flexibility (the ability to customize their analyses according to the situation), which is essential when working in a local setting.

Flexibility is a vital part of operational work, being why this has also received particular focus in the design of MA systems in the pursue of overcoming flaws in traditional MA. These kinds of integrated systems provide the flexibility for OM to extricate information they seem essential for their operational work, by facilitating collecting, managing and analyzing information in “real-time” without having to wait for monthly reports (Davenport, 2000).

Some local systems are developed just for the sake of complementing integrated systems (Dechow & Mouritsen, 2005), and notifying OMs about the need to improve operations and reduce cost (Jönsson, 1998) . This is explained by Van der Veeken & Wouters (2002), they state that the knowledge OMs possess about production processes enables them to visualize aspects that might be invisible for MA systems. Thus, the local system may have surpassing information value to OMs than the MA systems, which might be the reason they don’t always adopt MA information. Moreover, Curry et al. (2019) pose the reflection about the information that OMs find useful:

> "Operations manager should be given the opportunity to evaluate the information they use and find relevant to their operational work. More specifically, there is a need to explore the types of management accounting information operations managers use, understand how they use it, and analyses the reason for which they use it"

There is little to no research within this field to fully draft an answer for the type of MA information OMs use and the whole reasoning behind this. Leading to a clear gap in the field of MA in PE, that need to be covered in future studies

Chenhall & Morris (1986) acknowledged that environment and organizational structures had influenced the relevance of MAs, and if appropriately utilized MAs can contribute to improving their company's performance. Nonetheless, MAs may be excessive in production orientation operations if decisions are based on MA information that is not aligned with process-orientated objectives (Maskell, 2000; Curry et al. 2019). The perceiving view of MAs might be affected by the overload of information they provide for operations managers. Thus, the information should be "carefully chosen and contextualized relevant to the operations managers if it is to generate action" (Curry et al. 2019).

2.1.4 Concluding remarks on previous literature

The MA role has been researched in several different settings in the last half-century. Academic professionals share the same opinion when it comes to transformation in the role of MAs; the time for bean counter has passed, and MAs are perceived as a strategic business partner, with influence in decision making (Burns and Baldsvinsdottir, 2005; Windeck et al. 2015 Winde). However, there is new studies arguing for hybridization of the MA role in specific settings (E.g. introducing ERP and other company-wide IT systems) (Hofstedt & Nilsson, 2018). Some even argue that the MAs are switching between bean counter and business partner (Mack and Goretzki, 2017). Hence, adapting to the requirements of different situations.

MAs are no longer only connected to financial analysis, but rather involved in several parts of a company (Burns and Baldsvinsdottir, 2005). It is notably the role of MA in a PE that has gotten researchers to debate whether MAs are essential for OMs, or if they are just a redundant workforce (Hansen & Mouritsen, 2006). Some researchers even claim that MAs harm cost minimization in PE. One key issue is the MAs ability to be flexible and provide information with a contextual anchor in a local operation setting (Curry et al., 2019). In an attempt of overcoming flaws in traditional MA, some customized designed MA systems were developed, to provide flexibility for OM to extract necessary information (Davenport, 2000). This is also one of the enigmas in the literature that has been illuminated. There is a need to understand the behavior of OM and understand what kind of information seems relevant for their operational work (Curry et al., 2019). Because of this gap in the litterateur, Curry et al. (2019) ask for more studies within this field to understand the role of MA in PE. Primarily, studies conducted on micro-level instead of macro-level.

2.2 Theoretical Perspective

2.2.1 Technology Background

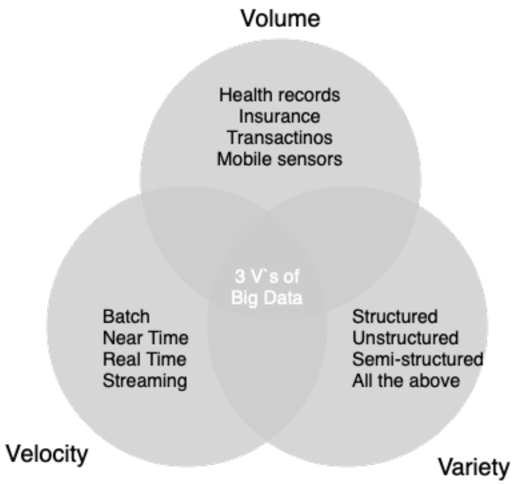
We are indeed in one of the fast-changing technology phases of human history. The world's most valuable resource is no longer oil, but data (The Economist, 2017). Leveraging this resource for visualization, structure and support optimal decision making has become a commercialized privilege for many companies. Visualization tools like Power Bi and SAP Lumira have become a well-used tool amongst companies with substantial data lakes (system or repository of data stored in its natural/raw format) that want to sort and visualize it in an easily and understandable way.

Companies have had a rapidly growing volume of data, sourcing from different areas of the business, e.g., transactional data and access to trillions of bytes of information about customers, vendors, operations and production process. Error historic of equipment from an enormous amount of networked sensors that are integrated into the physical world is also a fuel source for data — covering everything from mobile phones to industrial machines that create and communicate data in the era of IoT (Mckinsey & Company, Inc., 2011). Despite the current optimistic view, Big data was an issue just a few years ago, with root caused back to storage and CPU-technologies being overwhelmed by an exponentially growing data volume in the early 2000s, resulting in a scalability crisis for IT (NG Data, 2018). However, once more, we dodged this problem with Moore's law, a remarkably prescient observation that the number of transistors on an integrated circuit would double every two years. Rapid development within storage and CPU technology resulted in paramount capacity, speed and intelligence; they also fell in price. Big data was no longer an issue, but rather an opportunity to achieve a competitive edge.

2.2.2 Big Data

"The enhanced role for business analytics is driven by an explosion in the amount of new data available for analysis." (Brands & Holtzblatt, 2015)

TechAmerica Foundation (2012), in their attempt to demystify big data, states that this form of data is not a technology, but somewhat a phenomenon as a result of an immense amount of raw information generated across society and collected by commercial and government organizations. They further define it as,



"a term that is used to describe data that is high volume, high velocity, and/or high variety; requires new technologies and techniques to capture, store, and analyze it; and is used to enhance decision making, provide insight and discovery, and support and optimize processes." (ibid.)

Figure 1: Examples of data sources for high-, volume, velocity, and/or variety.

High volume, velocity and variety describes that big data increases, it comes quicker, and it comes in different forms. Figure 1 show some of the sources where big data emerges from. The volume and variety of computer-generated data have doubled every two years, and most of it has origins from unstructured (because it is raw) data such as emails, twitter, Facebook post and images (Rajaraman, 2016). The big data use cases are massive; for example, companies can through this opportunity get insight into customer's preferences and purchasing behavior, which is providing them with an enormous advantage when customizing products and services, specific to the respective individuals.

Industrial big data is the same phenomenon as ordinary big data, but instead of accumulating data from customers, it comes from industrial machines, and it requires a stronger computing power. IIoT-sensors (sensors connected through Industrial Internet of Things) integrated into machines produce a massive amount of data. This data is categorized as substantial heterogeneous data (ibid.) and could contain everything from vibration-, and pressure data from pipes to errors in systems and equipment.

2.2.3 Analytics - Data driven decision

Analytics is defined by Gartner (2019), as something that is used to describe statistical and mathematical data analysis that clusters, segments, scores, and predicts what scenarios are most likely to happen. Previous research shows us that analytics have been used a lot during the half last century in both different forms and complexity, but not necessarily in combination with big data (Russom, 2011). Analytics covers a wide range of topics, both in breadth and depth.

McKinsey Global Institute (2016) argues that analytics that leads to data-driven decision have been shaking up multiple industries, and the effects will only become more definite as adoption reaches critical mass – and as machines achieve unique capabilities to solve challenges and understand language. Therefore, those who are in the frontier to harness these capabilities effectively will be able to establish momentous value and differentiate their organization, establishing an essential advantage in contrast to their competitors.

However, Russom (2011) further reveals that there is a rush to analytics, which results in many organizations embracing analytics for the first time and thus get confused about how to properly use it. This is also supported by McKinsey Global Institute (2016), they emphasize the hard work that legacy companies must conduct by overhauling or change existing systems. Some companies have invested densely in technology yet lacks the necessary changes in their organizations to make the most out of those investments. The struggle to develop business processes, talent and organizational muscle to capture real value from analytics is a real issue (ibid.). Furthermore, it is essential that the results from analyzing data must be presented effectively, or else it is virtually useless. Managing to communicate findings with key stakeholders as effectively as possible, is a must (Miller, 2019).

One way of presenting the findings in an understandable way for stakeholders is through sophisticated visualization tools, like Power BI and SAP Lumira. Nevertheless, there is still issues and still some way to go within data visualization (Wang, Zhang, Shi, Duan, & Liu, 2018) when it comes to presenting the true reflection of a complex reality in a simplistic way.

2.2.4 Big data analytics

BDA is really about the two aforementioned sections – big data and analytics. Hence, BDA is where advanced analytic techniques operate on big data (Russom, 2011). BDA usage has been, during the last two decade, on the agenda for many companies, especially with their exponential growing data volume, cheaper computing power and sophisticated analytic software's available in the market (Laventhal, 2011).

Organizations use this phenomenon to take better decisions in their business (data driven decisions), which can be seen by the increase in analytics parallel with the growing raw data. However, as previously mentioned, it is vital to have the right and accurate analysis in order to take the optimal decisions. When companies rush with BDA, inappropriate analysis of big data can lead to misleading conclusions (Rajaraman, 2016).

2.2.5 Maintenances and its digitalization journey

In order to grasp the underlying connections of maintenances, technology and business, the sections are structured as following. Firstly, an introduction of the maintenances background is presented to give a holistic understanding of the status quo and how important maintenances is for industrial companies. Secondly, a presentation of what maintenances is and how many branches it is divided into is provided. Furthermore, in this section, a description of the three most used maintenances strategies will presented with a table that displays the pros and cons with each strategy.

Additionally, a historical overview of the development of maintenances will be provided to enlighten the reader about the extensive evolvement maintenances have gone through since the 1940, and how technology have played a part in this. Then, a short description of maintenances in Oil & Gas (O&G) sector will be presented to show the value, proper maintenances, provides for companies like EnergyCo and explains their incentives to reach best practices. Followed by a conclusion on the litterateur presented so far.

2.2.4.1 Background

Development within every type of industrial sectors is moving towards a capital-intensive and technical, complicated constructions and machine. These types of equipment often have high interruption costs, thus rigid requirements to regularity and efficiency, safety level and life cycle cost (Thematic Research, 2019). The government have increased demands in regulations and requirements with regards to working environment and safety. Companies are trying to meet these requirements, while also securing their competitive and economical advantage (Stenstrom et al. 2015).

Industrial maintenances have evolved in the last 60 years and have become a strategic concern for companies across different industries. The transformation of maintenances within the organization has been, rapidly, moving from a mere inevitable part of the production, to become an essential aspect of how a company achieves its desired strategical objectives. Previously, production and manufacturing industries did not have a full capacity utilization because of lower demand; therefore, when a failure occurred, they had time to conduct corrective maintenance without affecting the production and delivery of the order (Rastegari, 2017). However, this is not the case now. A small delay in production will have tremendous ripple effects on the whole value chain, leading eventually to high costs.

Costs connected to operations and maintenance of industrial plants is imperative for profitability and survival of many companies. Belgian Maintenance Association (2016) estimates that the European Union spends 10% of its GDP on overall maintenance, which results in about 1200 billion euro per year. This is equivalent to 35 million people working full-time (7% of the European population), whereas 6 million of them are employed within industries. Experience and previous projects have proved possible to reduce maintenance costs in Norway, with up to 20% (Bye, 2009). Formerly, maintenance has often been recognized as a “necessary evil”, and not as an investment to achieve better profitability. Mainly because when discussion about cost reduction emerges, the measures are often either reorganization or downsizing. Investments in maintenance competence and technology have previously not perceived value contributing; however, this has changed. Companies are now acknowledging the benefits emerging from integrating technology in maintenances, because, using the right tools can improve the efficiency and productivity of their maintenance processes.

In this thesis I have limited the definition of maintenances to only embody the activities conducted in the PE.

2.2.3.2 What is maintenance?

British standards institution (2010 p.14) defines the term maintenances as a “combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function". Maintenance is a highly costly source for industrial companies; however, maintenances are very broad, and the differences on maintenances practices for various industries is significant. Thus, so are the costs. Companies have substantial losses connected to decrease in production efficiency, therefore, to minimize that loss, the asset integrity (operative time of critical equipment, component and plants) must be obtained at a certain level at all time. During the lifetime of machines, different approaches towards maintenance have been central, which is illustrated in Figure 2.

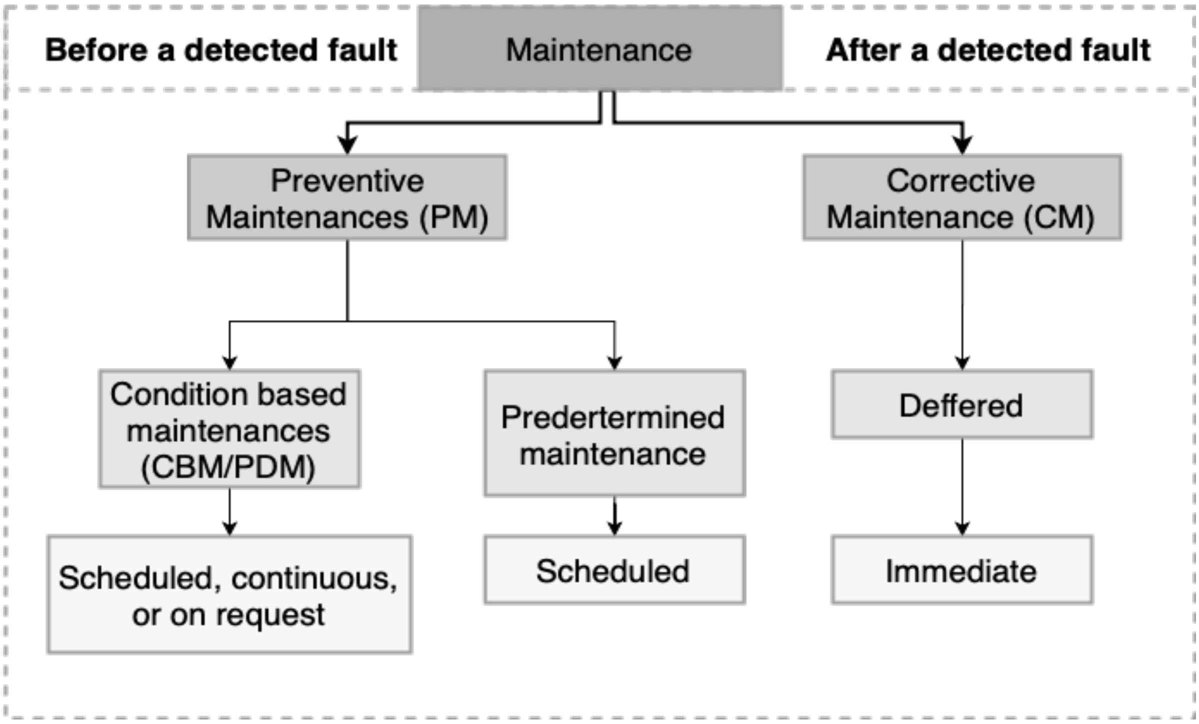


Figure 2: Overview of different maintenance approaches (British Standards Institution, 2010)

Figure 2 shows us that maintenance is divided into two groups, Preventive maintenance (PM) and Corrective Maintenance (CM). PM corresponds to "retaining in", meaning the goal is to retain the status quo condition of the equipment. In contrast, CM corresponds with "restoring to", meaning restoring the condition of the component to satisfying (functional) level. PM is yet divided into predetermined (periodic/time-based) maintenances and condition-based maintenance. CM is divided into Deferred and Immediate. Cooke and Paulsen (1997) define proper maintenances with two characteristics; 1) few CM activities are conducted and 2) as little PM as possible is undertaken, and as a result of this we achieve low downtime, thus high production efficiency. Different technological solutions are used in each one of these strategies to optimize maintenances activities and gain other benefits (e.g., simplifying procedures, optimizing equipment, provide better maintenances schedules and scaling education of employees) to cut costs. Below, is three of the most implemented branches (strategies) are explained more in depth.

Corrective Maintenances – "Run-to-failure"

CM has previously been the standard of conducting maintenance within industrial companies. This kind of maintenance is associated as profoundly costly because it results in unpredicted stops and potentially damages equipment and machines (Bye, 2009). CM practice is not desirable for managements in current management practice because of the high costs (ibid.). If maintenance is done after an equipment breakdown as a result of the "Run-to-failure" strategy, equipment's are driven to breakdown and then exposed for CM. This is more commonly used for non-safety-critical equipment's and when the costs to "run to failure" surpasses the gain of conducting maintenances (Bjarne Syre, 2009).

Preventive Maintenance – "Fix it before it breaks"

PM is conducted before a function failure occurs and contains activities with the primary purpose of; 1) preventing potential failure which could damage components, 2) preventing harm to humans and environment, and 3) reduce the need for CM (Bye, 2009). Additionally, this type of maintaining is essential to maintain a sufficient level of safety, while also maintaining regular and routine maintenance to support components and equipment's, and decrease their probability of breakdown (Amiri, Honarvar, & Sadegheih, 2018). Predetermined Maintenance is what we know as the traditional PM, but since technology has evolved, we also have gotten a new branch called condition-based maintenances (CBM), also known as predictive maintenances (PDM).

The ideal maintenances - Predictive maintenance. "If it ain`t broke, don't fix it"

When computers turned into a commodity, companies could use them to track and prescribe the respective predetermined maintenances intervals before their deadline was due. During this period, it was not common to store systematic registered data from the maintenance to determine the proper length of the maintenance's intervals. Thus, leading to change and reparation of components long before it was necessary, resulting in unpredictable high maintenances costs. Predictive maintenance (PDM) and condition-based maintenance (CDM) are terms often used about each other. PDM is maintenances strategy that bases their maintenance assessment on the real-time condition of the platform, with information derived from embedded sensors, external test and measurements with the help of built-in diagnostic equipment (Mrad, Foote, Victor, & Jerome, 2013). In practice, it could mean that employees can look at a screen and see in real time what kind of temperature and pressure each individual valve have, and if any deviation in data is observed actions will be taken shortly. PDM has been adopted widely in O&G industry over the last two decades. Volatility in commodity price is pressuring the industry to cut operational expenditure by optimizing maintenances scheduling, and by that increase the productivity (Thematic Research, 2019).

> "Adoption of predictive maintenance can help in early detection of faults in equipment, thus minimizing unplanned downtimes." (Ibid.)

In the last years, different kind of technology has been used to achieve optimal PDM. Mrad et al. (2013) analyzed and found indications that areas with the highest impact on CBM are sensor technologies, health assessment and analytics (which includes prognostic and diagnostic methods), communications technologies, and decision support. Notably, not all of these areas are equally mature. However, with easier adoption of technologies and cheaper prices, companies can achieve a more comprehensive implementation of CBM, particularly in the O&G sectors.

It is important to understand both sides of sides of every single maintenance's categories; positive and negative. We can observe from Syre`s (2009) table, there is a trade-off between having greater possibility to prevent errors and failure, implementation of that strategy and keeping the cost down, and vice versa. Table A explains why companies are using different kind of maintenance strategy for their production sites.

	Implementation	**Possibillity to prevent errors and failure**	**Knowledge demand**	**Investment requirements**	**Operation costs**
Corrective maintenance	Easy	Small	Small	Small	Small
Calender based preventive maintenances	Relatively simple	Relatively good	Competence to observe	Limited planning of intervals etc.	Limited
Condition based	Relatively complex	Good	Knowledge about surveillance	Significant	Limited
"Design out" demand for maintenances	Difficult	Excellent	Design knowledge	Significant	-----

Table A: Positive and negative sides with possible maintenances strategies (Bjarne Syre, 2009)

2.2.3.3 Development of Maintenance

The development of maintenance has been "provoked as a result of the increased complexity in maintenances processes and variety of products, growing awareness around the impact of maintenance on the environment and safety of personnel, the profitability of the business and quality of products" (Arunraj and Maiti, 2007). They further introduce categorization of the evolution of maintenance over time.

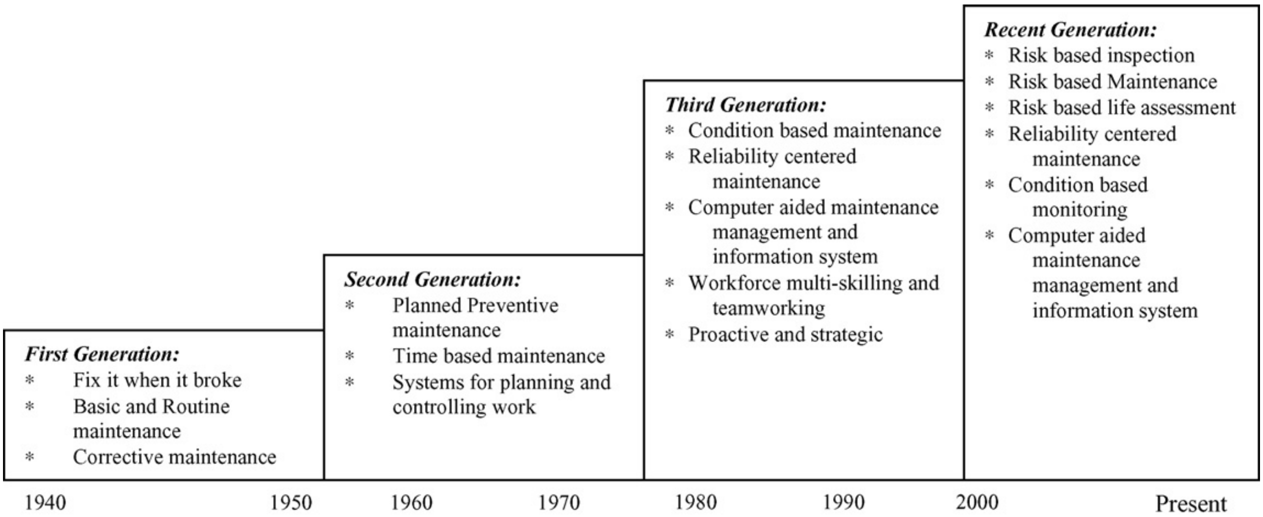


Figure 3: Categorization of the evolution of maintenance over time (Arunraj & Maiti, 2006)

First Generation

The first generation was mainly practiced during the time before the Second World War. With little mechanized industries, the mind-set was affected by essential and routine maintenance, and a reactive approach to failure, which results in CM.

Second Generation

This generation was primarily practiced during the period between World War 2 and the 70ths. During this period, industries were characterized by greater decency on machines, and the cost associated with maintenance became higher than the operating costs. Therefore, organizations used policies like planned preventive maintenance, time-based maintenance (TBM) and system for planning and controlling work. Notably, companies were criticized for having too often unnecessary treatment, which negatively affected the standard operations, and resulting in loss of potential production.

Third Generation

This generation took places between the 80s and 2000 and was typically defined by extended growth in plant complexity, advanced use of automation, Just-in-time (JIT) production system, rising demand for the standard of products and service quality and more tight legislation on service quality. This generation introduced the maintenances techniques; Condition-based maintenances (CBM), reliability centered maintenances (RCM) and computer-aided maintenances management.

Fourth Generation

The increased focus on risk-based inspection and maintenances, in addition to CBM and RCM, evolved and became famous even after 2000. Before 2000, safety and maintenances were distinct and autonomous activities. In this generation, which covers 2000 and until now, technological advancement has been enormous, enabling industries to have more sophisticated RCM and CBM while having risk as focal in the assessment. Companies have access to myriad amount of data that gives a good fundament for a data-driven decision based on analytics and reliable information systems. Industrial internet of things (IIoT) sensors is one of the core drivers for providing live data which allows those responsible for condition-based maintenances to make decisions in seconds.

2.2.3.4 Oil & Gas recognize technological usage in maintenance

Kusumawardhani (2016) states that the O&G sector faces significant challenges to ensure that future production and economical is optimized. They are struggling with current issues such as growing maintenance backlogs and facility unreliability. The development in the 90ths have been affected by changes in O&G companies' planning and execution, primarily, because of stricter demand regarding profitability (AAD, 2001). With increased access to sophisticated data machines, industry companies have gone from a primitive maintenances process to leverage their historical maintenance data to build an optimal maintenances management system.

2.2.3.5 Concluding remarks on previous literature

Maintenance has been an essential part of the company's activities and investment area in the last two decades. The main drivers behind the paradigm shift within this field has been because of 1) cost pressure, 2) the need to have a proactive approach rather than reactive in order to minimize or eliminate machinery breakdown, 3) ageing infrastructure, which leads constant need for inspection and monitoring, and 4) shortage of skilled workforce. This has resulted into the invention of different maintenance strategies and techniques. (Thematic Research, 2019).

However, all the different maintenance strategy and technique have their pros and cons (Bjarne syre, 2009; Malmholt, 1997), which is illustrated and summarized in Table A. The maintenance strategies with a massive effect on the possibility of preventing failure or breakdowns have the downside of both substantial investment cost and demanding knowledge from the employees. Meaning an optimal maintenance strategy varies from industry to industry, depending on whether the potential gain and benefit exceed the underlying costs and downsides. Previous literature indicates that PMD/CMD, compared to CM and traditional PM (Predetermined Maintenance), is remarkably more challenging to implement in companies because if its complexity (Arunraj & Maiti, 2006; Bye, 2009; Bjarne Syre, 2009).

2.3 Theoretical Framework

2.3.1 Framework for studying the role of management accountant and technological innovation in unison.

My review of current organizational and management research show that technology, especially information and communication technology, is changing the way some businesses create and capture value, how and where people work, and how decisions are taken (Cascio & Montealegre, 2016). Integration and implementation of a new technology into a company will yield ripple effects that changes the dynamic of the organization. Previous literature argues that changes in the role of certain actors in an organization is just a secondary effect of how employees interact with the technology (Hofstedt & Nilsson, 2018; Dechow, Mouritsen 2005, Quattrone, Hopper 2005), and not directly because of the technology itself. Therefore, it is essential to have a fundamental understanding of the entire forces that shapes the technological process, and its effect on the role of MAs. Making it evident to study the role of a MAs and technology implementation in an exploratory case study to fully observe the driving force behind the changes. The Technology Power Loop from Scarbrough and Corbett (1992) provides precisely this opportunity. This framework allows us to clearly study MAs, BDA and PE in unison, to fully understand how BDA influence the role of management accountant in a PE.

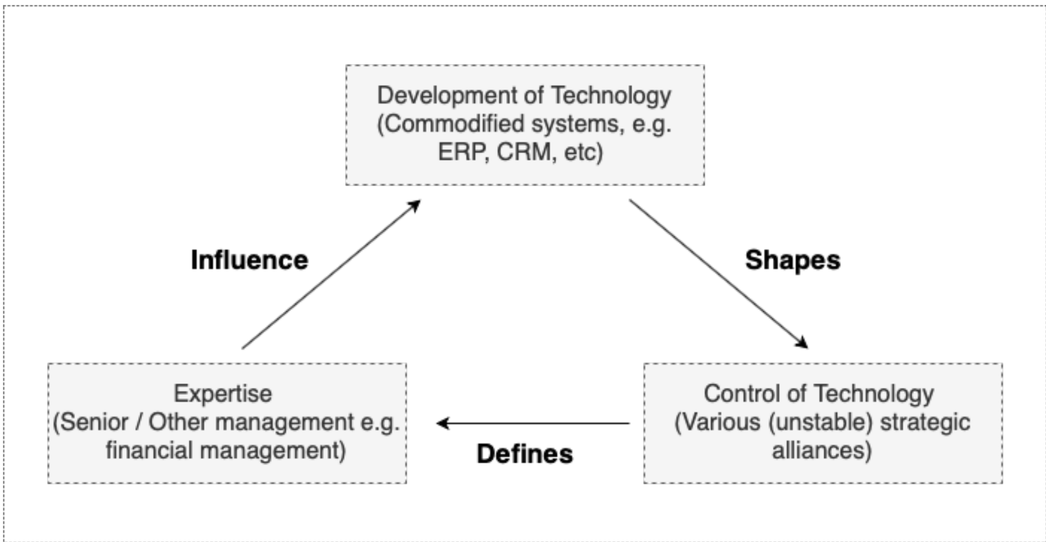


Figure 4: Theoretical framework. Technology Power Loop developed by Scarbrough and Corbett (1992).

2.3.2 The Technology Power Loop as a tool to understand how technology influences the role MAs in a production environment

The Technology Power Loop (Scarbrough, Corbett 1992) depicts the relationship the forces that shape the technology process at its nexus with the individual organization. Relationships between expertise, technology and control and how internal, and external actors influence it. There is a loop and continuous rotation between how *expertise* influences the *development of technology*, how that development shapes the *control of technology*, and how the *control of technology* in turns defines *expertise*. Following individual powers, we can identify the shape of power distribution between different actors involved in the expertise, development, and control of technology. Primarily, to find out if there is a parity of power, or if it is centralized with one player.

This framework will be utilized as an analytical tool for understanding the synergy and ratification of technology amongst different parts within a company. It can be viewed as a conceptual framework that portrays imperfect power parity and tension between different actors. The way expertise, control and development are imitated affects the organizations. Notably, how these three aspects are mobilized consequent in the presentation of new technology can change knowledge, internal organizational communication and roles. The powerful liaison is in repeated rotation and show us how control of technology is leading to constantly changing expertise. Nevertheless, if control of technology is somehow unclear then the actors with the expertise might leverage their position, and centralization of power might occur.

Scarbrough and Corbett (1992) further argues that technological process of organization or industries might be biased to the vocational expertise, and not inversely. Resulting in a ´power loop` – "in which a powerful expertise is able to reproduce itself by maintaining complete control of the technology process" (ibid., p45). With technological determinism, organizations have no option but to adapt their technique and job to the requirements of technology.

2.3.3 Big Data Analytics and the Technology Power Loop

This section presents how data driven decision, as a result of BDA, is leading to better decision making in various businesses. Technology Power Loop illuminates how expertise, development and control of technology in legacy companies might change with the increasing leap in technological development and utilization. It can be argued that if the right analysis of the data is in place, the expertise from certain actors is no longer needed to take optimal decision. Nor is it necessary to base all decisions on subjective assessment of the situation. Hence, data driven decision provides an opportunity to be objective and take decisions based on facts. Thus, a minimalization of expertise occurs, resulting in shift of power between actors.

In a legacy company where majority of technological development is outsourced to external stakeholder, including vendors and consultants to maintenances, upgrade and support, have a great impact in the definition of the technological process. Suddenly, a new layer of actors is added. An illustration of how expertise is constantly changing. As BDA provides a fact-based decision making by utilizing existing data, the traditional way of taking decisions are reproduced. Thus, the role of MAs, and the liaison between expertise and technological development will evolve.

3. Methodology

How does Big Data Analytics influence the role of management accountant in a production environment?

Beneficial to answering the research questions in the most optimal way, I have chosen to structure the methodology in this following way. Section 3.1 presents the research design and explains why I have chosen an exploratory single case study. Section 3.2 displays data collection methods. Firstly, I am explaining how I chose EnergyCo as my case company, accompanied by a short description of the data gathering methods utilized: *Interviews* and *Participative observation*. Section 3.3 contains both a description of how the data was analyzed and an anonymous list of all the conducted interviews. Followed by section 3.4 where I present the data quality in two subsections: validity and reliability. Lastly, section 3.5 will highlight the limitations towards this study and its implication of the findings.

3.1 Research design

3.1.1 An exploratory single case study

Edmondson and McManus (2007) presented three different archetypes of methodological fit in field research; *Mature Theory*, *Nascent theory* and *Intermediate theory*. The literature on the role of MAs can be argued to belong in an intermediate stage, because "when theory is in an intermediate stage of development — by nature a period of transition — a new study can test hypotheses and simultaneously allow openness to unexpected insights from qualitative data" (ibid.). I chose to investigate how the adoption of a technological solution influence the role of MAs in PE by conducting a single exploratory study, instead of quantitative or qualitative multiple. It enables the opportunity to investigate one specific case, while also map the landscape and study the current state of each individual part of the MAs role in a big company. When searching for literature covering this topic, I found that this field of research is established but still lack findings in some fields, especially how the implementation of data technology influences the MAs in PE. Previous research, with a hybrid data collection approach, have presented provisional explanations of these phenomena, while also introducing a new construct and proposing relationships between it and established constructs (McKinsey Global Institute, 2016). Furthermore, it is favorable to use qualitative design in the field with little prior research as it might help study the underlying dynamic of complex phenomena within their context (Baxter & Jack, 2010).

Qualitative design studies have two primary approaches; multiple and single case studies. Yin (2014) have argued that a single case study contributes with a higher possibility for empirical depth and a more in-depth analysis of the phenomena. While multiple case studies have the benefit of providing analytical payoff such as cross-case analysis, resulting in a more dominant conclusion, relative to single studies (ibid.).

I chose to conduct an exploratory case study in this particular situation because of the lacking literature on this specific topic. By answering the question, I believe this will contribute to filling some of the gap identified in the current literature.

This research follows an interpretive methodology, meaning, the actors (emic) 'associate their own subjective and intersubjective meaning as they interact with the world around them' (Olikowski & Baroudi, 1991), and integrate it into the researchers (etic) interpretation and account. Thus, enabling the researcher to cover nonverbal behavior and linguistic descriptions into the result (Haskell & Headland, 1991).

3.2 Data Collection

3.2.1 Selection of the case company

My research site is EnergyCo, a global energy company whose main products are oil and gas. Contact with EnergyCo was a result of my curiosity within the energy sector and the supervisor`s and university`s relation with the company. Through this connection, I was able to work as an intern at EnergyCo for three to four weeks. Enabling me to get access to employees, documents and observation of the working environment. Thus, the initiation phase started. Conversation and interviews with key employees lead to some interesting findings which resulted in tentative hypothesis and emerging research questions. During the stay in EnergyCo, I conducted 14 interviews which helped me map the landscape and understand the complexity and underlying conflicts. Seven (50%) of the total informants chose not to get recorded since they were afraid of any ripple effects to develop from telling their view of things. Furthermore, I chose to anonymize the interviews in order to assure the informants that information provided to me could not be connected to them afterwards.

EnergyCo has their most significant and most mature business area operates on the Norwegian continental shelf and employs almost 95% of the total workforce of more than 20 000 and contributes with 74% of total revenues of over 20 billion USD in 2018. Production on the Norwegian continental shelf is divided between 40 EnergyCo-operated fields and ten partner-operated fields of varying production capacity. Production facilities are mainly situated offshore making development and production complex endeavors, which lately has been reflected in rising costs. A digital strategy was launched in 2017 to address the rise in costs, as well as other strategic goals of safety, high-value creation and low carbon footprint. The maintenance process is like other functional areas subject to digitalization, and a digital project was launched in 2017 within the maintenance management group. The goal of the project is to optimize maintenance programs through analyzing and visualizing data. EnergyCo believes the maintenance programs are growing too large, drives costs and compromises on safety.

3.2.2 Interviews

EnergyCo was informed that my thesis would have a focus on BDA in the maintenance process and MAs in PE. They were also informed that each interview would take approximately 50-60 minutes. All interviews were conducted during October 2019, and some of them were done through Skype because of the geographical issues. There was no clear plan on whom to interview because of the size of this company. However, in several cases, interviewees suggested that I should talk to some specific people involved in the maintenance process, in order to grasp the full picture. The sample resulted in a diverse group of people with different tasks and roles, but with one thing in common: their connection to maintenances and the use of BDA. The roles ranged from analysts, designers of dashboards (data visualizations), users of the dashboards, engineers, data governance (responsible for data flow in EnergyCo), senior advisors, leaders within the maintenances process and other people involved directly or indirectly to BDA and PE. The main purpose for achieving a diverse group is to make sure there is a broader perspective on the issued topic, i.e., what kind of changes does implementation of BDA bring for the role of MA in maintenance.

The interviewees did not receive any preparation material in advance because I wanted to avoid having the interviewees overthink the questions. Instead, I wanted to make sure they felt secure and safe when talking to me – making the interview more like an in-depth unstructured conversation, rather than a formal interview. Allowing their perspective on how their role and environment has changed since the introduction of BDA come to the surface. I had made an interview guide pre hand with open-ended questions to make sure I covered the focal areas and gained a better understanding of the status quo of EnergyCo. This approach made me avoid incisive multiple presumed statements regarding this issue. The interviews were semi-structured by nature, in order to achieve the aspired conversational atmosphere, and also be enough prepared to keep on track according to the "red thread" of the thesis. Nonetheless, the interviewees had the opportunity to talk freely and present issues or topics I did not expect.

3.2.3 Participative observation

Participative observation is defined as "the systematic description of events, behaviour, and artifacts in the social setting chosen for study" by (Marshall & Rossman, 1989). Using this research gathering method enabled me to utilize my full senses to provide a "written photograph" of the case under study for the research (Erlandson, Harris, Skipper, & Allen, 1993)- by checking for non-verbal expression of feelings, interaction and communication between participants, and how much time they use on different activities (Schmuck, 1997) . Therefore, supplementary to the interviews I had a three-week internship within the reliability analyses (RA) department at EnergyCo. In this way, I was able to share my experience by not merely observing but also feeling it.

During my appearance in EnergyCo I interacted with different people: users, designers, managers, engineers, people that previously had worked offshore on the plants, high level senior managers, and colleagues throughout coffee breaks, lunch and casual talks before and after the interviews. Enabling me to get information and insight about the atmosphere, challenges, tensions and (honest) opinions of current company landscape. Which affords me access to the "backstage culture". DeWalt & DeWalt (2002) argue that participative observation improves the quality of data collection and interpretation and facilitates the development of new research questions and hypothesis.

Arriving in a new company as a student, especially when it is an engineer heavy company, a lot of the information throughout the day is hard to consume because of its complexity. All the meetings, discussion, observation, conducted interviews and observation of main statements and stories from that day provided a lot of data in a short amount of time. Therefore, after each working day, at the time of the internship, I took 20-25 minutes to write reflection and observations either in my black notebook or a word document. This helped me reflect on the day that went by, while also making sure I did not miss the small details that makes the grand picture when analyzing the findings afterwards.

When it comes to the ethics, being *participant as observer* made it easy for me to ensure transparency about my intentions from the start of the internship, while also declaring it again before I conducted interviews. It was important to make sure any question that members in the community had about my sudden appearance was answered. Furthermore, as DeWalt & DeWalt (1998) advises, I also made most of my field notes publicly in an open area at the office to reinforce that I was collecting data for research purpose.

3.3 Data analysis

While collecting data, I analyzed it at the same time. When the data collection took place, I transcribed the interviews. I wrote summaries for the interviews where I could not record, while also comparing and analyzing the data from interviews I had already conducted. This helped me structure my findings, understand the complexity and see the underlying inter-organizational tension. Additionally, this further improved my questions and approaching technique for the remaining interviews. By steering the interviews in the right direction, I had more time allocated towards relevant topics.

Interview	Role	Department	Recorded	Length	Data
1	MA	RA	No	65 min	16.10.2019
2	Data Governance	Other	No	60 min	16.10.2019
3	MA	RA	Yes	55 min	17.10.2019
4	MA	RA	Yes	55 min	17.10.2019
5	Strategy Advisor	Other	No	105 min	21.10.2019
6	MA	RA	No	60 min	22.10.2019
7	MA	RA	Yes	77 min	23.10.2019
8	MA	RA	No	80 min	23.10.2019
9	User	Other	Yes	60 min	23.10.2019
10	MA	RA	Yes	58 min	24.10.2019
11	Leader of MAs	RA	No	60 min	24.10.2019
12	OM	Other	Yes	40 min	29.10.2019
13	Manger	Other	No	45 min	30.10.2019
14	OM	Other	Yes	60 min	31.10.2019

Table B: Anonymized list of conducted interviews at EnergyCo, either from the department RA or Other.

3.4 Data quality

3.4.1 Validity

Validity displays the extent to which the results measure what they are supposed to measure. Yin (2014) divide it into three categories; Construct, internal and external validity.

Construct validity is concerned with the extent to which the research measures what it claims to measure (Yin, 2014). To achieve high construct validity, one must ensure that the chosen research question is studied and covered by the respective measures (Dubois, Gadde 2002). Case studies are criticized for allowing errors of subjective judgments when collecting data, and Yin (2014) presents guidance for how to increase construct validity by suggesting having multiple data sources, gathering a chain of evidence and having key informants review the drafted case study. All of these suggestions were followed and applied in the study. Several different sources of evidence within the case company were used to achieve enriched empirics, and the presentation of the findings under chapter 5.0 Empirics provides a logical chain of evidence that lays a logical path for the development of my conclusion. I also used informant 05 and 11 were used as potential routers to review the drafted case study during the data collection period.

Internal Validity is concerned with the relationship between the dependent and independent variable. Making sure that the observed changes in one variable (dependent) are caused by the studied (independent) variables, and not by other exogenous variables (Ryan et al. 2002), and its internal validity is established when the research demonstrates a causal relationship between two variables (Yin, 2014). Yin (2014) further explains that because of the natural form of exploratory case studies the internal validity becomes partially irrelevant; the purpose of this research form is to produce new propositions rather than testing hypotheses. Nonetheless, on the point of credibility and authenticity broader sense, internal validity also relates to interpretations made by the researcher when collecting data. With this in the mind, measures were taken to ensure credible results and high internal validity. Empirics were reviewed and identical questions were asked in multiple interviews to cross-validate evidence. Thus, securing the quality and objectivity of observed patterns. Moreover, producing transcripts and conducting individual analyses on each transcript before the empirical discussion took place, while also making sure the interviews had open-ended questions helped to intend to achieve high internal validity.

External validity is concerned with whether a study's research findings can be generalized to other relevant settings or groups; the transferability of the findings (Miles et al., 2014), and if the findings can be generalized beyond this study. However, as Dubois and Gadde (2002) explain, generalization is hard for case studies because they are constrained by the contextual and environmental factors of the case itself. Nonetheless, Yin (2014) claims there is a second kind of generalization, the analytical one, which is essential when conducting case study research. By following Yin (2014) precautionary measures to increase external validity, I have anchored my analytical framework in extant theoretical concepts and the research questions are drafted to be generalizable to other empirical settings.

3.4.2 Reliability

Yin (2014) explains reliability as the possibility to which the results can be reproduced when the research is repeated under the same conditions, and if the findings are stable over time. Yin (2009) presents two tactics a researcher can follow to achieve good documentation. The first tactic is to use a case study protocol where detailed documentation is noted, and the other tactic is to develop a case study database (Yin, 2009).

By following the guidelines of Yin (2009) I tried to minimize errors and avoid subjective biases to increase external validity. To enable this, I tried to provide full transparency in my work, while also following case study protocol: taking notes every day, making a transcription of the interviews and storing summaries of my reflections. All the research documents have been applied throughout the study in a cloud database containing everything from interview materials such as audio files, transcripts, research notes and analyses that was created. The interviews were also transcribed right after the interviews, some even within a couple of hours. In this way, I also managed to analyze each interview individually before looking at them from a collective view when approaching the empirical analyses.

It is necessary to emphasize that because the interviews had a semi-structured nature, the liability of the context might influence the results. Thus, other researchers can't achieve the same result when examining the same case, because the design cannot be replicated. However, as Saunders et. al. (2016) argues, this does not have to be a problem for studies examining complex circumstances or cases. Furthermore, all the data is anonymized and coded and even though the case company is an English-speaking company, all the respondents chose to have the interviews in their mother tongue: Norwegian. Therefore, all the transcripts are freely translated from Norwegian to English when quoted in this thesis.

3.5 Limitations

This thesis has intended to increase understanding of the changes to the role of MAs following adoption of BDA in PE. However, I am aware that there is some limitation when it comes to the contributions of this study.

Firstly, limitation regarding my choice of method. Exploratory single case studies are argued to provide the opportunity to gain an in-depth understanding of one specific case, a phenomenon, but as a result, it contributes to less generalizable findings because of the differences in organizational uniqueness, and the context which the study is taking place. Nonetheless, since the research question was developed with heretofore theoretical concepts into consideration, it provides the means of achieving a higher extent of generalizability in the findings. Moreover, I acknowledge that more research is needed in different contexts to validate my findings.

Secondly, the timing of the study. Previous literature has implied that the role of MAs has changed over time (Granlund & Lukka, 1998; Siegel and Sorensen, 1999; Burns and vaivio, 2001; Holtzman, 2004; Burns and Baldsvinsdottir, 2005), therefore, the creation of a positive perspective might take longer time to achieve and materialize. In this case study, because of the freshness of BDA and establishment of RA, my answers could be negatively influenced. Therefore, a longitudinal case study would have been preferred to capture the whole picture and verify the findings with several repeated observations. Nonetheless, this was not feasible with the time constraint that was attached to the format of the thesis.

Thirdly, a limitation concerns the data collection process. Since 7 out of 14 interviews were conducted without recording and I only had to rely on the notes taken under the process, risk of not covering the holistic perspective from the interviewees on this topic was evident. Especially, when the data was collected fall 2019 and the thesis submitted spring 2020. However, I was aware of this issue beforehand and try to mitigate the risk by combining the interview notes by taking daily reflection notes at EnergyCo, during the data collection process.

Lastly, consideration of the honesty in the answers of the respondents is a limitation. Nevertheless, all interviews were transparent and began with an explanation of the purpose of this study, while also reinsuring the anonymity of the interviewees' answers as well their position in EnergyCo. The interviews were in a broad sense very informal and my perception was that the respondents shared and described their honest opinions. While most of the interviews were conducted face to face, a few interviewees had different geographical locations which forced usage of skype. Opening the risk of weakening my choice of interpretive methodology, by not fully capture the nonverbal behavior and linguistic descriptions into the findings, nor could the interviewees sense the informal atmosphere that I tried to create for each interview.

4. Empirics

This chapter presents the necessary findings from the study to answer the research question. The Technology Power Loop framework is used as pegs to showcase the findings and illustrated how the adoption of BDA is influencing the role of MAs in a PE, at EnergyCo. Therefore, the chapter is divided into four subsections, with the fourth one being the summary.

Section 4.1 presents the findings regarding the *development of technology* and the implication of it on the role of MAs. Section 4.2 shows, also, the implications on the role of MAs, but from the findings connected to the *Control of technology*. Further, this section will touch upon the power distribution between the MAs and end-users. Section 4.3 follows the same structure as above and presents the findings connected to *Expertise* and the role of MAs. Lastly, the summary of all these previous sections will be provided to clarify the changes in the role of MAs.

4.1 Development of technology and changes to the role of MAs

4.1.1 Driving force behind the introduction of technology (Big data analytics) in EnergyCo

Costs had been raising lately, and the focus on increasing revenue and keeping high safety levels have never been so important. In 2017 EnergyCo launched their digitalization strategy, called DMVA, with the intention of cutting costs and maintaining the competitive advantage they had gained throughout the last half-century. A newly established department within maintenances management called RA was included in this new digitalization strategy to cut down the cost. RA has over 25 employees (MAs) all around Norway but with one leader. The employees (MAs) are mainly engineers from different fields, while the only one with a business background is the leader of RA. This is contradicting with the traditional role of MA, where a MA has business and financial background. It seems that this particular setting (operational work) requires more flexibility from the MAs and a better understanding of the operational setting. Hence, the difference in structuring the department.

> "when it comes to cost cutting, we either have to cut down on employees or change suppliers (external costs)" [RA, Leader of MAs – 11]

The latter seems to be difficult, and if not impossible at this stage of the market's lifespan. Because there is a limit to how low suppliers will reduce their prices before it becomes unprofitable for them. Hence, the digitalization initiatives purpose is to achieve effectiveness in the internal processes and contribute to costs savings, while also maintaining the high level of safety. In this case, I am looking at only one of these areas: Maintenances. EnergyCo wishes to reduce the cost of maintenances activities on their plants in the Norwegian continental shelf.

4.1.2 Development of Big data analytics

> "This is the first time in our company that we are trying to do this in so large scale" [RA, MA – 04]

Conducting analysis to optimize different parts of maintenances activities is not new, but this is the first time they are using big data analytics to scale it and visualize it in dashboards for easier user experience and complex information consumption. EnergyCo has stored data for a while and accumulated over 20 petabytes (20 x 10^9 megabyte) of data. This opens vast opportunities to conduct analyses, and take better decisions based on those results. Which is one of the main reasons for the development of BDA in RA. However, when asking three of the MAs for why they are they started with BDA, they answered:

> "The starting point for the dashboard is a bit unclear. It started as a need to demonstrate that we were able to digitize internally in the department (RA)" [RA, MA – 01]

> "The purpose of the dashboard is to show the potential for optimizing the test frequency (preventive maintenances). That is the main purpose of the dashboard." [RA, MA – 07]

> "…because with these dashboards you can quickly scroll through information in 15 minutes. It is important to understand that all of these analyses shown in the dashboards would have taken you, manually, 15 days to conduct each time. While this dashboard updates monthly or quarterly by itself" [RA, MA– 04]

It seems that in this case, MAs are conducting analysis based on what they believe is necessary for the different operational plants, rather than actually developing dashboards based on demand from the potential users. This was confirmed in another interview as well. One of the MAs describes that the process of their analysis and development of new dashboards starts internally, meaning, many of their projects were not a result of demand from the users, but rather an internal decision. Furthermore:

> "…., the interesting thing we found out when trying to "sell" our dashboard to one of the operations managers (OM) was that they already had their own dashboard with similar usage." [RA, MA – 07]

Making it clear that the communication between the developers (MAs) and the users are not optimal. In the quote above, the OM had tried to solve an important issue by themselves, by making a new system to support their decisions. They had used internal IT-function and external consultants to develop the dashboard for their own production site. This indicated that there is actually a legitimated need for decision supporting systems, but it needs to be done correctly.

When MAs in RA work with BDA, they need the help of external IT consultants (e.g. from Accenture) to develop the dashboards. Putting another layer between the developers and users. Each MA is responsible for one or two dashboards to develop and keeping it operative. It needs to be maintained, updated and changed according to any possible feedback from the users. RA is using the "shotgun" strategy (shooting with a shotgun and hoping some of them hits). Therefore, not all of the initiatives (dashboards) are a "hit", but they still need to keep it up to date because they have already invested resources to develop it. Resulting in "locking resources" (MAs) into low activity areas. The process of development is presented below in a simplistic way, for illustrative purposes.

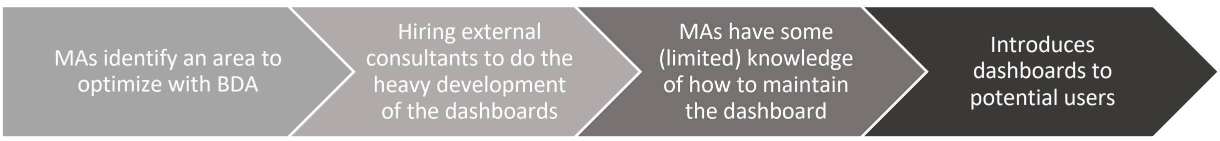


Figure 5: Process of how BDA are conducted, and dashboards developed at EnergyCo.

4.1.3 Changes to the role of MAs

Creating a new department (RA) with MAs from different backgrounds (mainly technical engineers with PhDs) are contradicting with the traditional way of how literature is describing them. Previously, they were MBA students with financial backgrounds and mostly worked within the finance department. However, now, the only one with a business understanding is the manager of RA. After talking to the manager, he explained that the mental process behind establishing this new department type is because MAs needs to understand the sensitive and complex technicality aspect that can be found in production sites. Thus, MAs that understand the underlying factors, which a person (like himself) would struggle to fully grasp. Nonetheless, even when he acknowledges that the main job of a MA is to optimize and reduce costs, therefore needs a business understanding. He believes this is the new way of structuring MAs for PE. There is only need for one person with a business background, and that is the leader.

4.2 Control of technology, power distribution and the changes of the role of MAs

4.2.1 Control of technology

MAs are the ones behind the designing, maintaining and partially developing these dashboards with help from external consultants. Thus, controlling the technology. Nonetheless, the tension and lack of balance in the power distribution between the designers and the users is clear. Mostly because all the BDA are conducted in a “push” manner, and not “Pull”. In this case, the users become internal “customers”, and the same rules of selling a product apply here – If the product does not properly fill an essential need, the incentives to use it won’t be there. However, in the question about what the interviewer believed was the cause behind the low usage activities of the dashboards, he replied:

> “I believe, firstly, that they are not informed enough about it, and secondly, that they already get the information we are providing from other sources”.
> [RA, MA – 07]

The MAs acknowledge the weakness of the shotgun strategy – all of the shots do not hit. OMs have most likely already solved their issues because they have done their jobs for years. OMs have had control of whatever technology they used internally with the help of EnergyCo IT function before RA came in. In one of the interviews, one MA showed the dashboard he had responsibility for. The function of this particular dashboard was to use BDA to provide recommendations that optimize a certain maintenances frequency on plants. The dashboard showed a huge amount of backlog of recommendation that should have been executed but was not. The MAs explanation was:

> "…this group of recommendation (pointing on some numbers in the dashboard), there is nothing that indicates why they should have not been followed based on the data we have conducted the analysis on. It must be some other factors for why operations managers do not follow our recommendations. And we don't know why…there may be some recent manual reviews from those who know the plant well.…in the end it must get manually assessment from the professionals who will feel if the interval (frequency of maintenances) needs to be reduced or not. So, what we show from the analyses is just a recommendation" [RA, MA – 07]

The professionals taking the decisions whether the frequency of maintenances should be lowered (to cut costs) are not basing their decisions on analyses visualized in a dashboard from an external person that does not know the plant well enough. It is, in the end, the professional its selves that has the total risk, and few wrong decisions could have catastrophic consequences, both financial and for the safety.

> "The requirement in our company is that safety-critical errors must be held below 4%. Now it is 3,32%. And they on the plants are the end-user of the dashboards"
> [RA, MA – 07]

The trust towards these analyses becomes even hard for the users when combining the 4 % error limit and the percentage of data that are damaged (not usable) within the 20 petabytes, which amounts for approximately 7 %. This indicates that accountability might be the main reason why big data analytics is not used by OMs. Uncertainty and high responsibility of risk lead to the more defensive use of analysis amongst the users of the analyses.

The MA further explained that:

> "It is my job to try and illuminate how bad the data foundation is, because a lot of the time it is very bad…. Our job is to just showcase the weakness in our analyses, because the decision maker will take the last call anyway" [RA, MA – 07]

4.2.2 Power distribution

MAs are the one in control of the technology: Design, development and maintenance. However, it is the users that have the actual power. They can decide not to use it, and the whole process will end. Interviewees put the spotlight on some core factors that determine why the analysis is not used to optimize.

Poor data foundation

As mentioned earlier, the 7% damaged data scares user to change their current practice of taking decisions and adopting big data-driven decision methods.

Culture & Labor union

> "70-80% of the preventive maintenances (PM) is conducted to check if there are any errors. They are testing. There is no guarantee that the equipment will work after you are finished testing, it can stop working 5 seconds later. So why are we using so much resources on this...?" [RA, MA – 06]

> "Culture and labor unions are the biggest barrier for why adoption of technological solutions fails in the company" [RA, MA – 06]

The consensus amongst the MAs and other employees working onshore are that the offshore employees do not like changes. They know that if changes arrive, and optimization becomes a reality, they won't be needed. If they cut the 70-80% PM by going back to CM, it means that those people responsible for these maintenances' activities will become redundant. Therefore, the labor union are against all form for digitalization which leads to downsizing.

Safety is one of the ground pillars of EnergyCo. It is deep in the company's roots. You see it everywhere, in every room and every presentation. This culture around safety is positive and necessary, however, some of the interview subjects express their frustrations. They call it the "ultimate card", when played, no arguments can win over it. If a plant chief, OM or offshore employees uses this card, the initiative that is under the scope will not go through. The respondents are very aware of the importance of having safety in focus, but they believe too much focus can have a negative effect on other areas: such as innovation and cost reductions.

Oversimplification of a complex reality

> “EnergyCo has a generation shift, previously, the plants employees came into administration at onshore, this is not the case now” [RA, MA – 06]

EnergyCo has grown in recent years, and many of the new hiring’s have a PhDs, especially within RA. Previously, people that worked onshore was the same employees that first worked offshore. They knew the ins and outs of the production environment. Thus, taking everything into consideration when planning for improvement and technological implementations. This is not the case now. Many of the feedbacks (from interviews and internal EnergyCo documents) from the users have focused on the analyses ability to provide the true reflection of the production site.

The dashboards are double-edged swords. They must be easy to understand, easy to consume information from and easy user experience (finding information). However, this might lead to an oversimplification of a complex reality.

4.2.3 Changes to the role of MAs

The changes in the role of MAs are remarkable. Previously, MAs were providing advisory for managers to help them achieve better decisions. However, new technological advancement is allowing MAs to conduct analysis with the help of BDA and then presenting it through sophisticated visualization program (PowerBI). The MA information is arguably more accurate and better than before because of the new technology, and we could assume the users would be more inclined to use it. Yet, it does not look like to be the case. Leading to a question about the role contribution the MAs are providing for the business. Figure 5 right below, is displaying the power distribution between MAs and users and illustrates that the actors (users of the analysis and technology) at the local site possess the dominant position. Notably, because of the accumulated knowledge employees have about the production when being close to it.

Therefore, even though the MAs have control over the technology, which the OMs oversaw before the adoption of BDA, the MAs lack the power to have a desired impact on the business process: achieving optimization (because the users do not utilize the information MAs provide).

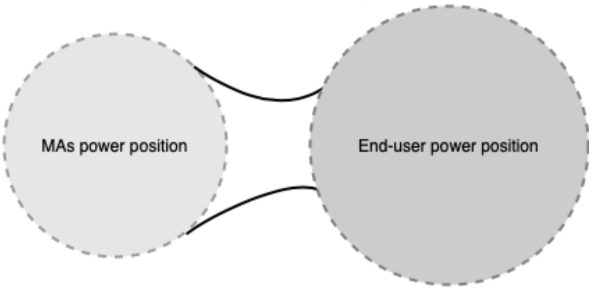


Figure 6: Conceptual illustration of the power distribution in the relationship between MAs and end-users

4.3 Expertise and the change to the role of MAs

The BDA was optimistically described by the MAs and indicated to have a simplified overview and providing understanding of the extensive amount of data in a short time; to take more precise decisions in the production sites. MAs argue that the drivers for adopting BDA are to increase the quality of decisions, optimize current processes by highlighting potential improvements, and cutting cost in a secure way when addressing a production site. They further emphasize that it will motivate and help OMs by providing them with an overview of their historic.

> “this helps you (users) have a better overview over your own history, and through visualization your motivation might be triggered, and this also makes it easier to access your own historic.” [RA, MA – 08]

Pre-Analytics the OM managers had to use a lot of their time and resources to create a foundation which they based their decisions on; conducting testing’s, scrolling through internal data and using their intuition (part of their accumulated expertise). After the introduction of BDA, MAs are the ones that understand most of the fundamentals around the technology and how it works. However, since they are outsourcing partially the development too external consultants, their knowledge is limited. In combination with the generation shift, these MAs do not have the necessary experience and understanding of the production and local settings on the plants. Thus, making it hard to fully grasp the true picture of the situation in their analysis. This is something that they are aware off, because of the feedbacks and lacking usage of their analyses. This results in requirement changes in the role of the MAs; having a deeper understanding of the environment they are analyzing, while also obtaining full control the technology they are using. In this case, the MAs had to face the challenge of widening their expertise. Their role requires to be more technology-oriented and learn to use it optimally and simplistically display the complexity. A skill that is yet to be mastered.

4.4 Summary of the changes to the role of MA incorporated with BDA in a production environment

Previous sections portray the changes that MAs at EnergyCo are facing when adopting BDA to optimize maintenances activities in a production environment. The findings imply that the role of the MAs has gotten new requirements when trying to customize analyses for a different part of a production plant; something that is necessary when working with complex technical systems. Going from the traditional way of conducting analyses the MAs were required to adopt a new method of creating analyses with even more data foundation (BDA). The sphere of the production environment requires more narrow and detailed calculations to become an accurate reflection of reality and contribute to better decision making.

However, the tradeoff between both catching the complex scope of the environment and making it easy to understand is clearly affecting the MAs role and creating a multitude of obstacles. The diversity between the production sites demands a whole new approach of analyses, then what was previously the practice: the homogenous set of work practices. Customization towards each plant is key. Therefore, the role now incorporates a holistic understanding of the underlying aspects of production sites.

Mainly, since the OMs does not trust changes in their decision making when they are aware of the large numbers of variables they need to account for when going through a decision-making process. This has opened a door into the power dynamics between the different entities in EnergyCo. Engineers and professionals close to the plants have the last word. Resulting in a change in the role of MAs, because they are no longer contributing to strategic decision making, nor having the impact which we previously associated with the MAs.

For EnergyCo this introduction of BDA and shows significant potential, however, it does not seem to be fully utilized at this moment. The costs clearly out weight the benefits, leaving

MAs with mediocre and little influence over the maintenances processes in the company. Table C, below, summarize the observed changes to the role of MAs in EnergyCo when implementing BDA for PE.

	Pre- Analytics	**Post-Analytics**	**Changes to role of MAs**
Development of Technology	OMs developed new systems supporting their decisions, using internal IT-function and external consultants. No communication with other functions or MAs.	Emerging of a new department of MAs with a non-business background using external IT-consultant to develop new MA systems (BDA and PowerBI) for optimization of maintenances activities.	The newly established department of reliability analysis (RA) for production environments at EnergyCo was a point of origin for a new form of MA function.
Control of Technology	Resides within each OMs function, because no one else has the same knowledge about the production. Internal IT-function would be the point of support.	MAs, from RA, take over the control of technological solutions (MA systems) implemented towards the optimization of maintenances activities using BDA.	Control of technology lays at MAs, but the power to use the information from the technology is up to each user belongs to the users. Thus, the actual power is not with the MAs. They need to conduct analyses based on aggregated data for smaller settings (i.e. optimization of a valve type at a plant).
Expertise	Operational managers and Internal IT-function had knowledge of the developed systems.	MAs “pushed” new MA systems on OMs, with limited knowledge of the technology and the practicality of it.	MAs are required to adapt to new technology, by learning how to manage and maintain it. Requiring in-depth knowledge and understanding of the production and local setting.

Table C: Summary of the changes to role of MAs

5. Discussion

In this chapter, I am discussing the empirical findings against the literature, in order to answer how BDA, influence the role of MAs when trying to optimize maintenances activities. This is especially important because it provides an insightful contribution to the debates about the role of MAs in PE. Which is directly addressing the call from Curry et al. (2019) for more case studies at a micro level to fill the gap within this literature. Especially, because this field needs research that provides a more nuanced portrayal of MA in this context.

The discussion will be structured as follows: Section 5.1 explains how MAs are redefined in the adoption of BDA. Section 5.2 examines the role MAs have in PE, with focus on MA systems and how MA functions are structured. Finally, in section 5.3, a new label of MAs in PE will be proposed to contribute to a stronger understanding of MAs within this literature field.

5.1 Redefined MA in adoption of BDA

I argue that we no longer have either a business partner or bean counter, but rather an adaptive form. Someway similar to a "hybridization form" which is mentioned in previous literature, a term which is connected with accountants broadening their expertise into other non-accounting fields (Caglio 2003, Burns, Baldvinsdottir 2005, Byrne, Pierce 2007, Hyvönen et al. 2009, Newman, Westrup 2005). My findings indicate that the current leading view of the role of a MA being labelled in a binary fashion (either bean counter or business partner) is too simplistic.

Complementary to the research of Mack and Goretzki (2017), I too observed that the MAs are switching between these stereotypes rather than belonging to one of them. My research shows that MAs act to a certain degree, as a control-type performing business analyses and internal consultant. While also being the one that "sits and just crush numbers", that automatically gets visualized in the dashboards. I observe that the MAs are no longer just conducting analyses, but they are designers and developers of the dashboards too. They are not contributing to help managers take optimal decisions, but rather just creating great sophisticated tools. Thus, lacking a fundamental skill of being a business partner and consulting your company to achieve better financial results.

Like previously, technological advancement has been the driver of change for how MAs have evolved throughout decades. It is clear that EnergyCo`s management acknowledges the value of MAs information and have tried to scale the analyses by introducing the use of BDA and making the consumption of the information easier for end-users by visualizing it on PowerBI or SAP Lumira. Nonetheless, since there is a lack of skills within the development of this sophisticated technology an external actors (consultants) help is necessary. Resulting in a weaker (power) position for the MAs since they have limited knowledge about the technology and not a strong control of it. They always need to bring back the consultants to make major changes. With lacking expertise around the technology, the power naturally shifts towards the end-user.

My findings also reveal that the MAs are indeed adaptive to modes of mediation (configurations of technologies, artefacts, entities and spatial settings) and that MAs are adjusting to fit their current context. Which is complementary to the findings of El-Sayed & El-Aziz Youssef (2015) and Hofstedt & Nilsson (2018) – they argued that MAs have no longer binary role labels, but rather defined by the work they are doing, which seems to be the case in this study. The new ways of conducting and presenting data have changed the way MAs at EnergyCo work. They now need to learn more about the context which they are trying to optimize and learn in-depth on how this new technological tool can help optimize the maintenances activities.

5.2 Overview of MAs in PE

5.2.1 MA systems face redundancy in PE

Prior to the introduction of BDA, the OMs had control over their decision-supporting systems. They knew the amount and type of information necessary to take decisions. However, it seems that because the managers wanted the MAs to utilize technology (BDA) to decrease the cost of maintenance. Identical to what Deshow & Mouritsen (2005) observes in their research, I too see that EnergyCo is forcing the development of some local systems (dashboards) just for the sake of complementing integrated systems and leverage the myriad of big data available. Indenting to notify OMs about which operations needs to improve, identify (unnecessary) high-cost sources and hopefully decrease or eliminate them.

However, the costs in EnergyCo has gone up in the last year, with root cause back to several factors, two of them being: 1) the implementation of BDA and the extra unused layer with employees (MAs) it brings, and 2) mismatch between the introduction of new professions with little business understanding and the desired goal of achieving cost minimization. These MAs have done what they are good at, making great dashboards (tools to analyze) for the production, but they don't have the necessary understanding of the underlying financials to properly reflect around the connected costs.

Hence, these MA systems do not seem to yield optimization and lower costs. This aspect has precisely been the reason for the rise in the ongoing discussion regarding the level of relevance MAs has in the production environments – because, historically, the work MAs have done in PE has been weak. My findings support some aspects of the statement from Hansen and Mouritsen (2006) about MAs being redundant in PE. It seems that the MAs are only superfluous when they are trying to quantify certain areas of the production environment for simplicity, and not including expertise from OMs when conducting analyses about the maintenances at the production site. In this case study, the communication between the designers (MAs) and the end-users (OMs) have been extremely weak. So weak, that some might even question if the MAs truly knew what the purpose of these analyses was. Arguably, two root cause behind this lack of interaction with end-user might come from 1) the MAs not being an expert in product design, but rather just be in expert in the technical part of the product / Analyses, and 2) access to the myriad of raw data blinds the MAs to see the need for users. Without the inclusion of the OMs, the analyses won't be reflecting the true picture of the PE. Thus, not be useful. Therefore, the inclusion of end-users should be a part of developing technology.

This is something that is emphasized in previous literature within this field (Van der Veeken & Wouters, 2002). It seems that the knowledge OMs possess about processes enables them to visualize aspects that remain invisible to the MA system. As displayed in Table C, in chapter four, before the adoption of BDA, the local systems had more impactful information than the MA systems were providing, which explains the reason why OMs are not using the new information from MAs. An aspect which is also reflected in the findings of Curry et al. (2019).

The MAs are struggling to have the ability to customize their analyses according to the environment, something that is vital when working towards PE. They are lacking the flexibility to capture the true picture of the production site, mainly because of its complexity. Putting even more focus on having the inclusion of the end-user in the development of the technologies.

5.2.2 Establisment of a new MA functions for the PE to tackle previous flexibility issues

Before RA, EnergyCo did not have division that focused on precisely this area of maintenances. The employees working with maintenances did not try to optimize the activities with regards to cost, but rather just follow the standardized (vendor recommendations) maintenances activities that accompanied each equipment and machines. I witnessed that EnergyCo now have designated MAs in place for conducting analyses. All the MAs have an engineer background, which is not usual for a typical MA. However, the traditional MAs with business background would have struggled even more capturing the complexity of PE. The company are aware of the "flexibility" challenge when it comes to the MAs in PE and trying to compensate for that by having MAs that have deeper understanding of the technicality in the PE. Even though, my findings show that it did not work I believe they are in the right direction. The idea of having only one businessperson, the manager, in the function and the rest being engineers can truly help the address the criticism that MAs gets when trying to provide analyses in PE. Perhaps, if executed correctly, this might even be the new blueprint of how MAs in PE are organized in big companies.

The findings are in accordance with the research of Byrne & Pierce (2007), which argues that the MAs are in some way playing a crucial part in shaping their role. However, in legacy companies like EnergyCo, majority of the way MAs are executing their jobs are decided by macro-level decisions in the company. I.e. the push towards usage of technology (BDA, PowerBI and SAP Lumira) and the way they are organized. Hence, resulting in a fixed frame where they further can evolve their role.

5.3 Unfoldment of a new MA role with an *adaptive form*

The findings have led to unfolding of a whole new label for MAs and how the role can be categorized. Even though, these finding are from a production setting, it can still be used to understand the role of an MA in other contexts too. I argue for a new label regarding the role of a MA named *adaptive form,* because the findings show a new MA that have gone past the simplistic labels of either being a business partner or a bean counter, and into a new generation of MAs. A generation that are trying to tackle the previously mentioned issues connected to the traditional role of MAs (with a financial background) in PE. This *adaptive form* can be best described as being in a liquid condition, where the role of MAs is not fixed, but it will conform to the shape of its predetermined container. The shape of this metaphorical container represents the pressured guidelines that arrives from the top of the company: e.g. Strategy, KPIs. In some way, similar to the findings of Byrne & Pierce (2007), the MAs play a crucial part in shaping their own role. However, only to a certain extent. My findings display the MAs as very adaptive within the predetermined context (container). Nonetheless, there is still some defining parts of the role of MAs that retains compact through the evolution; seeking optimization and cost saving. Hence, this role will have the same underlying mission, but the process of reaching the mission will be distinct.

Even though EnergyCo have not succeeded yet with their new MAs-function, they are on the right path towards achieving the prementioned mission because they understand the issues connected to the traditional role of MAs. They tried to compensate lacking ability to be flexible and provide information with a contextual anchor in a local operation setting, by having MAs with a different expertise and educational background to fully grasp the true picture of the production site. MAs with the characteristics from the *adaptive form* are more likely to produce accurate analyses that are representational of reality at the PE when compared to the traditional MAs; that can trip into the pitfall of being too blinded by financial numbers. Nonetheless, I identified a tradeoff in this case study, showing that if not implemented wisely, *adaptive form* will lead to disruption of the core parts of what defines a MA (achieving optimization and cost savings), because of their inadequate business and financial understanding. Thus, not yield the results that a MA is supposed to contribute with.

The issue at EnergyCo emerges from the ineffective construction of the MA container. The MAs did a great job in executing the project they were assigned to, by utilizing their skills to visualize BDA results in sophisticated tools (PowerBI and SAP Lumira). The only issue here was the predetermined framework they had to work within, which evidently defined the outcomes of their work. As MAs with an *adaptive form* they just fitted to the contextual setting and produced analyses.

6. Conclusion

This study contributes to the ongoing literature on the role of management accountants (MAs) in a production environment (PE) by answering the research question:

> *How does Big Data Analytics influence the role of management accountant in a production environment?*

While the previous literature (Granlund & Lukka, 1998; Siegel and Sorensen, 1999; Burns and vaivio, 2001; Holtzman, 2004; Burns and Baldsvinsdottir, 2005; Hofstede & Nilsson, 2018) provides an essential understanding of the role of MAs in general, there are no present studies to my knowledge that explores adoption of BDA and its influence on the role of MAs in PE. Thus, the empirics were gathered through an exploratory case study within a large energy company (EnergyCo) that implemented BDA in their maintenances process. Previously, the driving force for change on the role of MAs in the literature were technological advancement; it seems to be the case in this study too.

It was observed through the adoption of BDA in EnergyCo that the role of MA changes as a consequence of new required information in their analyses; mainly because of new modes of mediations (configurations of technologies, artefacts, entities and spatial settings). This has influenced the role of MAs to no longer be either a control-type performing business analyses and internal consultant (Business partner), or someone that "sits and just crush numbers" (bean counter). Which is similar to the findings of El-Sayed & El-Aziz Youssef (2015) and Hofstedt & Nilsson (2018), where they argued that MAs are no longer labeled into binary role, but rather defined by the work they are doing. My study illustrated that MAs in these settings are no longer just conducting analyses, but they are essentially contributing as designers and developers of dashboards (where the BDA analyses are visualized). They are not contributing to help managers take optimal decisions, which is a common characteristic of MAs, but rather just creating great sophisticated tools. However, this leads to a lack of a fundamental skill of being an MA and providing decision-support for the company to achieve better financial results.

Furthermore, I found that MA systems are facing redundancy in the PE because they are struggling to customize their analyses according to the environment, something that is vital when working towards PE (Curry et al. 2019). This issue has been illuminated by the lacking optimization and minimization of costs. The absence of flexibility to capture the true picture of the production site is an issue for MAs, mainly because of the PE complexity. This problem could arguably be minimized by having a deeper inclusion of end-users during the development of technology to provide valuable insight for the MA, thus decreasing the risk of not capturing all the complex aspects of PE. Moreover, as an attempt to solve this issue of lacking flexibility, EnergyCo established a new MA function containing employees with a different educational background (engineers) than what is associated with traditional MAs (business background). Resulting in an discovery of a whole new way of organizing the MA function - only one with business background is the manager, while the MAs have engineer backgrounds.

Additionally, previous research argues that MAs are switching between bean counter and business partner, while other argue for a combination of these two and labelled it “hybridization form” (Caglio 2003, Burns, Baldvinsdottir 2005, Byrne, Pierce 2007, Hyvönen et al. 2009, Newman, Westrup 2005). Some even argue that MAs are switching between these stereotypes rather than belonging to one of them (Mack and Goretzki, 2017) and that MAs are playing a crucial part in shaping their role (Byrne & Pierce, 2007). My study supports some aspects of these arguments and presents an unfoldment of a new MA role with an adaptive form, which is the result of MAs adapting to the implementation of BDA in the PE. This new form has gone past the simplistic labels of either being a business partner or a bean counter and into an adaptive form that conforms to the shape of its context (container). The container is often predetermined by the company and managers; therefore, the MAs will only be able to shape their role to a certain extent because of the constraints. This emphasizes the issue of having effective construction of the MA container, so the MAs can reach the desired goal of optimization and cost reduction.

7. Practical Implications

This study may have practical implications for managers of MAs and C-level managers of companies like EnergyCo, who wish to use BDA and MAs to achieve optimization in productional settings (i.e. maintenances). My findings have identified a gap between designer/developer and the end-user, and suggest that the organization needs, in a larger extent, to involve the end-users in the initial stage (development phase) of the processes, and not vice versa. Including end-user in the process of designing both the analyses and the dashboards yields higher quality MA information in form of accurate representation of reality, which can triumph over local information systems. Moreover, it provides an opportunity to validate the data before the analyses are conducted and makes sure there is an actual need for that analyses.

In this way, it does not matter if the MA does not have the proper expertise (as an result of using external consultants for the heavy develop of the technology) about the technology, because the end-user already has established a fundamental understanding of how it works by being included in the development process. Thus, creating more trust and helps closing the communication gap between the MAs and the end-users. It also eliminates the issues regarding accountability, because there is more transparency around the technology and the end users are not as apprehensive anymore.

With regards to the novelty of the MA role and its evolution, I recommend improving the frameworks that the MAs are going to work within. They are adaptive to the context and environment and must therefore have clear guidelines of what is expected from each individual; to achieve the overall mission of cost reduction while maintaining safety levels. Since the new form of MAs does not necessarily have the fundamental understanding of how to achieve better financial results, EnergyCo should invest in providing courses and workshops to help the MAs learn about the cost side.

Finally, I recommend that EnergyCo change their current practice of using “Push” methods when developing product and start adopting a “pull” method, which is the common practice. Many of the dashboards that have required resources to build are not used. This is a clear sign from the “customers”, that there is no need for it. EnergyCo need to do more research, be in dialog with the end-users and map their overall needs. If there is no need, don’t create a dashboard.

8. Research implications and future research

8.1 Research Implications

With the discussion in previous sections in mind I propose a few changes to the Technology Power Loop. Scarbrough & Corbett (1992) lays a solid framework for how we can look into the technological power loop at EnergyCo. When it comes to technology used in PE, *Development of technology* is representing the starting point of the process and will affect the way both *Control of technology* and *Expertise* is respectively shaped and defined. However, this framework does not consider the effect external parties have on the Technology Power Loop in a PE, nor does it emphasize inclusion of the end-user in the development of the technology. I argue that this is necessary to include in the framework, because the PE is a rather complex than most other environments, especially, when it comes to engineering heavy companies; where each area requires its own branch of technical specialization.

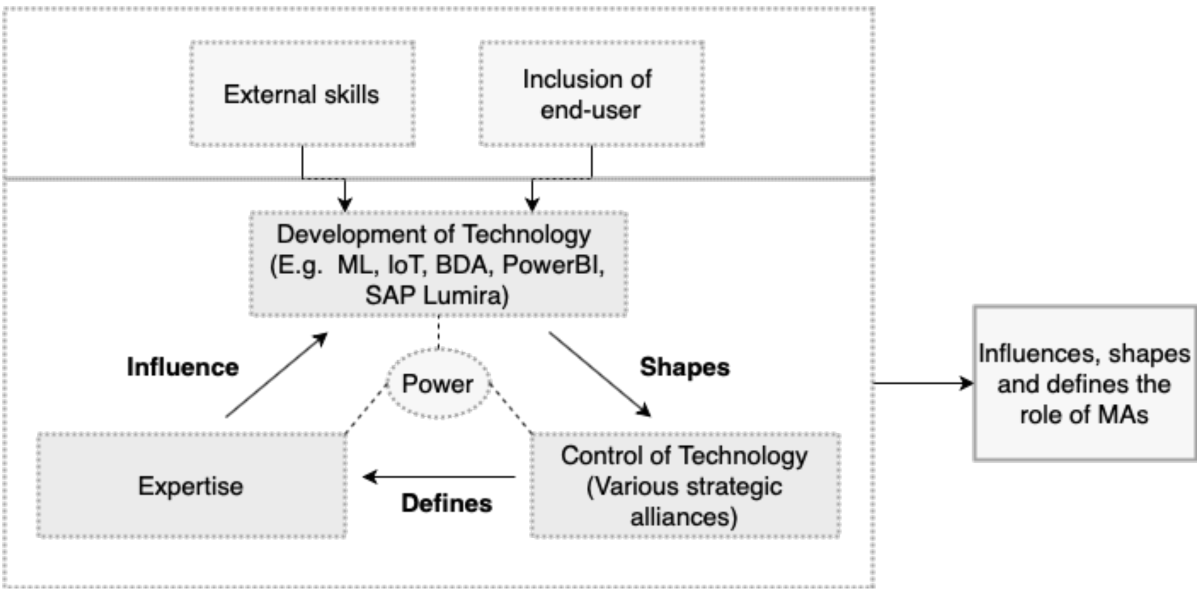


Figure 7: Revised Technology Power Loop contextualized to production environment.

Since this is a loop, it is more clear that the external help and inclusion of end-users in the development of technology will affect the whole model, and have a greater impact in influencing, shaping and defining the role of a MA, as is evident by my findings and illustrated in the revised Technology Power Loop above. Nonetheless, it is vital to remember that the impact is variously distributed based on the company structure and environment. Figure 7 makes it easier for future researchers to use this framework in the case of studies within a similar field.

8.2 Future research

Given the small amount of literature on the role of MAs adopting technological solutions in PE, there are multiple alluring pathways for future research. As mentioned under the limitation, a longitudinal case-study would be beneficial to study the evolving of the MA role over time. Especially, when the establishment of RA (the focal function of the study within EnergyCo, containing MAs) function within and adoption of BDA is so fresh in this case company. By generating several in-depth findings from repeated observations and comparing them would help strengthen the foundation of this literature.

As displayed in the empirics and discussion, most of the interviewees' descriptions and opinions were reflecting mostly the view of a MA, and not necessarily the OMs. A more in-depth study focusing on the other side, the OMs, to understand their needs, attitude and behavior would help reinforce current literature. This is an understudied area that I argue deserves more attention; understanding the OMs would result in making high-quality MA systems and delivering valuable information.

Previous literature argues strongly that the root cause for MAs being perceived as redundant in PE is their lack of flexibility and ability to truly reflect the reality in their analyses. My findings support some aspect of this; however, it would be intriguing to have in-dept case studies to find out if there could be other reasons for the clash between MAs, OMs and PE. Notably, because research from other fields have shown that individual incentives might be a big barrier for digitalization and adoption of the technological solution of the user side (i.e., doctors that don't want to have AI diagnostic of the patient because it could undermine the need for their expertise). It would also be interesting to have a holistic view on how power is distributed between entities, how it shifts and if decentralization of power is beneficial in such cases. During practical implications, I recommended EnergyCo to shift from a "Push" to "Pull" method when developing new dashboards using BDA towards the production. I would encourage future research to investigate how this recommendation influences the role of MAs and the utilization of future dashboards amongst the end-users. Especially, to see if this solve the majority of the aforementioned issues at EnergyCo.

9. Referances

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Appendices

Interview guide – semi structured – EnergyCo

Research question: *How does Big Data Analytics influence the role of management accountant in a production environment?*

Phase 1: Setting the limits and frame for the interview.	**1. Small talk (3min)** - Informal chat
	2. Information (3-6 min) Elaborate about the topic for this interview: Explain what the interview is going to be used for: Inform that this is a voluntary interview; they can end it at any time. Mention that you need to record the interview and that this is fully confidential and anonymous. Get their consent. - Ask if the respondent have any questions or issues. Make conceptual clarification: **Start recording.**
Phase 2:	**3. Transition questions (5min)**
Phase 3: Focus questions are to be used as pegs for discussion. They are not to be read up straight from the paper.	**4. Key Questions (30-40 min)** **→Expertise (Search for examples!)** **1)Background** a. Who are you? b. What is your official title/role? c. What kind of task do you do in your job? **2) Maintenance process** a. What is your knowledge around the maintenance process? b. What do you know about the implementation of BDA?

	d. What do you feel about this digital change (Mapping the attitude)? e. What do you think is the benefits, challenges and risks working towards PE? - What did you guys do to avert the challenges and risks? → **Development of Technology** **3) Implementation of BDA** a. Who is developing this technology? b. What was the intentions behind this digital solution? c. What was the drivers behind the choice of this technology? - Top-down? - Your own group/function are behind this? d. Are you guys the first to have this kind of preventive maintenance? e. Who had the project of implementation? External or internal consultants? f. Was anyone from the offshore maintenance team, C&F and maintenance function in this project/implementation group? g. How was the implementation of sensor technology? Step by step. h. Have you achieved the desired results? **4) Future change?** a. What changes do you wish to see in today's situation? b. What do you think works well today? c. What would you have done differently when implementing this again? d. What is the "end game" with this project/pilot? What will this project mean for the future of maintenance process?

	→ Control of Technology **5) How much do you interact / Cooperate with other functions within the maintenance process weekly/monthly? (Power aspect)** a. What is the reason for this interaction/lack of interaction? - Before technology - After technology b. Do you feel this help or burdens the job you are supposed to do? - Worker dislocations - Role displacement c. How is the culture for helping each other across functions? Do you work in multidisciplinary teams? d. How much do you trust each other's decisions? **→ Data processing** **6) Processing of the data from the sensors** a. Who is responsible for processing the data? - Gathering the data - Processing it - Completing it / Finishing it b. Who is making the analyses? c. What kind of tools do you use? d. Are you happy with these tools? f. Who do you ask if you need to know anything about the technology? - Who have the knowledge and competence? e. Who gets the analysis afterwards and takes decision based on it?

Phase 4: Summarize	**5. Summary** - Summarize the respondent's answers and information. - Prepare items that may seem unclear. - Ask follow-up questions if something feels unanswered. - Ask if there is anything the respondent wants to add. - Ask the respondent if there are other key people I should interview. - Ask: If you came up with a tip to the top, what would it be? - Thank the respondent. Ask if you can contact him again if you are wondering something. Ask for contact information. - End the interview. **Quit recording.**