

The use of big data analytics and artificial intelligence by controllers

A knowledge-based view from multiple Finnish companies

Master's Thesis
Ilona Partanen
Aalto University School of Business
Accounting
Spring 2024

Author Ilona Partanen

Title of thesis The use of big data analytics and artificial intelligence by controllers - A knowledge-based view from multiple Finnish companies

Programme Master's degree

Major Accounting

Thesis advisors Jukka Sihvonen and Seppo Ikäheimo

Year of approval 2024

Number of pages 82

Language English

Abstract

The role of controllers has significantly evolved with the advent of new technological developments, such as big data analytics. A newcomer to this business landscape is artificial intelligence (AI), which has the potential to further transform the work of controllers. Controllers are integral to the decision-making process of a company, as they provide vital management accounting information to the company's management.

The chosen perspective for this study is a knowledge-based view, focusing particularly on tacit knowledge, which is crucial in the value creation process of a company. This perspective helps understand how tacit knowledge is shared among controllers regarding analytics tools, as well as how the organisation as a whole assists controllers in adapting to and utilising analytics and AI tools.

The study is conducted as a qualitative study with semi-structured interviews. Seven controllers from seven Finnish companies participated in the research. These companies are large enterprises operating in five different sectors in Finland and globally.

The theoretical framework covers big data analytics, artificial intelligence, and their practical applications and impacts. Related topics such as business analytics, business intelligence, and advanced analytics are also discussed. Additionally, enablers and inhibitors of artificial intelligence and big data analytics are explained. Furthermore, the role of controllers within the organisation and the current state of their responsibilities are described.

The research findings indicate that companies are becoming aware of personalised challenges faced by controllers, and organisations are striving to encourage the sharing of knowledge about the use of analytics applications in various ways. Methods varied from formal training sessions and company manuals to informal channels. The use of big data analytics applications is common among controllers, and their proficiency level is relatively high for using big data analytics applications. However, there was no evidence of widespread use of artificial intelligence. The work of controllers has evolved with these technological developments, freeing up time for value-added tasks. It is believed that this trend will continue, and tasks will continue to evolve as artificial intelligence is implemented into the work of controllers.

Keywords Big data, big data analytics, artificial intelligence, advanced analytics, controllers, knowledge-based view

Tekijä Ilona Partanen

Työn nimi Kontrollereiden big data -analytiikan ja tekoälyn käyttö – Tietopohjainen näkemys useista yrityksistä

Koulutusohjelma Kauppatieteiden maisterin tutkinto

Pääaine Laskentatoimi

Työn ohjaaja(t) Jukka Sihvonen ja Seppo Ikäheimo

Hyväksymisvuosi 2024

Sivumäärä 82

Kieli Englanti

Tiivistelmä

Kontrollereiden työnkuva on muuttunut merkittävästi uusien teknologisten kehitysten, kuten big data analytiikan myötä. Uutena tulokkaana on tekoäly, mikä voi muuttaa kontrollereiden työtä entisestään. Kontrollerit ovat tärkeä osa yrityksen päätöksentekoprosessia, sillä he tuottavat tärkeää johdon laskentatoimen tietoa yrityksen johdolle.

Valittu näkökulma tutkimuksessa on tietopohjainen näkemys, jossa keskitytään erityisesti hiljaiseen tietoon, mikä on tärkeä osa yrityksen arvonluomisprosessissa. Valittu näkökulma auttaa ymmärtämään, miten hiljaista tietotaitoa analytiikkatyökalujen osalta jaetaan kontrollereiden kesken, mutta myös miten organisaatio kokonaisuutena auttaa kontrollereita sopeutumaan ja käyttämään analytiikka- ja tekoälytyökaluja.

Tutkielma on toteutettu laadullisena tutkimuksena puolistrukturoiduilla haastatteluilla. Tutkimukseen osallistui seitsemän suomalaisen yrityksen seitsemän kontrolleria. Yritykset ovat suuryrityksiä, ja toimivat viidellä eri toimialalla Suomessa ja maailmanlaajuisesti.

Teoriaosuudessa käsitellään big data -analytiikkaa, tekoälyä ja niiden käytännön sovelluksia ja vaikutuksia. Lisäksi sivuavia aiheita, kuten liiketoiminta-analytiikka, business intelligence -toiminnot ja kehittynyt analytiikka esitellään. Myös tekoälyn ja big data -analytiikan mahdollistajia ja estäjiä selitetään. Myös kontrollereiden osuutta organisaatiossa ja heidän työnkuvansa nykytilaa kuvataan.

Tutkimustulokset näyttävät, että yritykset ovat havahtuneet henkilöityneiden kontrollereiden ongelmiin, ja organisaatiot pyrkivät kannustamaan jakamaan eri tavoin tietotaitoa analytiikkasovellusten käytöstä. Tavat vaihtelivat muodollisista koulutustunneista ja manuaaleista epävirallisiin kanaviin. Big data -analytiikkasovellusten käyttö on yleistä kontrollereiden keskuudessa, ja heidän osaamisensa on hyvällä tasolla big data -analytiikan käytön osalta. Kuitenkaan laajamittaisesta tekoälyn käytöstä ei ollut näyttöä. Kontrollereiden työ on muuttunut näiden teknologisten kehitysten myötä vapauttaen aikaa arvoa luovaan työhön. Uskotaan, että kehityskulku jatkuu entisestään ja työtehtävät jatkavat muuntautumistaan, kun tekoäly saadaan implementoitua kontrollereiden työhön.

Avainsanat Big data, big data -analytiikka, tekoäly, kehittynyt analytiikka, kontrollerit, tietopohjainen näkemys

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Abbreviations

AA	Advanced analytics
AI	Artificial intelligence
BDA	Big data analytics
BI	Business intelligence
GDPR	General Data Protection Regulation
KBV	Knowledge-based view

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1 Introduction

“The whole thinking process is still rather mysterious to us, but I believe that the attempt to make a thinking machine will help us greatly in finding out how we think ourselves.”

- Alan Turing, 1951

1.1 Motivation

In the dynamic landscape of modern business, the role of business controllers has reformed significantly. Traditionally responsible for management accounting reporting and analysis, controllers now find themselves at the intersection of data-driven decision-making and strategic planning. The emergence of big data analytics (abbreviation: BDA) and artificial intelligence (abbreviation: AI) presents unprecedented opportunities for controllers to harness vast amounts of information and derive valuable management accounting insights to improve the organisational success.

In the context of accounting, controllers play a pivotal role as providers of vital management accounting information to the top management (Youssef & Mahama, 2021). The controllers serve as a foundation for the strategic decision-making process within the enterprise (Bhimani & Willcocks, 2014). Recent findings suggest that the emergence of big data has the potential to revolutionise the responsibilities of controllers and they must adapt their tasks and skillsets (Andreassen, 2020; Oesterreich & Teuteberg, 2019; Szukits, 2022; Youssef & Mahama, 2021) to uphold their significance in the decision-making landscape and as being the professionals of management accounting in the companies.

The quotation in the beginning of the paper is made by Alan Turing who is considered as one of the pioneers of computer science (Nilsson, 1998, chapter 1.1) and who is famous for the empirical test called the Turing test or Imitation game as Turing himself called it (Turing, 1950). Turing has been considered as the first to see the possibility of machines thinking intelligently – like humans. With the Turing test it may be possible to conclude the level of intelligence of a machine and it is seen

closely related to artificial intelligence. (Nilsson, 1998, chapter 1.1.) But why has AI sparked a lot of conversation nowadays especially in the world of business even though it was invented decades ago?

ChatGPT, a large language model chatbot, by OpenAI Foundation is an example of one of artificial intelligence's newest manifestations which was launched in November 2022. The AI tool which produces human-like text might not be the most used AI tool used by controllers, but ChatGPT was an excellent example of how far AI has come and what potential it harnesses, and perhaps many realised it just when it was launched. Most researchers agree that ChatGPT passes the Turing test, even though it is seen a bit outdated to measure the intelligence of the machine (Biever, 2023). Media was very interested in it (see: Lock, 2022; Paukku, 2023), and it created a lot of discussion of how advanced AI is nowadays.

However, it can be stated that AI has its pitfalls as well. Artificial intelligence can be really effective and precise when it comes to understanding structured numerical data, but for example written language data or other unstructured data can be more challenging for it: "*They [machines] do not understand about the validity, truth or lies of things*" says professor Petri Myllymäki in Helsingin Sanomat -newspaper's interview (Paukku, 2023) when discussing artificial intelligence, meaning that machines do not understand lies or the context of the text necessarily.

Big data has made its breakthrough into the business world already (Davenport, 2013, chapter 0) and big data analytics with it. No wonder since big data and big data analytics has made a ground-breaking change by accessing, managing and analysing vast amount of data (Chen et al., 2012.) Nevertheless, companies often struggle with data and are even overwhelmed by it (Davenport et al., 2001) so analytics from unstructured data is not easy to access. Moreover Boobier (2018, 22) addressed a question of whether it is easier for a businessperson to try to learn technology or should an IT person instead try to understand business issues. Probably that is the question the organisations are trying to solve.

There has been evidence of controllers being resistant to adapt new advanced technologies and being comfortable just using spreadsheet solutions like Excel (Schmidt

et al., 2020). Meanwhile, Olszak and Mach-Król (2018) claim that organisations are failing to benefit from the utilisation of big data. There has been recent evidence that big data can transform the role of controllers, which forces them to adapt with their tasks and skillsets (Andreassen, 2020; Szukits, 2022; Youssef & Mahama, 2021), but have they adapted into these changes? The knowhow knowledge of the use of big data analytics and AI applications is tacit knowledge but the issue with tacit knowledge is that it cannot spread easily in the organisation (Grant, 1996).

Big data can be overwhelming, but it is also a big opportunity for the organisations who learn how to use it and make an advantage of it. Companies are progressively trying to enhance their data processes in order to gain competitive advantage (Bhimanani & Willcocks, 2014). Businesses that describe themselves as data-driven, succeeded in performing on operational and financial results (McAfee & Brynjolfsson, 2012). Studies have shown that adopting advanced analytics (abbreviation: AA) solutions and applications can create business value within the companies (Brynjolfsson et al., 2011). Artificial intelligence has been steadily integrated into the organisations and increased business growth across various industries (Eriksson et al., 2020; Makarius et al., 2020). No wonder, since there is evidence that organisations that adopt AI solutions into their organisation have enhanced their overall financial performance (Davenport & Ronanki, 2018) and it is becoming a key element in order to generate business value and gain a competitive advantage (Enholm et al., 2022).

We live in a time where technologies are developing rapidly, and companies are trying to keep up the pace. Controllers may find it difficult to adapt to use these new technologies, because their education might not match when they must use these emerging advanced technologies. Nevertheless, they might feel pressure to use them in their daily work. Furthermore, Szukits (2022) emphasised that it is not just organisational and technological issues that come with this new data analytics era, but in addition there are behavioural consequences in executive decision-making procedure.

The use of big data and advanced analytics are increasing rapidly in the business world (Leventhal & Langdell, 2013). but perhaps artificial intelligence is taking over the spotlight. The era of AI has begun, but are the controllers keeping up with the

pace adapting new technologies? It has been said that the era of AI is not just an addition to the digital revolution, but it is rather a period of its own (Naqvi, 2020, 26).

1.2 Research objectives

This master's thesis aims at explaining and understanding how big data analytics techniques, like business intelligence (abbreviation: BI) and advanced analytics and additionally artificial intelligence are used by controllers and how they are dispersing the tacit knowledge amongst them. The selected point of view is knowledge-based view by Grant (1996). The study is conducted by using a qualitative research method by interviewing controllers from selected Finnish companies.

This study is primarily focused on addressing this fundamental research question:

RQ1: How does the knowledge-based view explain the utilisation of big data analytics and artificial intelligence by the controllers?

To help understand the whole phenomenon around the topic, there are additionally three sub research questions:

SRQ1: In which level are controllers currently using big data analytics and artificial intelligence?

SRQ2: How does organisations support controller's use of big data analytics and artificial intelligence?

SRQ3: What do controllers think of the future of big data analytics and artificial intelligence in their work?

The study is also trying to answer what is the general attitude towards big data analytics and AI among the controllers. Consequently, the study will try to identify the possible inhibitors there might be when adopting or utilising these techniques. Moreover, the study is trying to draw a picture of the current use of big data analytics within the controllers, and to do so the study is trying to figure out the general attitude of its current situation, but likewise its future: What do they think of using AI and its future? Similarly, the study wants to find out more of controllers' capabilities to use new technologies and are their skills met when using these applications.

Finland was chosen due its digitalised nature and accessibility. According to World Economic Forum's report from 2020, Finnish people's digital skills are best in the world (Schwab & Zahidi, 2020), so the study concentrates on Finnish controllers in the matter. Additionally, the report found out that Finland is top-tier in future-oriented policies, which means that Finland is providing new technologies and is well prepared for automation (Schwab & Zahidi, 2020).

The study is using the knowledge-based view (abbreviation: KBV) (Grant, 1996) in order to conclude how the tacit knowledge of the use of big data analytics is spreading amongst controllers. KBV is emphasising tacit knowledge over explicit knowledge in the organisation, and organisation's tacit knowledge becomes crucial for generating business value. The study aims to find how the tacit knowledge of the use of the big data analytics is spreading across the company. Controllers are part of the financial function and important for supporting the decision-making processes in the enterprises (Bhimani & Willcocks, 2014) and thus can be considered as the key for providing vital financial information, and they might have tacit knowledge which is not shared with rest of the controllers or organisation.

This qualitative study aims at understanding the phenomenon around big data analytics and AI within the controllers. The use of these kind of analytical tools is growing fast (Chae et al., 2014), so the subject is topical to study. There have not been a lot of studies where big data and big data analytics are combined with controllers (Rikhardsson & Yigitbasioglu, 2018). While previous research has explored the application of these technologies in various business functions, limited attention has been paid to specific utilisation by controllers, who play a critical role in shaping financial strategies and resource allocation. Every year new big data analytics and AI applications arrive, and in addition the old ones are updated, therefore restructured research is justified. Additionally, KBV is creating more insights in order to understand how the tacit knowledge is spreading in the organisation.

The study is paying attention to the current skillset of the controllers and how the organisation supports them in order to fully benefit big data analytics and AI. However, developing analytical capabilities in the organisation may be expensive (Szu-kits, 2022) and additionally there has been evidence that controllers are lacking the

skills in analytics (Oesterreich & Teuteberg, 2019). There is evidence suggesting that controllers have shown resistance to embracing new advanced technologies, often preferring to rely solely on Excel (Schmidt et al., 2020).

Whatever the reason is to use or not to use big data analytics and artificial intelligence, this thesis is trying to present the state of the use of these techniques by the controllers. It is meaningful to study qualitative data when trying to apprehend the reasons and causes, as this study aims to understand the use of AI and big data analytics. Because the data is collected by semi-structured interviews, it is possible to understand the phenomenon generally better and get valuable information of the reasons and thoughts of controllers over the topic.

1.3 Structure of the thesis

This master's thesis consists of six main chapters. The first aims at introducing the topic and provide information about the motive of the issue at hand. The second chapter is going through the topic's literature and reviewing it. There will be definitions and more context for the topic. This chapter will also introduce analytics, big data, big data analytics, business intelligence, advanced analytics and artificial intelligence, and focuses on those in business perspective. In addition, the controllers will be defined, there will be also an introduction of knowledge-based view, and in addition the enablers and inhibitors of big data analytics. The chapter two will also introduce the practical use of big data analytics. Lastly, the chapter will provide a summary of the literature review. The third chapter will introduce the data and method used in this study. Next chapter is presenting the findings of the study and the chapter after that will be the discussion where the results are discussed in the context of the theoretical framework. In the sixth and the last chapter will provide the conclusions of the study and in addition, limitations of the study and suggestions for future research.

2 Literature review

This chapter introduces definitions and insights of analytics, big data, big data analytics, business intelligence, advanced analytics and artificial intelligence. The chapter will present the knowledge-based view, the enablers and inhibitors of AI and big data analytics and additionally the use and impacts of big data analytics and AI. Sometimes some of these concepts overlap and in colloquial language these concepts can cross or mean even the same thing. However, in this thesis these concepts are defined and in interviews the concepts were clarified to the interviewees to avoid any misunderstandings.

Figure 1 is presenting the somewhat linear flow of development of the analytics from data mining to artificial intelligence. Business intelligence and AA lies between these two. Data and analytics are the basis of all these concepts. Moreover, the concept of big data is also important when considering analytics and artificial intelligence. AA and AI are often built to access and analyse big data, so the concept is important within the topic. Competitive intelligence is also introduced in this chapter.



Figure 1: The road to artificial intelligence (adapted from Boobier, 2018, 27)

2.1 Definition of (business) analytics

There is definitely more than one definition for analytics but usually definitions have something to do with the use of data. In the context of this study, there is often a focus on business analytics; however, it is imperative to elucidate the fundamental term to fully comprehend the essence of analytics. Only after defining analytics, it is possible to truly understand what business intelligence, advanced analytics or artificial intelligence means.

Data is the basis of analytics. Data is used in organisations for collecting information of for instance competitors, customers and other stakeholders. The collected data can be used for analysing background information of current situations, to observing trends and changing business situations and monitoring the company's stakeholders. (Olszak & Mach-Król, 2018.)

Oxford English Dictionary defines analytics as “*The collation and analysis of data or statistics, esp. by computer, typically for financial or commercial purposes; the data that results from this; (also) software used for this purpose.*” (Oxford University Press, n.d.) Even the Oxford dictionary acknowledges that the financial and commercial purposes of analytics are the most common ones.

According to Davenport and Harris (2007, chapter 1) analytics is a wide-ranging use of data and by using statistical, quantitative and different models and methods to analyse it in order to create fact-based decisions and actions by management. However, Davenport later added that analytics does not have to always drive decisions and actions to be analytics (Davenport, 2013, chapter 1).

Holsapple et al. (2014) refer to business analytics when speaking of analytics, and usually within the business context that is the standard. They define business analytics being evidence-based problem acknowledgement and solving which occurs within the context of business circumstances. Seddon et al. (2017, 247) define business analytics as “*the use of data to make sounder, more evidence-based business decisions*”. When speaking of analytics in this study, the context is always business analytics. This is emphasised to the interviewees as well.

In this thesis the used definition of analytics will be driven from Davenport and Harris (2007, chapter 3), Davenport (2013, chapter 1) and Holsapple et al. (2014) and can be considered more as the definition of business analytics:

Analytics is evidence and fact-based statistical and quantitative analysis which can be used to drive business decisions and actions.

2.2 Big data, big data analytics and advanced analytics

How does big data differ from analytics? They certainly are related: big data movement attempts gain insights from data and transform that into business advantage

like analytics, according to McAfee and Brynjolfsson (2012). However, there are three differences in big data: variety, volume and velocity. That means that there is a lot of more data, data is becoming more real-time, and the sources of data are more versatile. (McAfee & Brynjolfsson, 2012.) Big data can be defined by the amount of data and according to Kaisler et al. (2013): big data is the data amount above the technology's ability to supply, sustain and develop it proficiently.

Table 1: Differences of BI and big data (adapted from Olszak & Mach-Król, 2018, 4)

	Business intelligence	Big Data
Purpose	Analysis of internal business processes, improvement of operational and tactical decisions	Analysis of the whole environment of the organisation: internal resources, customers, suppliers, users of the Internet, and communities of practices
Scope	Organisation	Whole environment of the organisation
Content/ Data	Well-structured information, internal data originating from databases, Enterprise Resource Planning, transaction systems	Unstructured content, external data that comes from public, open resources, the Internet, mobile devices, and social media
Used tools, technologies	Online Analytical Processing (OLAP), data mining, data warehouses	Advanced data mining, predictive modelling, web mining, opinion mining, text mining, exponential random graph models, search-based applications, dashboards, SOA (Service-Oriented Architecture), Hadoop, Spark, MapReduce, parallel processing, real-time processing, and machine learning techniques

As seen in Table 1 of Olszak and Mach-Król's (2018), big data's data sources are unstructured data which could be social media and other external data, so businesses could conduct valuable information from those sources to create business value. They have listed main differences in purpose, scope, content and technologies of big data and business intelligence.

The growing volumes of data from various sources demand technical capabilities that traditional applications may struggle to accommodate (Schmidt et al., 2020). As said, big data means vast quantities and complex data sets from several sources

and because of that the data must be analysed, visualised, stored and managed by advanced techniques (Chen et al., 2012).

According to Chen et al. (2012) big data requires advanced technologies in order to manage and gain insights from the data and these technologies are called as big data analytics. Commonly, BDA is referred as business intelligence, business analytics, real-time analytics or predictive analytics. Analytics can be predictive, prescriptive or descriptive (Chen et al., 2012.) which can be used for visualising the past, making assumptions of the future and estimate the optimisation (Appelbaum et al., 2017). Big data is seen closely related to AI, since it can use and analyse great quantities of data to make or to help make business decisions (Sestino & De Mauro, 2022).

Business intelligence and analytics are meant for supporting business decisions, and usually these mean data assembly, analysis and information supply (Rikhardsson & Yigitbasioglu, 2018). Business intelligence's main sources are internal databases like enterprise resource planning (abbreviation: ERP) systems (Olszak & Mach-Król, 2018). Business intelligence has been a layout on top of the spreadsheet solutions like Excel, VisiCalc and Lotus 123 and it has slowly become a cornerstone in decision-making in the business world (Boobier, 2018, 18). Nevertheless, Excel continues to maintain its position as a fundamental data storage and basic data analysis platform (Schmidt et al., 2020). Some of the BI software and systems might not be anything more than enhanced management information technology, but some are providing even advanced analytics and cloud-based solutions (Boobier, 2018, 18). Furthermore, Bose (2009) pointed out the managerial point of view of business intelligence: getting the up-to-date and accurate information to the right people in order to make enhanced business decisions.

Seddon et al. (2017, 237) define business intelligence as “*information technology (IT)-based tools, e.g. data warehouses, online analytical processing (OLAP), statistical and quantitative tools, visualization tools and data mining tools that enable BA [business analytics]*”.

This study will rely on mostly Olszak and Mach-Król's (2018) definitions of business intelligence:

Business intelligence is analysis of internal processes which seeks to improve operational and strategic decisions by using structured data usually from Enterprise Resource Planning (ERP) systems.

Big data is defined in this study mostly by relying on McAfee's and Brynjolffson's (2012) definition:

Big data is characterised by its large volume, real-time or near real-time data generation, and diverse data sources, setting it apart from traditional analytics.

Big data analytics is defined by using the definition of Chen et al. (2012):

Big data analytics is advanced techniques which aims to store, manage, analyse and visualise big data.

According to Boobier (2018, 19) the utilisation of business intelligence tools will be the foundation in the utilisation of advanced analytics and AI. This is due to that if the company has successfully adopted business intelligence tools, then adopting more sophisticated tools like advanced analytics will be easier, when the foundation is built for it.

As the name suggests, advanced analytics is an advanced version of traditional analytics. However, the term lacks clear definition. Advanced analytics can sometimes be a synonym to predictive analytics, but sometimes predictive analytics is seen as subtopic of advanced analytics (Boobier, 2018, 20). Bose (2009) defines advanced analytics as a group of tools which are used to gain information that predicts outcomes and helps solving problems. Kaisler et al. (2014, 729) see advanced analytics as a software which uses several analytics methods which can be used to provide from big data to "*descriptive, predictive and prescriptive results*".

Analytics including autonomous alignment, predictive and prescriptive are advanced analytics which contains comprehensive functionalities of simulation, statistical analysis, data mining and optimisation (Davenport & Harris, 2007, chapter 1). Advanced analytics tools are linked with big data and can be used as a tool for solving complex issues (Kaisler et al., 2014).

Mire et al. (2022, chapter 0) define advanced analytics as "*a mixture of machine learning, artificial intelligence, graphs, text mining, data mining, semantic*

analysis. It is an approach to data analysis. Beyond the traditional business intelligence, it is a semi and autonomous analysis of data by using different techniques and tools.” It seems important to emphasise that the book where this citation is from is made typically for computer science students and specialists, so this definition is lacking the business aspect. Usually, business orientated references do not include artificial intelligence in advanced analytics (see: Bose, 2009; Olszak & Mach-Król, 2018).

Boobier (2018, 20) uses Gartner’s – one of the leading companies in the field of analytics – definition of advanced analytics: “*The analysis of all kinds of data using sophisticated quantitative methods (e.g., statistic, descriptive, and predictive data mining, simulation and optimisation) to produce insights that traditional approaches to business intelligence - - are unlikely to discover.*”. Moreover, he listed advanced analytics’ most typical capabilities which are decision-tree analysis, pareto analysis, clustering/k-means, Holt-Winters methodology, rules of association, logistic regression, linear regression, correlation and Bayes law (Boobier, 2028, 21-22). There is also way to define advanced analytics by its levels. Chae et al. (2014) uses three levels by defining advanced analytics: experience as basic, statistical methods as intermediate and mathematical optimisation as advanced.

Kaisler et al. (2014) found out that in fast paced world the analytic methods like advanced analytics must adapt to nonstop data-flowing and analysis to keep up. The data cannot be static historical data sets, but rather continuous streaming of real-time information. Additionally, they noted that the data should be analysed without or with little human supervision over it.

Advanced analytics can be seen as a subtopic of big data analytics, since they both are based on big data and both are meant to analyse the data (Chen et al., 2012; Kaisler et al., 2014), but the difference is that advanced analytics usually refers beyond business intelligence solutions (Boobier, 2018, 18). However, where the line is draw between these two is not clear since both, BDA and AA, includes predictive analytics (Boobier, 2018, 18; Chen et al., 2012; Kaisler et al., 2014). Nevertheless, perhaps it is not really meaningful to draw a clear line between these two, but rather just see advanced analytics as an advanced extension of BDA. In this paper, when

speaking of big data analytics, it will include the advanced analytics in it, but advanced analytics refers only to these most advanced BDA tools.

This thesis's definition is conducted from Bose's (2009) and Davenport's and Harris's (2007, chapter 1)'s definitions:

Advanced analytics is a collection of tools employed for predicting outcomes, problem-solving, and comprises autonomous alignment, predictive and prescriptive analytics, along with comprehensive functionalities such as simulation, statistical analysis, data mining, and optimisation.

2.3 Artificial intelligence

The field of artificial intelligence has its roots in the 1950s, but the rise of AI can be considered as seen only recently. There are five reasons why AI became so popular: the massive amount of data, modern data storage, effective computational processing power, worldwide network and new algorithms and approaches. (Naqvi, 2020, 39-40.)

Oxford Dictionary defines artificial intelligence as "*The capacity of computers or other machines to exhibit or simulate intelligent behaviour; the field of study concerned with this.*" (Oxford University Press, n.d.). Common dictionaries usually are not taking any point of view therefore this definition is lacking business-oriented perspective. Naqvi (2020, 43) defines AI as "*The technology with the ability to achieve goals in uncertain environments*". This definition is lacking both business and technological point of view, but the definition could be concluded as being a simplified and easy to understand.

Mire et al. (2022, chapter 1.3) defines artificial intelligence as "*branch of science that studies and develops devices aimed at stimulating human intelligence processes. The primary aim of AI is to improve the speed and efficacy of regular processes.*". Munoko et al. (2020) defines AI as a technology which is encoded to imitate human-thinking and it can observe environmental signals, and taking those into account it can make decisions or act. Enholm et al. (2022) sees AI as application which can achieve goals by recognising, understanding, making suggestions and learning from data. The main difference of AI from advanced analytics is the capability to make the decisions (Boobier, 2018, 37).

Artificial intelligence is probably currently the most sophisticated method to use analytics. There is not a lot of scientific research of its use in management accounting and in decision making yet. However, auditing is benefitting from AI and there is a lot of studies and books about it (Munoko et al., 2020; Zhang, 2022) and it is not just big auditing companies who use it, but there is also evidence of its use in small auditing companies (Rikhardsson et al., 2022).

One of the most notable new innovations in area of AI is ChatGPT by OpenAI Foundation. ChatGPT understands natural human language and it is capable to produce human-like written text (Lock, 2022). It might not be typically meant for controllers, but it is a good demonstration how evolved artificial intelligence is. It is possible to ask questions from it, and it will reply. One can also have a conversation with it because it remembers the previous messages. Therefore, perhaps AI could define itself. When asking from ChatGPT to define AI, it responded this: *“AI stands for Artificial Intelligence, which refers to the ability of machines or computer systems to perform tasks that would normally require human intelligence, such as recognizing speech, making decisions, and learning from experience. AI systems use algorithms, mathematical models, and large datasets to analyze and interpret complex information, and can adapt their behavior or responses based on changing input or feedback. AI technology can be applied to a wide range of fields, including robotics, healthcare, finance, and transportation, among others.”* (OpenAI, 2023.)

The use of ChatGPT might be a bit debateable since there are some issues with it. ChatGPT sources are a bit controversial, and it uses the material of others, consequently one cannot trust or use blindly its texts without critically evaluating it first. It lacks critical thinking, it has limited knowledge of current issues, and it can give completely false and inaccurate answers (Lock, 2022). However, it is a great example of just how far AI is developed and what it can actually do. As one can see, its definition of artificial intelligence is quite correct when comparing its answer to previous definitions mentioned in this thesis. It could be argued that the level of its intelligence is rather good, and it can gather and combine information well and as stated before, it does pass the previously mentioned Turing’s test (Biever, 2023).

Artificial intelligence has different levels, and not all applications of AI work in a same intelligence level. Narrow AI or weak AI means a system working with very limited knowledge base but typically previously the task was done by a human but now the machine has accomplished to complete the task. Artificial general intelligence on the other hand is almost human-like capability but managed to do by a machine. (Naqvi, 2020, 45.)

There is no articulate consensus of the definition of AI (Loureiro et al., 2021) but almost all of the definitions accept that AI means the computer or other device have a human-like capability to perform tasks which usually has required human intelligence (Enholm et al., 2022). That is why also this study emphasises the human-like thinking capabilities when defining AI. The definition of AI used in this this thesis is based on the definitions of the papers of Mire et al. (2022, chapter 1.3) and Munoko et al. (2020):

A technology which aims to human-like thinking, can understand the environmental signals and make decisions and acts.

2.4 Business controllers

Accounting professionals are in the financial core of companies. They can be for example financial managers, controllers, accountants or auditors. This study focuses on controllers, or more specific: business controllers. Controllers are often divided into two groups: financial controllers and business controllers. Business controllers are same as management accountants, but especially in Finnish context management accountants are often called business controllers. Usually, financial controllers focus on financial accounting and analysing financial statements and business controllers on the other hand focus on management accounting, and they provide budgeting, internal business information and business analysing. It is common for organisations to have more than one controller (Andreassen, 2020) therefore this study aims to focus on controllers as an organisation level group more than controllers as individuals as did previous study by ten Rouwelaar et al. (2021).

Important decisions require skilled individuals when business becomes more data-centric and analytical capabilities become crucial for them (Davenport et al., 2001).

Controllers are being crucial information providers to the top management (Youssef & Mahama, 2021) and the financial function is a source for the enterprise's business decisions (Bhimani & Willcocks, 2014). Controller function is important in the organisation for raising awareness of the cost structure and resource allocation and it enhances the organisation's processes and decisions (Wolf et al., 2015).

There has been recent evidence that big data can transform the role of controllers, which requires them to adjust with their tasks and skillsets (Andreassen, 2020; Oesterreich & Teuteberg, 2019; Szukits, 2022; Youssef & Mahama, 2021) in order to maintain their importance in the company's decision-making process. However, even though there is evidence of the transformation of the role, the responsibilities stay the same: to provide information for the top management (Spraaakman et al., 2021).

Szukits (2022) found out that controllers' importance grew in the eyes of top management in the decision-making process when the organisation started to use advanced analytics. Oesterreich and Teuteberg (2019) discovered that currently analytics skills of the controllers are insufficient, and the role has undergone significant transformation in recent years due to emerging technological advancements. Ten Rouwelaar et al. (2021) discovered that controllers' IT skills positively correlates with the effectiveness of their job.

In addition, studies have revealed that big data analytics and other new innovations allow controllers to reduce the time spent in the data collection and focus on more analysing the data (Andreassen, 2020; Appelbaum et al., 2017). Nevertheless, that requires the controllers have IT and data analytics skills in order to succeed (Andreassen, 2020). Controllers are now facing the pressure to leverage big data by analysing it and making forecasts by using analytical tools (Appelbaum et al., 2017).

2.5 The enablers and inhibitors of BDA and AI

Just having the AI technology or big data analytics in the organisation does not mean that those will create value as there must be also capable people using the new technology. It may help to put pressure to accounting function to be digitalised if the organisation is already digitalised (Bhimani & Willcocks, 2014). Enholm et al.

(2022) created an organisational framework to identify enablers and inhibitors and impacts of when implementing AI system in organisation. It is quite similar to the TOE-framework by Pumplun et al. (2019).

There are three main enablers and inhibitor types: technological, organisational and environmental as one can see from the Figure 2. These enablers and inhibitors help to identify difficulties and advantages for AI readiness in the organisation (Enholm et al., 2022.) In the original framework by Enholm et al. (2022) the framework covers impacts of AI as well, but this study focuses only on the enablers and inhibitors. This framework could also stretch to big data analytics readiness since there are a lot of in common with AI and big data analytics and those both require a lot of effort from organisation to adopt (Bose, 2009; Enholm et al., 2022; Pumplun et al., 2019). Big data analytics and advanced analytics are linked with big data (Kaisler et al., 2014) and similarly AI's core enabler is big data (Enholm et al., 2022).

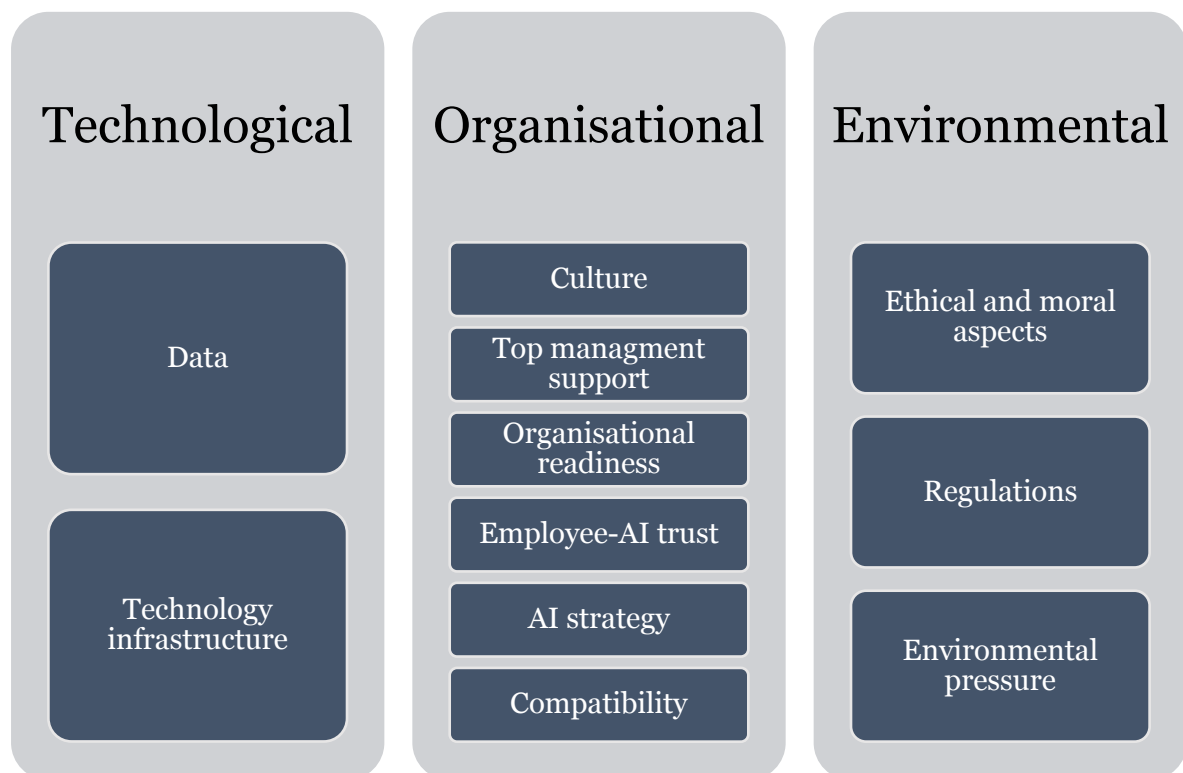


Figure 2: Enablers and inhibitors of AI (adapted from Enholm et al., 2022, 1716)

In technological enablers, the core enabler is data, especially big data (Enholm et al., 2022). As stated earlier, big data is closely related to artificial intelligence,

because big data is using and analysing vast amounts of data in order to help make the business decisions (Sestino & De Mauro, 2022). To develop successful AI applications there must be great quantities of data available (Pumplun et al., 2019). But data is not enough since there must be also a functional technology infrastructure. Companies which want to adopt AI must have access to cloud-base solutions and own the right computer hardware and solutions. (Enholm et al., 2022.) Likewise, advanced analytics need the right IT infrastructure (Olszak & Mach-Król, 2018).

In addition to technological enablers, organisational enablers are needed: top management support, organisational readiness, AI strategy and compatibility, organisational culture and employee-AI trust (Enholm et al., 2022). Organisation's culture is seen as one of the most important factors for organisation in order to adopt AI successfully, but additionally top management's support and overall innovative culture is important (Pumplun et al., 2019). This can be seen when organisations are adopting advanced analytics solutions, since if the organisation was earlier eager to adopt BI solutions, then they are more likely to take actions to adopt advanced analytics solutions (Bose, 2009). Furthermore, there are findings that support the claim that technological orientation is needed from the organisation in order to adopt advanced analytics (Szukits, 2022). Therefore, effective management support plays a necessary role in cultivating a culture that embraces the adoption of new digital technologies (Schmidt et al., 2020).

By organisational readiness one means financial resources, employee's technical skills and the use of experts. Usually available financial resources are shown in a budget, but budget can be a good thing or a bad thing, depending on the size of the budget and is there any obligations of the return of the investment. Naturally the higher budget there is, the more financial freedom there is to help build knowhow. If there are some expectations of the return of the investment it can reduce the project's agility. The employees should have technological knowledge but more importantly, professional qualification. The solution for the qualified staff cannot be outsourcing, since there is also need of in-house experts who know the company's domain knowledge. (Pumplun et al., 2019.) Likewise, the individual's personal

expertise and enthusiasm play a significant role, as one's own knowledge and passion for digital technologies can enhance the execution of tasks (Schmidt et al., 2020).

Other organisational enabler is employee-AI trust. AI changes the dynamics in organisation, since AI can do tasks which previously was done by humans so new roles emerges and old ones can radically evolve. (Enholm et al., 2022.) There must be a trust to the AI system and understanding the purpose of it by employees. However, the trust might take a while and AI does not have any emotions or empathy skills, so there can be a lot of challenges. (Makarius et al., 2020.)

AI strategy is important organisational enabler when adopting AI systems to organisation. AI strategy should tell how organisation is adopting and implementing AI system to harness its advantages, but it should not just tell the wanted achievements of the implementation but similarly provide plans in practice and timetable for the project. (Enholm et al., 2022.) Advanced analytics projects also require strategy and good project delivery in order to succeed (Willigers, 2020). The last organisational enabler is compatibility which means the compatibility between preferred system and technology, and it can be shared to two subcategories: business processes and business cases. The company needs to modify its business processes to align with the new demands stemming from AI utilisation. However, that is not enough, but additionally business cases must be considered: there should be a clear problem to use AI as a problem solver. (Pumplun et al., 2019.)

The environmental enablers are ethical and moral characteristics, regulations and environmental pressure. Ethical and moral aspects require the company to consider ethical and moral issues in AI system: the system must be aligned with company values, the possible bias and discrimination in the system must be root out, the system secure must be in an adequate level and the transparency must be maintained in the system. (Enholm et al., 2022.)

In addition, regulations should be taken into account by following laws and regulations. For example, the General Data Protection Regulation (abbreviation: GDPR) by the European Union restricts a lot of processing of personal data (Pumplun et al.,

2019). In addition, advanced analytics require the data security, especially if it is outsourced (Boobier, 2018, 23). Environmental pressure, on the other hand, means pressure to adopt AI systems outside of the company such as customers, competitors or other stakeholders (Pumplun et al., 2019). In their study, Schmidt et al. (2020) emphasise that the incorporation of advanced analytical tools beyond Excel could be delayed, given that stakeholders may not expect or request the use of these sophisticated techniques. However, competitive pressure is important driver to deal with AI system in order to gain a competitive advantage (Pumplun et al., 2019).

2.6 The use and impacts of BDA and AI

Adapting advanced analytics solutions can create business value (Brynjolfsson et al., 2011; Davenport & Harris, 2007, chapter 3; Kaisler et al., 2014). There is also indication that when using advanced analytics in supply chain management processes, there is a positive impact on operational performance (Trkman et al., 2010). The use of analytical tools is growing at high speed especially in manufacturing-related data (Chae et al., 2014). According to Bose (2009) advanced analytics will be a spearhead in business intelligence sector. However, 15 years is a long time in technological context, therefore the prime time of advanced analytics might be over, and artificial intelligence might have affected to that.

Advanced analytics and business analytics have increasingly piqued interest of businesses (Chae et al., 2014). In addition, artificial intelligence studies have gradually increased in the context of accounting in the last decades (Sutton et al., 2016). However, there have been relatively low number of studies which combines controllers and business intelligence and business analytics applications. Papers of big data mostly emphasises the positive possibilities of big data applications but do not critically evaluate the subject. (Rikhardsson & Yigitbasioglu, 2018.). It has been argued that IT systems, such as big data, business analytics and ERP systems, are the central force in shaping the role of controllers. The controllers can rely too much on the ERP tools and thus there is a risk of losing the judgment when analysing the business if the controllers just blindly trust the numbers without understanding the context and the origin of the numbers. (Heinzelmann, 2018.)

Big data has a great potential in the organisations to be use in the strategic decision-making (Chen et al., 2012) but recent evidence shows that so does artificial intelligence (Keding, 2021). Digitalisation has created more visibility to financial figures, helps in the decision-making process and creates more accuracy for the numbers in managerial accounting but, on the other hand, there can be issues with data security and lack of digital skills (Quattrone, 2016). In managerial accounting big data creates more opportunities to find valuable insights from a data that has not been earlier utilised before. This kind of data can be unstructured like photos and text. (Warren et al., 2015.) Artificial intelligence supports management with the strategic decision-making process by providing inventive ways to leverage knowledge (Keding, 2021).

In recent years, artificial intelligence has been steadily integrated into essential organisational functions, leading to business growth across various industries (Eriksson et al., 2020; Makarius et al., 2020). No wonder, since there is evidence that organisations that adopt AI solutions to their organisation have increased their revenues and reduced the costs and thus enhanced their overall financial and accounting performance (Davenport & Ronanki, 2018). Artificial intelligence is becoming progressively crucial for organisations in order to generate business value and gain a competitive advantage (Enholm et al., 2022). However, AI does not erase the need for human evaluation and vision in the decision-making process (Lehner et al., 2022).

There is most evidence of the use of AI in accounting within the auditors. Most of the auditing companies employ under 50 employees, consequently AI is not just the leverage of big auditing companies (Rikhardsson et al., 2022). Perhaps auditing is easier to be assisted by AI since there is a lot of phases which could be automatised, and structured auditing data is often available. According to Naqvi (2020, 46) the requirements of intelligent audit automation are robotic process automation, expert systems, process mining and machine learning. These are all AI methods and are seen as “*toolkit of intelligent audit automation*”.

AI could influence auditing in two ways: it can be a risk of bias when auditing customers are using it in their accounting (Rikhardsson et al., 2022) but also it can be

an effective tool in auditing by speeding up the processes (Munoko et al., 2020; Rikhardsson et al., 2022). In addition, it can deliver better insight into business procedures and generate a competitive advantage (Munoko et al., 2020). According to Naqvi (2020, 118) the audit automation process is based on preaudit evaluation, risk evaluation, audit processes, post audit management and assurance, forensic and valuation.

Munoko et al. (2020) identified AI auditing applications which used assisted AI, augmented AI or autonomous AI. Assisted AI is only supporting humans to make decisions, augmented AI is more sophisticated than assisted AI and it does some of the decisions, but not all. Autonomous AI is the most advanced form of AI, and it can operate in its own. AI auditing applications covered by the study were for example risk assessment, selecting transactions, evaluating controls and substituting auditor judgment.

One of the findings of Rikhardsson et al. (2022) were that some of the auditors especially working in small or medium sized auditing companies are lacking the skills of using AI. Furthermore, Zhang (2022) raised the issue of explainability in the results when using AI in auditing, however they created explainable artificial intelligence tools to make AI results more transparent.

There are other risks involved in use of AI in auditing. Munoko et al. (2020) pointed out the ethical concerns and if those are neglected it could destroy the benefits of its use. There are a lot of stakeholders within the auditing profession and the use of AI could increase responsibility and expectations gap. One solution for these threats could be a collaboration between the stakeholders and developing a guidance and governance to use of AI. Lehner et al. (2022) identified five challenges what it comes to AI in ethical decision-making in accounting: neutrality, confidentiality, transparency, responsibility and reliability.

Even though basic descriptive financial analytics data and operational data have been a corner stone in business analytics for a long time also the use of big data analytics techniques are becoming more widely adopted by businesses (Leventhal & Langdell, 2013). Szukits (2022) noticed that when using advanced analytics as a

decision support, it has a positive influence of the perceived value of the information processed.

Advanced analytics methods are increasing in companies to gain more profits or reduce the costs (Leventhal & Langdell, 2013). Advanced analytics needs foundation of data integration and mining (Bose, 2009). That means that problems with big data must be solved before adopting advanced analytics techniques. Likewise, Olszak and Mach-Król (2018) concluded that organisations require suitable IT infrastructure to perform well enough with advanced analytics. Szukits (2022) findings similarly support that the company's technological orientation plays an important part in the use of advanced analytics.

According to Bose (2009) there are several applications which could be seen as opportunities when using advanced analytics. Data mining can be used to optimise especially customer relationships, text mining for gaining insights of trends and relations and web mining for e-commerce marketing. It could be argued that advanced analytics have a strong implication in consumer-based business. However, he likewise noted the possibility of the use of advanced analytics in more strategic matters: identifying market opportunities, forecasting sales or supply chain management. Leventhal and Langdell (2013) listed as possible business applications of advanced analytics for example as price optimisation, portfolio optimisation and demand/supply chain forecasting.

Bose (2009) pointed out problems with advanced analytics. For instance, advanced analytics' investment needs to be fully organisationally bought-in but additionally implemented accordingly to succeed. In addition, privacy regulations must be considered carefully, and the staff using it must be trained properly. Additionally, the data used must be available. As mentioned before, Willigers (2020) emphasised significance of wholesome project delivery when conducting an analytics project, but likewise the importance of understanding that the good analytic results call for analytical attitude and business intuition.

Anglo-Swedish company AstraZeneca has formed advanced analytics centre which involves about fifty data scientists aiming to create an innovative way of decision-

making in the context of drug development. They are using advanced analytics techniques in that team (Willigers, 2020). Willigers (2020) pointed out a classic principal-agent problem within the use of advanced analytics and artificial intelligence especially in the medicine industry. This usually appears when objectives of data analytics and the medicine industry are not fully aligned. As mentioned before, digital orientation requires adequate knowledge, financial resources and senior management's attitude and behavioural, but the managerial perception is lagging behind of the constant development in analytics (Szukits, 2022).

Some companies are coping with the ever-evolving analytics by outsourcing analytics. There have been arguments that supports that in the future outsourcing of big data analytics becomes more popular and enterprises must be ready for external service providers (Bhimani & Willcocks, 2014). By outsourcing companies could potentially save a lot of time and money. It might not however, be that straightforward since, for instance Boobier (2018, 23) addressed a security issue regarding outsourcing data analytics. There can be issues in the data privacy and if the outsourced data get in the wrong hands which may cause a reputation risk for companies outsourcing their analytics as well as cost a lot of money. Cybersecurity has become one of the biggest risk management challenges and it is not limited to a certain type of organisations but rather is concerning all organisations (Haapamäki & Sihvonen, 2019).

AI is helping businesses to systemise the disaggregated data and converting the data into business decisions (Sestino & De Mauro, 2022) which is the controllers' main function. Enholm et al. (2022) also supports the claim that with vast amounts of data and AI system, managers can be better informed and thus make better decisions. There is a lot of implications of AI which can be used in business of which Sestino and De Mauro (2022) have identified six topics: business implications, human implications, industrial functions, social functions, predictive methods and recognition methods. Considering the subject of this thesis, the most important of the identified implications can be deemed to be the business implications. Business implications of AI can be, for instance, decision support systems, robotic process automation, expert system and process mining. AI can be vastly helpful in management decisions by helping human judgment. (Sestino & De Mauro, 2022.)

Big data and AI are believed to shape jobs in the future. Big data has been called a disruptive force in the accounting context (Rikhardsson & Yigitbasioglu, 2018). As mentioned previously, controllers must adapt their skillsets and tasks due to big data (Andreassen, 2020; Oesterreich & Teuteberg, 2019; Szukits, 2022; Youssef & Mahama, 2021). In the survey by Davenport and Ronanki (2018), they interviewed 250 executives and two thirds believed that that AI would considerably change the organisation within the time range of three years. The survey additionally concluded that businesses could benefit from AI to gain cognitive insights. (Davenport & Ronanki, 2018.) The change might similarly affect to the number of the employees since the use of AI has sparked discussion of jobs which might be replaced by AI solutions. Robot employees are probably the future trend (Loureiro et al., 2021), but it will remain to see which jobs can be replaced by a robot or automation.

Report by World Economic Forum from 2020 indicates that in addition that Finnish people are the best in digital skills, the percentage of jobs at risk of automation is one of the lowest in the world (Schwab & Zahidi, 2020). The report agrees that digital skills correlate with the low percentage of jobs at risk of automation. However, in Finland over 30 % of all jobs can be considered as being at risk of automation and therefore Finland is, like many other countries, facing the challenges caused by technological disruption of labour markets. However, especially management accountants often have tacit knowledge which might not be easily automated by machines (Quattrone, 2016), therefore the risk of automation of business controllers might be lower.

Auditors do not seem to be worried about the potential risk of automation of their tasks and they believe there is still a need for human agency even though there is a lot of auditing processes which already are replaced by AI which previously were done by a human (Rikhardsson et al., 2022). Furthermore Naqvi (2020, 4) agrees that automating audit does not mean that there is no need for human work anymore, but it rather has the potential to eliminate errors and to give auditors the ability to work with wider capability. Similarly, Makarius et al. (2020) pointed out the benefit of artificial intelligence. They concluded that the use of AI could reduce the amount

of manual work of employees and give them the possibility to concentrate on other, more important tasks that has the potential to create more value to the organisation.

One of the most pressing risks of AI and big data analytics is cyber security, especially when the data is shared with third parties, as described in the earlier example of outsourcing the organisation's analytics. The risks could be diminished by establishing a thorough cyber security plan (Haapamäki & Sihvonen, 2019). On the other hand, even if the organisation would invest effort and resources into AI projects, there are no guarantee of its success. One of the biggest issues seems to be the fact that organisations do not have thorough understanding of how artificial intelligence can create value in their organisations and what kind of other leverages it could bring with it. (Enholm et al., 2022.)

However, despite all the evidence that advanced analytics and artificial intelligence is spreading in the business world and the businesses are benefitting it, there has been evidence that controllers are resistant to adapt other tools than Excel (Schmidt et al., 2020). Additionally, Excel still seems to be dominant data analytics tools for controllers according to Spraakman et al. (2021) and Schimdt et al. (2020).

2.7 Knowledge-based view and analytics skills

There has been a paradigm shift from data-centric world to a knowledge-centric world (Kaisler et al., 2013), therefore knowledge is becoming more important than data. This is why the study focuses on knowledge, and to be specific the focus is on the knowledge-based view. Knowledge is simply defined as which is known and it can be divided into explicit knowledge and tacit knowledge (Grant, 1996), which are defined later in this section.

The knowledge-based view can be seen as a prolongation of the resource-based view, where the organisational advantages could be seen as developed from the company's resources. The knowledge-based view emphasises the fact that knowledge is strategically the most important resource of the organisation. Utilising knowledge creates value within the organisation. (Grant, 1996.) Recent evidence by the knowledge-based view suggests that controllers' knowledge have become more crucial due to

big data and is essential in order to create high-quality decisions (Franke & Hiebl, 2023).

To share the knowledge within the organisation is essential in order to gain competitive value but what makes it hard is that there is explicit knowledge, which is easier to share, and tacit knowledge which is not easy to spread around in the organisation. Explicit knowledge means knowing theories and facts which could be considered as easy to share, but tacit knowledge is harder to share, because it means *knowing how* and it cannot be exposed easily by communication. (Grant, 1996.) Controllers gain their explicit knowledge from their education, and it will be later shaped by experience and practice in their work and eventually their knowledge will transform into tacit knowledge (Herden, 2020).

Tacit knowledge can be seen as more important than explicit information when it comes to creating business value (Grant, 1996). Big data is seen as explicit knowledge (Sumbal et al., 2017) and it is supported by Franke and Hiebl (2023) asserting that big data is code-based, therefore it can be communicated and thus it is being explicit information according to the knowledge-based view. Big data is the foundation of big data analytics and AI (Boobier, 2018, 19) and those methods are just coded information, consequently one could stretch the idea that big data analytics and artificial intelligence are likewise explicit information. However, “*knowing how*” is not explicit knowledge (Grant, 1996), therefore knowing how to use them is rather tacit knowledge.

In addition to sharing, aggregation of information and appropriability of information are important aspects when utilising value from the knowledge. According to the knowledge-based view, variations in a company's success can be linked to the competence of its employees and how well they collaborate and apply their knowledge within the organisation. (Grant, 1996.)

The core of the knowledge-based theory is tacit knowledge and how to transfer that from explicit knowledge. The primary duty of the management of the company is to make environment where knowledge can be transferred into value (Grant, 1996.), and thus management's support can be considered as important when adopting AI

and big data analytics solutions to the company (Schmidt et al., 2020). The organisational knowledge is based on individuals' knowledge (Grant, 1996) and individual's personal knowledge and enthusiasm towards new analytics solutions plays an important role when implementing those to the organisation (Schmidt et al., 2020), therefore KBV is justified method to examine the implementation of artificial intelligence and big data analytics.

There are some previous studies from the knowledge-based views and analytical skills or big data (Franke & Hiebl, 2023; Gupta et al., 2021; Herden, 2020; Sumbal et al., 2017; Öhman et al., 2021), and most of them are made by using qualitative methods (Gupta et al., 2021; Herden, 2020; Sumbal et al., 2017; Öhman et al., 2021), but there was one quantitative study as well (Franke & Hiebl, 2023). To sum up, these studies gave insightful results that analytics resources, especially big data, can help improve making better decisions, but tacit knowledge is needed in order to use the analytics resources (Franke & Hiebl, 2023; Gupta et al., 2021; Herden, 2020; Sumbal et al., 2017; Öhman et al., 2021). Studies revealed that big data can be important source of information for boards to make better decisions in marketing (Gupta et al., 2021), in supply chain management and purchasing (Herden, 2020; Öhman et al., 2021) and in oil business (Sumbal et al., 2017).

Franke and Hiebl's (2023) study revealed that data-driven culture and the width of big data sources can only improve the decision-making quality if the skills of management accountants' analytics skills are good enough. Sumbal et al. (2017) noted something similar: organisations need employees who are experienced and the have tacit knowledge that helps them to make sense of big data.

2.8 Summary of the literature review

The chapter two has defined big data, big data analytics, advanced analytics and artificial intelligence, but also introduced us to analytics, competitive intelligence and business intelligence. Knowing the meaning of analytics and business intelligence is important, since both can be seen as foundation of AI and big data analytics. That means that if the organisation has adopted to use some business intelligence tools it

will lower the barrier of adopting more sophisticated tools like advanced analytics. (Boobier, 2018, 19.)

Likewise, the research object, controllers, were introduced. Controllers are important information provider for the top management (Youssef & Mahama, 2021) and there has been evidence that controllers are facing requirements for adjusting their skillsets and tasks due to the rise of big data (Andreassen, 2020; Oesterreich & Teuteberg, 2019; Szukits, 2022; Youssef & Mahama, 2021). There will be more details of the controllers and about the interviews in the next chapter.

As stated, big data has three main qualities: large volume, real-time velocity and variation of sources (McAfee & Brynjolfsson, 2012) and big data analytics are advanced technologies which can analyse big data in order to visualise, store and manage the data (Chen et al., 2012). Closely related to big data analytics, advanced analytics are a collection of tools to help prediction and problem-solving which are using more sophisticated methods like predictive and prescriptive analytics (Bose, 2009; Davenport & Harris, 2007, chapter 1). Artificial intelligence has been deemed as the most advanced of these techniques mainly because it is capable of human-like thinking and is able to take environmental signals into account in the decision making (Mire et al., 2022, chapter 1.3; Munoko et al., 2020).

There are enablers and inhibitors when organisation is adopting AI or big data analytics tools, which either accelerate the adoption or make it more difficult. The core is big data (Enholm et al., 2022; Kaisler et al., 2014) but likewise organisational culture, management support and overall readiness are important enablers (Bose, 2009; Enholm et al., 2022; Pumplun et al., 2019; Szukits, 2022). In addition, implementation strategy must be set up (Enholm et al., 2022; Willigers, 2020), and the organisation should also protect the data (Boobier, 2018, 23) and take into account the laws and regulations applicable (Pumplun et al., 2019).

Big data analytics are becoming increasingly more popular (Leventhal & Langdell, 2013), and the use of these kind of techniques is growing fast (Chae et al., 2014). There is abundant evidence indicating that the adoption of advanced analytics data can yield significant business value (Brynjolfsson et al., 2011; Davenport & Harris,

2007, chapter 3; Kaisler et al., 2014; Leventhal & Langdell, 2013), but slowly artificial intelligence has integrated into businesses (Eriksson et al., 2020; Makarius et al., 2020) and it is said to be creating business value and enhancing the overall financial performance in the company similarly as big data analytics (Davenport & Ronanki, 2018; Enholm et al., 2022).

Advanced analytics have many opportunities in the organisations: identifying market opportunities and forecasting sales (Bose, 2009), price optimisation and demand/supply chain forecasting (Leventhal & Langdell, 2013). The problems identified with adopting to advanced analytics are inappropriate IT infrastructure (Olszak & Mach-Król, 2018), immature technological orientation (Szukits, 2022) and weak project delivery during the implementation (Willigers, 2020).

Auditing is considered benefitting a lot from AI by speeding up the processes and creating a better insight to business processes to be audited (Munoko et al., 2020; Rikhardsson et al., 2022; Zhang, 2022). However, there are some ethical concerns when using AI in auditing, like a possible increase of responsibility gap (Munoko et al., 2020). However, auditing is not the only accounting aspect which can utilise AI, and AI is helping businesses overall to make better business decisions when huge amounts of data can be processed effectively (Enholm et al., 2022; Sestino & De Mauro, 2022).

Artificial intelligence can cause a major revolution in organisations (Davenport & Ronanki, 2018) and AI based robot employees could be a trend of the future (Loureiro et al., 2021). There are a lot of auditing processes which have been already replaced by AI (Rikhardsson et al., 2022) but there is still need for human agency (Makarius et al., 2020; Naqvi, 2020, 4; Rikhardsson et al., 2022).

In addition, knowledge-based view was introduced, which gave the guidelines to the point-of-view of the study. In the core of KBV is that tacit knowledge within the organisation is their competitive advantage (Grant, 1996). Big data analytics and AI are explicit knowledge therefore the spread of that knowledge is easier. However, “*knowing how*“ is not explicit knowledge (Grant, 1996), but rather tacit knowledge,

and the organisation should handle the problem of spreading the knowing how knowledge in order to gain competitive advantages.

When reflecting the theory into the research questions, the assumption could be that the controllers want to use big data analytics, advanced analytics and artificial intelligence, because these tools are creating overall business value (Brynjolfsson et al., 2011; Davenport & Harris, 2007, chapter 3; Davenport & Ronanki, 2018; Enholm et al., 2022; Kaisler et al., 2014; Leventhal & Langdell, 2013). Furthermore, in Finland general knowledge in digital skills are best in the world (Schwab & Zahidi, 2020), consequently it would indicate encouraging results that if somewhere these methods are utilised somewhere, it is in Finland. The theory implicates that by adopting this kind of tools, the financial performance of the organisation would improve and if these tools are not used, perhaps there might be some barriers in the implementation or other reasons why the implementation has not yet been done in the financial department.

The study aims to conclude how the tacit knowledge is shared in the organisation. Perhaps there can be one pioneer controller within the controllers in the organisation who is sharing their knowledge with others. Perhaps organisations are trying to push the controllers to be more data-oriented by investing new technological applications, providing IT skills courses or releasing working time in order to innovate new approaches to analytics. But is it still enough for the controllers even though organisations support the implementation of the advanced technologies? Are there other barriers?

It is clear, that artificial intelligence is making headlines in the business world, and perhaps big data analytics and advanced analytics have been overshadowed by it. How have the controllers adopted to this situation where new advanced technology can offer them effective methods to do their work more precise and more insightful?

3 Methodology

In this chapter the structure of the empirical part is explained. First the research design is explained. After that, the data and the data collection is described. Lastly, the trustworthiness of the study is considered.

3.1 Research design

After a careful consideration the chosen method was qualitative. The reason is that there was no intention to make any generalised assumptions, but rather to understand the phenomenon around the artificial intelligence and big data analytics combined with management accounting professionals. Qualitative study is particularly well suited for investigating non-numeric data, enabling a comprehensive understanding of the phenomenon at hand. A good qualitative study is based on theory, well-defined and documented, and analysed in a credible manner to enhance the understanding of how management accounting functions in diverse social, institutional, cultural and organisational sceneries. (Vaivio, 2008.)

The selected method to approach the issue was multiple case study in order to get a wider and more diversified understanding. Multiple case study is suitable for collecting rich and comprehensive data. The aim of a multiple case study is to examine different case companies; thus, the goal is not to study in-depth a single organisation, but rather to identify certain patterns among organisations and examine similarities and differences in the phenomenon across different organisations. This approach helps to identify, for example, similar problems in management accounting across different types of organisations. (Vaivio, 2008.)

The study was conducted as a qualitative study and the used method was semi-structured interviews. Semi-structured interviews are excellent for capturing diverse viewpoints from the study subjects (Myers & Newman, 2007). The questions presented in the interview situation can be found in the appendices (Appendix 1). However, it is important to clarify that specified and clarified questions were also asked during each of interviews.

Qualitative research demands more objectivity from the researcher than quantitative research, because often the research involves researcher's close or even personal interaction with the research site, therefore this requires cautiousness from the researcher (Parker, 2012). Problems in conducting qualitative research may arise if the study is too narrowly theorised, resulting in poor research outcomes, or if only official perspectives are gathered during data collection, leading to failure (Vaivio, 2008). Management accounting procedures and practices in the organisation can be complex, consequently qualitative method is justifiable to understand the phenomenon (Parker, 2012).

3.2 Data and the data collection

The goal of the study is to examine the phenomenon of the use of AI and big data analytics by the controllers, so it is meaningful to describe who the controllers are. To understand more widely applications and conceptions of big data analytics, AI and advanced analytics, this study has not narrowed the interviewees to a certain job title, but rather trying to keep it as wide as possible within the range of all sharing responsibilities of a strategic controller task in their work. The interviewees are specialised in and working with management accounting. The controllers did not have to have any educational experience of analytics or artificial intelligence substance knowledge. They might not even have any experience of using AI or BDA in their work.

The primary data is constructed from collecting it by interviewing seven controllers from different organisations from various industries. All organisations had in common that they are based on Finland, they all are defined as large enterprises, and they all somehow emphasised their controllers to be keen on analytics. In this context large enterprise means that they employ more than 250 employees and their yearly revenues are more than 50 million euros or their balance sheet's value is more than 43 million euros. The large companies were chosen due to resource-based view of the previous studies, where the emphasis is that an organisation can gain a competitive advantage from its resources (Barney, 1991). Finland as a region was

selected due to its characteristics of high digital skills and future-oriented policy (Schwab & Zahidi, 2020) but additionally for the convenience and access reasons.

The chosen organisations were selected from LinkedIn, which is a social media platform for businesses, employees and employers. LinkedIn is a popular place for job openings. First phase was to search from LinkedIn open business controller, financial controller and controller positions where the employer implied that they appreciated skills or interest to analytics, business intelligence, advanced analytics or artificial intelligence. Because of the small amount of the matching job openings, also Finnish business controllers' LinkedIn profiles were searched manually and if there was indication of analytics skills and the company matched the criteria, they were contacted. This phase took place in October and November 2023. The job applications were read manually and only part of those were selected in the next phase.

The company was reached by LinkedIn or via email. Totally 37 invitations for interview were sent and seven interviews were settled. Before each interview the interview questions were sent beforehand to the interviewees. Reading the questions was optional for the interviewee, but some of the interviewees wanted to think the answers beforehand. Moreover, the interviewee aimed to become more familiar of the company before the interview, therefore the interview would be easier to conduct. The interviews took place in Teams, which is a tool for online meetings. The interviews were recorded and transcribed and analysed for the study's purpose.

Table 2: Overview of the interviewed companies

Interviewee / Company	Total employees	Total of number of controllers in the organisation	Industry	Title	Experience in current profession in years	Date of the interview	Length of the interview
A	8600	13	Health services	Business Analyst	1	7.11.2023	29 min

B	300	3	IT services	Business Controller	5	7.11.2023	38 min
C	5300	17	Tourism and hospitality	Head of Business Control	3	9.11.2023	57 min
D	900	15	Banking	Business Controller	5	15.11.2023	59 min
E	4300	25	Industrial products and services	Business Controller	4	20.11.2023	43 min
F	3300	25	Health services	Business Controller	2	24.11.2023	39 min
G	2400	75	Industrial products and services	Head of Global Project Control	8	28.11.2023	60 min

One notable thing of the Table 2 is that the total employees -column is somewhat debatable since it differs from the companies on the list. Some companies on the list functions in Finland and employ only employees in Finland, therefore in those cases the number is right. Nevertheless, most of the companies are part of an international group, therefore in those cases it counts only the company's employees working in Finland. However, there are examples of companies which are divided into several

different companies which offers different products and/or services, and in those cases the total employees are only employees in the same subcompany. Thus, conclusions made from the total employees -column should be avoided as the information referred depends on the structure of the company as explained.

In addition, the total number of controllers in the organisations -column is determined by the interviewee and the number represents either all the Finnish controller colleagues or the controller colleagues who are working closely by the interviewee, but they can be working outside of Finland. This is due to the fact that the study aims to examine the controllers as a group rather than individual, but when interviewing only one person from the company, there is a possibility that they might not know the working style of the colleagues they are not in touch. That is why the interviewer has asked to determine this amount by themselves who they see as their controller colleagues and can speak for their colleagues.

3.3 Trustworthiness of the study

The study is qualitative, thus there was no intention to make generalised conclusions. The aim was more to study the phenomenon. The reliability of the study can be examined by repeatability of the study. The data collection could be repeated and then create another quite similar study. Validity can be measured by examining how well the study is measuring the study matter. The selected research method was carefully chosen to examine accurately the controllers and their adaption of big data analytics tools.

The seven selected interviewed companies represent large companies in five different industries. One employee from each company represented the controllers in their company. The number of the interviews are in a decent level to claim that the study is comprehensive. As a conclusion, it can be stated that even though generalised conclusions cannot be drawn, the interviewees represent their company, and seven large companies are in a Finnish context a prominent result.

It is important to note, that even though the study focuses on controllers as a group rather than as an individual, the individual opinions, perceptions, assumptions and judgments can affect the results. The aim was to avoid this by clarifying the

interviewees that the answers should be in a generally representing the organisation's controllers rather than the individual's opinion. The semi-structured interviews have its faults and advantages, and some interpretive challenges can occur. Moreover, the used terms and analytical tools do differ when discussing the matter and there can be minor misunderstandings by the interviewee and the interviewer. As correct as possible interpretation was aimed to be ensured by asking corrective questions.

To conclude, all studies have their limits and weaknesses. The study is carefully considered and conducted, and all debilitating factors were tried to identify and prevent. However, the reader should take these mentioned factors into account when reading this paper.

4 Findings

This chapter presents the findings of the study. The next sections 4.1.1-4.1.7 will introduce the organisations included to the study and their controller teams. Sections 4.2-4.6 will provide more deeper findings of the studied organisations.

4.1 Organisations involved in the study

Total of seven different organisations were interviewed for this research. Next sections will give general information of the interviewee, the organisation, how many people do they employ, how are their managing their data and analytics and what their problems are with the implementation of big data analytics and AI. Afterwards, the chapter will provide more deeper findings by explaining what kind of big data analytics tools they have adopted, what are the main factors behind adopting these forms of analytics tools, which problems do they have but additionally how do the controllers spread the tacit knowledge within the organisation and how they are seeing the historical and future change of the controller function.

4.1.1 Company A

Company A is a large Finnish company working in the health care industry. They employ about 8600 employees. The interviewee who represented the company works as a Business Analyst and has worked in the position for one year. He is the first one to work as a business analyst in the company, thus the position is still being shaped. There are total of 13 business controllers in the organisation. The interviewee is responsible for monthly reporting, developing the analytics and business intelligence solutions in the organisation, doing ad hoc analytics like forecasting and additionally he is part of their artificial intelligence team, which aims to find adoptable AI solutions for the company. He does most of the analytics work in their team, therefore he was recommended to be interviewed from the company.

The company is working in the health care industry where their operations rely mostly on personnel, rather than technological advantages, thus the organisation emphasises technological implementation in the administration and the financial departments. However, they do have access to excessive amount of nearly real-time

data, which is collected to one data platform. Due to regulation of the health care industry, there are limitations of the gathering and the use of data. They have a data team who is managing the data collection. The interviewed business analyst uses python programming language in order to analyse this data. Nevertheless, they have faced problems with the quality the data and how to access it, but mostly these problems now have now been overcome.

“The ones who work with data, they [analytics tools] are really significant that almost daily we are using them - - but when it comes to advanced analytics techniques, I’m practically the only one using them. In my team, we still rely quite a bit on traditional Excel, but I think we will gradually switch from that as well.”

- Interviewee from Company A, freely translated

The company has adopted business intelligence tools and advanced analytics tools, nevertheless, still there are a lot of controllers who rely only on Excel and even the BI tools are not used by all of the controllers however, there has been an attempt to take next steps forward to move beyond Excel organisation. The organisation has a vision in their strategy that they are trying to adopt artificial intelligence into their organisation and currently they are in the phase where they are charting the options for their organisation.

4.1.2 Company B

Company B is one of smallest company of the study, but still it is classified as a large company in Finnish context. It employs about 300 employees, and they have three business controllers at the moment and one data analyst who is, as the interviewee called them, the controllers’ “right hand”. The company works in IT sector and thus, it is in a rather good place in its big data analytics implementation although being one of the smallest companies in the study. The interviewee of the company is one of their business controllers who has worked there for five years.

“So, I have been really excited that these [analytics tools] were implemented. It has taken our organisation significantly forward in terms of how much we have been able to lead with data. Previously, it was all a bit of leading by intuition, and relying on Excel reports to give us some results on a monthly basis - - and then we would ponder over them once a month. Everything else in between was done somewhat based

on gut feeling. But nowadays, in our organisation, everything leads to data-driven decision-making. It has indeed propelled us forward quite a bit, and even the management has noticed it.”

- Interviewee from Company B, freely translated

During the time he has worked there he has witnessed the company's controllers' shift from being dependent for Excel to a place where Excel is rarely used anymore. First, he had a crucial role in being a data analyst by implementing big data and advanced analytics tools into the organisation rather than being a classic business controller, but during the last couple of years his role has shifted towards being a more traditional controller. His responsibilities are now forecasting, budgeting, optimisation and guiding the business into right direction.

The Company B's controllers are quite effective in using advanced analytics tools. All of the reporting is done in the BI tool. They are not using any artificial intelligence tools other than ChatGPT, which is used mainly for guiding the use of other analytics tools. However, they have had some conversations of implementing some AI methods into the organisation, but it has not actualised yet. After the first phase of implementing advanced analytics tools, they were excited to create sophisticated analytics which was not used to anything because the reporting was not understandable. Now they have tried to create more comprehensible reporting which can be used in effectively in the decision-making process.

4.1.3 Company C

Company C is working in a tourism and hospitality sector. It employs over 5000 employees and 17 business controllers. They can access a lot of data from their customers, competitors and other stakeholders within the limitation of GDPR. Therefore, they have built an extensive BI system. Due to their industry, the Covid-19 pandemic and global geopolitics have negatively influenced the company by reducing their business and confusing their advanced analytics systems. Especially their advanced analytics tools became quite irrelevant since those rely on historical information and could not understand these unforeseen situations for example in forecasting. Additionally, it has delayed artificial intelligence implementation since now

they have no relevant historical data to teach the AI system, therefore currently the controllers do not use any AI tools.

“The sophisticated [analytics] tools, partly because they rely heavily on previous behaviour, had to be somewhat turned off because they, well, don't really understand or grasp what is actually happening. We had to develop other ways to get the data out in understandable formats. Now, we closely monitor what happens to competitors' capacity and try to respond to it. In this quite static industry, if you think about it, before the pandemic, we had a pretty good idea of what would happen in the next twelve months. But now, we really don't know.”

- Interviewee from Company C, freely translated

The interviewee from the Company C is titled with Head of Business Control, and he is in charge of planning the customer experience, like planning the budgeting and return of investments calculations of services to their customers. He describes himself more as a business challenger rather than a business controller because he challenges currently used presumptions and tries to analyse the impacts and the future. The company has a rather big data analyst team supporting the controllers. The controllers can request new data possibilities, BI solutions or other data-related needs and the data analyst team is trying to fulfil them.

As asserted previously, the Company C has adopted big data tools but in addition, several advanced analytics tools in order to gain insight their vast amount of data. The organisation has a long history of using enterprise resource management tools and sophisticated analytics tools, and they describe themselves data oriented since they have always had access to great amount of data. However, there is still some reliance on Excel, which is hard to rid of because it is a habit from the history. They have experienced some issues with the analytics tools. For example, some terms in the analytics tools have caused misunderstandings and sometimes data is filed in a wrong format to the system, and it creates issues when analysing the data.

4.1.4 Company D

Company D is working in the banking service and employs roughly 900 employees. They have 15 business controllers, and the controllers are supported by a team of data analysts and data scientists. There is also a team dedicated in enhancing the

reporting in the organisation. The interviewee from the company works as a Business Controller and he has five years of controller experience in the company. His main responsibilities are being the right hand of the business line manager and providing supportive information to them in the scope of financial framework. He has previously done report developing in the same organisation.

They have built a massive business intelligence system. As does Company C, also Company D accesses a lot of sensitive information due to the banking business, therefore they have built the systems carefully and have selected access views in order to maintain the data security. This sometimes causes problems and delays when implementing new reporting tools. Despite the access of big data, they have not implemented any advanced analytics tools for the controller team and analysis is mostly done in Excel. However, the interviewee considered that there might be advanced analytics tools in the data analyst team, but he was not sure. Furthermore, he pointed that it might not be practical for the controllers to use them, because perhaps it is not included to their role to know about advanced analytics, since they have dedicated analytics team for that. Moreover, it requires a lot of time for them to get to know new technologies even though it would speed up their process.

"It would be nice to try to think a bit outside the box regarding that [advanced analytics and artificial intelligence] to own work, but at times, it has felt like everyday life often wins at that point, as there have been so many other things going on that the time investment in it has still been minimal. A somewhat challenging classic dilemma: there's an awful rush to push the wheelbarrow, and then someone offers a tractor, but, you know, it tends to be like that sometimes."

- Interviewee from Company D, freely translated

Regardless of high reliance to Excel, there has been experiments of artificial intelligence projects among the controllers. However, those remained as experiments and did not become a routine. The organisation has been described as technology-oriented, and the organisation supports the shift to rely more on advanced analytics and artificial intelligence. They have a working hour model where some of the working hours are dedicated to learning new skills and the organisation offers a lot of courses and learning opportunities. In addition, the controllers are eager to learn new and have quite positive attitude towards new innovations like advanced

analytics and artificial intelligence, but for some reason the steps for implementing advanced analytics tools have not been made.

4.1.5 Company E

Company E is manufacturing several industrial products and services, and it employs about 4300 employees. Company E's representative in the interview was a Business Controller who had been working in the company for four years in different business controller positions. He is financially responsible of one of the company's main business lines in a certain area. He does reporting, budgeting, estimating and monitoring expenses, and in addition he is sort of a business partner to the area manager. In his business line there are 25 business controllers which he sees as his colleagues and can represent them in the interview.

Company E is a big company with a lot of data available, consequently they have an ERP system which supports their BI tools. They have several "data cubes" which are meant for different uses and different user types. They use several advanced analytics tools for analysing, optimising, estimating and doing other ad hoc analysis. Despite the advanced analytics tools, Excel still plays a significant role in the organisation however it is only meant for individual ad hoc analysis. However, they believe that the use of Excel will decrease among the controllers. There are no artificial intelligence tools or even planning to adopt one, nevertheless the organisation is technology-oriented, and they do invest analytics systems, therefore perhaps in the future the company will invest also to that.

"In practice, everything relies on those [analytical tools] being reliable to use, and it's more like things are highly automated nowadays. The role of the controller is more about trying to find any bugs there might be, and then perhaps the most significant amount of time goes into fixing those bugs."

- Interviewee from Company E, freely translated

The have experienced problems with the data validation, meaning that the data filled in is in a wrong format or is missing and thus the mistake multiplies in the different add-on tools. This can take a lot of time to solve, and usually business controllers are the ones to notice these issues. Another challenge is several different

ERP tools around the company due to the many mergers and acquisitions. So, despite officially having only one ERP system, the reality is that there are several ERP tools and the transfer towards one ERP system is moving slowly. Each team has their own key-user who is helping others with the analytical tools. They have numerous places to ask help with the analytical tools. However, the controllers' skills using the analytical tools like BI tools or advanced analytics tools are in the level that they can navigate in the systems, but not all know how to make reports in BI tools.

4.1.6 Company F

Company F is working in the health care industry as does the Company A. The company employs about 2500 employees and 25 business controllers. The interviewee of the company is a Business Controller who has worked there for about two years. His main duties are enhancing the data and analytics systems by building new reports and, additionally, more traditional business controller tasks such as calculations on profitability and other monthly reporting. The company has adopted BI solutions and advanced analytics solutions. Moreover, they are in the edge of adopting new AI tool in addition to their previous ChatGPT based tool. Therefore, it could be stated that they are one of the most advanced companies when comparing the analytics tools implemented. However, Excel still plays a great role in their everyday work, but it is main tool only in ad hoc calculations and not in reporting.

“We have more pressure to utilise them [analytics tools], and it's expected of us. The goal is to utilise that data because it mostly comes from operational activities. - - We aim to create reports and analyses based on that, so they can be used within our units, allowing our unit manager to make better daily decisions using them, simulate, or optimise the personnel structure. It involves a lot of human management.”

- Interviewee from Company F, freely translated

They have experienced some validations issues with the data and other technical issues when building new reports. They have tried to solve the problems with their backend IT-team and providing in-house and external training sessions with the personnel. The company has implemented data-based decision-making into its strategy and thus they have invested in analytics tools and in addition, AI has been raised as one the company's themes for the following year.

It could be concluded that the companies A and F share a lot of similar traits but partly it may be explained by the industry being the same. For example, both interviewees agreed that when the business is personnel-oriented, the pressure to adapt new technological innovations is in the back-office. Likewise, both companies access a lot of real-time data.

4.1.7 Company G

Company G is working in the industrial products and services industry like Company E. There are some other resemblances with Company G and E than just the industry. They both have gone through mergers and acquisitions in the past years and that has complicated the data management, since they have many systems which are not compatible with one another. They do access a lot of data as well as the Company E, and they have built an ERP system.

“Different teams across the organisation use a variety of resource and management tools without much coordination. Now there's an attempt to harmonise this, but it's surprisingly difficult because [Company G] is such a large firm, and the business divisions have been given a significant level of autonomy with their responsibility for profits. Consequently, they have the autonomy to define the most effective tools and practices for themselves, and these don't align. - - As a result, we're currently in a situation where we're unintentionally duplicating development efforts, costing hundreds of thousands of euros.”

- Interviewee from Company G, translated freely

The interviewee from the company works as a Head of Global Project Control. Hence, he is not a traditional business controller, but rather a project controller who is responsible for managing the project costs and profits since the company can have massive projects which involves globally subsidiaries and several business units. He is working also as a supervisor for other project controllers, and he is involved with enhancing their reporting and analytics tools.

Company G has adopted BI tools, but not any advanced analytics or artificial intelligence tools and consequently they rely mostly on BI reports and Excel. However, they are in a verge of launching a new advanced analytics tool. The main reason for why they have not yet adopted advanced analytics or artificial intelligence is that the data they have was not validated and thus cannot be used without careful validation

first. Consequently, first their primary goal is to manage their data better in order to adopt more advanced analytical tools. The interviewee believes that in the future they are ready to adopt AI solutions to their controller function. However, despite the fact that new tools will be implemented, he believes that Excel will play a great role also in the future.

4.2 Overview of the adaption of BDA and AI

All the companies involved to the study have adopted business intelligence and big data applications to their controller’s work. All of them had some sort of BI tool in order to handle their data and make reports. Surprisingly all companies had the same BI tool: Microsoft Power BI. Many of them agreed that it is easy and intuitive to use. Microsoft Power BI was used daily in most of the companies.

Table 3: Overview of the adaptation of analytical tools by the controllers

Com-pany	Excel	Big data / Busi-ness intelligence	Advanced ana-lytics	Artificial Intelli-gence
A	Widely used	Microsoft Power BI	(Python)	Searching for the solutions
B	Occasion-ally used	Microsoft Power BI, Snowflake	WorkDay Adap-tive Planning, Al-teryx	ChatGPT
C	Widely used	Microsoft Power BI, Snowflake, Oracle Financial Services Analytical Applica-tions	Anaplan, IBM Cognos Analytics	(IBM Cognos Ana-lytics)
D	Widely used	Microsoft Power BI, Tableau	-	ChatGPT, other

E	Widely used	Microsoft Power BI	Anaplan, Oracle Hyperion Planning	-
F	Widely used	Microsoft Power BI	Anaplan	ChatGPT, soon Microsoft Copilot
G	Widely used	Microsoft Power BI, Microsoft Dynamics	Soon OneStream Software	-

Other tools used concurrently with Microsoft Power BI were Snowflake in Company B and C, Oracle Financial Services Analytical Applications in Company C, Tableau in Company D and Microsoft Dynamics in Company G. Overview of the adapted tools can be seen in Table 3.

Most of the companies have also adopted advanced analytics systems, which they used for analysing the data from BI tools. Only company that did not use any advanced analytics tools was Company D. Company A used Python programming language in more advanced analytics rather than more user-friendly analytics software, but the interviewee from the Company A was the only in the company who used Python, other relied only on Excel and BI tools. Anaplan was the most used advanced analytics tool, and it was used in Companies C, E and F. Company B used WorkDay Adaptive Planning and Alteryx tools. In addition to Anaplan, Company C used IBM Cognos Analytics and Company E used Oracle Hyperion Planning. Company G is soon starting to use OneStream Software, which is an advanced analytics tool.

Despite the quite widely adopted big data analytics tools, the reliance to Excel was mentioned a lot in the interviews. There was only one company, Company B, that said that they rarely use Excel anymore. Company D relied mostly on Excel if they needed to do analysis from the data from different big data analytics tools, the analysis is done in Excel. There was no evidence of the shift or pressure to move beyond

Excel in the company. However, the interviewee mentioned that there are several data analysts and data scientists who might use advanced analytics.

Company A's main analytical tool was Excel, but there is an attempt to get rid of it by creating more data-oriented working culture and the interviewee believed that gradually they are depending less and less on Excel. Company F and G had somewhat similar experiences with company A: Excel is the main tool in analysing, but reporting is done in BI tools. Company C and E have faced issues with Excel, due to the amount of data they have, and Excel is no longer eligible for doing the analysis properly, therefore they have advanced analytics tools for that. Despite that, "the Excel habit" is hard to get rid of, and still some controllers in the company rely quite a bit on Excel.

Company G also relied on Excel heavily and there was no evidence of shifting towards more advanced tools. In fact, the interviewee mentioned that the analytics tools they have built, are meant to resemble Excel in order to personnel to adapt to the tool better when the user interface is familiar and intuitive. Despite that, the management felt negatively reporting done in Excel, since if the reporting is going to be frequent, it should be done in BI tool.

"All controllers must be familiar with at least the basic functionalities of Excel. Many of our reports and interfaces are built to resemble Excel to be user-friendly. When OneStream was being developed, the aim was for it to be very Excel-like. I'd say I don't see us ever abandoning Excel, nor do I see it being worthwhile, as it provides a sort of sandbox environment where you can do practically anything."

- Interviewee from Company G, freely translated

Almost all companies agreed upon the fact that the analytical tools are helping and enhancing the performance of the controllers. In Company D the analytics tools were seen to decrease the workload of the controllers as the reporting can be done much faster and in a more straightforward manner.

Many of the interviewees acknowledged that use of these tools is usually quite straightforward, and they have adapted well to use them. Company B's business controllers were stated as being excited to use analytical tools, and they believed that these tools create valuable information to their work, as previously they had to rely

a lot on a gut feeling especially in forecasting. In Company C the general feeling is perhaps not that excited, and there is still a need for validation calculation in Excel. However, the interviewee concluded that generally the knowhow of the analytical systems is not in the level where it should be.

“The challenge is that while the results are clear to oneself, making them clear for the business managers, that's the biggest challenge there. In practice, in my work, it means getting the data to yield a result in a way that even if something is statistically significant, shaping it in a way that the business understands it, that's the challenge.”

- Interviewee from Company A, freely translated

As one can conclude from the quote from Company A's interviewee, the analysing results are easy to understand by himself, but the challenge comes from transforming the results into understandable format for the rest of the business. In Company D on the other hand, the analytical tools have brought more transparency, new point-of-views, and effectiveness to the reporting.

“Probably the biggest question is about artificial intelligence—how to integrate AI into the company's decision-making process. Can we, for instance, entirely rely on AI for decision-making? It could generate answers for us through machine learning, identifying anomalies or determining net present value, and these kinds of capabilities might represent the most significant area for development. Of course, there's always the possibility of further advancements in utilising current analytics or data that we haven't yet optimised for proper analysis or reporting. The more we leverage this data, the greater potential we have to discover a lot more.”

- Interviewee from Company B, freely translated

No company used regularly artificial intelligence applications or tools, but there were some ad hoc things which included some use of AI applications. For example, occasionally Companies B and F used ChatGPT to guide them if they faced some issues in the analytics tools or if they needed help creating correct input or query to the system. Likewise, Company D had some experience of the use of AI, but the interviewee was not sure which kind issues it had solved, but he said that the cases have been only sporadic experiments. This was quite surprising since they did not regularly use any advanced analytics tools. Company D has ChatGPT available as well, therefore when asking if he used it for in the same way as in the Companies B

and F, he felt that if there is need for guidance from AI in order to use the analytics tools, there has been a failure in communications and the in the training in the company.

As stated in the company's introduction part, the Company C which is working in the tourism and hospitality industry has faced a setback what it comes to implementing advanced analytics and artificial intelligence, since Covid-19 pandemic and global geopolitics hit the industry harder than the other industries. They currently do not have enough stable financial data to teach the systems, so artificial intelligence implementation for the controller function is frozen at the moment. Correspondingly, other companies like Companies E and G struggled with data, since if the data is not well validated it cannot be utilised in the use of AI. The main problem with the data is several data sources which are validated differently or wrongly. Therefore, they must first deal with the data issues, before considering AI tools.

Almost all interviewees were excited to talk about AI and they did see it as important thing in the future, but most of them agreed that it is not topical yet in their work. Especially the controller from Company B was very excited about the future of AI. Company A was actively searching for the AI solutions, but they still have not found any solution to put to practice. Companies B, D and F used ChatGPT but it was not seen that important tool in their daily work. Company C had an AI tool IBM Cognos analytics, but they did not use any of the features. Company F was currently launching Microsoft Copilot tool, which uses AI. To conclude, it can be averred that the phase of AI implementation is still being at its early stages and in some companies the implementation has not even started.

4.3 Factors behind the implementation of big data analytics and AI

Additionally, the aim for the interviews was to identify which factors affect when adopting new big data analytics tools. One important factor, which almost all the companies mentioned, was the individuals who had a personal interest in more advanced analytics. Companies A, C, D and E emphasised the importance of the enthusiastic and skilled controllers or "pioneers" who are driving the more data-

oriented culture to the team. They can spread the enthusiasm to other controllers and share the tacit knowledge. Most agreed that this plays crucial role when implementing new analytics tools into the controller team. Company A has a strategy where they are trying to employ individuals who are interested in AI and have strong analytical mindset and the interviewee saw the enthusiastic employees as most important factor.

The interviewed controllers described different reasons to adopt big data analytics and AI. All of the interviewees were asked that if they feel that their organisation is technology-oriented, and everyone agreed saying that they are. They were also asked how it can be seen in their daily work. In Company A, the top management is trying to lob new technological innovations into their administration and finance, since when working in personnel-intensive business, they cannot implement technology a lot into their operative work, therefore they focus on optimisation of non-operative work.

All of the interviewees were asked if their companies' management sees these analytical tools as important, and all of them answered that they believe that. This appears in practice as that they are encouraged to use and develop these. Furthermore, some of the companies had implemented into their strategy to become more data-oriented or to make decisions based on data. In Company A, the company's strategy and vision includes that they are trying to adopt artificial intelligence tools. Some of the companies had a company strategy which encourages adopting new analytical innovations into their work. Company F's strategy is to make data-based decisions and AI is one the rising themes for the next year. In Company D they aimed to develop reporting according to the needs of the business, trying to identify the elements they want to emphasise and bring a narrative storytelling through the reporting in order to make it more comprehensive.

Company B experienced that there was a slight pressure from competition that made them to take the next step in their analytics tools by implementing advanced analytics tools into their organisation. They had new top manager who had previous experience from a company who had already adopted successfully advanced analytics tools, and the manager wanted to pitch the idea to Company B as well. The top

manager succeeded and then the management team decided to invest into these new tools. According to the interviewee the results have been excellent, and they have been able to make better business decisions which are based on data rather than just a gut feeling. In addition, he concludes that the top management is rather supportive for the use of big data analytical tools and tries to encourage the employees to develop the reporting all the time.

“Perhaps it comes from a lack of visibility into a specific aspect, say, for example, some sales cases. Then there arises a need to refine that data into a format that's easier to track, usually stemming from the business side - - generally, it's this business-oriented necessity. There are already so many reports that there's no sense in creating unnecessary new ones; typically, there's always a specific need driving their creation.”

- Interviewee from Company E, freely translated

Company E emphasised the need for the new system for the most important factor when implementing a new big data analytics system. When the controllers see some necessity or they notice a poor visibility to a certain financial aspect, so they need to have a strong reason for the new applications. Just creating new systems and reports does not bring any value, if they do not serve any specific need. Company A, B, C and E emphasised the fact that they are accessing a lot of the big data, which requires them to have more advanced analytics systems in order to analyse it since Excel is not suitable for big data.

Some of the companies had a dedicated artificial intelligence team or team for enhancing analytics and reporting who seek AI or other analytics solutions for their company. Company A had an AI team that is trying to find AI solutions to their team. Yet no AI solutions had not implemented in the controller function, but the interviewee thought that in the future they might be using some AI tool.

All of the interviewees were asked if they see their company as a technology-oriented company which can be seen as an indicator of the adopting of big data analytics. All of them agreed saying that they believe their company is. Some agreed to this very strongly, other were saying that they are quite technology-oriented but in some aspects they could be more digitalised.

One factor which did arise in the interviews were that they access a lot of data, and they want take advantage of that data with better analytical tools. For example, Company C access a lot of data of their customers, competitors and other industry related data. Companies A and F also mentioned the access of data as one of the factors. Company F mentioned the will of making data-based decisions as an important factor. The company wanted to benefit the current data they got better.

Company D emphasised as the biggest factor the business' specified need for the better sight for the numbers. If there is a need for highlight or create a visibility to a certain business aspect by analytical tools, they try to find a way to visualise that. The tools they have adopted are more informative and give more insights and trustworthiness to the figures, therefore they have received a lot of praise from the top management. Company D works in the banking service therefore the industry is quite regulated, and consequently they always need to have extra cautiousness when working with their data. Company E brought up quite similar factor as Company D: the lack of visibility to a certain business data and business need for the analytical tool. The interviewee mentioned that if there is no need, there should not be any analytical investments.

Companies A and F both work in a health care industry and there was a similar pressure in their administration to adopt more digital innovations, since they cannot utilise a lot of digitalisation in their operational work. They do access a lot of data, consequently they wanted to benefit from it by implementing analytical tools which help them to find insights and valuable information from the data.

4.4 Problems with the adaptation and in the use of analytical tools

Most of the interviewees believed that their expertise of using analytical tools is in a decent level. However, many brought up that many controllers' education is not prepared for using analytical tools and the transition can be slow with some of the controllers. In these cases, training sessions and proper introduction is needed, according to them. Therefore, the problems usually were not related to the expertise of the controllers. Moreover, the interviewee from Company D emphasised that it is not

necessarily important the controllers to know all the knowhow of analytics if they have a good data team backing up them.

The validation problems with the data were the most common one which the interviewees brought up. There were problems with the source of the data, the validation problems with the data and the flow of the data. Almost all of the companies mentioned validation problems or bugs as a problem when asked of the biggest issues. Company G had severe data issues due to many mergers and acquisitions. They see that they first need to fix their master data in order to create high quality reporting. Company B was really eager to implement advanced analytics tools, and they have created a lot of sophisticated analysis. However, they realised that just creating analysis and reports do not benefit the company if the results are not interpreted correctly. After realising that they started focus on creating reporting which is easier to understand.

“Perhaps we focused a bit too much initially on creating a lot of highly sophisticated analysis, but then the aspect of how to utilise these was somewhat neglected. We realised that just creating reports doesn't significantly drive the business forward. So, we've been trying to solve this by creating more easily understandable reporting.”

- Interviewee from Company B, freely translated

Company C has had issues with the cohesion of the data and the systems meaning that different people use the filters and the concepts differently in their BI tool, and there can be misunderstandings even though they are using the same data. The problem is in the end user or in this case in the business controller. They need more clarification through rules and instructions in the organisational level.

“I'd say that nowadays, it's difficult to manage without them [analytical tools]. All the work is built on them, and if there's a bug in any system, it practically freezes everything. They are heavily relied upon, interconnected in such a way that if there's a bug in one system, it quickly spreads to others, causing data to be corrupted. Essentially, everything depends on them being reliable.”

- Interviewee from Company E, freely translated

Companies E and G has faced issues with the several ERP systems they have which do not sync with each other. The systems are not synced, the data does not flow

easily, and the data is not accessible. They have tried to harmonise the situation by implementing only one ERP system but so far, they have not succeeded in their plan.

4.5 Spread of tacit knowledge within the controllers

When discussing of the ways of how tacit knowledge of big data analytics and AI spreads within the controllers, the elements which were mentioned were meetings, seminars, trainings, ad hoc conversations and workshops. These could be with another controller or controllers, an IT specialist from their own organisation or external consultant. Furthermore, company's own instructions were seen as good way to spread information, however, many of them said that massive group information calls or meetings do not work well, and instead smaller interactive groups where one can ask questions and more instructions should be preferred. Furthermore, there are a lot of unofficial conversations which can lead into spread of tacit knowledge.

As mentioned before, Company A had a special AI team which included employees from various teams, and they were looking for AI solutions they could implement into their organisations. They had regular meetings. Similarly, they organised workshops where they could brainstorm with external AI specialists how they could benefit from AI. They have not yet implemented any AI solutions.

Company E had a Teams channel for every analytics system and reports. Teams channels are internal communication forums where one can send messages and files. In the Teams channels they can ask questions or seek help if they are facing any issues regarding to the analytical tools and the key user will answer to them or tries to solve the issue, and if they cannot help, they will try to seek help elsewhere. Despite these channels the interviewee said that usually they just ask from another colleague, even though the general guidance is to ask from the Teams channel, thus everyone can learn from the answer.

There are other examples of a specific teams set up in order to develop the analytical tools. In Company E they had a developer team who are taking actions to enhance the system with the help of external consultants. Almost all of the companies had some sort of data team backing up with the data and the systems, mostly including internal employees. Company E had a system where one controller was assigned to

work as a key user in some analytics tool. Key users help others with the use and advice the other team members in updates and new features. Company D has a backup data analytics team who is responsible for developing the analytics systems. Most of the companies had had some trainings held of the analytics tools and how to use them. Company E had regularly meetings where new updates and other general information regarding the analytical tools is being shared. These meetings are recorded and shared to the employees. Only Company B did not have any training sessions of analytics, but the interviewee believed that if the controllers wanted to have some, the company would organise some training for them. In addition, they have had meetings with the analytics service provider. Furthermore, the company works in the IT industry, and they have in-house consultants who can help them, but naturally their external clients are prioritised first. There is somewhat same mentality in Company C as it is in Company B; they do have training sessions available, consequently if one wants to learn more, the training is available, but it is up to the employee if they want to take the time and learn.

There was also evidence of sharing new ideas and thoughts of analytics in the meetings in almost all of the companies. Company F has taken actions to spread the tacit knowledge of the analytical knowhow. They organise best practice meetings where the controllers can share to one another the best ways to use the analytical tools. In these meetings one can share new practices and discuss about the development of the analytical tools. In addition, the company aims to document more of the practices, consequently the learning process is enhanced. This all is due to their strategic decision to increase the knowhow knowledge of the controllers. In Company C they have a similar system as in Company F, whereas they have a couple times in quarter a best practices clinic session, where they share knowhow knowledge of the analytics tools. This has been experienced as a very effective learning method.

Company D did not have any advanced analytics solutions in the use of controllers. They do have a data team to support them and making reports. That has its pros and cons as the knowhow of the analytical tools is not spreading when the controllers are not actively participating in the development process. Nevertheless, the interviewee from the company said that the controllers are open to adapt more advanced

analytics systems and probably it would speed up the daily routines. They have had trainings and conversations with the data team and interviewee believed that it has helped the controllers to learn more.

“Like I said, we have the team dedicated to developing reporting, and they solve a lot of these technical solutions. It's both a good and a bad thing because when they handle these tasks, the expertise in that area [controller team] might not necessarily grow since those challenges don't always arise in that particular role.”

- Interviewee from Company D, freely translated

One interesting insight was from Company B and F, where the knowhow knowledge was derived from AI, a more specific from ChatGPT. If they faced any issues with analytical tools or needed help with the query or input when using Standard Query Language, they tried to seek help from ChatGPT to solve them. The other option was to go colleague and find the solution together to the problem.

Company D had a specific working hours model in which a certain percent of the working hours is allocated for cultivation and can be used for gaining more knowledge of analytics or AI. However, the interviewee admitted that he had not used it for analytics purpose, but it could be used for that. There were no other companies who used working hours models for cultivation like the Company D's.

All interviewees were asked if they believed that the controllers' knowhow of analytical tools is in a decent level to use them. Almost all of them agreed. In Company B the knowhow was in a level that they had been asked to consult other organisations and the interviewee believed that their knowhow is better than average business controller's knowhow. Only the interviewee from Company C said that the current knowhow is not yet in the level it should be, but it is constantly developed.

Furthermore, the scope of the use of analytics tools was discussed with the controllers. In Company D the interviewee stated that the background, ambition, the nature of the job and the need of the reporting affects a lot how and how much the controllers use the analytics tools. Interviewee from Company C thought that all of the basic use was quite similar, however when it comes to something more advanced the role is usual more analytical although also the person's own analytical mindset affects it.

In Company G all controllers should use the same systems and tools, but there are differences due to habits and regional customs. They are actively trying to standardise the tools by training and monitoring therefore every controller should know how to use and utilise the same tools. Furthermore, one important aspect was that the controller can be replaced with another controller from the company if needed and still the practices and skills should be the same. But in practise they have still a lot of communication and training to do before they can say that all the controllers are using the same tools.

In the Company G there has been an issue when analytics is done by some skilled employee in one's own Excel sheet, and the tacit knowledge has not been shared which can lead to a situation where the job has been personified. Then if the employee is sick, on holiday or leaves the company, the company is in trouble. That is why the BI tools are great way to share the reporting and analytics and make them more accessible and it can reduce the risk of jobs being personified. They also try to arrange meetings of controllers in a small interactive group where one can share the tacit knowledge with the another.

4.6 The change and the future of the controller function

The interviewees were also asked about the historical change they have experienced in their working career in their current position and previous controller positions in the technological context. They were also asked to think what the future of controllers will be and how the technological innovations can change the position.

4.6.1 Thoughts of the historical change

The interviewees were asked of how the technology has changed the controllers' job, and the general opinion was that digitalisation has been increasing the overall performance. They have now more time for analysing the business when they do not have to search for the data from different sources and because some reports are done automatically. Thus, they can focus more on enhancing the business by providing valuable information.

Company B's interviewee saw that after the process of implementing the advanced analytics tools the controllers' return of investment has been increased and they have been able to drive the business forward. He described that it was a costly and big investment to shift from using only Excel to a very data-oriented company, but the investment has been successful.

“Nowadays, we're better able to drive the business forward. I guess our so-called return on investment is significantly better now than it was back when we were constructing those reports.”

- Interviewee from Company B, freely translated

According to the interviewee from Company A, there has been a shift from doing only Excel calculations and slowly collecting data into being a more strategic business controller who can provide strategic information and being a business partner in the organisation. There is a similar reckoning in Company F as well, that nowadays the search of data is quicker than before, and it releases time to do deeper analysis and search for better insights.

There was somewhat similar experience in Company C, where the interviewee said that the amount of time when retrieving the numbers from the sources and creating visualised graphs took before hours, but now, due to more sophisticated tools, it takes only couple of minutes to do. He also pointed out that a controller is highly paid to search for information for hours, instead the focus should be rather in the analysis of the business. He commented that: *“data analytics tools help to answer the 'why' question the most effectively”* (freely translated) meaning that they can now find very precious insights of their business, and for example, they can find the reasons why the figure was lower than expected.

Interviewee from Company E pointed out the difference when there has been hired a technology-oriented person versus non-technology-oriented person. The technology-oriented person is often much quicker to adapt all the systems and they will adjust very quickly to the working environment. Quite the contrary, the non-technology-oriented person needs more time to become acquainted with the systems and the orientation to the work takes more time.

The one notable thing that has changed, is the amount of data available. Company C's interviewee pointed out that: "*The amount of data I have easily accessible now is exponential compared to when I started*" (freely translated). Moreover, Company D have noticed how they can find synergies and correlations much easier and make vastly more in-depth analysis than before.

Company C's interviewee brought up that building BI tools enhance the cohesion, when all the departments in the organisation are using the same data and the same numbers when talking of the financial figures. Therefore, the risk of errors in the reporting is decreasing and the trustworthiness is increasing. Company E pointed out that nowadays all of the controllers' work is based on these systems, and it is a requirement that one can use them.

All of them agreed the fact that nowadays they have more time to analyse the business and have better tools to do that. Additionally, they can access the data easier than before. Consequently, they can be more effective in their work and provide better information for the business than before.

4.6.2 The future of the business controllers

When asking of the future of the role of business controllers several things were mentioned. Some of the interviewees saw that there will be a split to a two different business controller functions in the future. The human judgment, forecasting and vision will become more important since the manual work is reducing.

Company C's interviewee considered that in the future business controllers are divided into two groups, meaning that some business controllers become more like traditional financial controllers and some of them become more as a business challenger or as a business partner for the company. By business challengers he meant employees who are challenging the current business styles and are constantly analysing the data, searching for new opportunities and questioning the old ways. He believes that this happens at least in the bigger companies. In Company G the interviewee had a similar thought of the split, that there will be operational business controllers and strategical business controllers.

The interviewee from Company D predicted that business controller will become more of a future forecaster. Even though the AI can find correlations from different data sets, which can correlate but in real life they do not have any causalities with each other. According to the interviewee from Company D the last decision must be made by human so the false conclusions made by AI can be detected and corrected. Company G's interviewee had somewhat similar idea of the future of the controller function. The forecasting of the future will be more important and there is need for the human vision to judge the analytics.

Even though the manual work has been reduced already, there is still room for more automation. In Company E the interviewee believes that in the future there will be less manual work and practically controller can only check the validity of the numbers and create analysis. One of the main tasks for the controller in the future is to intervene deflections made by AI.

Many of the interviewees thought that even though the technological innovations enhance the performance, there is no need for layoffs. The main idea behind this was that they can then focus on more value creating work and thus be more valuable to the company. Company A had an idea of controller to become more like an internal consultant to the company, who can analyse the business' need rather than focus on controlling side. He also foresaw that controllers can be more creative in their work. In Company D the interviewee predicted that even if in the future there was an AI tool doing the analysis effectively, there is still a place need for human scepticism and searching for opportunities for the analytics in order the business to gain advantage of it.

Company G did see that there will always be need for business controllers, because of the systems and data will have bugs and errors, and when these occur there is a need for the human judgment.

“And I'll add to this now that it's the very reason why controllers are needed in any organisation at all. It's because systems don't operate as they should, so we need a person who can take A and B and merge them into one.”

- Interviewee from Company G, freely translated

Most of them agreed that in the future the technological and analytical knowhow is going to be a requirement for a controller. Interviewee from company F pointed out that in the future business controllers' role is getting more closer to data analysts since the technical knowhow is going to be more important. Additionally, the understanding of the analytics process becomes more crucial in order to controller to succeed in one's job.

Many of the interviewees saw that the significance of artificial intelligence will increase and become more evident in the daily work of controllers.

"The biggest question is probably related to artificial intelligence, how to integrate AI into the company's decision-making process. Can we, for example, make some decisions entirely using AI, so that it could provide us with answers through machine learning? Like identifying anomalies or realising that business' net present value is worthless. - - There's always the possibility that with current analytics or data that we don't yet know how to analyse or report properly, there's potential to find optimisation opportunities. The further or the more we can leverage that data, the more we can discover."

- Interviewee from Company B, freely translated

Interviewee from Company B envisaged that artificial intelligence could offer deeper and more valuable insights from the data which currently cannot be found. There can be anomalies or other business areas which need enhancing. Therefore, the expected potential for AI is high at least in Company B.

To conclude the future thoughts, the main ideas were that there will be a split to two different business controllers at least in the bigger organisations and the manual work will still reduce. The time reduced from manual work will increase the need for human judgment, vision and forecasting will become more important.

5 Discussion

The preceding chapter provides an overview of the empirical findings, while the following section delves into a comprehensive analysis of these findings within the context of the study's theoretical framework. The discussion begins by examining the present state of artificial intelligence and big data analytics implementation, followed by an evaluation of the knowledge-based perspective regarding the utilisation of analytical tools within the organisation. Additionally, attention will be given to identifying the factors that enable or inhibits the adoption of AI and big data analytics. The final part of the chapter synthesises these discussions to contemplate the evolving role of the controller function in the future.

5.1 Big data analytics and artificial intelligence implementation

As mentioned in chapter four, all interviewed companies had implemented business intelligence and big data solutions to their controllers' work. All of them had the same BI tool: Microsoft Power BI, but they had also other big data tools to manage their data. According to Boobier (2018, 18) business intelligence tools have become a corner stone in business decision making and this study's findings agree with this as well.

Six out of seven of the companies had implemented some advanced analytics tools into the work of the controllers and this is in line with Leventhal and Langdell's (2013) findings which indicates that advanced analytics techniques are increasingly adapted by businesses. However, some of the companies had problems with integration and validation of data, especially Companies E and G, which makes more difficult them to fully utilise the data and use its potential. There are similar findings in earlier studies (Bose, 2009; Olszak & Mach-Król, 2018; Szukits, 2022) which supports this finding.

Bose (2009) pointed out that business intelligence solutions provide better and up-to-date information and help in the decision-making process and Chen et al. (2012) highlighted the great potential of big data in the decision-making. Many of the controllers emphasised the effectiveness of accessing data and processing it with the

business intelligence tools. Data tasks which previously took a vast amount of time are now quite fast to do. Due to the current effectiveness, they can now access more information which is important when making decisions, and many of them told that they do more data-based decisions nowadays. Especially companies which had adopted advanced analytics tools saw that they can now provide better data and thus the company can make better decisions. This is supported by previous studies and papers, which have shown that adopting advanced analytics solutions can create business value (Brynjolfsson et al., 2011; Davenport & Harris, 2007, chapter 3; Kaisler et al., 2014).

There were similar findings in this study as in the papers of Quattrone (2016) and Warren et al. (2015). The study of Warren et al. (2015) found out that big data has created a better visibility to financial figures, and it creates an improvement in decisions, and this quite similar as the findings in the Quattrone's (2016) paper. Additionally, the paper by Warren et al. (2015) also found out that big data helps utilise valuable information from the data which earlier was not possible, and the findings of this study align with that. In the interviews there were similar comments about the data and how nowadays they can analyse it more in-depth and find correlations which has not been identified before.

Excel is still keeping strongly its place as the basic data analytics platform, since six out of seven controllers said that it is their main analytical tool. This is in line with the findings of Schmidt et al. (2020) where Excel was said to be fundamental data storage and data analytics platform still. Only Company B's controller did say that they rarely use Excel nowadays. In Company G they were trying to build their new analytical tool to resemble Excel to make it easier for employees to adapt that which does tell the significance and the level of adoption of Excel.

All of the companies had their own data analytic or data scientist teams who backed up the controller function. There was no evidence of outsourcing analytics or data management even though Bhimani and Willcocks (2014) concluded that outsourcing is going to be a trend. It may be that the companies are concerned of data security issues as Boobier (2018, 23), Quattrone (2016) and Haapamäki and Sihvonen (2019) addressed.

The adoption of AI was still in very early stages, but it sparked a lot of discussion with the controllers. Most of them were excited about it and believed that AI will be one of their tools in the nearby future. They had many ideas how they could benefit from it in the controller function: finding anomalies, determining net present values of their projects in real-time, getting better insights of their current data and thus making better decisions. These are in line with the findings of Sestino and De Mauro (2022).

They did not have any AI based analytics tools, but many of them did have access AI tools which uses large language model like ChatGPT or Microsoft Copilot. The controllers had found different uses for these tools as well. In Companies B and F, the interviewed controller used ChatGPT to guide them with their analytics tools when they were facing difficulties. Perhaps these large language models are the first AI tools to spread widely into the organisations and analytical AI tools are coming afterwards, since many of the controllers believed that in the nearby future, they will be using more AI tools which are more meant to ease and help the controllers' work.

5.2 KBV and big data analytics

Controllers play a vital role in supplying essential information to the top management (Youssef & Mahama, 2021), while the accounting function serves as the foundation for the business decisions of a company (Bhimani & Willcocks, 2014). All of the interviewed controllers saw themselves as an information provider for the top management. Some of them called themselves as "a mini-CFO" or as a financial right hand of the business lead, therefore it was clear that in their point of view they provide crucial information for the top management. The information is based on the data they access, and they need to use their analytical and technological skills to access it. This section will introduce the ways of how this kind of knowhow knowledge is spreading among the controllers.

As described, controllers' basic education is explicit knowledge, and this knowledge will transform to tacit knowledge within time when doing the practical work and gaining experience (Herden, 2020). Tacit knowledge is valuable and can create business value (Grant, 1996), therefore the organisations had different approaches to

spread the controllers' valuable knowhow of analytical tools. There has been evidence that controllers' IT abilities positively correlates with the efficiency of their work (ten Rouwelaar et al., 2021). Mostly the companies relied on spreading the knowhow of analytical tools by organising meetings and other gatherings, but there were also training sessions and forums to spread knowledge.

Organisation's knowledge is naturally based on the individuals' knowledge (Grant, 1996), but there is also risk of the personified jobs if the tacit knowledge is not shared. In Company G, the management has noted this risk of personified jobs where the tacit knowledge and information are dependable on one person's knowhow, and they are trying to spread the tacit analytical tool skills by having small interactive groups. There is a threat, that if tacit knowledge is not shared and the skilled employee quits or becomes sick, there is a threat that there will be a gap in the organisation's knowledge. According to Grant (1996) it is management's duty to make an environment where the tacit knowledge is shareable and can be transformed into value, and this was also seen in Company G.

Recent findings suggest that big data has the potential to alter how controllers operate, demanding adjustments in their responsibilities and their skillsets (Andreasen, 2020; Oesterreich & Teuteberg, 2019; Szukits, 2022; Youssef & Mahama, 2021). This study supports these findings, since the interviewees agreed that the skillset of the controllers has changed, and nowadays they must have some analytical tool skillset in order to succeed in controller function. This claim is supported by the claim that IT skills correlate with the success of the controller job (ten Rouwelaar et al., 2021).

One evidence of how big data analytics is changing the job of controllers, is from Company E, where they had noticed that when employing a technology-oriented person for controller job, the induction is easier and faster compared when employing a non-technology-oriented person. This is in line with Sumbal et al. (2017) findings which implicates that organisations need skilled employees which already have tacit knowledge in order to make sense of big data.

In Company A there was some similar evidence, where the management had a strategy where they wanted to employ AI-interested employees to create more data-oriented culture into their organisation. Franke and Hiebl's (2023) study concur with this by stating that there is a need for employees who have good analytical skills in order to create data-driven culture and improve their big data utilisation. Additionally, the management's support is crucial when adopting big data and AI (Schmidt et al., 2020).

One aspect which all of the companies agreed on, was that nowadays the controllers have more time to do value-creating work, when collecting the data and the analysis does not take as much time as before due to big data and big data analytics. Mostly interviewees told that the extra time goes to doing more analysis (and by that creating more value to the company), but additionally in meetings and in training sessions. This is aligned with the previous studies which agrees that big data analytics and other new advances allow controllers to decrease the time spent in the data collection and concentrate on more analysing the data (Andreassen, 2020; Appelbaum et al., 2017).

Utilising analytics, particularly big data, can enhance decision-making, yet the effective application of these resources requires the incorporation of tacit knowledge (Franke & Hiebl, 2023; Gupta et al., 2021; Herden, 2020; Sumbal et al., 2017; Öhman et al., 2021). Almost all of the companies agreed that the controllers' current use of analytical skills is at a good level. That would implicate that the companies have been succeeded in transforming the tacit knowledge into explicit knowledge. However, one should note that there were differences in type, quantity and level of sophistication of the analytical tools in the companies, consequently the level of knowhow might not be in the same level in the companies.

Some of the interviewees commented that they do not feel the pressure for adapting and gaining skills to deal with new analytical tools. However, one should note that all of the interviewees were relatively young, meaning that many of them were graduated 2-10 years ago and none of them are not going to retire any time soon. Perhaps there could be feeling of pressure if the interviewees were older and not so used to

IT infrastructure. In Company E they admitted that younger employees are easier to train to use the IT infrastructure than if the employee was older.

5.3 The enablers of big data analytics and AI

As acknowledged in the previous section all of the companies had implemented business intelligence applications, most of them had advanced analytics applications. AI implementation was in its early stages or not implemented at all. Sections 5.3.1-5.3.3 will go through the key enablers and inhibitors behind the implementation of AI and big data analytics.

5.3.1 Technological needs

Data and technology are the two technological enabler or inhibitor according to Enholm et al. (2022). As Finland is one of the top-tier countries in future oriented policies (Schwab & Zahidi, 2020) the assumption was that the selected companies had somewhat good prerequisite to adopt new analytical solutions.

As mentioned before, the core enabler is data (Enholm et al., 2022), and many of the interviewees told that the company have access to a lot of data due to their business and the size of their company, therefore it was natural to want to take an advantage of it. In order to do that, the companies have invested in better analytical tools, since in many of them it was realised that big data needs efficient data storage and control, but also effective analytical tools to analyse the data correctly. Therefore, the core reason and the simplest motive for wanting to adopt more advanced technology is that they do access the data but had not yet utilised the data in the level they had desired.

“When we have so much data, and we understand the benefits within it, - - we acquire numerous data points about customers and additionally with access to competitor data - - the limitations of using Excel quickly become apparent.”

- Interviewee from Company C, freely translated

However, even though the participated companies were big and have the resources, it creates challenges in the data access especially if the growth is due to acquisitions and mergers, and the IT infrastructure is not aligned across the organisation. This

was especially the case in the Companies E and G. They had problems with trying to manage with several ERP systems, data validation and data quality, thus the adoption of better big data tools and not to mention AI tools becomes very problematic. Both of them have a mission to harmonise the tools to match with one other, but so far, the harmonisation has been challenging to achieve. This matches with the findings of Pumplun et al. (2019) which claims that in order to develop a successful AI infrastructure there must be numerous quantities of accessible data.

The problems with the Companies E and G are also in line with the findings of Enholm et al. (2022) and Olszak and Mach-Król (2018), since they claim that there must be a functional IT infrastructure in order to adopt AI and big data analytics. Functional technological infrastructure is seen as the second enabler (Enholm et al., 2022). Most of the interviewees believed that they have rather good IT infrastructure and that their organisation invests into efficient tools, even though some of them faced data validation issues.

5.3.2 Organisational support

As mentioned in the section 5.3, the organisational enablers and support for the implementation is one of the three enablers of AI and big data analytics. The interviewees were asked different questions of how their organisation is supporting them to adapt the analytical tools. Mostly the interviewees pointed the same things as the others: creating technology-oriented culture, employing eager individuals, investments to the systems, training sessions with other controllers or specialists and building a data team to back up the controllers.

According to Pumplun et al. (2019) organisation's culture is an important factor. Especially this had been noticed in Company A where they had a clear mission to employ more data oriented and AI-interested employees to their organisation in order to create a culture through eager individuals. This is supported by Schmidt et al. (2020), who stated that individual's own interest and expertise is an important factor.

“That [artificial intelligence] is the rising theme and over the past years there has been a lot of talk about artificial intelligence. Because of that,

we have started to include in job applications the desire to create a certain kind of culture through individuals."

- Interviewee from Company C, freely translated

All of them were asked if their culture in the organisation was seen as technology-oriented and all of them agreed to that. This was not a surprise since it has been considered that Finland stands out as a leading nation in forward-thinking policies for the future (Schwab & Zahidi, 2020). In addition to the organisation's culture, the support of top management is also a central factor (Pumplun et al., 2019). All of the interviewees agreed when asking if they believe that the top management sees these analytical tools as important, and they do invest to these. They described how the management encourages them to utilise and develop analytical tools and have objectives to be more data-oriented or to invest in AI applications. These strategies are aligned with the claim of Enholm et al. (2022) and Willigers (2020) where strategy is one the enablers of AI and AA implementation.

Additionally, there is a need for the resources, adequate skills and experts (Pumplun et al., 2019) when adopting new AI and big data analytics solutions. The resources were mostly allocated into their data team that was meant to maintain, store and utilise the data available and provide help and support for the controllers to enhance their data usage. According to the interviewed controllers, six out of seven believed that currently the controllers in their organisation have adequate skills in order to manage the daily work. The remaining one believed that the skills are not yet in the level they should be, but they are constantly trying to enhance the skills. These findings do differ from the findings of Oesterreich and Teuteberg (2019), who claimed that currently controllers presently lack adequate analytics skills. However, there could be geographical differences with the skills, since Oesterreich and Teuteberg (2019) studied German controllers instead of Finnish ones, but major difference is also that their study was quantitative, and this study is qualitative.

The adequate IT skills were maintained or gained by organising training sessions, employing skilled staff, making manuals and channels for seeking help with IT systems. All of the interviewed controllers believed that they do have enough support

from the company. They believed that if they needed more help or support from the organisation, the organisation would provide them the needed resources for that.

Some of the companies had set up teams of internal employees or with external experts as well to seek for AI solutions to their organisations. These teams were not limited to controllers, but some of the teams included controllers as well. Interviewee from Company A was part of their AI team, and they were trying to identify different solutions and uses of AI into their organisation. They consulted external experts regularly, but team was gathered from internal employees only. Pumplun et al. (2019) emphasised that skilled employees cannot be replaced with external experts, since there must be domain knowledge involved when implementing an AI system.

There were no direct questions of the AI enabler, employee-AI trust, by Enholm et al. (2022) in the interviews. However, especially when asking of the future thoughts of controllers, many of the controllers seemed to be excited of adopting AI into the controller function. None of the controllers mentioned of that they would be worried of their future jobs or having other concerns related to AI. Some of them even mentioned that they do not believe that it reduces the number of controllers. Additionally, there were ideas of how the controller function evolves by adopting more analytical technologies and AI. Consequently, the risks introduced by Enholm et al. (2022) and Makarius et al. (2020) were not identified by the controllers. However, one should notice that there was not a direct question of this employee-AI trust, so the results could differ if the interviews would have included a question of this.

5.3.3 Environmental pressure and limitations

Enholm et al. (2022) introduced ethical and moral features, regulations and environmental pressure as environmental enablers. There were no mentions of the moral dilemmas when considering AI or big data analytics systems. However, about half of the controllers mentioned that they respect GDPR in their data collection and managing, but probably the truth is that all of them do respect the laws and regulations set by the European Union as well as local laws and regulations, but they did not remember mention that, since it was not directly asked. Pumplun et al. (2019)

mentioned GDPR as one the inhibitor which must be considered carefully. However, GDPR only inhibits personal data collection, and therefore it does not include data including no personal information. Thus, especially A, C, D and F worked in consumer related industry whereas B, E and G worked mostly business to business industry, therefore GDPR does not affect them as much it affects to first mentioned companies.

As mentioned in the section 4.3, Company B was influenced by competitive pressures, and they decided to upgrade their analytics tools after a new top manager, experienced in successfully implementing such tools, advocated for the change. The management team approved the investment, resulting in improved data-driven decision-making.

Both Company A and F works in the health care industry and the interviewed controllers had somewhat similar experience of the pressure to adapt AI and advanced analytics into their work. They both recognised that when the operative work is quite human-oriented and it cannot utilise technology as much as like manufacturing industry, the pressure shifts to administration and back office. The word pressure is perhaps exaggeration since they did not mention the pressure, but rather they described that the focus on more in the back office than in the operative work.

5.4 The future of the controllers

There was a question of how the controllers see the future the controller function when considering all the technological changes, and there was a consensus that it is going to change, but there were different opinions of how it would change. Previous studies (Andreassen, 2020; Oesterreich & Teuteberg, 2019; Szukits, 2022; Youssef & Mahama, 2021) concurs the change of controller function in requirements and skillsets.

All of them pointed out that big data analytics and AI are reducing their time in data collection and thus they can focus on more on work which creates value, like providing good quality information to the top managers. Research indicates that advancements like big data analytics enable controllers to minimise time spent on data collection, allowing them to concentrate more on analysing the data. However,

succeeding in this shift requires controllers to possess IT and data analytics skills in the decent level. (Andreassen, 2020.) Consequently, the controllers saw that their work become more important and valuable to the company when they adopt new analytics technology. Szukits (2022) found out something similar: the top management saw the company's controllers as more important after they started to use advanced analytics technology.

AI is believed to be changing the role as well, mostly by effecting the work and providing better insights. The skillset of a controller is going to be involving more understanding how analytics and AI works, but it is not necessarily a must to know how to code or build analytics systems, since they have analytics team for that. The general opinion on AI was that they are still waiting for the right AI application for them, which is not yet in the markets, but all of them agreed that there will be great benefits using AI in their work.

There were some discussions with the controllers if they do they feel pressure from the management to leverage more big data, to adopt new analytical tools or to gain more knowhow of analytics, but there was no evidence of that. The management was said to be supportive and cheering towards the more analytical mindset, but they did not feel it as pressure. This is quite the opposite finding as the study of Appelbaum et al. (2017) where the controllers were feeling pressure to leverage big data.

As mentioned previously there was different ideas of how the role of the controller is going to be evolving in the future. According to Oesterreich and Teuteberg (2019) there has been recently a vast change in the controller role due to technological advancements. In Company A, there has been a change to the controller function already due to technological change since they hired their first business analyst into their controller team to provide more analytical mindset into their work. The company was trying to lure more analytical people into their organisation by preferencing people who are keen on AI and analytics in the recruitments.

Other saw that there will be a distribution of controllers into two groups: traditional financial controller and business challenger. Others believed that controllers become more forecaster than before. However, one mentioned that forecasting is more

of an artwork than analytical work, since you must have some vision when selecting the numbers in the forecast calculation, so the technological advances do not affect to that as much. Other idea of the future of the controllers is that it will be more like being an internal consultant to the company.

No interviewees believed that emerging technologies could replace them, so the consensus was that there will be no layoffs due to that. However, there was an agreement on that AI is going to change the role's skillset and thus the role can be changed drastically. Nevertheless, the importance of controllers is growing when they can do more value-creating work.

6 Conclusions

The concluding chapter of the study initially consolidates the primary discoveries gathered throughout the research. Subsequently, it explains the principal conclusions derived from these findings. Furthermore, the chapter engages in a thorough examination of the limitations inherent in the research process, thereby concluding the research endeavour comprehensively. Lastly, it offers recommendations for prospective possibilities of research to guide the future studies in the field.

6.1 Research summary

The objective of this master's thesis was to explore and comprehend the utilisation of big data analytics practices, including big data and advanced analytics, and additionally artificial intelligence, among the controllers. It aimed to unravel how these tools are engaged by controllers and how the tacit knowledge of these skills is dispersed among them.

The selected point of view was knowledge-based view, and the study uses KBV by Grant (1996) to investigate the spreading of tacit knowledge regarding big data analytics within the organisation, particularly among controllers. As integral members of the financial function, controllers play a vital role in informing decision-making processes within the enterprise and especially the information they provide is important for the management (Bhimani & Willcocks, 2014) thereby ensuring the provision of accurate financial information. The knowledge-based view prioritises tacit knowledge within the organisation, which is essential for generating business value. This study attempts to elucidate how awareness and understanding of the use of big data analytics spreads in the company. Therefore, the research question was combining KBV, controllers and their use of big data analytics and artificial intelligence. To explore more the phenomenon, there were three sub research questions to help examine the matter. The first sub research questions aimed to detect the extent to which controllers incorporate big data analytics and artificial intelligence into their professional practices. The second sub question intended to understand the organisational context of how the organisation is supporting controllers' leveraging of big data analytics and artificial intelligence currently. This question aimed to uncover

the support systems, resources, and structures within the organisation that facilitate or hinder controllers in adopting and utilising these technologies to their fullest potential. The last question delved into controllers' attitudes toward the future role and impact of big data analytics and artificial intelligence in shaping their professional roles and responsibilities.

The selected method was qualitative study conducted by using semi-structured interviews from multiple Finnish companies and their controllers. The study was conducted with a clear focus on predefined objectives and guiding research questions. The interviews' lengths were from around 30 minutes to 60 minutes and took place in autumn 2023. The interviews were recorded, transcribed and analysed afterwards.

6.2 Main findings

This section will go through the main findings and conclusions of the study by presenting the research question and the sub research questions.

RQ1: How does the knowledge-based view explain the utilisation of big data analytics and artificial intelligence by the controllers?

Companies have identified the issues of personified controllers' jobs, and additionally that the analytical skills and skills using analytical tools is dispersed unevenly among the controllers. Mainly the skilled controllers have gained their tacit knowledge by their own interest in analytics and analytical tools, from their previous jobs or the trainings held by the employer.

Controllers serve as vital role in supplying information to top management, positioning themselves as strategic partners in decision-making processes (Youssef & Mahama, 2021). The evolution of expertise from explicit to tacit knowledge underscores its value in generating business value (Grant, 1996). Organisational approaches to disseminating this knowledge varied, from formal training sessions to informal forums, so there was a clear intention to spread the tacit knowledge. The desire to share knowhow came both from the controllers but also from the management.

The arrival of big data has reshaped the controller's role, necessitating adjustments in skillsets and responsibilities and this study agrees with the previous studies (Andreassen, 2020; Oesterreich & Teuteberg, 2019; Szukits, 2022; Youssef & Mahama, 2021) on this. Skilled employees with tacit knowledge are essential for navigating the complexities of big data (Sumbal et al., 2017). Strategies to foster a data-oriented culture highlights the importance of management support in driving organisational implementation and these actions were detected in the results.

In addition to the change in controllers' role, this study agrees to the studies of Andreassen (2020) and Appelbaum et al. (2017) that the arrival of big data has released the time of the controllers, affording them more time for value-adding work. Effective application of analytics requires the integration of tacit knowledge, accomplished by many companies as evidenced by controllers' perceived proficiency in analytical skills.

The study indicates that younger controllers may find it easier to adapt to new technologies, highlighting the importance of ongoing skill development. Overall, the findings underscore the transformative impact of big data analytics on the role of controllers, emphasising the importance of knowledge dissemination, skill development, and organisational support in navigating this digital frontier.

SRQ1: In which level are controllers currently using big data analytics and artificial intelligence?

The study agrees that there is a widespread adoption of business intelligence and big data solutions across all participating companies, with Microsoft Power BI emerging as the predominant BI tool. This aligns with Boobier's (2018, 18) assertion that BI tools have become integral to business decision-making processes. Additionally, companies have widely integrated advanced analytics tools into their controller functions, indicating a growing adoption of advanced analytics techniques as highlighted by Leventhal and Langdell (2013).

However, challenges related to data integration and validation hinder the full utilisation of data potential. This resonates with earlier studies by Bose (2009), emphasising the importance of overcoming such difficulties to solve the full benefits of BI and big data. The study's findings corroborate previous findings indicating that BI

solutions provide timely and improved information for decision-making processes (Bose, 2009). Access to comprehensive data and streamlined data processing through BI tools enables controllers to make more data-driven decisions (Chen et al., 2012) and this study supports this claim. This is particularly evident in companies leveraging advanced analytics tools, where improved data quality leads to enhanced decision-making capabilities, consistent with prior research highlighting the value creation potential of advanced analytics (Brynjolfsson et al., 2011; Davenport & Harris, 2007, chapter 3; Kaisler et al., 2014).

Moreover, similar to findings in studies by Quattrone (2016) and Warren et al. (2015), big data has enhanced visibility into financial figures and facilitated better decision-making. The findings support these claims, underscoring the newfound ability to delve deeper into data and uncover previously unidentified correlations.

Despite the wide spread of big data analytics, spreadsheet solution platform Excel remains a foundational tool for data analytics, with only slight deviations across companies. The absence of outsourced analytics teams suggests a preference for in-house expertise, possibly influenced by concerns over data security, as noted in prior studies and books (Boobier, 2018, 23; Haapamäki & Sihvonen, 2019; Quattrone, 2016).

While AI adoption remains nascent, controllers expressed their enthusiasm for its potential impact on their function. They envision AI tools enhancing anomaly detection, real-time project valuation, and data insights. The utilisation of large language models like ChatGPT and Microsoft Copilot hints at the initial integration of AI into the controller function, with anticipation for broader adoption of analytical AI tools in the future. However, so far, the study reveals that the use of AI is not very widely spread and especially the controllers' analytics tools are not utilising it.

SRQ2: How does the organisation support the business controller's use of big data analytics and artificial intelligence?

In conclusion, the organisational support plays a pivotal role in facilitating the implementation of AI and big data analytics according to the interviews conducted and this is aligned with findings of Pumplun et al. (2019). Key elements of organisational support include fostering a technology-oriented culture, hiring individuals with

enthusiasm for analytics, investing in systems, conducting training sessions, and establishing dedicated data teams. The importance of organisational culture, particularly evident in Company A's mission to recruit data-oriented employees, aligns with scholarly findings emphasising individual interest and expertise (Schmidt et al., 2020).

Top management support is also crucial, with all interviewees affirming their organisation's investment in analytical tools and encouragement to utilise them. Company strategies further reinforce this support, as noted by Enholm et al. (2022) and Willigers (2020). Adequate resources, skills, and expertise are essential, mainly allocated to data teams responsible for managing, storing, and utilising data. Despite one controller expressing concerns about skill levels, overall, controllers believe they possess sufficient support and IT skills, augmented by training sessions and access to manuals. In contrast, these findings diverge from findings of Oesterreich and Teuteberg (2019), who asserted that controllers currently lack sufficient analytics skills, however one should note that their study differs geographically.

Some organisations have internal or internal/external teams dedicated to exploring AI solutions, emphasising the importance of domain knowledge in implementing AI systems. While employee-AI trust was not directly addressed, controllers generally expressed excitement about integrating AI into their roles, without concerns about job displacement. However, the absence of direct questioning on this aspect suggests potential variations in results with a more focused inquiry.

SRQ3: What do the controllers think of the future of big data analytics and artificial intelligence in their work?

In the discussion of the future of controller function when considering technological advancements, there is consensus that change is inevitable, though opinions on the nature of this change may vary. Past studies align with this perspective, highlighting shifts in skill requirements and functions (Andreassen, 2020; Oesterreich & Teuteberg, 2019; Szukits, 2022; Youssef & Mahama, 2021).

Controllers pointed out that big data analytics and AI streamline the data collection, enabling them to focus on value-added tasks such as providing high-quality information to top management. This sentiment is reinforced by research emphasising

the importance of IT and data analytics skills for controllers (Andreassen, 2020). Similarly, top management perceives controllers as more pivotal with the adoption of advanced analytics technology (Szukits, 2022) and there was somewhat same experience from the controllers, that they see themselves more pivotal in the future, mainly due to the resources transferred to value-creating work allowed by the technological advancements.

AI is anticipated to further transform the role by enhancing work processes and insights, necessitating a deeper understanding of analytics and AI functionalities. However, controllers do not feel pressured by management to adopt these technologies, contrary to previous findings where the controllers felt the pressure to leverage big data (Appelbaum et al., 2017). Discussions on the evolving controller role include the emergence of distinct roles such as traditional financial controllers and business challengers, or a shift towards a more consultative role within the organisation. While controllers do not foresee being replaced by emerging technologies, there is acknowledgment that AI will reshape the skillset required for the role. Despite these changes, the importance of controllers is perceived to be increasing as they undertake more value-driven tasks.

6.3 Limitations of the study

Given the qualitative nature of the study and the interviews, it is inevitable that the authors' interpretation may influence the data and the analysis. However, the attempt was to eliminate any bias and errors by predefining the terminology for the interviewees, by making a thorough plan for analysis and detecting possible pitfalls. Naturally, the qualitative study limits the generalisation as well, nonetheless it was not the intention for the study.

Due to semi-structured interviews, there was different follow-up questions in each interview and thus the discussed things differed. This allowed to examine the phenomenon more in-depth and find valuable insights from each interviewed organisation. This reduces the comparison between the organisations, nevertheless it was an accepted choice because there was a desire to build a better understanding of the

subject. It is important to note that variables and conditions can vary a lot in each participating company, so the comparability is reduced.

Considering the inexperience of the author and the nature of the study, it is important to emphasise that there is a potential risk for interpretation of the author in the interviews and the data analysis. This was diminished by acknowledging the risk and trying not to affect the results by steering the interviewees. Analysis was attempted to be as objective as possible by following a predefined plan. Additionally, the results driven from the data are more applicable when connecting them to existing theory.

One other limitation of the study is that the selection might have some bias, when the selection was done by two different paths from LinkedIn: from job openings and from individual business controller profiles. This decreases the repeatability of the study, but this selection method was justified to get adequate number of organisations to participate in the study.

6.4 Suggestions for further research

According to knowledge, no equivalent qualitative research combining the perspectives of knowledge-based view (KBV), big data analytics, artificial intelligence, and controllers has been conducted previously. Therefore, similar research could be carried out again, for example, after a certain period of time, and compare the research results to this. Artificial intelligence can be assumed to be even more developed then, potentially leading to significant changes in the research findings.

The study unexpectedly found out that health care industry has a certain pressure to adopt big data analytics and artificial intelligence especially into their back-office work, so perhaps the Finnish health care industry could be examined more thoroughly. The research could focus on data-driven individuals hired by the healthcare companies and concentrate on whether such a strategy is effective and how these individuals affect to the organisation.

This study lacks generalisability due to study's qualitative nature, so quantitative and anonym study of the current analytics software skills of controllers would

enlighten the skillset of controllers. This would help the organisations and preferably business schools to target the skills which needs to support more.

Lastly, as the management's support is an important factor when adopting new technology, it could be insightful to study them more in the process when utilising big data analytics and artificial intelligence. This study did not focus on the matter from the managerial point-of-view even though management's actions in the matter was studied.

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Appendices

Interview Framework

Definitions and example applications used in the interview:

Big data analytics differs from traditional analytics due to the large volume of data, real-time or near-real-time data generation, and diverse data sources. Its purpose is to generate valuable insights from extensive and diverse data to create business advantage.

E.g., BI tools such as SAP S/4HANA, Oracle Financial Services Analytical Applications (OFSA), Microsoft Power BI, Tableau, Snowflake, Azure

Advanced analytics is a collection of tools used for predicting results, problem-solving, and includes autonomous targeting, predictive and prescriptive analytics, and comprehensive functions such as simulation, statistical analysis, data mining, and optimisation.

E.g., Oracle Hyperion Planning, Workday Adaptive Planning, OneStream Software, Anaplan

Artificial intelligence is a technology that aims to mimic human thinking, capable of understanding environmental signals, making decisions, and taking actions.

E.g., IBM Cognos Analytics, Sage Intacct, SAP S/4HANA Finance, BlackLine, Jedox, Oracle AI, Tableau AI, Azure AI

Questions:

1. What is your job role? How long have you been in this position? Describe general tasks in your role. How many controller colleagues do you have in the organisation?
2. Do you use big data, advanced analytics techniques, or artificial intelligence to support your work in any way? If yes, what and in what context? How often are these used?
 - a. Provide a situation where you use these applications.
 - b. Do only some of your controller colleagues use these applications? Describe the extent of usage.
 - c. How do you perceive the usage of the applications and the results they provide?
 - d. What are the most common challenges in using these? How have they been addressed?
 - e. Do you feel that the controllers' skills are sufficient for using them?
3. How does the organisation support the adoption and use of these applications for controllers?
 - a. Does your employer invest in these? Does your company's management consider the adoption and use of these applications important? How does this manifest in controllers' work?
 - b. Is some work time allocated for using these applications or training on their usage?
 - c. Do you consider your organisation's culture to be technology-oriented?
 - d. How do you share tacit knowledge among controllers regarding the use of these applications?
 - e. Do you communicate with experts to enhance the efficiency of using these applications?
4. How do you evaluate the impact of these applications on controllers' performance and competitiveness?
5. How has the role of controllers evolved with technological changes, and how do you expect it to evolve in the future?
6. Would you like to mention anything else on this topic?