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HOW INDUSTRY 4.0 IMPACTS THE MANAGEMENT ACCOUNTANTS' ROLE

AN EXPLORATORY THESIS

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ABSTRACT

In the 21st century, the emergence of Industry 4.0 has revolutionized the commercial landscape, culminating in significant adaptations within business management. This fourth industrial revolution, born out of digital transformation and automation advancements, extends its implications beyond the technological realm, touching aspects like products, business models, economic structures, the work environment, and skill development. With Industry 4.0 deeply entrenched in data-centric operations, the management accounting (MA) field stands at the crossroads of a transformative shift. This research dives into the consequential role evolution of management accountants in this digitized age.

The study seeks to answer pivotal questions surrounding the definitions, components, and implications of Industry 4.0 on MA. Utilizing an exploratory approach through semi-structured interviews from professionals across sectors like IT, E-commerce, retail, and automotive, the research captures both the expansion of management accountants' strategic role and the surge in interdisciplinary skills, particularly in data analytics and IT. Key revelations include management accountants' transition from traditional financial functions to roles imbued with strategic and technological dimensions, underscored by job title evolutions like the emergence of 'finance business partners'. Moreover, in this digital age, there's a pronounced need for a balance between traditional financial prowess and modern technological acumen.

While Industry 4.0 presents opportunities, challenges like resistance to change, technological complexities, and data overload are palpable. It's pivotal for finance business partners and professionals to recognize these shifts as not just organizational but deeply personal, necessitating proactive adaptation. The research also acknowledges inherent constraints, such as the limited number of interviewees, regional focus, and the swift pace of technological change, suggesting a need for expanded future studies.

In conclusion, Industry 4.0 blends technology and human skill, prompting a transformative era for management accountants. Embracing adaptability and ongoing learning is vital for finance professionals to harness this digital age's opportunities and challenges.

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INTRODUCTION

The turn of the 21st century is seeing the advent of the fourth industrial revolution and the digital metamorphosis of the commercial landscape, often known as Industry 4.0. This revolution is making a substantial impact, more than just being trendy rhetoric, as indicated in the literature (Ardito et al., 2019; Buer et al., 2018; Schroeder et al., 2019 as cited in Ghobakhloo 2020). From the moment "Industry 4.0" was made public in 2011, it promptly engaged the interest of international industrial figures and governmental bodies, as it imposed a need for digital transition as advanced by Nascimento et al.(2019) as cited in Ghobakhloo (2020).

According to Pereira and Romero (2017) the term "Industry 4.0" is a relatively recent emergence, born from the surge of technological breakthroughs and transformative shifts in the worldwide industrial arena. The phrase "Industry 4.0" made its debut in a November 2011 article by the German government that resulted from a high-tech strategy initiative for 2020.

According to H. Kagermann et al, (2013) as cited in Wadan et al. (2019) “Industry 4.0” is presently utilized in scientific and economic discussions as a term denoting the escalating digitization and automation of production systems involving both humans and machines, and their interconnectedness. According to Wadan et al. (2019) “Platform Industry 4.0” defines Industry 4.0 as: “[...] availability of all relevant information in real-time through the networking of all instances involved in value creation as well as the ability to derive the best possible value stream from data at all times.”. Gilchrist, (2016) as cited in Ghobakhloo (2020) suggests that in the setting of Industry 4.0, networked computers, smart materials, and intelligent machines interact, communicate, and largely operate with minimal human intervention.

Pereira and Romero (2017) believe that the advancements in digital transformation and rising interconnectedness will present organizations with fresh challenges. Industry 4.0 is anticipated to significantly modify products and manufacturing systems in terms of design, processes, operations, and services. Moreover, it could influence management practices and future job markets, fostering new business models that will substantially impact industry and markets.

Pereira and Romero (2017) add that the potential transformations driven by Industry 4.0 extend beyond the industrial sector, influencing six primary areas: (1) Industry, (2) Products and services, (3) Business models and market, (4) Economy, (5) Work environment, and (6) Skills development.

An in-depth examination reveals that the application of I4.0 has been predominantly technological, with limited attention given to its implications for people, processes, society, and economic impact as stated by D. Buhr, (2015) as cited in Wadan et al. (2019). In addition, according to Wadan et al. (2019) a survey by PricewaterhouseCoopers (PwC) in Germany in 2016 suggests that companies anticipate direct revenue growth and cost reductions due to digitalization. However, current literature indicates that alongside large infrastructure issues, adaptations in business management are necessary as outlined by Wadan et al. (2019).

Considering that Management Accounting (MA) is heavily reliant on data, and I4.0 revolves around data, it can be inferred that the role of MAs will undergo significant changes due to the I4.0 phase according to Wadan et al. (2019). Traditional roles of management accountants will need to be reimagined to stay relevant and provide added value in this new environment. It's critical to understand how the role of a management accountant can be redesigned and how they can interact with key stakeholders in the context of Industry 4.0.

Hence, the principal objective of this study is to comprehend the changing role of management accountants in the context of Industry 4.0 and identify the skills required for management accountants in this new industrial era. The guiding research questions are:

1- What is Industry 4.0 and its key components?
2- How is the role of the management accountant evolving?

This research is significant as it will enhance understanding of the role evolution of management accountants in the era of Industry 4.0. By identifying the primary changes in management accounting practices, this study will provide valuable insights for both scholars and professionals. The results can help organizations better equip their management accounting functions to meet the challenges and opportunities brought by Industry 4.0. It will also guide management accountants to adapt to their changing roles, ensuring their sustained relevance and efficiency.

The organization of this thesis is as follows: (1) Introduction, which gives an overview of the research topic and outlines the research problem and goals; (2) Literature Review, reviewing relevant literature on Industry 4.0, management accounting, and the role of management accountants; (3) Research Methodology, describing the research design, data collection methods, and data analysis techniques; (4) Results, presenting the findings from the data analysis; (5) Discussion, interpreting the findings and drawing connections to existing literature; (6) Conclusion, summarizing the main findings.

I. LITERATURE REVIEW

1. Industry 4.0.

a. Introduction

In today's rapidly evolving business landscape, the concept of Industry 4.0 has gained significant attention and has become a subject of great interest in both academic and practical realms. Before delving into the intricacies of Industry 4.0 and its implications, it is essential to establish a foundational understanding of the broader context. This chapter aims to provide a comprehensive introduction to Industry 4.0 by exploring the definitions, historical trajectory of industrial revolutions, and key components associated with this transformative concept.

To begin, we will examine the fundamental concepts of "industry" and "industrial revolution." Understanding the concept of industry is crucial as it forms the basis for comprehending the subsequent advancements and paradigm shifts brought about by Industry 4.0. We will explore the characteristics of industry, its role in economic development, and its evolution over time.

Subsequently, we will embark on a historical journey to trace the trajectory of industrial revolutions. By examining the first three industrial revolutions, we can gain insights into the progressive nature of industrial transformation and the underlying factors that have driven societal, economic, and technological changes throughout history. We will explore the key characteristics, technological advancements, and socio-economic implications of each revolution, providing a historical context for the emergence of Industry 4.0.

Having established the historical backdrop, we will then shift our focus to the core subject of this thesis, Industry 4.0. We will define Industry 4.0, drawing upon insights and perspectives from existing literature. This section aims to provide a comprehensive overview of the concept, its scope, and its potential implications for industries, organizations, and society as a whole.

Furthermore, we will explore the key components that underpin Industry 4.0. These components encompass a range of advanced technologies and concepts such as cyber-physical systems, the Internet of Things (IoT), big data analytics, artificial intelligence, and digital connectivity. By

examining these components, we can gain a deeper understanding of the technological foundations and enablers that drive the transformative power of Industry 4.0.

Through this comprehensive exploration, we aim to provide a solid foundation for understanding Industry 4.0 and its significance in the context of industrial revolutions. By examining the definitions, historical trajectory, and key components, we lay the groundwork for further research and analysis in subsequent chapters. This thesis seeks to contribute to the existing body of knowledge by shedding light on the implications, challenges, and opportunities presented by Industry 4.0, ultimately aiming to provide valuable insights for both academic and practical stakeholders in the ever-evolving business landscape.

b. What is an Industry?

"Industry" is defined By according to Merriam-webster Dictionary (2023) as a "manufacturing activity as a whole" or " a distinct group of productive or profit-making enterprises or " work devoted to the study of a particular subject or author" for example we say **the Shakespeare industry** to describe Shakespeare's plays, including stage, screen, and television productions, Cambridge dictionary (2023) defines it as "the companies and activities involved in the process of producing goods for sales, especially in a factory or special area". Which relates to Merriam-webster Dictionary (2023) 's definition.

On the other hand, Lasi et al. (2014) define it as "the part of an economy that produces material goods which are highly mechanized and automatized". Most of the definitions shared above are converging to the same description of what an industry is, hence in this thesis we will refer to Lasi et al. (2014)'s definition.

c. What is an industrial revolution?

Revolutions are defined as the major historical turning moments. A revolution is a disorderly, transformative event, or set of related incidents, that seek to alter a country, a region, or society as well as the industrial, and more recently, the corporate world as suggested by Groumpos (2021). When the general population rebels against the government, generally because of perceived tyranny or political incompetence, a revolution—a fundamental and comparatively sudden change in political power and political organization—occurs as described by Hayek (1963); as cited in Groumpos (2021, 464). However Groumpos (2021) thinks that the term "Revolution" does not

apply well to other contexts, including those in the business, industrial, and general scientific fields. In actuality, the reasons for and objectives of revolutions differ. Indeed, the term "revolution" has been frequently used in relation to "industrial" and frequently not as appropriately as prudent.

According to Clark (2010) The word "Industrial Revolution" is vague, loaded with connotations, and is viewed differently by various authors. Initially this term described the enormous shift the British economy underwent between 1760 and 1850, where Britain transitioned throughout these years from being a largely independent, self-sustaining, to having an economy that relied heavily on imported food, raw resources, and energy as well as one where the vast majority of people worked in industry and trade.

Clark (2010) argues that “industrial revolution” term has come to mean the shift in the global economy that began around 1800 from the pre-industrial economy, which had extremely low rates of efficiency growth, to the modern economy, which has rapid and sustained efficiency growth even though that change from slow to rapid rates of efficiency advancement had nothing to do with industry or industrialization in the first place, Therefore “the more general use of the term ‘Industrial Revolution’ the ‘industrial’ component is a misnomer, but a misnomer that we have to live with.” (Clark 2010).

Lasi et al (2014) also believe that technological advancements and industrialization have sparked paradigm shifts which today are ex-post named “industrial revolutions”.

In brief, multiple research studies have been conducted on the subject of industrial revolution, While the predominant opinion suggests that the term is a misnomer, in this thesis, we will adhere to the common definition.

d. From Industry 1.0 to 4.0

After providing an overview of the relevant terminology, the subsequent topic of discussion will be industrial revolutions.

i. First industrial revolution (1.0)

The human civilization began a new period in its method of wealth creation at the beginning of the nineteenth century: industrial production, also known as the so-called Industrial Revolution as presented by Devezas, Leitão, and Sarygulov (2017). This first industrial revolution is considered

a significant turning point in human history, because it changed almost every facet of daily life as articulated by Kumar, Bawge, and Kumar (2021).

According to Weightman (2007) ; as cited in Groumpos (2021) the First Industrial Revolution's beginning was the most significant development in human history since the domestication of animals and plants.

While Groumpos (2021) advocates that historians continue to disagree about the exact timing of the First Industrial Revolution (F.I.R.), as well as the speed at which economic and social change occurred. Nevertheless, by most, the use of steam power and the mechanization of production signaled the start of the First Industrial Revolution in the 18th century. Devezas, Leitão, and Sarygulov (2017) also believe that water and steam-powered mechanical manufacturing facilities were introduced during the first industrial revolution, which occurred at the turn of the eighteenth and nineteenth century.

During this era, manufacturing, in particular, was set to experience significant changes according to Anderl et al. (2015); As cited in Kumar, Bawge, and Kumar (2021). Groumpos (2021) believes that the transition involved moving from manual to machine production methods, new ways for producing chemicals and iron, an increase in the use of steam and waterpower, the development of machine tools, and the emergence of the mechanized industrial system. This revolution was reflected on many fronts, according to Kumar, Bawge, and Kumar (2021) the impact is represented by socioeconomic and cultural features, also this changed how the jobs were conducted and introduced a new set of skills to be learned, according to Kumar, Bawge, and Kumar (2021) by acquiring the unedited skills that did not include the ability to use hand tools but instead to operate a machine, the traditional role of the worker was drastically altered. As a result of the birth of the first modern industry, labor division and the specialization of work caused by the multipurpose spindle for spinning cotton or wool as well as the so-called "factory system" based on Crafts (1996); as cited in Kumar, Bawge, and Kumar (2021).

ii. Second industrial revolution (2.0)

The industrial sphere once again saw an imaginative upturn in the middle of the 19th century after a temporary decline in advances Kumar, Bawge, and Kumar (2021). The adoption of the First Industrial Revolution's (F.I.R.) original discoveries, including mechanical spinning and weaving, slowed down as their markets matured in the late 1830s and early 1840s, causing an economic

recession according to Donovan (1997); as cited in Groumpos (2021). Late in the era, innovations emerged including the rising use of locomotives, steamboats, and ships, as well as hot blast iron smelting. As a result, the Second Industrial Revolution (S.I.R.) started in the 19th century with the invention of electricity and the use of assembly lines and new technology as described by Groumpos (2021). This brief period of history was marked by a fresh and stronger acceleration of the industrialization process brought on by technological advancements, which include the use of new energy sources, such as electricity, and lighter materials, such as alloys and synthetics as stated by Mokyr (1998); As cited in Kumar, Bawge, and Kumar (2021). Devezas, Leitão, and Sarygulov (2017) also mentioned that the introduction of electrically driven mass production and the intensive division of labor served as the foundation for the second industrial revolution, which took place around the turn of the twentieth century. Or so called by Lasi et al. (2014) "the intensive use of electrical energy".

Groumpos (2021) gives a description of what happened in that era by, according to the author the Second Industrial Revolution (S.I.R), also referred to as the Technological Revolution, occurred between 1870 and 1914 (the start of World War I), and was a period of rapid industrialization and standardization. The broad adoption of technological systems like telegraph and railroad networks, gas and water supplies, and sewage systems—which had previously been confined to a small number of select cities—was made possible by advancements in manufacturing and production technologies. New technological systems were introduced at the same time, most notably electricity and telephones. A handful of significant inventions caused things to accelerate. Consider automobiles, aircraft, and chemical fertilizers. All these inventions made it possible for us to move more quickly and accomplish more. People moved to where the jobs are, and in the early 1900s, workers were moving from their rural homes to metropolitan regions and factory positions. Compared to just 6% in 1800, 40% of Americans resided in cities by 1900. Electric lights, radio, and telephone developments changed how people communicated and lived together with the rise in urbanization. When you give it some thought, the second industrial revolution really was what made the contemporary world possible.

The aforementioned statements demonstrate the profound influence that this second industrial revolution has exerted on various aspects of society.

iii. Third industrial revolution (3.0)

The Third Industrial Revolution (T.I.R.) started in the 1950s of the 20th century , just a few years after World War II, when computers and memory-programmable controls allowed for some automation as presented by Groumpos (2021).

According to Devezas, Leitão, and Sarygulov (2017) the use of electronics and information technology (digital revolution) to further automate manufacturing, was the primary driver of the third industrial revolution, which took root from the 1960s through the 1990s. or as referred to by Lasi et al. (2014) "the widespread digitalization".

This revolution according to Kumar, Bawge, and Kumar (2021) compared to Industry 1.0 and 2.0, is more well-known since most people today are familiar with industries that rely on digital technologies for manufacturing. Industry 3.0 may have been and still is a direct effect of the enormous development in computer and information and communication technology industries for many countries.

Groumpos (2021) advances that the 3rd Industrial Revolution is also called the Automation Revolution, it brought semiconductors, mainframe computing, personal computing, and the Internet—revolution. The same idea has been advanced by Kumar, Bawge, and Kumar (2021) as they suggested that the switch from mechanical and analog technologies to digital ones was brought about by the third industrial revolution, or the digital revolution as some experts prefer to call it. The spread of digital logic technology, which includes computers and the World Wide Web, proved crucial. Groumpos (2021) also highlights that industries were severely impacted by the switch from analog electrical and mechanical equipment to widespread digital technology, particularly the global communications and energy sectors. Production started to be automated, and supply networks went global, thanks to electronics and computer technology. This idea was confirmed by Kumar, Bawge, and Kumar (2021) who emphasizes that high-level factory automation has developed as a result of the effective fusion of diverse information technology components, specifically programmable logic controllers (PLCs) and robots.

As previously noted, the third industrial revolution did not represent a departure from the previous industrial revolutions, but rather a transformation in how work was conducted. Consequently, it is reasonable to assert that this revolution had significant implications for the skills and knowledge required of workers in order to remain effective in this new era.

iv. Fourth industrial revolution (4.0)

Industry 4.0 according to Oztemel and Gursev (2020) is not a new notion and was on the agenda of academic study in many years with varied interpretations, However, the name “Industry 4.0” is newly released and highly recognized not only in academic life but also in the industrial society.

Throughout my literature review, the majority of articles examined have put forth the suggestion that that this term first appeared around 2011, Devezas, Leitão, and Sarygulov (2017) mentioned that this term appeared the first time in 2011 at the renowned Hannover Fair as a type of project in the high-tech strategy of the German Industry. The following year, the (German) Working Group on Industry 4.0 was established, and its final report was presented in April 2013 at the Hannover Fair once more. The same has been advanced by Groumpos (2021), according to him Industry 4.0 was originally brought up in Germany in 2011 as a suggestion for the creation of a new German economic paradigm based on high-tech strategies.

The term was formally accepted at the 2015 World Economic Forum (WEF) Annual Meeting in Davos, Switzerland, in January of that year. The book "The Fourth Industrial Revolution," authored by WEF founder and president Klaus Schwab, was then published shortly after as reported by Devezas, Leitão, and Sarygulov (2017). The term is currently becoming more prevalent as a result of the formation of an industrial platform called "Industry 4.0" that is made up of three well-known industry organizations as advanced by Lasi et al. (2014).

According to the German Federal Government, Industry 4.0 is described as a developing framework where manufacturing and logistics systems, represented by Cyber Physical Production Systems (CPPS), leverage the vast information and communication networks available globally to facilitate highly automated information exchange. This results in the alignment of production and business processes according to Kamarul Bahrin et al. (2016); As cited in Vaidya, Ambad, and Bhosle (2018). This revolution is also characterized using information and communication technology, mostly in industry but also in other aspects of society as mentioned by Groumpos (2021).

Devezas, Leitão, and Sarygulov (2017) advance that now, the majority of economists concur that the fourth industrial revolution is upon us. The drivers and technologies for this revolution are multiple and divers, Demir, Döven, and Sezen (2019) think that Its drivers are straightforward and comparable to previous revolutions: Using revolutionary technology, boost productivity and

accomplish mass production. Lasi et al. (2014) advance that Industry 4.0 is also intended to achieve the development of unique products in a batch size of one while preserving the favorable economics of mass production, therefore, leveraging the different technologies in order to achieve smart manufacturing as put forth by Demir, Döven, and Sezen (2019).

According to authors this fourth revolution has multiple pillars, for Erol et al. (2016); As cited in Vaidya, Ambad, and Bhosle (2018) : Internet of Things (IoT), Industrial Internet of Things (IoT), cloud-based manufacturing, and smart manufacturing are the four key forces behind Industry 4.0, which aid in turning the manufacturing process into a fully digital and intelligent one.

Demir, Döven, and Sezen (2019) also believe that many popular technologies are assisting in the development of Industry 4.0. The internet of things, robotics, and artificial intelligence (AI), big data, and cloud computing are the primary technologies that are currently in vogue. Additionally, Smart factories, smart logistics, virtual and augmented reality, and ambient intelligence are other technologies that enable Industry 4.0.

Consequently, This will increase productivity and alter current production dynamics between suppliers, manufacturers, and consumers as well as between people and machines as reported by Rüßmann et al. (2015); As cited in Vaidya, Ambad, and Bhosle (2018). Also, it will lead to "the linkage of real objects and people with information-processing/virtual objects" in the words of Devezas, Leitão, and Sarygulov (2017)

e. key components of Industry 4.0.

After our initial exploration of Industry 4.0, its drivers, and consequences, we will delve into its key components and how is it different than the previous ones.

According to Kumar, Bawge, and Kumar (2021) the current period, known as Industry 4.0, is characterized by a shift towards automation and digitalization, reshaping the manufacturing sector and the nature of products themselves. This shift is largely driven by the emergence and adoption of nine pivotal technologies, marking the advent of the fourth industrial revolution:

1. **Cyber-Physical System (CPS)** - Defined by Kumar, Bawge, and Kumar (2021) as intertwined systems of natural and man-made entities with computational and

communication aspects. They facilitate real-time data exchange and bridge the gap between tangible and virtual elements.

2. **Internet of Things (IoT)** - Represents the convergence of enhanced connectivity and data exchange among systems, services, and physical objects within manufacturing, including applications in heating, lighting, and remote monitoring.
3. **Internet of Services (IoS)** - A critical component in the automotive industry, the IoS delivers tailored digitalization services, enhancing safety and facilitating communication across channels.
4. **Big Data and Analytics** - Pivotal in predictive manufacturing, big data processes large volumes of daily information. It emphasizes four dimensions: volume, variety, value, and velocity.
5. **Augmented Reality (AR)** - A technology beneficial for maintenance operations, AR reduces errors and time required for tasks by supporting predictive maintenance and lowering costs.
6. **Autonomous Robots Reality (AR)** - Robots showcasing enhanced flexibility and functionality. Future robots are expected to collaborate with humans and other robots, surpassing current manufacturing capabilities.
7. **Additive manufacturing (3D printing)** - Central to Industry 4.0, it uses smart manufacturing capabilities and explores new materials for 3D printing, linking progress to the potential of additive manufacturing.
8. **Cloud Computing (CM)** - Offers vast storage at low costs, accommodating user needs and facilitating data-driven production systems. It's becoming more prevalent in data system architectures with the growth of cloud-native software.
9. **Simulation** - A method for predicting outcomes of real or virtual systems. It uses real-time data to replicate human interactions and machinery, allowing adjustments in virtual environments before real-world application.

Through the introduction of these disruptive technologies, Industry 4.0 propels innovation beyond what was previously considered achievable according to the article “What Is Industry 4.0 and the Fourth Industrial Revolution?" by McKinsey (2023). The present revolution distinguishes itself by offering numerous advantages when compared to its predecessors.

According to Groumpos (2021) Industry 4.0 has the potential to bring about some amazing improvements in manufacturing settings. Examples include machines that can foresee problems and autonomously initiate repair procedures, or self-organized logistics that respond to unforeseen changes in production. Industry 4.0 has the potential to alter how people perform their jobs. It can draw people into smarter networks, which could lead to more effective working. While Greenwood (1999); as cited in Kumar, Bawge, and Kumar (2021) believe that the ability to merge digital, physical, and biological domains through technology, which has a significant impact on a wide range of industrial disciplines, is what defines the fourth industrial revolution.

On the other hand, similarly, to its antecedents, the current revolution has exerted a significant impact on various domains, and occupations.

Kumar, Bawge, and Kumar (2021) suggested that many vocations have changed as a result of Industry 4.0. People have always been required to master new daily duties, but now they are also required to use high-tech gadgets, which are quickly becoming the most significant aspect in their working lives. Industry 4.0 is portrayed as a comprehensive change characterized by digitalization and automation of all aspects of the business, including the production process.

This assertion finds validation in the information posited by Devezas, Leitão, and Sarygulov (2017) who provided the information about the recent (January 2016) release of a critical assessment by the World Economic Forum titled "The Future of Jobs: Employment, Skills, and Workforce Strategy for the Fourth Industrial Revolution."

Figure 1, displayed below, presents a table that compares initially the visions of Industry 4.0 and 5.0. However, in order to maintain alignment with the subject and purpose of this master's thesis, the discussion will focus solely on Industry 4.0. Therefore, only the relevant portion of the table concerning Industry 4.0 will be presented.

	Industry 4.0
Motto	Smart Manufacturing
Motivation	Mass Production
Power Source	Electrical power Fossil-based fuels Renewable power sources
Involved Technologies	Internet of Things (IoT) Cloud Computing Big Data Robotics and Artificial Intelligence (AI)
Involved Research Areas	Organizational Research Process Improvement and Innovation Business Administration

Figure I: Industry 4.0 vision (Demir et al.2019)

Finally, It is imperative to note that, the term "industry 4.0" is not widely used outside of the German-speaking world according to Lasi et al. (2014). This was confirmed by Wadan et al. (2019) when suggesting that although the term "industry 4.0" is often used in German-speaking nations, the same principles and ideals are utilized under different titles in the international setting, such as "industrie du futur" in France, or “Industrial internet” as per Grangel-González et al. (2016) or as mentioned by Roth (2016) “internet of things” or “Smart factory” in the international context.

In conclusion, the phrase "Industry 4.0" refers to several improvements in industrial systems. These advancements have not only technological but also organizational repercussions. Groumpos (2021) labeled it as game changer across industrial settings, as it will alter how goods are manufactured and distributed.

It is noteworthy that with each Industrial revolution previous modes of living have been altered, industry 4.0 is no exception, while the subject hasn’t been sufficiently addressed considering the limited number of research in relation to this topic, there is no reason to believe that it this fourth industrial revolution will not fashion our ways of living.

Below figure 2 illustrates the timeline related to the four industrial revolutions.

Figure II : Four Industrial Revolutions (Vaidya et al, 2018)

f. Conclusion

In conclusion, this chapter has provided a comprehensive introduction to the concept of Industry 4.0, starting with a focus on defining and clarifying the terms "Industry" and "Industrial Revolution." By establishing a shared understanding of these fundamental concepts, we have laid the groundwork for a deeper exploration of Industry 4.0 and its implications.

Through our examination of the historical trajectory of industrial revolutions, we have highlighted the progressive nature of industrial transformation and its profound impacts on various aspects of society. By tracing the development from the first industrial revolution to the emergence of Industry 4.0, we have identified key characteristics, technological advancements, and socio-economic implications associated with each revolution. This historical context has provided valuable insights into the transformative power of Industry 4.0 and its significance in the broader context of industrial development.

Furthermore, our analysis of the key components of Industry 4.0 has shed light on the technological foundations and enablers that drive this paradigm shift. From cyber-physical systems to the Internet of Things, big data analytics, artificial intelligence, and digital connectivity, these components form the building blocks of Industry 4.0 and underpin its transformative potential.

The insights gained from our literature review and historical analysis will serve as a solid foundation for the subsequent chapters of this thesis. They will inform further research and analysis, enabling a deeper exploration of the implications, and opportunities presented by Industry 4.0.

As we progress through the subsequent chapters, we will explore the implications of Industry 4.0 on the management accounting and consequently the role of management accountant.

Overall, this chapter has set the stage for a comprehensive examination of Industry 4.0, positioning it within the broader context of industrial revolutions and providing a foundation for further analysis. By understanding the definitions, historical trajectory, and key components of Industry 4.0, we are well-equipped to explore its implications and contribute to the ongoing discourse surrounding this transformative concept.

2. The changing role of management accountant with Industry 4.0.

a. Introduction

In response to advancements in management accounting practices, the role of a management accountant has undergone significant transformations over the years. These transformations can be understood through the lens of management accounting versions, which include Management Accounting 1.0, 2.0, and 3.0. Each version represents a distinct phase in the evolution of management accounting and reflects the changing needs and challenges faced by organizations.

In this chapter, we will explore the evolution of management accounting from its early stages to the latest iteration, Management Accounting 4.0. We will examine the characteristics and key developments in each version, as well as the technologies that have shaped their evolution. By understanding this evolutionary journey, we can gain insights into the changing role of management accountants and the impact of technological advancements on their practices.

We will begin by delving into Management Accounting 1.0, which emerged prior to the 1950s. This phase was primarily focused on calculating product costs and achieving organizational goals. We will explore the manual procedures, cost determination methods, and accounting systems that were prevalent during this period.

Moving forward, we will investigate Management Accounting 2.0, which arose during the 1950s and 1960s. This phase marked a shift in the role of management accounting from a line function to a staff function. We will examine the technologies and innovations that enabled management

accountants to support line management in planning, decision-making, and performance evaluation.

Next, we will explore Management Accounting 3.0, which emerged in the 1990s and extended until the 2010s. This phase was characterized by the utilization of non-financial data and data analytics, as organizations sought to generate value through efficient resource utilization. We will examine the advancements and methodologies that facilitated this shift in management accounting practices.

Finally, we will delve into the latest version, Management Accounting 4.0, which aligns with the industry 4.0 movement. This phase leverages advanced technologies such as smart sensors, IoT, CPS, Big Data, cloud computing, AI, and blockchain. We will explore how these technologies enable real-time decision-making support, agile planning, and customized information delivery, transforming the role of management accountants in today's digitalized business environment.

By examining the evolution of management accounting from 1.0 to 4.0, we can gain valuable insights into the changing landscape of the profession and the challenges and opportunities that arise with each version. Throughout this chapter, we will analyze the influences of technological advancements, shifts in organizational needs, and the expanding role of management accountants. This exploration will provide a foundation for understanding the transformative effects of Industry 4.0 on management accounting practices, which will be further examined in subsequent chapters.

b. An overview of the historical progression of the Management Accountant's Role

Järvenpää (2007) suggests that a management Accountant is viewed as the person responsible for executing or implementing management accounting practices. Consequently, any alterations or advancements in management accounting practices will have a direct influence on the role of a management accountant.

A widespread and frequently utilized definition of management accounting is presented by (Institute of Management Accountants; 2008):

“Management accounting is an essential part in any organization´s activities and involves partnering in management’s decision making, devising planning and performance management systems, and provides expertise in financial reporting and control in order to assist management in the formulation and implementation of an organization’s strategy.”

As we proceed, we will initially touch upon the historical progression of management accounting role. This exploration provides a brief overview of how the roles have flexibly adjusted and evolved to meet the shifting demands of various business eras. After establishing this context, we delve into the significant transformation of the management accountant's role in the era of Industry 4.0. The latter part of this study underscores the consequent changes in practices, responsibilities, and the overall significance of management accountants in today's digitalized business environment.

According to Cooper and Dart (2009) the term "management accounting change" serves as a comprehensive descriptor of this paradigmatic shift in expectations of the management accountant, capturing two central aspects of evolution: firstly, the integration of novel tools and methodologies that hold the potential to enrich accounting practices, and secondly, a transformation in the accountant's function. This alteration sees accountants transitioning from being mere providers of information to a role of increased importance, specifically acting in an advisory capacity that is central to managerial decision-making.

Wadan et al. (2019) Also, advances that management accountant has a crucial role in facilitating decision-making processes within organizations. By providing critical information to internal users, it enhances their capacity to make informed and effective decisions, leading to significant improvements in operational efficiency and effectiveness. Over time, the focus of management accounting has undergone a noteworthy evolution. Traditionally, it was primarily concerned with cost determination and financial control. However, in the contemporary business environment, its role has expanded and transformed. Today, management accounting is integral to the creation of value, achieved through the strategic utilization of resources. This shift highlights the dynamic nature of the role of management accountant and its responsiveness to the changing needs of businesses.

Dai and Vasarhelyi (2023) advance that historical advancements in technology have given rise to three significant transformations in the landscape of management accounting. The initial phase, known as Management Accounting 1.0, predominantly depended on manual procedures until the advent and widespread adoption of computers and database systems, notably enterprise resource planning (ERP) systems. This technological leap drastically altered how accountants gather, process, analyze, and report information, marking the transition to Management Accounting 2.0. Nonetheless, Management Accounting 2.0 primarily concentrated on financial data and control over procedures, neglecting insights from non-financial data and their interrelations with financial data. This limitation prompted a paradigm shift towards Management Accounting 3.0, driven by the growing use of non-financial data and data analytics. This era signified a considerable change in the accounting profession's mindset. Accountants began to unravel patterns concealed within the company's financial and non-financial data, even incorporating exogenous information sources such as news and social media. As depicted in figure 3, each iteration of Management Accounting has its distinct focuses and tools, culminating in the advent of Management Accounting 4.0.

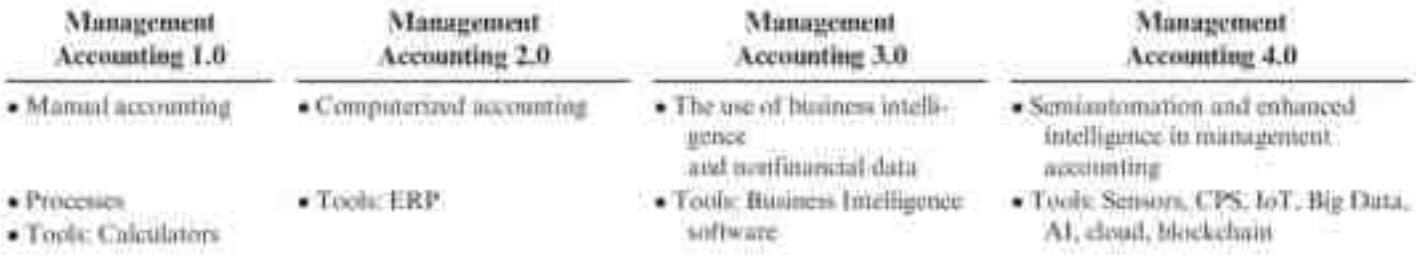

Figure III : Management Accounting 1.0–4.0 (Dai and Vasarhelyi 2023)

This latest version emerged in tandem with Industry 4.0, a movement built upon the technological foundations that companies implemented to enhance manufacturing and business operations. In this phase, accountants leverage the data collected across the value chain and smart functionalities to greatly augment the effectiveness, efficiency, and timeliness of decision-making support. To define it succinctly, Management Accounting 4.0 harnesses technologies endorsed by Industry 4.0, including smart sensors, the Internet of Things (IoT), Cyber-Physical Systems (CPS), Big Data, cloud computing, artificial intelligence (AI), and blockchain. These tools are used to collect transaction-related data throughout the value chain, model and visualize business activities, and immediately intercede in risky transactions and processes. This iteration enables robust, efficient,

and real-time decision-making support through agile planning, using a range of measures, pinpointing inefficiencies in real-time, and delivering customized information.

The timeline for the evolution of management accounting from 1.0 to 4.0 is not universally agreed upon and can vary depending on the source. However, it is generally acknowledged that these phases align roughly with the progress of industrialization and technological development. Here's a rough estimate:

Management Accounting 1.0: Prior to 1950
Management Accounting 2.0: 1950s-1980s
Management Accounting 3.0: 1990s-2010s
Management Accounting 4.0: 2010s until now

i. Management accounting 1.0

The (International Federation of Accountants, 1998) characterizes management accounting prior to the 1950s as a technical endeavor instrumental in achieving organizational goals. Its primary focus was on calculating the cost of products. In the context of the time, the technology involved in production was relatively straightforward, with each product undergoing a variety of distinct procedures. Costs associated with labor and materials were easily identifiable, and manufacturing operations were primarily regulated by the speed of manual tasks. Consequently, direct labor served as an instinctive means to allocate overhead costs to individual products. In addition to a concentration on product costs, budgets and fiscal control mechanisms were applied to manage production processes.

During the nineteenth century, the emergence of management accounting systems (MAS) in the United States was documented by Chandler (1977). These systems encompassed a range of accounting methods, both simple and intricate in nature. To determine the costs associated with converting raw materials into finished goods, cost accounts were utilized. Notably, the utilization of sophisticated accounting procedures can be traced back to this era as well. Porter (1980) states that as early as the first quarter of the nineteenth century, certain companies in the USA employed advanced sets of cost accounts. These new accounting systems aimed to regulate and document cash disbursements, thereby providing management with accurate and timely expenditure reports.

According to Shah (2015), cost accounting underwent a significant transformation during the nineteenth century. It evolved from being a mere tool for assessing internal conversion processes to also being employed for evaluating the performance of subordinate managers. Concurrently, internal accounting systems were developed to evaluate costs, throughput, and working capital. The late nineteenth and early twentieth century witnessed the emergence of new cost measurement techniques aimed at analyzing productivity and establishing the relationship between profits and products as outlined by Askarany (2004). Shah (2015) adds that these techniques had a profound impact on accounting practices in the twentieth century. Some of them formed the basis for developing standards to monitor labor and material efficiencies, as well as costs. This era marked the development of scientific management, which focused on gathering precise information concerning the efficiency of workers engaged in specific tasks. Additionally, variance analysis of actual costs versus standard costs for operational control purposes was also developed during this time.

ii. Management accounting 2.0

According to Shah (2015) during the 1950s and 1960s, the emphasis of management accounting shifted towards providing information for planning and control objectives. This transformation is recognized by (the International Federation of Accountants, 1998) as a shift in management accounting's role from a line function to a staff function. In this phase, management accounting entailed providing support to line management through the utilization of technologies like decision analysis and responsibility accounting. The focus of management controls during this period was predominantly directed towards manufacturing and internal administration, rather than strategic and environmental considerations as reported by Abdel-Kader and Luther (2004).

According Hopper, Scapens, and Ashton (1995) the field of management accounting has traditionally operated in a reactive manner, addressing issues and taking action within the management control system only when deviations from the business plan occur. Over the years, more than 30 popular cost and management accounting techniques have been introduced, with the majority of these innovations emerging in the last two decades. As explained by Hagerty, (1997) as cited in Shah (2015), the major developments in management accounting since the 1950s can be categorized as follows:

- In the 1950s, notable cost and management accounting innovations included Discounted Cash Flows, Total Quality Management, Cusum Charts, and Optimum Transfer Pricing.
- The 1960s witnessed advancements such as Computer Technology, Opportunity Cost Budgeting, Zero-Base Budgeting, Decision Trees, Critical Path Scheduling, and Management by Objectives.
- During the 1970s, the field experienced innovations such as Information Economics and Agency Theory, Just-in-Time Scheduling, Strategic Business Units, Experience Curves, Portfolio Management, Materials Resource Planning, Diversification, Matrix Organization, and Product Repositioning.

These developments in cost and management accounting have significantly influenced the way organizations approach financial planning, decision-making, and performance evaluation. They have enhanced the ability to analyze and manage costs, optimize resource allocation, and align strategic objectives with operational activities.

Additionally, the Western established markets faced a formidable challenge in the early 1980s due to intensified global competition and the aftermath of the world recession triggered by the oil price shock of the 1970s. This intensified competition was closely intertwined with the rapid advancements in technology, which exerted a significant influence on various aspects of the industrial sector according to Abdel-Kader and Luther (2004). For instance, the implementation of robotics and computer-controlled processes yielded improvements in quality and cost reduction across numerous cases. Furthermore, the advent of personal computers and other computer developments brought about substantial changes in the nature and accessibility of data available to managers. Consequently, the effective management of information systems, encompassing their design, maintenance, and interpretation, assumed crucial importance as stated by Hopper, Scapens, and Ashton (1995)

In response to the imperative of addressing global competition, organizations sought to confront the challenge by implementing novel management and production techniques while simultaneously exercising cost control measures, often by reducing wastage of resources in business processes (International Federation of Accountants, 1998). This approach was frequently complemented by empowering employees within the organizational framework. In such an

environment, the diffusion of management information and decision-making throughout the entire organization became essential. Consequently, management accountants, serving as the primary providers of this crucial information, face the challenge of ensuring the availability of relevant information to support managers and employees at all hierarchical levels. To accomplish this, the utilization of process analysis and cost management technologies becomes imperative as put forth by Abdel-Kader and Luther (2004).

According to Hagerty, (1997) and Smith, (1999) as cited in Shah (2015) In the 1980s, several significant innovations in cost and management accounting emerged. These include:

- **Activity-Based Costing (ABC):** ABC introduced a more accurate method of allocating costs by identifying and assigning them to specific activities that consumed resources.
- **Target Costing:** Target costing involved setting cost targets for products or services based on market conditions and customer demands, in addition to managing costs during the design and development phase to meet those targets.
- **Value-Added Management:** This approach focused on identifying and improving activities that directly added value to products or services, while eliminating non-value-added activities.
- **Vertical Integration:** Vertical integration involved integrating different stages of the production and distribution process within a single company to gain control, reduce costs, and improve coordination in the supply chain.
- **Benchmarking:** Benchmarking involved comparing an organization's performance, processes, and practices against industry best practices or competitors to identify performance gaps and areas for improvement.

These innovations in cost and management accounting during the 1980s brought significant advancements in cost control, operational efficiency, and strategic decision-making within organizations.

iii. Management accounting 3.0

During the 1990s, the global industry faced significant uncertainty and experienced unprecedented advancements in manufacturing and information processing technologies according to Hopper,

Scapens, and Ashton (1995). The proliferation of the worldwide web and related technologies, such as E-commerce, intensified the challenges posed by global competition. As a response, management accountants shifted their focus towards generating value through the effective utilization of resources. This involved leveraging technologies that could evaluate the drivers of customer value, shareholder value, and organizational innovation (International Federation of Accountants, 1998).

Scholars such as Hagerty, (1997) and Smith, (1999) as cited in Shah (2015) have identified several noteworthy cost and management accounting innovations in the 1990s. These include Business Process Reengineering, Quality Functional Deployment, Outsourcing, Gain Sharing, Core Competencies, Time-based Competition, and Learning Organization. Furthermore, in the literature, different methods have surfaced, including ABC and Life cycle costing.

These innovations have played a pivotal role in shaping the landscape of cost and management accounting practices. They have empowered organizations to enhance resource allocation, improve performance measurement and decision-making, and drive strategic initiatives. Furthermore, they reflect the ongoing evolution of cost and management accounting techniques, adapting to meet the evolving needs and challenges of the modern business environment.
In order to summarize the evolution of management accounting practice up until now and provide a concise visual representation, Figure 4 is presented below:

Figure IV: The Evolution of Management Accounting (Shah 2015)

Figure 4 illustrates the progressive stages of development in management accounting over time. It captures the key shifts and transformations in the field, highlighting the emergence of new techniques, approaches, and strategic considerations. The figure aims to provide a comprehensive overview of the evolution of management accounting practice, offering a visual reference for understanding the changing landscape of the discipline.

iv. Management accounting 4.0

The Fourth Industrial Revolution, often referred to as Industry 4.0, signifies substantial transformations occurring in our commercial landscape, predominantly influenced by the progression of information technology according to Morrar et al., (2017) as cited in ALAM and HOSSAIN (2021). Essentially, this revolution prompts a fundamental shift in production paradigms, moving from mechanistic procedures towards a digital-based format. Such alterations also encompass the extensive integration of the internet with other groundbreaking technologies in virtually all aspects of life as suggested by Morrar et al., (2017) as cited in ALAM and HOSSAIN (2021).

Nair and Nian (2017) advance that management accounting constitutes the methodological compilation of management reports that offer precise and prompt financial and statistical data to facilitate management decision-making. Practices in management accounting are employed by organization managers at disparate hierarchical levels. Concurrently, these practices afford a level of autonomy to managers, as they are devoid of limitations other than the cost-to-benefit analysis of the gathered information relative to the enhancement of managerial decisions. This pivotal trade-off helps to ensure optimal utilization of resources within the decision-making process.

According Bhimani & Bromwich, (2009) as cited in ALAM and HOSSAIN (2021) present-day business discourse is frequently punctuated by terms such as artificial intelligence, big data, cyberspace, informatics, Internet of Things, and robotics. Consequently, management accounting - a pivotal system for information production within an organization - has undergone significant transformation in order to keep pace with the requirements of the increasingly digitized business environment.

Nair and Nian (2017) also have suggested that elements of advanced production technology could potentially influence management accounting practices. Within a manufacturing system, the production procedures dictate the type of costing system a company will utilize. Essentially, the Fourth Industrial Revolution will bear significant implications on the design of the costing systems used for production processes. This technological influence is particularly noticeable in stages of the manufacturing process that involve electronics and automation. The adoption of modern management accounting methodologies exerts a comprehensive impact across all organizational structures.

Dahal (2019) identified the following instances of alterations in management accounting (MA) practices as a result of the fourth industrial revolution:

1. The extension from product-oriented to channel and customer profitability analysis signifies the necessity for MA to support sales and marketing functions.
2. The transition towards predictive accounting highlights a key shift from using MA primarily for cost and profit reporting, to utilizing managerial economics for decision support and future-impacting analysis.
3. The integration of business analytics into enterprise performance management (EPM) methods indicates that advanced accounting functions acknowledge the competitive advantage offered by proficiency and capabilities in analytics.
4. The coexistence and enhancement of MA methods suggest that forward-thinking Chief Financial Officers and their MA teams are considering the diverse requirements of various types of managers within their organizations.
5. The approach of managing information technology and shared services as a business illuminates the role of MA in supporting internal records, technology, and shared services to function as a business unit.
6. The demand for improved skills and expertise in behavioural cost management necessitates the inclusion of change agents within an organization.

In addition to that, it is imperative for management accountants to adapt to and coexist with technological advancements. As every production procedure is being reshaped by Industry 4.0,

there is a compelling need for management accounting practices to transition from historical, short-term planning and control to a more forward-looking, strategic approach to planning and control.

Building upon this line of thought, Dai and Vasarhelyi (2023) articulated that the concept of Management Accounting 4.0 extends beyond merely incorporating Industry 4.0 technologies into the accounting domain. Instead, it signals the potential for a profound transformation of the management accounting paradigm, involving alterations in the profession's timing, methodology, and mindset.

Furthermore, Dai and Vasarhelyi (2023) underscore the centrality of analysis tasks within the framework of Management Accounting 4.0.. Four primary tasks are outlined: (1) timely data collection from novel sources, (2) development of an integrated data model to discern patterns and associations across multiple sources, (3) enhanced technological acuity to aid management accountants in navigating the tech-intensive environment, and (4) the establishment of continuous monitoring mechanisms and controls to enable real-time responses.

The article “What Is Industry 4.0 and the Fourth Industrial Revolution?" by McKinsey (2023) advances that the application of technology constitutes only a part of the equation for success in the Fourth Industrial Revolution, also known as Industry 4.0. Companies wishing to prosper in this new era must prioritize not only technology integration but also employee upskilling, reskilling, and strategic recruitment. Upskilling pertains to the process of equipping employees with additional skills to enhance their existing roles as the required competencies evolve. The main challenge, however, lies in reskilling, wherein employees are provided with entirely new skills to enable them to transition into different roles within the organization.

This idea has been supported by Pereira and Romero (2017) who believe that the advent of Industry 4.0 is set to initiate significant shifts not just within the industrial sector, but across various domains. Its implications and impacts can be systematically classified into six key dimensions: (1) Industry, (2) Products and services, (3) Business models and market, (4) Economy, (5) Work environment and (6) Skills development.

To ensure our discussion remains pertinent to this thesis, we will confine our discussion to only

two factors that directly correlate to our topic: the evolution of the work environment and advancements in skills development.

Work environment: The transformation of the work environment due to rapid technological progress is significant, with Industry 4.0 reshaping employment profiles and necessitating new skills. A critical shift is apparent in the human-machine interface, encompassing the evolving dynamics between workers and novel modalities of collaborative work as articulated by H. Kagermann Et al, (2013) as cited in Pereira and Romero (2017). The proliferation of robots and intelligent systems, coupled with the convergence of physical and virtual domains, signals a notable metamorphosis in contemporary workplaces. The escalating importance of human-machine interfaces will further enhance interactions among production elements, employees, and communication amongst smart machines and products, supported by the principles of Internet of Things (IoT) and Internet of Services (IoS) facilitated by Cyber-Physical Systems (CPS). Consequently, ergonomics should be considered within the framework of Industry 4.0, and future system designs should emphasize the significance of the human element as stated by Dombrowski and Wagner (2014); Zuehlke (2010); as cited in Pereira and Romero (2017). The incorporation of Industry 4.0 into manufacturing systems, along with the growing adoption of emerging technologies, will impact job descriptions, work management, organization, and planning. Roblek, Meško, and Krapež (2016); as cited in Pereira and Romero (2017) believe that the predominant challenge is to avert technological unemployment by reshaping existing roles and preparing the workforce for the new opportunities that will arise.

Skill development: A driving force behind demographic and social shifts, is a pivotal element for the successful embracement and deployment of the Industry 4.0 model. The anticipated future work environment calls for the emergence of new skillsets, making it imperative to establish avenues for acquiring these necessary capabilities through high-caliber training programs as mentionned by Erol et al. (2016); as cited in Pereira and Romero (2017). This impending industrial revolution will profoundly affect labor dynamics and job roles, thereby making it crucial to create more jobs than those potentially eliminated. The integration of new requisite skills into educational systems is crucial, as the importance of interdisciplinary comprehension and proficiency in both social and technical fields is expected to increase as described by Magruk (2016); as cited in

Pereira and Romero (2017).As Industry 4.0 paves the way for more automated tasks, workers must be trained to adapt to new roles. This imperative extends to engineering education, which holds immense potential in nurturing future professionals and familiarizing them with forthcoming technological trends and opportunities. Simultaneously, managers should adjust their strategies to align with evolving market needs as presented by Erol et al. (2016); as cited in Pereira and Romero (2017). Additionally, the necessity for highly trained staff in technology-related fields to meet Industry 4.0's demands is projected to rise substantially.

As a result, the influence of Industry 4.0 will extend significantly to the realm of management accountants, a profession predominantly concerned with aiding financial decision-making, budgetary control, and the management of crucial financial and operational aspects of a company through detailed business transaction analyses according to Ittner and Larcker, (2001) cited in Dai and Vasarhelyi (2023). The field of management accounting stands to gain from the deployment of equipment and infrastructures realized through Industry 4.0. Conversely, management accountants could reciprocate by lending their specialized knowledge and professional discernment to this emerging paradigm.

Beaman and Richardson, (2007) as cited in ALAM and HOSSAIN (2021) raised concerns about the potential marginalization of management accountants in the professional arena if they fail to develop IT skills and adapt to the digital climate. In this evolving environment, it is imperative for management accountants to augment their repertoire of skills, learning a wide array of soft and IT skills, alongside maintaining their traditional technical expertise.

Echoing this sentiment, ALAM and HOSSAIN (2021) advance that the digitized context has dramatically reshaped the roles of management accountants. Traditional skills are at risk of becoming irrelevant due to the swift progress of digital transformation. Supporting this perspective, according to ALAM and HOSSAIN (2021) CIMA (2019) presented survey results indicating a growing necessity for technological literacy among UK workers - '...a growing appreciation of the need to integrate with technology and be agile – 26% of workers said they think working seamlessly with new technologies will be one of the most important skills.'

The subsequent diagram (refer to Figure-5) illustrates a notable transition in the responsibilities and pertinent skills of management accountants as a consequence of digital transformation.

Figure V: Changing Role of Management Accountants (ALAM and HOSSAIN 2021)

Building upon this perspective Heinzelmann, (2019) as cited in ALAM and HOSSAIN (2021) believes that in the context of increased automation of routine tasks and reporting, management accountants are perceived to assume a business partnering role within the digitally evolved landscape. This role demands according to ALAM and HOSSAIN (2021) not just an understanding of the Enterprise Resource Planning (ERP) systems implemented within their organization, but also a profound knowledge of utilizing the data produced for informed decision-making. A comprehensive grasp of big data landscapes, artificial intelligence (AI), the Internet of Things (IoT), and other IT interfaces becomes crucial. Hence, IT proficiency, software competency, and big-data analytical capabilities become assets, particularly as the demand for traditional tasks like record-keeping, report generation, and manual data analysis declines. Additionally, the evolving role of management accountants calls for a forward-looking mindset, multi-tasking abilities, and empathy to operate efficiently within a collaborative team setting. This paradigm shift marks a departure from the conventional, individualistic, inward-focused, and self-centric roles traditionally associated with management accountants.

In light of this, Lawson, (2019) as cited in ALAM and HOSSAIN (2021) underscores the necessity for management accountants to concentrate on value generation, for this reason, their involvement should span strategic formulation and analysis, planning, and execution. In addition, they ought to direct their efforts towards evaluating risk exposure, scrutinizing investment decisions for long-

term value creation, and effectively communicating with enterprise leaders about the business's success.

This view has been echoed by Sorensen (2009) who believes that the position of management accountants is ascending within organizational structures, transforming them into respected business partners who play integral roles in top-tier decision-making. Further backing for this concept was provided by Holtzman (2004) who advances that the evolution of the management accountant's role is an ongoing process. They have transitioned from mere bean counters to strategic business partners, shifting their work from the back office to the forefront of operations, to successfully engage in business partnering, management accountants must consistently enhance their expertise across various fields and hone their communication skills to effectively liaise with both internal and external stakeholders at all organizational levels. This competency becomes even more crucial within the context of a multicultural society.

c. Conclusion

Throughout this chapter, we have delved into the profound transformation of management accounting practices and the impact of Industry 4.0, or the Fourth Industrial Revolution. We have seen how Industry 4.0 disrupts traditional production processes, ushering in a digital, internet-integrated approach.

As we examined the evolution of management accounting from 1.0 to 4.0, we observed how each iteration addressed specific challenges and incorporated technological advancements. This evolution reflects the dynamic nature of the field and the need for adaptability in response to changing business landscapes.

Building on this, management accountants are increasingly transitioning from their traditional roles as "bean counters" to pivotal business partners at the heart of decision-making. This evolution advances them to operational forefronts, necessitating continuous expertise development and improved stakeholder communication in our diverse multicultural setting.

A key focus of our discussion was the potential influences of advanced production technology on management accounting practices. We emphasized the importance of management accountants developing IT skills and adapting to the digital climate. The shift from traditional roles to more

strategic, technologically adept positions was highlighted, emphasizing the need for a comprehensive understanding of enterprise resource planning systems, big data landscapes, artificial intelligence, and other IT interfaces.

Furthermore, we emphasized the significance of soft skills in the new landscape. Multi-tasking, empathy, and effective communication were identified as essential attributes for management accountants in their evolving roles. These roles include strategic formulation and analysis, planning, execution, risk evaluation, investment decision scrutiny, and effective communication with enterprise leaders.

The chapter also explored the impacts of Industry 4.0 on the work environment and skills development. We underscored the necessity of developing new skills and reskilling the existing workforce to thrive in the digitalized business environment. Integrating the requisite skills into educational systems and training programs was emphasized, along with the importance of managers aligning their strategies with evolving market needs.

In conclusion, this chapter provided valuable insights into the transformative effects of Industry 4.0 on management accounting practices and the work environment. It underscored the imperative for management accountants to adapt and excel in this changing landscape by augmenting their skills and embracing their evolving roles as strategic advisors in the digital era.

II. RESEARCH METHODOLOGY

1. Introduction

To assess the potential changes brought about by Industry 4.0 on the role of management accountants, we will adopt an exploratory approach. Given the scarce research in this emerging domain, using this methodology is apt for understanding the evolving nature of the management accountant's responsibilities and required skills. The primary aim of this research is to shed light on the modern transformations and nuances, laying the groundwork for more in-depth studies in the future.

2. RESEARCH HYPOTHESES

We use a hypothesis-driven approach which will be confronted to the thoughts of our interviewees in the form of qualitative questions. Based on our literature review, we can formulate two main hypotheses centered on the main research problem that we aim to test through our experimental process.

H1 – Industry 4.0 technologies have led to an expanded strategic role for management accountants beyond traditional financial reporting.

From the literature review, it's evident that the trajectory of management accountancy is shifting in tandem with the innovations of Industry 4.0. Dahal (2019) underscores the need for a more forward-looking, strategic approach, which suggests a move beyond the conventional financial reporting role. This assertion, combined with Dai and Vasarhelyi's (2023) depiction of a broader transformation in management accounting, directly influenced the formulation of the first hypothesis. The outlined transition in methodology, mindset, and the expanding business partnering role described by Heinzelmann (2019), ALAM and HOSSAIN (2021) further emphasize this point, highlighting a discernible evolution in the strategic role of management accountants.

H2 – The integration of Industry 4.0 tools has increased the demand for management accountants to possess interdisciplinary skills, including data analytics and IT proficiency.

The formulation of the second hypothesis can be traced back to several insights in the literature. McKinsey's (2023) discussion on the significance of upskilling in the wake of Industry 4.0 provides a foundation. This is given particular relevance to management accountants by Erol et al. (2016), cited in Pereira and Romero (2017), who emphasize an interdisciplinary approach. The concerns voiced by Beaman and Richardson (2007) about management accountants' potential marginalization without IT adaptation further elucidate the shifting skills landscape. ALAM and HOSSAIN (2021) solidify this sentiment, underscoring the increased importance of technological literacy, understanding of big data landscapes, and proficiency in IT interfaces. These collective insights from the literature directly contributed to the formulation of the hypothesis that Industry 4.0 has intensified the demand for management accountants to possess a broader spectrum of interdisciplinary skills.

3. RESEARCH APPROACH

To bridge the gap between theoretical concepts presented in preceding chapters and the real-world shifts in the management accountant’s role, we chose semi-structured interviews as our primary qualitative data collection tool.

In preparation for these in-depth conversations, the research objectives were initially defined to explore the influence of Industry 4.0 technologies on the role of management accountants, guiding the formulation of pertinent research questions. This foundational phase shaped our interview collection, focusing on the pivotal elements of how management accountants are navigating this transformative era. A total of 12 individuals were interviewed via virtual communications, but data from only 8 was retained for this study. 4 participants were excluded based on the responses to questions 4 and 5 in Appendix 1, their exclusion was due to their lack of engagement with Industry 4.0 or were not positioned in roles that interacted directly with its components.

To facilitate these discussions, a detailed interview guide was constructed. This guide was tailored to cover essential topics, including the implications of Industry 4.0 on their tasks, perceived advantages, challenges, and the skills required for these technological changes. The guide's open-

ended questions were framed to allow participants to articulate their experiences and insights without constraints.

The chosen qualitative approach was instrumental in offering flexibility, allowing the research to naturally unfold and welcome unexpected revelations. Every piece of interview data will undergo thorough scrutiny to identify emergent themes and patterns, aiming to construct a multifaceted understanding of Industry 4.0's ramifications on the management accountant's role. This analysis is rooted in continuous interpretation, embracing any novel insights that surface.

Fundamentally, these interviews serve as the cornerstone for our practical inquiry within this study. As we sift through the gathered data, we expect to gain a deeper comprehension of the concrete effects of Industry 4.0 on management accountants. This qualitative exploration guarantees that each participant's viewpoint and experiences amplify our comprehensive examination of the thesis topic.

4. DATA COLLECTION

a. Sampling criteria.

The participants for this research were selected based on the following criteria:

1. **Professional Experience and Roles:** The study incorporated participants from various roles and career stages. This includes junior management accountants just starting their careers to seniors management accountants. Additionally, insights were gathered from AI/ML CFO Program manager and HR talent acquisition professionals. These diverse roles ensure a multidimensional understanding of the effects of Industry 4.0, capturing not only the perspectives from the management accounting field but also from those orchestrating technological implementations and talent acquisition. The selection was meticulously carried out to capture a spectrum of viewpoints from different hierarchical levels and organizational functions, which significantly bolsters the validity of the results.
2. **Exposure to Industry 4.0:** It's essential that participants are affiliated with companies that have either adopted or are knowledgeable about Industry 4.0 technologies. This

requirement ensures firsthand experience or informed perspectives on the technological shifts impacting their respective roles, irrespective of their position or tenure.

3. **Diverse Industry Representation:** To cultivate a comprehensive understanding, participants were sourced from various sectors, such as IT industry, E-commerce, retail, and automotive. This deliberate diversity guarantees a broad representation of experiences and perspectives, enhancing the depth and breadth of insights extracted from the research.
4. **Profiles Interviewed:** The following table provides a comprehensive summary of the interviewees, detailing their roles, companies, and associated seniority levels.

Name	Position	Company	Seniority Level	Industry
Maria	Finance business partner Senior director	Dell Technologies	Executive	Technology
Karim	Finance business partner	Dell Technologies	Mid-Level	Technology
Daryl	Finance business partner Lead for EMEA	Dell Technologies	Executive	Technology
Marc	AI/ML CFO Program manager EMEA	Dell Technologies	Senior	Technology
Nadege	Finance business partner manager	Amazon	Managerial	E-commerce & Retail
Carla	HR talent acquisition	Amazon	Mid-Level	E-commerce & Retail
Radi	Junior management accountant	Valeo	Entry-Level	Automotive
Ayoub	Management accountant	Valeo	Mid-Level	Automotive

Figure VI: Profiles table

b. Data analysis

In our exploration of the influence of Industry 4.0 on the role of management accountants, a systematic procedure was employed to process the interview data. All recorded conversations were meticulously transcribed to ensure the accuracy of the content. Choosing a qualitative methodology allowed us to identify and extract key themes and patterns that emerged from the participants' shared experiences and perceptions.

This comprehensive approach was instrumental in unveiling the multifaceted ways in which Industry 4.0 technologies and paradigms are redefining the responsibilities and skills of management accountants in contemporary settings.

To enhance the integrity and robustness of our findings, we didn't rely solely on the interview outcomes. Instead, the insights drawn from the interviews were cross-referenced with other relevant sources of information, especially scholarly articles. This data triangulation reinforced the credibility of the insights gleaned from the interviews and deepened the comprehension of the impact Industry 4.0 has on the management accountant role.

5. RESEARCH ETHICS

The study adhered to ethical principles of anonymity and confidentiality to safeguard the privacy of human participants throughout the research process, including data collection, analysis, and reporting (Allen 2017). Measures were taken to remove personally identifying information provided by the interviewees, ensuring the preservation of confidentiality.

Furthermore, the data collection approach prioritized anonymity, collecting information without disclosing personally identifiable details.

This research was conducted with confidentiality (Allen, 2017). Both instances involved the collection, transformation, and examination of information from participants. Rather than exposing individuals' experiences and behaviors, the focus of this study centered on understanding their actions and experiences. As responsible researchers, it is essential to respect the respondents' wishes, particularly when they express a desire for anonymity.

III. RESULTS AND DISCUSSION

1. Introduction

In today's digital age, marked by Industry 4.0, roles in many professions are changing, and management accountants are no exception. Their job used to be mainly about financial reporting, but now, with new technology, their role seems to be expanding and changing in new ways. This study aims to explore those changes in depth.

To get a clear picture, we spoke to a range of professionals directly. We chose interviews as our way to collect data because talking directly to people can give us real, in-depth insights.

We spoke to a mix of professionals from big tech companies to those in the automotive industry. They had different jobs – from finance business partner partners to tech role related to finance, and to HR, focusing on hiring for finance roles. They also had different levels of experience, from those just starting out to those in senior roles.

After gathering their insights, our findings will be presented in five subsections, each focusing on distinct facets of the evolving role of management accountants in the context of Industry 4.0. Through this structured approach, we aim to provide a clear and comprehensive understanding of how the role of management accountants is shifting in today's digital landscape.

2. Presentation of Results

a. Incorporation of Industry 4.0 Technologies

The shift towards Industry 4.0 has introduced a multitude of technological tools and applications into the realm of management accounting, fundamentally changing the landscape of how professionals operate in this domain.

Emerging as a central theme from our conversations is the growing adoption and integration of new technologies such as SFT (Sales forecast tool). These digital advancements have not just made reporting processes more streamlined but have amplified the precision of tasks like pricing decisions. For other interviewees, advancements such as Robotics have proven beneficial in automating repetitive tasks, freeing up time for more strategic endeavors. At the same time, the

infusion of AI and ML is heralding a new era, especially in the predictive facets of the business. A recurring reference was the IQM (Integrated quota management) tool, which utilizes AI and ML to propose sales targets based on a wide array of parameters. However, alongside its benefits, there's also a shared sentiment of potential growth, especially in refining specific processes and manual inspections.

The power of AI and ML hasn't just eliminated the monotony associated with traditional report generation and analysis. Their capacity to swiftly flag anomalies, such as potential frauds, and offer in-depth insights from vast data pools is commendable. This has shifted the focus of management accountants towards more proactive roles, emphasizing their strategic foresight and planning capacities.

Further, the broad application of Machine Learning, especially in predicting spending behaviors and harnessing Big Data, has been of significant utility. Such technologies have reshaped transactional pattern recognition, greatly aiding tasks like demand forecasting and inventory management. Interestingly, this perspective is shared also by the human resources representatives who also resonates with this evolution. The growing demand now is for management accountants adept at synergizing with these Industry 4.0 technologies. This synergy is not just a value-add; it's gradually becoming a requisite, ushering in a new era of real-time data analysis paired with strategic planning.

Yet, it's crucial to understand that this transition isn't universal. Some professionals have had limited interaction with these advanced tools. While AI and Big Data are undoubtedly making their mark, for some, they still play a secondary role, supplementing more conventional tasks.

To summarize, as the tides of Industry 4.0 technologies surge, the role of management accountants is undeniably transforming. While the incorporation of these technologies is largely beneficial, offering enhanced efficiency and precision, it's also ushering in a phase of adaptability and learning, setting the stage for a future brimming with possibilities.

b. The Changing Landscape of Management Accountants role and responsibilities

Interviews conducted with professionals in the field paint a vivid picture of the evolving role of management accountants in the era of Industry 4.0. There is a collective agreement that their traditional domain, rooted in financial tracking, is expanding significantly, influenced heavily by technological and strategic shifts.

It's evident from the conversations that management accountants are no longer constrained by the traditional paradigms of their roles. Instead, they are taking on responsibilities that delve deeper into business strategy and tech innovations. These real-world testimonies suggest a clear broadening of their scope—where they aren't just crunching numbers or generating reports but are actively involved in wider company planning, sales strategy, and business transformation.

A recurrent theme across interviews is the blurring line between the conventional duties of management accounting and overarching business strategy. This intertwining is further emphasized by their growing engagement with emerging technologies, notably AI and ML. As recounted by some interviewees, there are management accountants who, in the past, might have exclusively dealt with financial data but are now seamlessly navigating these tech areas. This narrative suggests a foreseeable future where these professionals are adept both in their core financial expertise and the latest technological trends.

Further insights reveal that management accountants are increasingly pivotal in steering company-wide strategies. Their role isn't merely about monitoring finances; it's about shaping and aligning financial goals with the company's larger vision. This sentiment is echoed by both newcomers to the field, who observe a rapid shift towards strategy-centric roles, and seasoned professionals emphasizing the crucial alignment of financial and business strategies.

The influence of Industry 4.0 on their roles is not just abstract but has tangible implications in the recruitment sphere. As indicated by and interviewee involved in hiring, there's a heightened expectation for today's management accountants to be multifaceted. Proficiency in numbers remains foundational, but a familiarity with tech trends and a knack for strategic thinking are becoming equally vital.

A notable evolution highlighted in the discussions is the transition in job titles. Traditional designations like ‘management accountant’ are gradually being overshadowed by roles like 'finance business partner'. This isn't merely a nominal change but signifies a more profound shift from routine financial reporting to a proactive involvement in strategy formulation and business value enhancement.

The interviews also touched upon the operational transformation powered by Industry 4.0 technologies. Expedited data access has led to a pivot from tasks like data preparation to a more profound analysis, pattern discernment, and robust strategic planning. This shift in focus, as recounted, isn't just about crunching financial numbers but about driving the strategic direction of businesses.

However, while the advent of Industry 4.0 is catalyzing these transitions, the core essence of management accounting remains intact. As emphasized by a respondent, while technological advancements like real-time data and predictive analytics are influential, foundational elements like financial analysis and strategy retain their central significance.

In conclusion, the interviews offer a cohesive narrative: Industry 4.0 is reshaping the landscape for management accountants, pushing them to embrace roles that are more strategic and technologically integrated. As they adapt and evolve, they stand poised to redefine their impact in the modern business ecosystem.

c. Skills Development and Relevance

In the realm of Industry 4.0 and its impact on the management accountant role, a complex and multifaceted skills development landscape has emerged. The collective insights gathered from the interviews paint a comprehensive picture of the transformation in skills, and their relevance, to cater to the demands of a rapidly changing environment.

A recurring theme across various levels of professionals is the necessity of foundational training in tools such as Power BI, and the like. However, what stands out is the shift from mere technical acumen to a blend of soft skills, deemed vital in the present context. Skills such as change

management, executive communication, cross-functional relationship management, emotional intelligence, and the art of storytelling with numbers have gained prominence.

These skills go beyond the conventional technical mastery and emphasize the ability to translate data into actionable insights. This transformation underscores the importance of data-driven decision-making, where accountants are now expected to weave numbers into coherent narratives that can guide organizational strategies.

Furthermore, the integration of AI and ML into financial roles demands not just the understanding of these technologies but also a particular skill set to exploit their capabilities. As emphasized, professionals aren't expected to become data scientists but must acquire foundational knowledge of these tools. An understanding of coding, statistical methods, and a perpetual curiosity about emerging technologies forms the bedrock of this evolving landscape.

From the perspective of the businesses they serve, technological proficiency must align with the organization's ethos. The ability to convert complex technological data into executable financial strategies, an alignment with consumer-focused strategies, and the aptitude to make financial narratives resonate with non-finance departments are seen as fundamental proficiencies.

On the recruitment front, the shift in demand for skills is equally tangible. While core accounting knowledge remains essential, it is now augmented by familiarity with AI, IoT, blockchain, and other cutting-edge technologies. Moreover, soft skills such as adaptability, critical thinking, and collaboration are not merely add-ons but recruitment keystones, reflecting a broader change in what is considered essential for the role.

While the emergence of these new skills is significant, the relevance of foundational financial skills has not diminished. Some professionals depend heavily on these foundational abilities to integrate new tools effectively into their workflow, focusing on deriving actionable insights, irrespective of the tools used.

This convergence of hard and soft skills, technology, and traditional financial acumen reflects a rich and complex evolving landscape. It illustrates a balanced ecosystem where traditional

financial skills are intertwined with technological understanding, emotional intelligence, agility, and the ability to craft coherent financial stories.

In conclusion, the influence of Industry 4.0 on the management accountant role has ushered in a period of both enhancement and transformation in skills development. The skill set now required is vast and varied, bridging technological savvy with a human touch, quantitative mastery with qualitative understanding, and traditional practice with innovative thinking. It paints a picture of a profession adapting and evolving, optimistic and ready to meet the challenges of an ever-changing industrial landscape.

d. Challenges and Opportunities

The integration of Industry 4.0 into management accounting has unveiled a range of challenges and opportunities. Reflecting on the gathered insights, a shared narrative emerges, highlighting the transformative journey professionals undergo as they navigate this dynamic landscape.

At the core of challenges lie resistance to change and skepticism, seemingly universal across multiple industries. This resistance is not just exhibited by individuals but is a manifestation of organizations as well. The introduction of novel tools and processes can often face friction, primarily from segments of the workforce anchored in traditional methodologies. There is a clear underlying theme of trust or, more specifically, a lack of it in these emerging technologies. While AI and ML offer transformative benefits, there is a palpable hesitance, with many finance business partners hesitant to detach from proven traditional methods.

Additionally, the rapid acceleration of Industry 4.0 technologies brings forth its set of complexities. Integrating new processes and managing their diffusion across the organization can pose daunting challenges. Notably, there’s the persistent issue of "garbage in, garbage out," underscoring the importance of quality data input for desired output. Furthermore, while these tools offer enhanced efficiency, their rigidity in adapting to dynamic changes remains a concern.

An interviewee provided a deeper dive into these complexities. He points out the dual nature of Industry 4.0. On one hand, real-time data access enables faster reactions and adaptability. On the other, it can also lead to an overwhelming surge of information. For someone relatively new to the

field, navigating this sea of data while ensuring accurate interpretations becomes a central challenge.

A senior management accountant perspective complements this view. As he emphasizes the pitfalls of data saturation and the dangers of overly depending on automation. Yet, he also acknowledges the upside: the potential of real-time data to expedite decision-making processes.

But it's not all storm clouds on the horizon. The silver linings are pronounced. For many, the advantages outweigh the tribulations. Automation, enhanced efficiency, and superior data utilization are some of the salient benefits. The potential to streamline work processes has also been recognized, leading to opportunities for personal and professional growth. With Industry 4.0 tools comes the promise of real-time data, enabling quicker decision-making processes. This immediacy, though double-edged, promises agility, provided professionals can adeptly manage the information deluge.

From a recruitment vantage point, while the rapid evolution of technology presents challenges in sourcing candidates with dual expertise in finance and technology, it’s also fertile ground for opportunities. Those willing to evolve, upskill, and adapt are poised to harness these opportunities, shaping groundbreaking projects and leaving an indelible mark on their organizations.

In a nutshell, as the tides of Industry 4.0 surge forth, the landscape of management accounting is reshaped, dotted with both challenges and opportunities. While some hurdles are formidable, the optimism remains tangible. Professionals stand at a crossroads, where embracing change, fostering trust in technology, and continuous learning can propel them into a future replete with unprecedented opportunities. This paints a canvas of an industry in continuous change but determined to adapt, innovate, and thrive.

e. Additional Observations

In the ongoing discussion about Industry 4.0 and its impact on management accounting, a few unique insights have emerged. These insights, although not aligning perfectly with earlier sections, still offer vital information about the future and the evolving roles of professionals in this space.

Many see the vast potential that new technology brings. They imagine tools that make their workdays more efficient, from better ways to manage time to personal assistant software. There's also a strong interest in how advanced data methods, like visualization and predictive analytics, might reshape their daily tasks and reporting duties.

Being able to adjust and change in this fast-moving world was another shared idea. As Industry 4.0 continues to grow, professionals must be ready to learn and change with it. This isn't just about using new tools, but about developing as professionals and meeting the new demands of their roles.

However, within this tech-focused view, there's a call for balance. Some highlighted the vast range of tasks within large organizations and expressed a need for tools that can bring data from different areas together. This would help them see the bigger picture and make better decisions.

And, importantly, many agree that while tech is great, people matter most. In hiring, for instance, the human touch can't be replaced by any machine or software. Soft skills, understanding, and judgment are vital in accounting roles. There's a hope that as companies use more tech, they'll also support their staff with training and resources.

Lastly, many emphasized the heart of their profession. Even with all the new tools, the real value comes from deep thinking and strategic planning. These technologies are just tools – the real work, and the true value, lies in how professionals use them to think ahead and plan.

In summary, these added insights give a more rounded view. They speak of hope, balance, and the ongoing dance between technology and human skill in the world of management accounting.

3. Discussion

Through our literature review and semi-structured interviews, we have managed to gain a deeper understanding of the way industry 4.0 may impact the management accounting role.

H1 – Industry 4.0 technologies have led to an expanded strategic role for management accountants beyond traditional financial reporting.

The Fourth Industrial Revolution, widely termed as Industry 4.0, stands at the intersection of transformative technological advancements, reshaping industries and their inherent roles. Amongst these transformations, the role of management accountants emerges as a focal point of discourse.

From varied insights, a compelling trend surfaces. These groundbreaking Industry 4.0 technologies are not mere instruments. They are, in essence, catalysts that are remolding the very essence of the management accountant's role. It's becoming clear, as stated by professionals, that the "era of spending countless hours on report extraction and analysis is fading" **(Appendix 3, Q2)**. Notably, this transition isn't just about adopting sophisticated tools. Management accountants are not only automating tedious tasks but elevating their positions to become integral contributors to business strategies.

The testimony of a senior director from the tech realm underscores this evolution. She emphasizes how advancements have "expedited our processes" and allowed a leap from operational tasks to ones that are "strategically aligned" **(Appendix 1, Q6).** Corroborating this, an EMEA AI/ML CFO Program manager in technology mentions the transformation from traditional management accounting roles to the emerging prominence of a 'finance business partner' role **(Appendix 3, Q3).**

Tech industry team is not the sole voices echoing this transition. The flourishing e-commerce sector, a child of technological innovation, reflects a similar trajectory. Here, management accountants grapple with evaluating the "profitability of AI-driven devices," signaling an unprecedented fusion of accountancy with cutting-edge technology **(Appendix 1, Q5).**

Furthermore, as these technologies ascend to the forefront, hiring preferences are evolving. It's no longer solely about financial aptitude. The modern-day management accountant must be well-versed in technology, possess strategic foresight, and embody a harmonious integration of these realms. An HR Talent Acquisition from the e-commerce sector articulates this, emphasizing the necessity for these professionals to metamorphose into "multifaceted professionals – part accountant, part technologist" **(Appendix 2, Q12).**

However, this transformation is not without its intricacies. While many celebrate the strategic expansion, some express reservations. A junior management accountant from the automotive arena labels it a "double-edged sword" **(Appendix 1, Q5).** The sentiment reflects the challenges faced by newer entrants, who while appreciating the agility and foresight brought by these tools, also grapple with the pressure to adeptly navigate them. Whether this is a factor of organizational pace, individual position, or simply a reflection of the broader industry transition isn't clear, but it emphasizes that the journey to full integration of Industry 4.0 in management accounting might be multifaceted.

Ultimately, the overarching consensus suggests an evolved role for management accountants, leaning more towards strategic analysis and foresight. Yet, as one one business partner in the automotive sector put it, while Industry 4.0's tools can be "enablers," they are "not end-all solutions" **(Appendix 1, Q15)**

Based on the responses, clear trends emerge. Senior professionals, especially in the tech sector, seem more inclined to stress the strategic enhancements brought by Industry 4.0. Meanwhile, those from e-commerce and retail highlight the integration of new technologies into profitability analyses, and newer entrants voice the challenges associated with rapid technological adaptation.

In alignment with the hypothesis - Industry 4.0 technologies undeniably expand the strategic purview of management accountants, transitioning them beyond the confines of traditional financial reporting.

Literature Review Cross-check:

The literature on Industry 4.0 and its transformative effects provides a robust framework to understand the nuances highlighted in the interviewee narratives. Historically, every technological evolution in the industry brought forth shifts in the roles of management accountants. The emergence of Industry 4.0 is no exception, as Dahal (2019) advances that it's imperative for management accountants to adapt and coexist with technological advancements.

The interviews often touched upon a movement from merely numerical responsibilities to those demanding a strategic mindset. The literature corroborates this, shedding light on how digital and

interconnected manufacturing is bridging departments together. Management accountants now find themselves in roles where they act as bridges between raw data and actionable business strategies. This goes beyond traditional financial reporting, echoing the broader sentiment in academic circles that management accountants are evolving into strategic business partners, as Heinzelmann (2019), as cited in ALAM and HOSSAIN (2021), believes they assume a more business-partnering role within the digitally evolved landscape.

Building on this, both interview results and the literature review present a congruent perspective. The interviews emphasize the tangible transition from traditional titles like ‘management accountant’ to more strategic roles like 'finance business partner', suggesting a deeper involvement in strategic formulation. Similarly, the literature paints a parallel narrative, underscoring the shift of accountants from mere "bean counters" to central decision-makers, actively participating at operational frontlines and necessitating improved stakeholder communication as put forth by Holtzman (2004) and Sorensen (2009). Both sources collectively reinforce the evolution of management accountants' roles in the Industry 4.0 era, highlighting their amplified strategic importance.

An interesting contrast arises when considering one interviewee's more reserved stance on the transformative effects of Industry 4.0. The literature suggests a universal shift, but as the interviews show, there are individual variations, potentially pointing to a broader spectrum of adaptation speeds across different entities or sectors.

In conclusion, the literature serves as a foundational bedrock, confirming and elaborating on the real-world experiences of our interviewees. This blend of theory and practice brings to the forefront the undeniable impact of Industry 4.0 on the evolving role of management accountants, as emphasized by.Ittner and Larcker (2001) cited in Dai and Vasarhelyi (2023)**.**

H2 – The integration of Industry 4.0 tools has increased the demand for management accountants to possess interdisciplinary skills, including data analytics and IT proficiency.

In exploring this hypothesis, a variety of perspectives emerge. These views, shaped by various facets such as industry, seniority, and function, shed light on the evolving nature of the management accountant's role in an increasingly digitized landscape.

From the tech sector, the evolution in the skill sets of management accountants is unmistakably highlighted by the Finance Business Partner Senior Director's insights. Drawing from **Question 7, Appendix 1**, the shift is articulated as: "the real growth was in soft skills—change management, communication, executive presence, and the art of storytelling with numbers." This assertion underscores the importance of striking a balance between embracing technological advancements and preserving the indispensable human element, a sentiment further emphasized by the statement, "the human element will always remain central" **(Question 15, Appendix 1).**

Elaborating on this, another viewpoint within the same sector from a Finance Business Partner suggests that the role is evolving beyond traditional number crunching. The professional emphasized, "we now leverage technology and data-driven insights to determine our organizations' financial futures" **(Question 10, Appendix 1).** This sentiment is echoed by the consensus on the pivotal role of continuous learning, particularly in data analytics, as indicated in **Question 13, Appendix 1**. Furthermore, the Finance Business Partner Lead for EMEA from this tech entity reflected on the importance of a harmonized approach combining technical expertise with soft skills, a sentiment found in **Question 10, Appendix 1.**

Switching gears to the e-commerce and retail realm, the discussion emphasized the bridging of technology and actionable financial strategies. As the Finance Business Partner Manager asserted, "Being able to translate intricate data from tools … into actionable financial strategies has become essential" **(Question 7, Appendix 1).**

The automotive sector provides a different angle. The perspective of a Junior Management Accountant, based on **Question 7, Appendix 1**, leans heavily towards agility, timely decision-making, and presenting data insights in a digestible format for non-financial teams. Concurrently, a Management Accountant from the same sector shared an acknowledgment of a "push towards digital literacy," suggesting a subtle yet significant shift in skill sets **(Question 7, Appendix 1).**

Peeling back another layer, the AI/ML CFO Program Manager EMEA expressed a salient point on the intersection of accountancy and emerging technologies. While accountants aren't expected

to metamorphose into data scientists, the necessity to grasp AI and ML basics is asserted as being non-negotiable **(Question 5, Appendix 3).**

Interestingly, an HR lens from an e-commerce and retail giant divulged evolving hiring trends. As derived from **Question 10, Appendix 2**, the emphasis is increasingly on a holistic approach, demanding management accountants to be well-versed not only in traditional financial matters but also in fields like data analytics, AI, and blockchain.

The examination of the collected interview responses revealed distinctive patterns based on three elements. In terms of seniority, those in senior roles underscored the importance of strategic adaptability combined with a harmonious blend of soft and hard skills. In contrast, individuals in junior roles showed a tendency towards valuing agility and an aptitude for translating financial insights effectively. When observed from an industry perspective, professionals in the tech sector laid emphasis on continuous learning, adaptability, and striking a balance between technical prowess and human-centric skills, while their counterparts in the automotive industry predominantly focused on agility and adaptability. Lastly, from a functional standpoint, the HR perspective distinctly indicated a shift in hiring trends. There's a growing inclination towards candidates possessing a comprehensive skill set that amalgamates technological expertise with essential soft skills.

In summary, while the integration of Industry 4.0 tools has certainly impacted the skill set required of management accountants, it's not solely about technology. The essence of their role remains intact — using numbers to make informed, strategic decisions. The journey is about embracing technology and simultaneously honing soft skills and human-centric capabilities.

In light of these observations, the results seem to corroborate the hypothesis. The data suggests that the integration of Industry 4.0 tools is indeed amplifying the demand for management accountants to develop and possess a more interdisciplinary skill set, especially one that melds data analytics, IT proficiency, and an assortment of soft skills. This synthesis of skills appears to be a prevalent expectation across various seniority levels, industries, and functional roles.

Literature Review Cross-check:

The interviews mirror the literature's narrative on Industry 4.0's influence on management accounting. The integration of Industry 4.0 technologies is undoubtedly redefining the contours of numerous professions, management accounting being no exception. Drawing from both the literature review and insights from the interviews, a fascinating tapestry emerges, underscoring the transformation in the role and requisite skills of management accountants in the era of the Fourth Industrial Revolution.

Dahal's (2019) assertion on the necessity for management accountants to embrace a forward-looking, strategic approach to planning and control finds echoes in the interview results. The importance of merging traditional financial acumen with digital-age proficiencies is a recurrent theme from the interviewees. This shift indicates the necessity of adapting to the technological advancements characteristic of Industry 4.0 (Dahal, 2019).

Furthermore, the intersection of management accounting and technology, as articulated by Dai and Vasarhelyi (2023), can be observed in the increasing demand for management accountants to be conversant with Industry 4.0 tools and techniques, particularly in areas such as data analytics and machine learning. The insight that foundational coding and statistical methods are becoming important, even if in-depth expertise isn't essential, further consolidates Dai and Vasarhelyi's (2023) perspective on the evolution of the management accounting paradigm.

The McKinsey (2023) article's emphasis on upskilling and reskilling to prosper in the Industry 4.0 era aligns with the interview findings that highlight a blend of soft skills, like storytelling and influencing stakeholders, with traditional accounting prowess. This blending of skills showcases a metamorphosis of the accountant's role from mere data handlers to strategic communicators. Such a shift resonates with the literature, emphasizing the importance of employee upskilling and reskilling in the Fourth Industrial Revolution (McKinsey, 2023).

ALAM and HOSSAIN (2021) provide a particularly enlightening stance on the digitization of the management accounting context. Their observations on the potential marginalization of management accountants who fail to integrate with the evolving digital landscape is underscored by the interview results which emphasize the value of both soft and hard IT skills in the modern

accounting landscape. The interview findings, pointing towards the industry's preference for candidates who amalgamate technological prowess with financial expertise, seem to be a practical manifestation of ALAM and HOSSAIN's (2021) insights.

To sum up, the landscape of management accounting is in flux, influenced by the innovations and requirements of Industry 4.0. The literature emphatically underscores the need for accountants to evolve and adapt to these changes, and the interview results reinforce this sentiment. The interviews and literature converge on the idea that while Industry 4.0 brings forth a wave of digital proficiency needs, the foundational pillars of finance remain steadfast. The contemporary management accountant, thus, stands at the intersection of finance and technology, wielding the tools of both worlds.

IV. RESEARCH LIMITATIONS

While this study endeavored to provide an in-depth examination of the impact of Industry 4.0 on the role of management accountants, several limitations must be acknowledged to ensure an accurate interpretation of the findings and to guide future research efforts.

1. **Scope of Participants**: The research primarily relied on interviews with management accountants and related professionals from three corporations. The perspectives gleaned may not necessarily be representative of the broader industry landscape, and there might be inherent biases or unique conditions within these companies that don't generalize across the industry.
2. **Sample Size**: The study incorporated insights from eight interviewees. While valuable, the size limits the generalizability of the findings. Broader sampling might have unveiled different or additional nuances related to the effects of Industry 4.0.
3. **Geographical Concentration**: The selected participants hail predominantly from the EMEA region. Cultural, technological, and organizational practices can vary greatly across different geographical regions, which might affect the adoption and impact of Industry 4.0.
4. **Technological Evolution**: The rapid evolution of Industry 4.0 tools means that some of the technologies discussed could become obsolete, or new technologies could emerge, shifting the management accountant's role even further in unforeseeable ways.

In conclusion, while these limitations present challenges, they also pave the way for further studies and explorations in this area. Future research could broaden the geographical and corporate scope, incorporate larger sample sizes, or utilize mixed method approaches to capture both depth and breadth in understanding the evolving role of management accountants in the era of Industry 4.0.

V. CONCLUSION

The dawn of Industry 4.0 marks a pivotal transition in our modern times, with reverberations felt in diverse sectors, including management accounting. The integration of technological advancements with human intelligence is ushering in transformative shifts, and this research aimed to delve deep into these transitions, especially in the context of management accountants.

From this research, several core revelations emerged:

1. **Expansion of Role**: The traditional responsibilities of management accountants are broadening substantially. Instead of just handling financial specifics, they're now instrumental in shaping strategic decisions, evident from evolving designations like 'finance business partners'. This progression is consistent across both the literature and insights from professionals.
2. **Diversification of Skills**: The contemporary management accountant isn't just a financial expert but is expected to be technologically adept. While foundational financial knowledge remains paramount, there's a heightened emphasis on understanding contemporary tools, including AI and ML. This sentiment resonates in both academic literature and the experiences shared by industry professionals.

These shifts present both opportunities and challenges. For instance, the inundation of data and rapid technological advancements, while promising, introduce complexity and necessitate continual learning.

Reflecting on the implications of these findings for someone in the position of a finance business partner, such as myself, the ramifications are profound. Understanding these changes is not just academic but deeply personal. With the role of finance business partners expanding, it's clear that we're not just observers of this transition but active participants. As the boundaries of our responsibilities grow, so does the need for us to be proactive, adaptable, and forward-thinking. This research doesn't just elucidate the evolving landscape; it provides a roadmap for professionals like me to navigate our career trajectories, ensuring we remain relevant, impactful, and primed to harness the opportunities that Industry 4.0 presents.

However, it's pertinent to acknowledge this study's boundaries. While insights were gleaned from eminent companies, they offer a snapshot of a broader, dynamic narrative. Rapid technological evolutions, varied regional experiences, and the inherent limitations of our participant group might color the conclusions.

To wrap up, Industry 4.0 is more than just a buzzword; it's a catalyst reshaping the domain of management accounting. This exploration serves as a foundational guide, spotlighting the nuances of the evolving role of management accountants. For finance business partners like myself, it underscores the importance of adaptability and continuous learning in this rapidly changing digital landscape. Embracing these changes positions us not just to respond but to lead in this transformative era.

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