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Technology with a Soul - From Industry 4.0 to Industry 5.0

SUPERVISORS

Prof. Bernardo Balboni

Prof. Cesare Fantuzzi

COORDINATOR

Prof. Tindara Addabbo

CANDIDATE

Mihaela A. Chelaru

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Abstract

The emergence of Industry 4.0 has brought about a massive shift in digital transformation of businesses, leading to alterations in operational procedures, organizational structures, quality of work and work conditions. The digital revolution holds immense potential for human progress and provides numerous opportunities.

This PhD thesis endeavors to explore the impact of human-centric factors in the digitalization process, where core human needs and interests are placed at the forefront, moving away from a technology-driven approach towards a thoroughly human and society-focused outlook. As a result, the roles of future employees will undergo a transformation, as the value placed on workers shifts from a mere "cost" to an "investment". The integration of advanced technologies and human values will drive the next industrial revolution, Industry 5.0, where technology has a soul, leading to a harmonious balance between efficiency and humanity.

The results of this empirical research will be beneficial to academics, providing insights into the subject matter. Additionally, the study will provide useful information to practitioners in setting up future scenarios and applications, as well as to institutions and policy makers in understanding and managing changes in policies in the context of rapid technological advancements. The thesis intends to serve as a valuable contribution to the relevant fields and communities.

Il sorgere dell'Industria 4.0 ha comportato un cambiamento massiccio nella trasformazione digitale delle imprese, con conseguenti mutamenti nelle procedure operative, nelle strutture organizzative, nella qualità del lavoro e nelle condizioni di lavoro. La rivoluzione digitale racchiude un immenso potenziale per il progresso umano e offre numerose opportunità.

Questa tesi di dottorato cerca di esplorare l'impatto dei fattori umano-centrici nel processo di digitalizzazione, in cui i bisogni e gli interessi umani fondamentali sono posti in primo piano, allontanandosi da un approccio guidato dalla tecnologia verso una visione completamente umana e incentrata sulla società. Di conseguenza, i ruoli dei futuri dipendenti subiranno una trasformazione, poiché il valore attribuito ai lavoratori passerà da un semplice "costo" a un "investimento". L'integrazione di tecnologie avanzate e valori umani guiderà la prossima rivoluzione industriale, l'Industria 5.0, in cui la tecnologia avrà un'anima, portando a un equilibrio armonioso tra efficienza e umanità.

I risultati di questa ricerca empirica saranno utili agli accademici, in quanto forniranno approfondimenti sull'argomento. Inoltre, lo studio fornirà informazioni utili agli operatori del settore per definire scenari e applicazioni future, nonché alle istituzioni e ai decisori per

comprendere e gestire i cambiamenti delle politiche nel contesto dei rapidi progressi tecnologici. La tesi vuole essere un contributo prezioso per i settori e le comunità di riferimento.

This thesis is structured as the following:

- The introduction outlines the goals of the doctoral thesis and subsequently discusses the author's personal motivations.

- Part One (Chapter 1) provides the context for understanding the pillars of the Industry 4.0 paradigm, starting from an exploration of the extensive literature concerning the diffusion, the relevant aspects, the effects, and the adoption of the Key Enabling Technologies (KETs) of Industry 4.0 (often labeled as the 4th Industrial Revolution) within a context of rapid technological change. This study serves to approach the paradigm of I4.0 in its multiple facets.

- Part Two (Chapter 2) explores the enablers and barriers of digitalization adoption and the performance outcome of digitalization via in-depth interviews with managers of SMEs. This research implies that there is a recognized need to describe the nature of digitalization, assess digitalization adoption factors and evaluate the performance outcome of digitalization in the context of SMEs.

- Chapter 3 focuses on the human side of the Fourth Industrial Revolution within an empirical study of International Knowledge Workers and the most important actors in one of the most innovative high-tech regions, Brainport Eindhoven in The Netherlands.

- Chapter 4 of this research delves into the topic of virtual teams and transformational leadership in the context of a virtual work environment. This is especially significant, given the impact that virtual working arrangements will have on the future of work. The chapter challenges the traditional leadership model under exceptional economic circumstances and identifies gaps in the current research regarding team dynamics, leadership, and motivation.

- Finally, last part outlines the contributions of the research to both academia and practitioners, suggesting the limitations of the research conducted and ways in which further investigation is needed.

“[…] os homini sublime dedit caelumque videre
iussit et erectos ad sidera tollere vultus.”

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Sono profondamente grata per il sostegno e la guida che ho ricevuto durante il mio percorso di dottorato. Questa tesi non sarebbe stata possibile senza l'incoraggiamento e la guida dei miei stimati supervisori, il *Professor Giovanni Solinas, il Professor Bernardo Balboni e il Professor Cesare Fantuzzi.* La loro competenza e saggezza sono state preziose per dare forma alla mia ricerca e per aiutarmi a superare le sfide che ho incontrato lungo il cammino.

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This thesis is is a demonstration of the tireless efforts of all those who have supported me along the way. I am eternally grateful for their generosity, wisdom, and friendship.

Thank you.

INTRODUCTION

What do we talk about when we talk about Digital R-Evolution?

The speed of change in the world is unprecedented in human history characterized by hypermodern societies (Lipovetsky & Charles, 2005) and marked by megachange (West, 2016) as well as the transformation of work and organizations. In recent decades, the digital transformation has exerted a profound influence on various aspects of daily life, work, and interpersonal relationships, attracting significant attention from both academia and practical fields (Stock et al., 2018; Van Veldhoven & Vanthienen, 2022).

The transformation has led to a radical shift in the way we operate and has introduced new technologies that have altered the landscape of many industries and sectors. The adoption of digital technologies has enabled businesses to streamline processes, increase efficiency, and provide customers with new and improved services. At the same time, the digital transformation has created new challenges and raised important questions about privacy, security, and the impact on society as a whole.

The concept of Industry 4.0, also referred to as the Fourth Industrial Revolution or the Second Machine Age, has the potential to significantly alter the workplace and the way people work (Stock et al., 2018). This transformation may impact the nature and quality of work and society as a whole (Brynjolfsson and McAfee, 2014; Ford, 2015; Fossen and Sorgner, 2019; Fukuyama, 2018).

According with Cambridge Dictionary, the concept of industrial revolution is defined as *'the period of time during which work began to be done more by machines in factories than by hand at home.'*[1]

Previous studies have established that the 4IR is characterized by automation, digitization, and interconnection (Lu, 2017; Roblek *et al.,* 2016; Posada *et al.,* 2015). The 4IR *is blurring the lines* between the digital and physical sphere (Schwab, 2016) in manufacturing and in other economic activities and connecting all actors in the value process. In the same vein, Calabrese *et al.*, 2020 argue that nowadays the adoption of the Industry 4.0 vision and its development has an important impact on the manufacturing industry. As Caruso (2018) claim, with the concepts I4.0 and 4IR scholars and institutions refer to the to *'the inchoate transformation of production*

[1]https://dictionary.cambridge.org/dictionary/english/industrial-revolution?q=the+Industrial+Revolution

of goods and services resulting from the application of a new wave of technological innovations'.

A humoristic and precautionary prediction affirms that the factory of the future will have only two employees: a human and a dog.

The man will be there to feed the dog. The dog will be there to keep the man from touching the equipment Warren Bennis, management consultant, cited in Berg *et al.,* (2018). Therefore, I4.0 is still a hot topic in both academic and professional fields (Chiarello *et al*., 2018; Liao *et al*., 2017); and the implementation of I4.0 technologies is still a widespread subject of research (Lee *et al*., 2015; Dalenogare *et al.*, 2018).

Other scholars (Arnold *et al*., 2016; Porter *et al*., 2014) delineate that the new phenomenon is more complex and interest not only manufacturing sector but its impact is much wider and interests socio-economic, geopolitical and demographic developments.

The literature on the subject of Industry 4.0 and the impact of digital technologies on work and society presents two contrasting schools of thought. On one hand, there is an optimistic view that emphasizes the vast potential of these technologies for human kind, work, and society (Christensen, 2013; Christen & Raynor, 2003; McAfee & Brynjolfsson, 2014; Susskind & Susskind, 2015, 2016; Brynjolfsson & McAfee, 2017; Schwab, 2017). On the other hand, there is a more cautious perspective that highlights the potential negative consequences such as job displacement, loss of privacy, and fears of absolute control, job loss, inequality, and insecurity (Fuchs, 2013; Holtgrewe, 2014; Garibaldo, 2016; EIT digital, 2019). Akst (2013) and Mokyr et al. (2015) have referred to this belief as *automation anxiety,* suggesting that technological progress will lead to widespread replacement of human labor by machines.

Taken together, the various findings that have been published thus far highlight the importance of reflecting and rethinking the current paradigm from multiple perspectives. The numerous studies that have been conducted on this subject have provided us with valuable insights and a deeper understanding of the topic. However, it is essential that we continue to examine this subject from multiple angles and view it from different perspectives in order to fully grasp its significance and impact. By doing so, we will be able to gain a comprehensive understanding of the topic and make informed decisions that will have a positive impact on the future.

Considering the decade-long advancement of Industry 4.0 and the recent impact of the pandemic, energy crisis, and war, it is imperative that we approach the challenges ahead with a sense of awareness and responsibility. As students, scholars, researchers, and practitioners, it is our moral duty to work collaboratively in writing a more favorable future, despite the uncertainty that exists in all aspects.

The primary aim of this interdisciplinary study is to gain a deeper understanding of the new 4.0 paradigms from a human-centric viewpoint. Our second objective is to offer a comprehensive examination of one of the most crucial and often misinterpreted concepts that impacts us all to some extent. Through this exploration, we aim to examine Industry 4.0 paradigm from various angles.

This dissertation is composed of four chapters.

- I - *Investigating the Impact of KETs and Their Adoption in the Context of Industry 4.0*
- II - *Digitalization in Small and Medium-Sized Enterprises: Enablers and Barriers*
- III - *Examining the Effect of COVID-19 on the Well-being and Retention Intentions of International Knowledge Workers in the High-Tech Cluster of Brainport Eindhoven*
- IV - *Exploring the Intersection of Virtual Teams and Transformational Leadership through an Integrative Literature Review and Identifying Avenues for Future Research*

In Chapter 1, the author seeks to provide a comprehensive overview of the key enabling technologies of Industry 4.0 and to examine their economic and technical potential in the manufacturing sector, as well as their limitations and interactions with human resources within the business environment. The author focuses on the Nine Pillars as profiled by the "Smart Factory" paradigm in the context of the digital transformation process of companies. The key enabling technologies analyzed in this chapter include collaborative robots, additive manufacturing, augmented reality, simulation, horizontal/vertical integration, the Industrial Internet of Things, cloud computing, cybersecurity, and big data and analytics. To further clarify the results, the author narrows the focus to three key enabling technologies that are most commonly used in the current industrial context: collaborative robotics, big data, and additive manufacturing.

The purpose of Chapter One is to serve as an introduction to the central theme of the thesis, providing an overview of the topic and setting the stage for the subsequent discussion.

In Chapter 2, the author conducts an analysis of how small and medium-sized enterprises (SMEs) manage digitalization and reap benefits from the utilization of modern technologies. The findings reveal that a variety of factors can facilitate digitization in SMEs, including the

availability of appropriate technologies and digital skills. On the other hand, there are also factors that pose as obstacles to digitization, such as a risk-averse culture within SMEs and the usage of outdated systems. The study concludes that successful digitization can only be achieved through the integration of a suitable combination of elements. This study provides a deeper understanding of the concept of digitalization, assesses the factors affecting digitization adoption, and evaluates the performance outcomes of digitization in the SME context.

In Chapter 3, the author endeavors to examine the impact of the Covid-19 pandemic on the well-being of International Knowledge Workers (IKWs) in the Brainport Eindhoven region. The pandemic has brought about measures such as social distancing, travel restrictions, and remote work that have had a widespread effect on individuals and society. Among the sectors most impacted by the pandemic is the labor market. Despite this, attracting, retaining, and developing international talent remain crucial global talent management challenges for many companies. Studies have shown that the retention of IKWs in the region depends on several factors related to their well-being, both in their working and personal lives. Key factors include family well-being, sense of belonging, and economic and career well-being, including opportunities for career advancement and work-life balance.

In Chapter 4, the author investigates the impact of digitalization on the workplace and forms of communication within a team. The COVID-19 crisis has led to an increase in virtual communication, requiring a transition from a physical to a virtual work environment and rethinking of leadership. Transformational leaders have the ability to motivate their followers through example in face-to-face work environments, and there is growing research interest in the role of transformational leaders in virtual teams. This study conducts a literature review to examine the existing literature on virtual teams and transformational leadership, identifying team, leadership, and motivation factors. The paper challenges an established leadership model in exceptional economic circumstances and highlights research gaps in team, leadership, and motivation factors. The findings of this study provide valuable insights for future research on transformational leaders and their influence on virtual teams, given the significance of virtual working environments in shaping the future of work.

In the constantly changing environment of today, the effects of Industry 4.0 have been heightened by the Covid-19 crisis, impacting not just employment, but also the arrangement of production procedures and the requirement for new business models. The author adopts a

positive outlook on digitization, perceiving it as a valuable opportunity and a critical element in overcoming the present difficulties. This viewpoint is based on the examination of four papers.

In conclusion, this research presents an overview of the key technological advancements of Industry 4.0 and its Nine Pillars. The examination focuses on three specific technologies: collaborative robotics, big data and additive manufacturing, in an effort to provide a more incisive understanding of the Industry 4.0 landscape.

The study also examines the adoption of digitalization in Small and Medium Enterprises, exploring the factors that either facilitate or hinder digitization. In addition, the study evaluates the impact of the Covid-19 pandemic on the well-being of International Knowledge Workers in the Brainport Eindhoven region and how digitalization has reshaped the workplace and forms of communication within teams. Overall, the study highlights the importance of digitalization in overcoming present difficulties and emphasizes the potential opportunities it presents. The findings of this study contribute to the existing literature and pave the way for further research on the subject of Industry 4.0 and its impact on work and society.

To summarize, the findings of this research offer valuable implications for both the academic and practitioners, highlighting its limitations and suggesting areas for further exploration.

Personal Motivation

The Danish Member of Parliament Ida Auken describes a future image of society as follows:

Welcome to 2030. I own nothing, have no privacy, and life has never been better. All in all, it is a good life. Much better than the path we were on, where it became so clear that we could not continue with the same model of growth. We had all these terrible things happening: lifestyle diseases, climate change, the refugee crisis, environmental degradation, completely congested cities, water pollution, air pollution, social unrest, and unemployment. We lost way too many people before we realized that we could do things differently.[2]

At a glance, Auken painted a scenario with quite pessimistic colors even though we can see a spark of light if *'we could do things differently'*.

Doing the things differently is what drives me in both professionaly and personally life. It is a mindset that carry on and which led me to explore and study the new 4.0 paradigm, innovation and its digital transformation.

Innovation is the key to expanding horizons, and it is an essential tool to create new strategies, find solutions, and trigger sustainability. I do belive in change and innovation as a force for good for a better working environment, industry, and society.

If a decade ago, the term 'industry 4.0' has been seen as a kind of mysterious and perhaps bizzare word, nowadays it has became a buzzword - everyone is talking about and the confusion increases at the same rate. Many scholars agree that the lack of consensus generates confusion and communication problems.

After a decade of I4.0, today a new industrial paradigm called 'industry 5.0' emphasis and turn on the light on the well being, society and people.

In conclusion, my drive to do things differently fuels my professional and personal life. My passion for exploring and studying the 4.0 paradigm, innovation, and digital transformation stems from my belief in the power of change and innovation to bring about a better working environment, industry, and society. I also believe that innovation is key to expanding horizons, creating new strategies, finding solutions, and promoting sustainability. It is my hope that this thesis will contribute to a better understanding of the role of digital transformation in shaping the future.

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[2] Auken, I. (2016) Welcome To 2030: I Own Nothing, Have No Privacy And Life Has Never Been Better. Retrieved from: https://www.forbes.com/sites/worldeconomicforum/2016/11/10/shopping-i-cant-really-remember-what-that-is-or-how-differently-well-live-in-2030/?sh=50ec440b1735
Accesed 20-05-2022

CHAPTER I

Investigating the impact of KETs and their adoption in the Industry 4.0 era [3]

Introduction

The factory of the future will have only two employees, a man and a dog. The man will be there to feed the dog. The dog will be there to keep the man from touching the equipment Warren Bennis, management consultant, cited in Berg *et al.,*(2018).

The Digital Transformation process has changed the way we live, work and interact with each other over the past few decades. Nowadays, due to social and economic complexities the acronym VUCA *volatility, uncertainty, complexity, and ambiguity* has become a trendy managerial term.

As Klaus Schwab, Founder and Executive Chairman, World Economic Forum (2016) stated:

"We must develop a comprehensive and globally shared view of how technology is affecting our lives and reshaping our economic, social, cultural, and human environments. There has never been a time of greater promise, or greater peril."

The objective of this section is to examine the influence of Industry 4.0's Key Enabling Technologies (KETs) on the digital transformation journey of manufacturing companies. It will provide an overview of the existing research on Industry 4.0 technologies, emphasize their advantages and highlight the hurdles encountered. Additionally, it will delve into the correlation between the implementation of these technologies and the role of human resources.

To this end we explore the nine enabling technologies that have great potential to change companies and to enable them to a I4.0 transition. For each technology we provide definition and characteristics, potentiality and limitation, along with some discussions.

[3] The author extends heartfelt gratitude to Prof. Giovanni Solinas for his inspiration, insightful feedback, and unwavering support in the development of this chapter. The author's appreciation for his contributions cannot be overstated and the chapter would not have been possible without his guidance.

Its second objective is to try to understand how to overcome the barriers to adopting the I4.0 concept in the Industry sector, especially in SMEs which have no few difficulties in developing and implement their own strategies due to lack of resources, flexibility and time (Lofving *et al.,* 2014; Schroeder, 2016). Due to lack of resources also the management needs a *methodical approach* to implement I4.0 strategy (Schröder, 2016). Gracel and Lebkowsky (2018) point out that I4.0 brings many challenges for businesses from a technological, strategic and people-related perspective.

In their research, Bauer *et al.,* (2016) shows that six out of ten manufacturing companies face management barriers such as the lack of necessary talent, the lack of courage to reach a radical transformation, when trying to implement Industry 4.0 technologies.

As underlined by Moeuf *et al*.,(2017) in order to adopt the enabling technologies managerial capacities are required.

Many authors (Balsmeier and Woerter 2019; Bresnahan *et al.* 2002; Fabiani *et al*. 2005) have highlighted the complementarity between information technologies and high-skilled workers. Acemoglu (1998) points out that '*new technologies are not complementary to skills by nature, but by design'*.

Finally, we conclude with the presentation of the managerial implications and possible further research paths and a reflection of the future trends in the field and highlighting the opportunities and challenges for the future research.

We argue that action 4.0 can unfold its potential only by means of the awareness, knowledge and adaptability of management and human resources.

Industry 4.0: Revolution or Evolution?

A very brief historical excursus of the Industrial Revolutions: from First to Fourth Industrial Revolution

To understand why the actual Fourth Industrial Revolution(4IR) is different we find that a brief examination of the past industrial revolutions is necessary to understand the actual context.

To understand the effects of the technological revolutions we need to open up the "black box" and to try to answer why, where and how the innovations appear and develop (Rosenberg, 1982).

The term revolution implies a *radical and profound change* of many phenomena (Encyclopedia Britannica).

From a historical point of view, a revolution refers to a movement, often violent, to overthrow an old regime and effect complete change in the fundamental institutions of society (L Neitzel). *Révolution industrielle* was for the first time used in the 1820s by the French writers regarding the process of the mechanization of the French cotton industry (Cameron, 1982).

Due to the technological change between 1760 - 1830, Thomas Asthon (1948) attached the label "first industrial revolution" (Crafts, 1996).

Technology is knowledge, as Simon Kuznets (1966) suggests that the current modern economic era, began in the second half of 18th century began with the following epochal innovation '*the extended application of science problems of economic production*'[4].

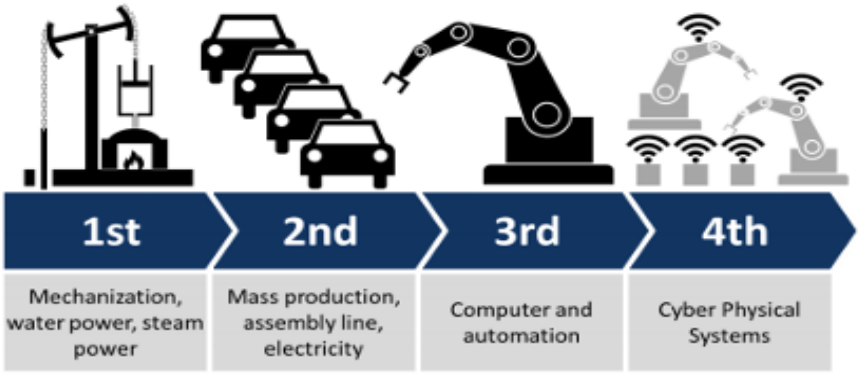

Fig.1 *The evolution of industry (credit: Christoph Roser at AllAboutLean.com under the free CC-BY-SA 4.0 license)*

The First Industrial Revolution began in the United Kingdom in the 18th century due largely in part to the introduction of steam power and to its technological progress. The steam engine, invented by Thomas Savery in 1698, then improved and perfected by James Watt, was the most important technology in mechanizing production, a triumph and a symbol of the factory system of production.

Mowery and Rosenberg (1989) consider the period between 1859-1873 constelated with dense innovations.

In the beginning of the 19th century, almost a hundred years after Watt's steam engine, new discoveries changed the work condition and the lifestyle. The Second Industrial Revolution started with inventions of internal combustion engines, electricity, the chemical industries,

[4] Kuznet S., *Modern Economic Growth*, cit., p.9

petroleum and their development led to a new era of better living standards and an important change in the manufacturing sector.

According to Mokyr and Strotz (2003) mass production and economies of scale in manufacturing changed the nature of the organization of production. As noted by authors, in many ways, the Second Industrial Revolution was the continuation of the First. Innovations such as the telephone, the gas turbine, the artificial fertilizer and mass production have led to the desire of goods and services by the population.

The Third Industrial Revolution is often referred to as the Technological Revolution. The heart of it is the Internet and the rise of information and communications technologies (ICT).The industrial revolutions are linked to the emerging *'constellation of innovations'* that has the potential to transform the economy and the social systems (Freeman and Louca, 2001).

In their analysis, Finkelstein and Newman (1984) identify six major drivers of the 3IR. They are: microprocessors, computer-aided design and manufacturing (CAD/CAM), fiber optics, biogenetics, lasers, and holography (Ibidem).

In the literature, technologies such as the steam engine, the electric motor, and computers are known as General Purpose Technologies (GPTs) and they are "engines of growth" characterized by pervasiveness, inherent potential for technical improvements, and innovational complementarities (Bresnahan, Trajtenberg 1995).

With the introduction of the internet, recent technological developments in industry had led to the Fourth Industrial Revolution (4IR). The term was coined by Klaus Schwab, founder and executive chairman of the World Economic Forum during the annual conference in Davos of WEF in 2016.

Previous studies have established that the 4IR is characterized by automation, digitization, and interconnection (Lu, 2017; Roblek et al., 2016; Posada et al., 2015). As Schumpeter (1942) states: *'process of industrial mutation that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one'* " (Schumpeter, 1942:83).

The 4IR *is blurring the lines* between the digital and physical sphere (Schwab, 2016) in manufacturing and in other economic activities and connecting all actors in the value process. The Cyber-Physical Systems (CPS) is one of the main components of the I4.0 paradigm and such a trend is transforming the manufacturing sector by integrating innovative functionalities such as the Internet of Things and Web of Things (Lee *et al.,* 2014; Lu, 2017). Herman *et al.,* (2015) found that the most repeatable components of the new paradigm are: the internet of things (IoT), cyber-physical systems (CPS), the internet of services (IoS), and smart factories.

Similarly, Roblek *et al.,* (2016) and Posada *et al.,*(2015) cited in Lu (2017) underline the most important features of I4.0 are automatic data exchange and communication; human machine interaction; optimization, digitization and customization of production processes.

Therefore, it can be said that I4.0 is not just a single technology but a complex mix, characterized by different technologies *all interconnected by cloud-based Internet* (Martinelli *et al.*, 2021).

As Gershenfeld (2012) observes: *"The revolution (...) is the ability to turn data into things and things into data"*. The Fourth Industrial Revolution or the Second Machine age brings new opportunities and challenges. For many scholars, its impact across the world is overwhelming due to the short time to adapt, the major changes almost happen in real time, affecting every aspect of society. The 4IR is more than a *technological-driven change*.

Historically, the introduction of the new technologies in industry was graduated, adapted and adopted widely (Bresnahan, 2010). Gracel and Lebkowski (2018) found that its transformative power brings various challenges for companies from different perspectives such as strategic, technological, and people-related perspectives. Some authors, Chen *et al.,* (2017) cited in Yang and Gu (2021) argue that the concept of I4.0 has been raised by Rostow in 1988[5].

Research method and research process

The author carried out an extensive examination of the available literature through a comprehensive literature review (CLR) to gather information relevant to the topic under investigation. The primary sources used for this review were five databases of publications including EBSCOhost, Emerald Insight, Taylor Francis, Science Direct and Google Scholar. The authors sought to cover both academic and business publications related to manufacturing and management. Additionally, other literature found on the internet was also reviewed to assess its contribution to relevant topics. The author leveraged these databases to gather information from engineering, manufacturing and management fields in both academic and business contexts. It is important to note that the term "Industry 4.0" encompasses a wide range of modern automation systems, data exchanges, and production technologies that are collectively shaping the future of manufacturing. The integration of these technologies, including the Internet of Things and cyber-physical systems, is leading to the development of intelligent factories and a shift from traditional to smart manufacturing. This transformation is

[5] Rostow W (1988) *Essays on a half century ideas, politics and action*

expected to result in more efficient business models through the organized collection and analysis of data.

The Comprehensive Literature Review (CLR) is a methodology (...) *which involves the use of mixed research techniques inclusive of culture, ethics and multimodal texts and settings in a systematic, holistic, sinergistic and cyclical process of exploring, interpreting, synthesizing, and communicating published and/or unpiblished information* (Onwuegbuzie and Frels, 2016).

A comprehensive literature review is an in-depth examination of the existing research and writing on a specific topic. The purpose of this type of review is to provide a comprehensive understanding of the current state of knowledge on a topic, identify gaps in the research, and determine the direction of future research (Behzadian et al., 2010; Ridley, 2012; Cooper, 2015; Creswell and Creswell, 2017).

Thus, we have extended the search to include multimodal texts and settings, referred to as MODES (Media, Observations, Documents, Experts, and Secondary Data) - Media: Using audio and video tools; Observations: Extending the function of qualitative observations to include examples that help strengthen understanding regarding the topic, concepts, and/or the research questions; Documents: Exploring special issues of journals, dissertations and theses, monographs, conference papers, and so forth; Experts: seeking out experts in the field of interest; and Secondary Data: Extending the search by analyzing and including results from secondary sources such as completed surveys, censuses, and records (Onwuegbuzie and Frels, 2016, pp. 178-211). This methodology allows both to address a wide literature and topic, and to highlight perspectives for further research (Grant and Booth, 2009).

Industry's 4.0 concepts in a nutshell

The concept of Industry 4.0 (I4.0) was first introduced in Germany in 2011 as a term to describe the trend towards automation and data exchange in the manufacturing industry through the use of new technologies and their interconnections, where the virtual and physical worlds merge (GTAI, 2011). The Industry 4.0 concept encompasses advanced manufacturing technologies that enable the capture, optimization, and distribution of data (BCG, 2016). In 2013, a I4.0 manifesto was published by the German National Academy of Science and Engineering (Acatech, 2013), and the German government announced its support for the initiative, incorporating it as a key aspect of the "High Technology Strategy for Germany 2020". The "Industry 4.0 Working Group" then developed the first application proposal, proposing the creation of "smart factories" that adopt a new approach to production and

manufacturing processes (Kagermann et al, 2013). This has led to the development of increasingly intelligent products that are uniquely identifiable and trackable, being incorporated into manufacturing lines.

Industry 4.0, which is considered the fourth phase of the integration between manufacturing and information technology (Drath and Horch, 2014), has emerged as a prominent research area over the past decade. For the first time in the history of industrial revolution, a visionary approach has been outlined for shaping the future of researchers and companies in this field (Kagermann et al, 2013). The primary objective of this movement is to enhance operational efficiency and ultimately boost the productivity of new business models, services, and products that are expected to have a significant economic impact compared to previous industrial revolutions (Bauer et al, 2014).

Studies have evaluated Germany's position and capabilities in terms of digital transformation (Heng et al, 2014). It is projected that Germany's initiative in developing Industry 4.0 will contribute up to €78 billion to its GDP by 2025 (Lichtblau et al, 2016), highlighting the significance of this philosophy in the industrial landscape of nations.

Despite the extensive discussions and coverage of Industry 4.0 (I4.0) in both academic literature and industry management, there is a lack of a universally accepted definition of the concept. This absence of agreement has been noted by several scholars and has resulted in confusion and difficulties in communication.

According to Otznel and Gurstev, 2020, I4.0 defines '*a methodology to generate a transformation from machine dominant manufacturing to digital manufacturing'*.

GTAI (Germany Trade and Invest, 2014) defines it as follows *"INDUSTRIE 4.0 represents a paradigm shift…refers to the technological evolution from embedded systems to cyber-physical systems."*

However, due to its innovative power, the phenomenon is often called "the Fourth Industrial Revolution" as GTAI further adds *"put simply, INDUSTRIE 4.0 represents the coming fourth industrial revolution"*. Klaus Schwab (2016) divides the concept of the Fourth Industrial Revolution into four main trends: advanced robotics, new materials, unmanned vehicles and 3D printing.

The most concise explanation of the new paradigm is the one provided by the consulting firm BCG which summarizes it as follows: "Industry 4.0 makes factories *smart*" (Boston Consulting Group).

Radziwon *et al.*(2014) argue that the label *smart* (or its interchangeably used - *intelligent)* becomes overused and abused in some contexts and many scholars refer to it as an approach, as

a technology or a paradigm. The term smart lacks an accurate and clear definition even though it is used by both scholars and practitioners (Radziwon *et al*.2014).

According to Kusiak (2018) as cited in Bravi and Murmura (2021) there is no generally accepted definition of smart manufacturing in literature. The National Institute of Standards and Technology (NIST) defines Smart Manufacturing as a *"fully-integrated, collaborative manufacturing systems that respond in real time to meet changing demands and conditions in the factory, in the supply network, and in customer needs."*

Posada *et al*.(2015) point out that the main I4.0 features are: digitization, automation, optimization, customization, and adaptation of production; human machine interaction (HMI); value-added services and businesses, and automatic data exchange and communication.

Lasi *et al.* (2014) listed the fundamental concepts related to the I4.o. The concepts are:

- Smart Factory
- Cyber-physical Systems
- Self-organization
- New systems in distribution and procurement
- New systems in the development of products and services
- Adaptation to human needs
- Corporate Social Responsibility

In a recent exhaustive literature review, Ozetmel and Gursev (2020) define the six design principles related to I4.0. The design principles are: interoperability, virtualization, local, real-time talent, modularity, service orientation and real-time.

According to multiple definitions, I4.0 concept implement the collaboration between humans and machines and to create a synergetic collaboration between them (Kagermann et al.,2012).

It is estimated that the I4.0 and its related technologies would have an impact on social life (Oztemel and Gursev 2020) on society and eventually can improve the individual's wellbeing (Yang and Gu, 2021). This is exemplified by the concept of *'Society 5.0'* which was launched by the Government of Japan in the 5th Science and Technology Basic Plan.

The new concept is defined as follows 'a human-centred society that balances economic advancement with the resolution of social problems by a system that highly integrates cyberspace and physical space'. The technical report established that the full implementation of the I4.0 technologies seek to lead to a better and a human-centered society, solving social issues.

Kaidanren, 2016 classified the progress of the society as the following:

- Hunting society
- Agrarian society
- Industrial society
- Information society
- SuperSmart society

The transition from agriculture to industrial society (Industry 1.0), from Industry 1.0 to 2.0 and then to 3.0 has been well acknowledged and embraced by society. Similarly, the transition from Industry 4.0 to Industry 5.0 will require extensive analysis to understand the changes that are irreversible.

In conclusion, it can be noted that the Fourth Industrial Revolution (4IR) is not just a technological revolution, but a gradual evolution of technology. While the terms Industry 4.0 and Fourth Industrial Revolution are often used interchangeably, it is important to emphasize that they are not synonymous. There is a lack of consensus on the definition of Industry 4.0 in both academic and industry circles. However, it is widely agreed upon that Industry 4.0 represents the Fourth Industrial Revolution chronologically and serves as an umbrella term encompassing a variety of enabling technologies and representing a new industrial paradigm.

There are still many unknowns, as Susskind (2020) notes, I4.0 could pave the way to a *'world without work'* or as the optimistics scholars and thinkers argued, I4.0 could lead to a better society in terms of life standards, sustainability and '*decent work*' conditions. Therefore, its enabling technologies could be a driver for a growing society and for sustainable development.

Industry 4.0 worldwide

As we saw in the previous section, the concept of Industry 4.0, which originated in Germany in 2011, has been widely adopted worldwide over the past decade. While the original term is "Industrie4.0", different countries use various terms to describe the concept. For example, the OECD (2017) uses terms such as "Smart Industry", "Smart Factory or Advanced Manufacturing", "Next Production Revolution", and "Industrial Internet", among others.

In the table below we have deliberately not included Italy since we have allocated larger attention in the next section.

Country	Label	Year
Australia	Industry 4.0 Testlabs	2016
Austria	Industrie 4.0 for Intelligent Production	2014
Belgium	Made Different	2015
Denmark	Manufacturing Academy of Denmark(MADE)	2017
France	Industrie du Futur	2012
Germany	Germany: Industrie 4.0	2011
Japan	Society 5.0	2019
The Netherlands	Smart Industry	2014
People's Republic of China	Made in China 2025	2015
Portugal	Indústria 4.0	2017
Singapore	Research, Innovation and Enterprise 2020 Plan	2015
South Korea	Manufacturing Industry Innovation 3.0	2014
Sweden	Produktion 2030	2013
Spain	Industria Conectada 4.0	2014
The United Kingdom	The Future of Manufacturing	2017
The United States of America	Advanced Manufacturing Partnership	2016

Table 2. Author's elaboration based on Majstorovic and Mitrovic, 2019; Yang and Gu, 2021 framework

In order to fully assess the impact of Industry 4.0 technologies, it is important to consider the influence of national strategies and their effect on technology adoption, innovation investment, and training.

The Italian Context

Industry 4.0 paradigm was introduced in Germany in 2011 as a Government initiative to strengthen the competitiveness of the German manufacturing industry (Stentoft *et al.,*2019). Italy presented its National Industry 4.0 action plan in 2016 which was re-named Enterprise 4.0 in 2017. A three-year period (2017-2020) plan based on some pillars ranging from research to tax incentives related to investments in enabling technologies. The plan has been a key instrument to sustain the digital transformation of national companies.

The interest and growing political attention towards greater digitalization of companies and society determined that in 2019 a new Ministry for Technological Innovation and Digitalization was established, which in December 2019 has presented Italy 2025 *"The strategy for innovation and digital transformation of the country"*.

Regarding the digitalization of companies, in 2020, the Italian government launched the new "Transition 4.0" plan, with a greater focus on innovation, green investments and the participation of SMEs and it is also the first brick on which the Italian Recovery Fund plan is based with an investment of about 24 billion Euros.[6]

The MISE plan includes several lines of intervention and among new measures including research and development we also find *Credito Formazione 4.0*.[7] The implementation of the plan will cover a period of almost 3 years, ending in June 2023.

Together with Innovative Investments we find the creation of the Digital Innovation Hub and Competence Centers I4.0, as a strategic guideline for intervention. At a national level, in Italy, the digital transformation accelerated in 2017, driven by organic and complementary measures to encourage investment in innovation and competitiveness.

Through the Horizon 2020 Program, the Framework Programme for Research and Innovation 2014-2020 (European Commission 2017) the KETs have been part of investments for the EU Industrial policy.[8]

Due to the pandemic caused by Covid-19, in 2020 *Fondo Nuove Competenze* (The New Skills Fund) was set up. Its first objective was to combat the economic effects of the virus. The FNC refunds the cost, including social insurance contributions, of the hours of work intended for the attendance of the programs of competencies development by workers. The plan provides EUR 730 million (2020-2021) used to refund employees. The project for the development of skills identifies the learning objectives in terms of competences, the beneficiaries of the project, the provider, the charges, the methods of carrying out the learning path and its duration.

[6] https://www.mise.gov.it/index.php/it/transizione40

[7] https://www.mise.gov.it/index.php/it/incentivi/impresa/credito-d-imposta-formazione

[8] https://ec.europa.eu/programmes/horizon2020/sites/default/files/h2020-wp1820-leit_en.pdf

The OECD survey (PIAAC) on adult skills shows that Italian workers have a low level of cognitive skills, particularly linguistic and mathematical skills, and are less likely to use certain cognitive skills that are determining factors for the performance of workers and companies. However, they have been shown to have a relatively high level of predisposition to learning and problem-solving skills.

This means that targeted policies in the field of vocational education and training could help to develop more skills and make full use of those already gained (OECD, 2018).

According to the OECD Survey of Training in SMEs, there are three major barriers that prevent SMEs from further investing to up and re-skilling their workforce: the lack of a learning culture in these firms, their relative inability to identify skills gaps and attract appropriately skilled workers, and their high sensitivity to the cost of training.

The FNC strument is an important labour market policy that can foster a culture of learning among SMEs in Italy. Furthermore, the majority of SMEs lack awareness of the existing policy instruments such as Tax Credit on Training 4.0, The New Skills Found etc.

Policy also should tackle the barriers to technology adoption. Thus, in order to encourage technology adoption, support programmes must run hand-in-hand with those to train and 'reskill' the workforce (Li *et al,* 2020).

Overall, the Italian context for Industry 4.0 is promising, with significant investment and support from both the private and public sectors. However, there are also challenges to be addressed, such as the need to upgrade the skills of the workforce and the need to address cybersecurity and data privacy concerns. Nevertheless, Italy is well positioned to take advantage of the opportunities presented by Industry 4.0 and to continue to develop as a leading player in this field.

In this section, we discussed the concept of the Fourth Industrial Revolution and Industry 4.0, but have yet to clearly define them. The following section provides a clear definition of the key enabling technologies and describes their impacts, challenges, and opportunities.

The Key Enabling Technologies of Industry 4.0: an overview

This section provides a brief overview of the enabling technologies and their impact on the digital transformation process of companies in the Industry 4.0 era. Furthermore, it delves into the evaluation of their strengths, opportunities, and limitations.

What is a Key Enabling Technology?

What is a KET? There is no agreed definition in the academic literature on what constitutes an "enabling technology" because it results in the European policy arena to profile technology clusters that can innovate and enhance productivity in different economic sectors (European Commission, 2017). The European Commission describes the concept of KETs as *"(...) knowledge intensive and associated with high R&D intensity, rapid innovation cycles, high capital expenditure and highly-skilled employment"* (European Commission 2009). It has identified six *"key enabling technologies"* (micro and nanoelectronics, nanotechnology, industrial biotechnology, advanced materials, photonics, and advanced manufacturing) defined as*..."multidisciplinary, cutting across many technology areas with a trend towards convergence and integration"* (Ibidem).

KETs are a policy concept introduced in 2009 to stimulate research and innovation into the complex and novel technologies to improve and promote European industrial competitiveness (European Parliament). The KETs are the fundamental key to the advancement of the technological level of companies and play an important role for industrial competitiveness in the digital transformation process. They are one of the crucial points of the MISE for the Transition 4.0 plan.

According to Teece (2018) in an industry, enabling technology can be used to drive technological change and applied for a variety of uses.

Rüßmann *et al*., 2015, in a report by the Boston Consulting Group, describes nine technology trends that form the foundation of the Industry 4.0 paradigm.

In this part we will provide an overview of each group of enabling technologies, starting from those identified by BCG (Rüßmann *et al*., 2015) and adopted by MISE (Ministry of Economic Development) with the National Industry 4.0 Plan: Advanced manufacturing solutions, Additive manufacturing; Augmented reality; Simulation; Horizontal/Vertical integration; Industrial Internet of things; Cloud computing; Cybersecurity and Big Data & Analytics.

More specifically the Nine Pillars of Industry 4.0 focused on below are:

Colaborative Robots (Interconnected and rapidly interprogrammable collaborative robots, *cobots*). The collaborative robots are a form of robotic automation which manipulates objects and its intended to interact with human operators in a shared workspace in industrial sectors (Collagte *et al.,*1996). *Cobots* are flexible and safe enough to work with human operators (Djuric *et al.,* 2016).

Collaborative industrial robots are used in manufacturing and in a wide range of applications and industries - automotive, pharmaceutical and chemical, electronics, plastics are some of the most common (Robotic Industries Association). The Advanced Manufacturing Solutions give the possibility to make complex production systems more flexible and effective, which can be revised and reorganized, overcoming the traditional division between automatic and manual systems, and their merger into a single system that integrates human and the robotic one.

In an extensive study on the effect of the industrial robots on the US labour market, Acemoglu and Restrepo (2017) had analysed the impact of the growth in the utilization of industrial robots (from 1990 till 2007) on local labor markets in the United States.

Romero et al., (2016) proposed the concept of human-automation symbiosis, which refers to the integration of human skills and capabilities with automated systems to create a symbiotic relationship that leverages the strengths of both. The authors emphasized that this symbiotic relationship is essential for achieving effective human-automation interaction and suggested that it should be characterized by mutual trust, adaptability, transparency, and collaboration. They also argued that the development of human-automation symbiosis requires a multidisciplinary approach that incorporates insights from fields such as psychology, ergonomics, human-computer interaction, and robotics.

Regarding the introduction of digital automation Berg *et al.,*(2018) proposed 4 models:

Model 1: robots 'do everything' - robots substitute for all labor in all tasks;

Model 2: robots 'cannot do everything' robots substitute only for some tasks'

Model 3: robots 'do not substitute for skilled labor'

Model 4: Adding a Non-Automatable Sector

In a recent review of the literature, Simoes *et al*., (2020) concluded that the objective of introducing cobots in the manufacturing processes reported by companies is basically to improve quality, flexibility and productivity. According to Daugherty and Wilson (2019) men and machines which work together form new professional experiences, new types of work and they would share a dynamic and different space.

Human beings are not adversaries who compete for their respective tasks but work collaboratively with machines to exploit what each can do best by becoming symbiotic partners pushing each other towards ever higher levels of performance (Daugherty, Wilson 2019)[9].

The recent advances in robotics technology have led to its widespread adoption in various domains such as education (Ospennikova et al., 2015), strategic technology management (Daim et al., 2018), mobile robots (Kermorgant, 2018), shipbuilding (Lee, 2014), colorectal surgery (Damle et al., 2017), service providers (Decker et al., 2017), procurement (Aleina et al., 2018), needle-punching systems (Chen et al., 2018), smart home applications (Do et al., 2018), electronic beacons (Alanso-Martin et al., 2017), and robotic surgery (Iavazzo and Gkegkes, 2017), among others.

Oztemel and Gursev (2020) highlight the importance of robots in Industry 4.0. With their ability to carry out difficult or heavy tasks, work in hazardous or unfavorable environments, and perform routine operations, robots are becoming the primary source of labor force despite the costs of construction and maintenance. Additionally, robots are expected to play a significant role in bridging the gap between people and technology through effective communication, which will become an increasingly important requirement in the years to come (Oztemel and Gursev, 2020).

There is no *race against machine (*Brynjolfsson and McAfee, 2011).

According to Berg *et al.*(2018) some sectors such as the arts and entertainment, home nursing care and a variety of service-related industries seem to be immune to automation.

To sum up, it is important to note that automation has the potential to impact various industries differently and that the extent of its impact also depends on many factors such as the nature of the work, the cost and availability of technology, and government regulations.

That being said, there are some industries and jobs that are often considered to be less likely to be fully automated, such as jobs that require high levels of creativity, empathy, and human interaction, such as education, healthcare, and the arts. However, it's possible that automation may still play a role in these industries by augmenting and enhancing human capabilities, rather than replacing them completely.

Additive Manufacturing

Additive Manufacturing, also known as 3D printing, is a manufacturing process that creates physical objects by building up layers of material, rather than subtracting material as in

[9] Paul Daugherty and James Wilson, in Human + Machine, show the results of a research conducted on 450 organizations within a sample of 1500 and present a new concept:'fusion skill'.

traditional manufacturing processes. It uses computer-aided design (CAD) software to create a virtual model of the object, which is then printed layer by layer using various materials such as plastics, metals, and ceramics.

According to Hassanin and Jiang (2015) AM can be defined as "*a group of fabrication processes where three-dimensional partes are constructed by adding layers of materials on point, line or planar surface".*

Burckhard and Wampol (2018) cited in Chiarello (2021) pointed out that additive manufacturing in general is having a strong impact on the way products are prototyped. Dilberoglu *et al*., (2017) suggests that due to its ability to create *sophisticated objects* with new materials, AM may become a *key technology for fabricating customized products.* The authors have doubts on its applicability to mass production and concluded that AM may not be used for the mass production of regular parts. AM finds applications in many different sectors as automotive manufacturers, healthcare, aerospace companies.

The Additive Manufacturing Market Report (2021) values the entire AM market at 7.17 billion euro in 2020.[10]

Augmented reality (AR)

In the Encyclopedia of Multimedia, Springer (2006) we find the following definition "Augmented reality is a system that enhances the real world by superimposing computer-generated information on top of it"[11] According to Krevelen and Poelman (2010) an AR system has three features:

1) combining real and virtual objects in a real environment; 2) aligning them with each other and 3) running "interactively, in three dimensions, and in real time".

The *Worldwide Quarterly Augmented and Virtual Reality Headset Tracker* examines augmented and virtual reality markets with a five-year perspective. According to the International Data Corporation (IDC) the worldwide shipments of augmented reality and virtual reality (AR/VR) headsets reached 8.9 million units in 2019, up 54.1% from 2018. Over the 2019-2023 forecast period this strong growth is expected to continue as global shipments climb to 68.6 million in 2023. More than half of all headsets will be shipped to commercial markets in 2023. According to the IDC the types of industries and use cases for these deployments will

[10] https://additive-manufacturing-report.com/
[11] https://doi.org/10.1007/0-387-30038-4_10

vary dramatically from training and services to retail and design.[12] Krevelen and Poelman (2010) list a varied range of fields where AR will support us maintenance, education, design and reconnaissance, just to name a few. Some areas of application who benefit from augmentation are: personal information systems, personal assistance and advertisement, navigation, touring and industrial (assembly, maintenance), and military applications.

Simulation

It is the fourth enabling technology of I4.0. Jerry Banks in *The Handbook of simulation* defines simulation as: "...*the imitation of the operation of a real-world process or system over time. Simulation is an indispensable problem solving methodology for the solution of many real-world problems... is used to describe and analyze the behavior of a system, ask what-if questions about the real system, and aid in the design of real systems* (Banks, 1998).

Imitating a real world system or process allows the practitioners to study the various phenomena in a safe environment.

The area of application: a simulation software platform can assist and support in modeling and analyzing virtually any problem in any kind of industry, including manufacturing, material handling, logistics, supply chain, crowd simulation etc.

Horizontal/Vertical Integration

Horizontal integration and vertical integration are two distinct strategies that companies can use to expand their operations and increase their competitiveness (Kenton, 2022).

Horizontal integration refers to the merger or acquisition of companies that operate at the same level of the value chain, such as two companies that produce the same product or provide the same service. Horizontal integration can increase a company's market share, reduce costs, and improve economies of scale (Kenton, 2022).

On the other hand, vertical integration refers to the acquisition of companies that operate at different levels of the value chain, such as a manufacturer acquiring a supplier or a distributor. Vertical integration involves a company controlling multiple stages of its production and supply chain. This results in reduced dependence on external entities for manufacturing and transportation.[13]

[12] IDC's Worldwide Quarterly Augmented and Virtual Reality Headset Tracker provides details on vendors, technology, market opportunity, and trend analysis in the newly created augmented reality and virtual reality device market

[13] Retrived from https://www.thebalancemoney.com/what-is-vertical-integration-3305807

Vertical integration can increase control over the production process, reduce costs and improve product quality, and provide access to new markets.

The benefits of vertical integration include greater supply chain resilience, increased market power, and cost savings through economies of scale. However, there are also drawbacks such as high costs, reduced flexibility, and a potential loss of focus. [14]

Firms, departments, functions and capabilities are increasingly integrated and consistent as cross-enterprise data integration networks evolve and enable fully automated value chains. In brief

- Horizontal integration occurs when a company grows by acquiring another firm in its industry that operates at the same point in the supply chain.

- Vertical integration takes place when a business expands by acquiring a company that operates either upstream or downstream in the supply chain.

Industrial Internet (of things) (IIoT)

The term Internet of Things (IoT) is a concept coined by Kevin Ashton in 1999 to promote radio frequency identification (RFID) (Tzafestas, 2018). The field of applications.

'The rise of IoT is approaching as the prices of IoT hardware are dropping, putting sensors, processing power, network bandwidth, and cloud storage within reach of more users and making a wider range of IoT applications practical'(McKinsey MGI, 2015).

IoT applications in relation to I4.0 are called "Industrial Internet of Things" and they are under the "Cyber-Physical Systems" paradigm.

The main application area of IIoT and where they play a decisive role are described below:

Smart Factory: production progress control, safety at work, maintenance, material handling, quality control, waste management;

Smart Logistics: traceability/monitoring of the supply chain through RFId (Radio-Frequency Identification) and sensors tags, cold chain monitoring, safety management in complex logistics centers, fleet management (e.g. via GPS / GPRS);

Smart Lifecycle: improvement of the new product development process (e.g. through data from previous versions of related products), the end of life management, supplier management in the development phase of new products. [15]

[14] Retrived from https://www.investopedia.com/terms/h/horizontalintegration.asp
[15] https://blog.osservatori.net/it_it/industrial-iot-definizione-applicazioni

The market for industrial Internet of Things was valued at 77.3 billion U.S. dollars in 2020[16] and is expected to grow by 421.28 billion U.S during 2021-2025[17].

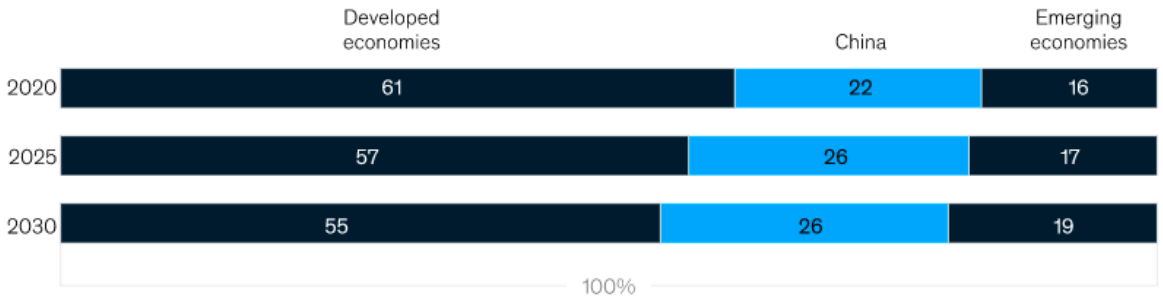

Fig.3 *Share of estimated global economic value enable by IoT* (McKinsey, 2021)

The Internet of Things Observatory of the POLIMI (Politecnico di Milano) conducted a survey involving 100 large companies and 525 SMEs based in Italy, with the aim of understanding the projects carried out with an Industrial IoT perspective and expectations for the future. A double-speed scenario emerges.

On the one hand, 97% of large companies know IoT solutions for Industry 4.0 and 54% have activated at least one industrial IoT project in the three-year period 2017-2019. On the other hand, only 39% of SMEs have heard of these solutions and only 13% have taken initiatives. The mainly lack of cultural and technological skills and barriers limit this phenomenon (Report PoliMi 2021).

Cloud Computing

Or the management of large amounts of data on open systems.

It is widely known as the provision of different computing services over the Internet ("the cloud"). These resources include tools and applications such as data storage, servers, databases, analytics, network, and software.

Peter Mell and Timothy Grance (2011) have provided the following definition of the paradigm *"Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."*[18] Some of most effective cloud computing

[16] https://www.statista.com/statistics/611004/global-industrial-internet-of-things-market-size/
[17] https://www.grandviewresearch.com/industry-analysis/industrial-internet-of-things-iiot-market
[18] Recommendations of the National Institute of Standards and Technology;

usage for achieve business goals as cost reduction, elasticity, optimal resource utilization and greater flexibility are: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), Hybrid cloud, multicloud and data backup, to name just a few. [19] The global cloud computing market is growing and is expected to reach 623.3 billion U.S. dollars by 2023.[20]

Cybersecurity

(security on networking and open systems)

The definition of *cybersecurity* varies in the literature and there is terminological confusion because of its nature. According to Craigen, Diakun-Thibault, Purse (2014) the definitions are *highly variable, often subjective, and at times, uninformative.* Oxford University Press,(2014) defines *cybersecurity* as "*The state of being protected against the criminal or unauthorized use of electronic data, or the measures taken to achieve this."* Amoroso, (2006) argue that Cybersecurity involves reducing the risk of malicious attack to software, computers and networks.

In their interesting analysis of critical assets and business impacts on cybersecurity in the context of Industry 4.0, Corallo, Lazoi and Lezzi (2020) argue that cybersecurity is one of the main challenges that companies are approaching and have to deal with in order to preserve their competitiveness.

Big Data & Analytics

Big Data was defined by Doug Laney in 2001 which described the 3V Model related to big data: Volume, Velocity and Variety. Today Laney's paradigm has been enriched by other variables and for this reason we talk about 6V (or more) of Big Data.

Patgiri and Ahmed (2016) claim that there are many V's in the Big Data paradigm. They are: Veracity, Value, Validity, Variability,Volatility, Virtual, Visualization/Visibility.

However the most accepted V's are volume, velocity, variety,veracity and value (Ibidem).

To analyze Data, there are four methodologies :

i) Descriptive Analytics - Tools aimed at describing the current and past situation of business processes and/or functional areas.

ii) Predictive Analytics -Advanced tools that analyze data to answer questions about what might happen in the future.

[19] https://www.ibm.com/cloud/blog/top-7-most-common-uses-of-cloud-computing

[20]https://www.reportlinker.com/p06009776/Cloud-Services-Global-Market-Report-COVID-19-Impact-and-Recovery-to.html?utm_source=GNW

iii) Automated Analytics - techniques include data/text mining, machine learning, pattern matching, forecasting, visualization. Those three analytics classes are part of the "Advanced Analytics" category. Advanced Analytics is defined by Gartner Information Technology Glossary as "*the autonomous or semi-autonomous examination of data or content using sophisticated techniques and tools, typically beyond those of traditional business intelligence (BI), to discover deeper insights, make predictions, or generate recommendations."*[21]

iv) Prescriptive Analytics uses technology to help businesses make better decisions through the analysis of raw data.

According to Eric Schmidt - executive chairman of Google - the amount of data we have created since the dawn of civilization to 2003, now every 2 days, we create the same amount of information.

The total amount of data created, captured and consumed worldwide has reached 64.2 zettabytes in 2020 and according to Statista forecast, is projected to reach more than 180 zettabytes due to Covid-19 pandemic.[22]

Industry 4.0 technologies generate data from a large number of items such as transactions, sensors reading, network traffic (Vaidya *et al.,* 2018). Digital technologies gather data in real time and analyze it in order to provide useful information to the manufacturing system (Lee *et al.,* 2015; Wang *et al.,* 2016).

Perrey *et al.,* (2013) claims that introducing big data analysis, it has shown an increase of 15–20% in return on investment.

Many authors agree that IoT,Cloud computing, Big data and analytics are 'base technologies' for Industry 4.0 (Frank et al.,2018; Zhong et al., 2017; Lu., 2017; Thoben et al.,2017)

In a recent study on the Internet of Things (IoT), Analytics and Big Data, Bressanelli *et al.* (2018) identified eight functionalities improving product design, attracting target customers, monitoring and tracking product activity, providing technical support, providing preventive and predictive maintenance, optimizing the product usage, upgrading the product, enhancing renovation and end-of-life activities.

A recent bibliographic analysis on the enabling technologies of Industry 4.0 conducted by Bigliardi et al. (2020) has found that the enabling technologies most frequently found in the literature are *Big Data, Smart products and Robots.*

The impact of the diffusion of Key Enabling Technologies (KETs) on regional economic growth has been studied and documented in the literature. Evangelista et al. (2017) found

[21] https://www.gartner.com/en/information-technology/glossary

[22] Amount of data created, consumed, and stored 2010-2025; Statista survey

evidence of the effects of KETs on regional growth. Montresor and Quatraro (2017) conducted research that showed that KETs moderate the level of technological correlation in a region and promote greater regional branching, resulting in a positive net effect on regional growth. Despite the positive impact of KETs on regional growth, the effectiveness of the implementation of Industry 4.0 technologies remains an area of ongoing research, as noted by Frank et al. (2019).

Thus, in the pursuit of Industry 4.0, Drath and Horch (2014) provide a set of eight planning goals that must be considered. These goals encompass various aspects of the digital transformation process, including standardization and the creation of a reference architecture (Dudek et al. 2015), efficient management (Oesterreich and Teuteberg 2016), the establishment of a reliable industrial broadband infrastructure (Hermann et al., 2016), and a safe and secure environment (Intel IOT Report 2016). Industry 4.0 also requires a reorganization of work processes (Ivanov et al., 2015) and the provision of personnel training and education programs (Kagermann 2014). The creation of an organizational framework to manage data, responsibility, and personal information is also crucial (Kagermann et al. 2011). To improve resource utilization, new materials, processes, and technologies must be employed to reduce resource use and environmental pollution (Kagermann et al., 2013). Additionally, self-behaving systems with minimal human interaction (Oztemel and Tekez 2009), a strong product and process interaction, and the ability to handle big data and perform analysis (Big Data analysis) are key components of Industry 4.0. Furthermore, adaptability and flexibility, resulting from the analysis of big data, are crucial for ensuring interoperability and responsiveness to changes.

The role of human factor

The World Economic Forum has emphasized the importance of the human capital and the role of innovation as drivers of economic success in the 4th Industrial Revolution.

The Future of Jobs Report (2020) on key findings pointed out that companies estimate that around 40% of workers will require a reskilling of six months or less and 94% of business leaders reported that they expect employees to pick up new skills on the job, a sharp uptake from 65% in 2018. Through I4.0 vision there is a large consensus that the work will change and the new skills will be needed (Fantini, Pinzoni and Taisch, 2020).

According to the Digital Economy and Society Index (DESI) – Report which is periodically developed by the European Commission and takes into account indicators such as connectivity, human capital, the use of internet services by citizens, the integration of digital technology by companies and the digitalisation of public services Italy ranks 25th out of 28 Member States,

well below the European average[23] (DESI 2020)[24]. The same report pointed out that there are important gaps regarding the Human Capital.[25]

The same report points out that there are important gaps regarding human capital and the digital (digital skills, the digitization of the companies) will play a key role and they are "crucial" for a "robust recovery" as a consequence of the impact of the current pandemic.

The World Economic Forum has emphasized the importance of the human capital and the role of innovation as drivers of economic success in the 4th Industrial Revolution and in the latest Future of Jobs Report outlined that almost half of all employees around the world will need reskilling by 2025.

The same Report (2020) on key findings points out that companies have estimated that around 40% of workers will require a reskilling of six months or less and 94% of business leaders have reported that they expect employees to pick up new skills on the job, a sharp uptake from 65% in 2018. In the vision of I4.0 there is large consensus on the fact that labour will change and new skills will be needed (Fantini, Pinzoni and Taisch, 2020).

In a recent study, The Infosys Knowledge Institute (2019)[26] report that one of the greatest barriers to digital transformation that manufacturers faced in 2018 is the lack of talent or skills required followed by the inability to experiment quickly. Moef *et al (2018)* pointed out that in order to implement the I4.0 vision relevant managerial skills are needed, and indicated a list of managerial capacities: control, optimisation monitoring and autonomy.

Other barriers on the digital transformation journey are: insufficient budget, risk-averse culture, legacy system, inability to work across silos, lack of corporate vision for digital, inadequate collaboration between IT and lines of business and the lack of change management capabilities.[27]

Building on the work of Mintzberg (1982), Torres (1999) and Greiner (1972), Moef *et al*.(2019) argues that the follows managerial features may underterm the adoption of I4.0 in SMEs: local management, short-term strategy, lack of expertise, non-functional organisation, limited resources, and a lack of methods and procedures.

[23]The DESI report tracks the progress made by Member States in terms of their digitisation. It is structured around five chapters: Connectivity; Human Capital; Use of Internet Services; Integration of Digital Technology and Digital Public Services.

[24] The DESI 2020 reports are based on 2019 data.

[25] Human capital is defined by the OECD as the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being.

[26] https://www.infosys.com/about/knowledge-institute/insights/Documents/manufacturing-industry.pdf

[27] In 2018 the Institute used a blind format for the online survey. More than 1000 CXOs have responded.They represent multiple industries from Australia, FRance, Germany, China, India, the UK and the US.

The recent Inapp Report by Checcucci *et al.,* 2020[28] suggests that the challenge of Industry 4.0 is often addressed from the point of view of technological innovation and reports that the Fourth Industrial Revolution's most significant influence on the job market will be related to the need for new skills. Therefore an important role will be played by the competencies of workers, both in relation to the technologies applied to production processes and regard to the so-called soft skills.

Also the EY Digital Manufacturing Maturity Index 2019, conducted on 150 Italian manufacturing companies, highlights how insufficient skills are one of the weaknesses in digital transformation processes: 84% of respondents report a lack of professional figures capable of implementing innovation and only 12% of companies have designed and executed a structured program for the development of digital skills[29].

The World Manufacturing Forum 2019 has shown the importance of the skills for the future of manufacturing and has outlined examples of emerging professional figures that the WMF believes will increase in importance in the future. The emerging roles are:

→ Digital Ethics Officer

→ Lean 4.0 Engineer

→ Industrial Big Data Scientist

→ Industrial Big Data Scientist

→ Collaborative Robots Expert

→ IT/OT Integration Manager

→ Digital Mentor.

In fact, the WMF Report (2019) underlines the importance of an educated and skilled manufacturing workforce due to the digitization of manufacturing. Indeed, the skills required of workers will change fundamentally. This heightens the need to train and reskill the current and future workforce, equipping them with the required skills and encouraging a culture of lifelong learning.

Shallock et al. (2018) focused on the design of a learning factory for Industry 4.0, considering the growing demand for future skills among production staff. Potts and Cunningham (2008) presented four models of creative industries that could have significant impact in shaping future

[28] INAPP Report (2020) "The Mature Workers in the process of Digitalization of Italian Industry"

[29] EY Digital Manufacturing Maturity Index 2019 - survey on the digitization status of Italian manufacturing companies carried out by EY: a sample of 150 industrial companies with a turnover more than 10 million euros and belonging to different production sectors.

systems, including the welfare model, competition model, growth model, and innovation model.

Another recent study on the identification of critical success factors, risks, and opportunities of Industry 4.0 in SMEs, demonstrated that one of the major risks for adopting I4.0 into SMEs is the lack of expertise and the lack of short-term strategy mindset. The same research indicated that the most important factor for success is *training* (Moeuf et al., 2019).

The Importance of Reskilling and Upskilling for Industry 4.0

According to a study by McKinsey Global Institute, around 375 million workers, or roughly 14 percent of the global workforce, may need to transition to new occupations by 2030 due to the impact of automation and technological advances (McKinsey, 2018).

The complementarity between information technologies and high-skilled workers has been well documented in the literature. Balsmeier and Woerter (2019) argue that the integration of information technologies has the potential to increase the productivity of high-skilled workers, thereby creating a complementary relationship. Same authors show that investment in digitalization leads to a shift in employment towards high-skilled workers, while reducing employment opportunities for low-skilled workers. This trend is primarily driven by firms that utilize machine-based digital technologies, whereas non-machine-based digital technologies do not appear to have a significant impact on employment (Balsmeier and Woerter, 2019)

Bresnahan et al. (2002) provide evidence that this complementarity is particularly strong in industries where workers are able to use information technologies to perform tasks that are more complex and require higher levels of skill.

Stokey (2018) also highlight the positive impact of information technologies on the productivity of high-skilled workers, finding that the use of information technologies is associated with higher wages for high-skilled workers and lower wages for low-skilled workers.

However, as Acemoglu (1998) notes, the complementarity between information technologies and skills is not a given. Rather, it is the result of deliberate design choices made by firms and policymakers. Acemoglu argues that the relationship between information technologies and skills is shaped by the institutional and technological context in which they are deployed. He suggests that the key to unlocking the potential of information technologies to complement high-skilled workers is to create an environment in which firms are able to invest in the development of new technologies and in the training of workers to use those technologies effectively.

Reskilling and upskilling competencies for Industry 4.0 refers to the process of developing new skills and updating existing ones to align with the changing technological advancements and requirements of the Industry 4.0 era.

To stay relevant in the Industry 4.0 era, employees will need to develop new competencies and skills, including digital skills such as data analysis, programming, and artificial intelligence. Additionally, employees will also need to enhance soft skills such as critical thinking, creativity, and communication, which are essential in the new digital age.

The literature suggests that information technologies and high-skilled workers can be complementary, but that this relationship is shaped by the institutional and technological context in which they are deployed. Firms and policymakers have a role to play in creating the conditions for this complementarity to occur.

According to the OECD Skills Outlook 2017 (OECD, 2017), as globalization and advancements in artificial intelligence continue to shape the labor market and the skills required for success, individuals' ability to continuously "learn to learn" throughout their lives becomes increasingly important. The report highlights that workers' cognitive skills and willingness to learn play a crucial role in participating and thriving in evolving markets. Furthermore, given the interconnected nature of today's and tomorrow's world, intercultural knowledge and understanding has become a key aspect of cognitive development, particularly for young individuals as they mature. Eccles and Gootman (2002) also emphasize the importance of having in-depth knowledge of multiple cultures in the cognitive development process.

As the digital transformation continues to impact the labor market, some jobs are being replaced by machines, while new ones are emerging. The World Economic Forum (2019) highlights the need for proactive and strategic action from all relevant stakeholders to address both job losses and talent shortages through reskilling and upskilling efforts.

Discussion and conclusion

The main goal of the current study was to determine, describe and explain the impact of enabling technologies of Industry 4.0 on the digital transformation process, their limitations, challenges and opportunities.

This study has shown that technological transformation processes are seriously questioning established paradigms and historical practices, not least the system of industrial relations. The interconnection and integration between digitization (the set of devices and sensors capable of transmitting and processing a huge mass of data at a speed until now unthinkable) and automation (availability of robots capable of replacing men’s work with greater speed and

productivity) have revolutionised production processes, enabling faster and more flexible production and have led to greater customisation of production.

To summarize, the nine enabling technologies examined are Advanced manufacturing solutions, Additive manufacturing; Augmented reality; Simulation; Horizontal/Vertical integration; Industrial Internet of things; Cloud computing; Cybersecurity, and Big Data & Analytics.

They offer numerous benefits to both small and medium enterprises (SMEs) and larger industries. Some of the key advantages include:

- Improved product design and development: Advanced manufacturing solutions allow for rapid prototyping and virtual testing, enabling companies to quickly bring innovative products to market.
- Increased efficiency and productivity: By integrating horizontal and vertical supply chains, companies can streamline production processes and reduce waste, leading to increased efficiency and productivity.
- Enhanced product quality: Additive manufacturing and simulation can help to produce products with improved mechanical and functional properties, leading to higher-quality products.
- Augmented Reality: Enhances the learning and training process by allowing workers to interact with virtual objects and environments in real-time, reducing the need for physical prototypes and increasing efficiency.
- Industrial Internet of Things (IIoT): The IIoT allows for real-time monitoring and control of production processes, enabling companies to respond quickly to problems and optimize performance.
- Cloud Computing: Allows for data storage, processing, and analysis in the cloud, reducing the need for expensive hardware and enabling SMEs to take advantage of big data and analytics tools.
- Cybersecurity: Protects sensitive data and intellectual property, reducing the risk of cyberattacks and ensuring business continuity.
- Big Data & Analytics: Helps companies to identify patterns and trends in production data, enabling them to make informed decisions and optimize processes.

Overall, the KETs have the potential to transform the way that SMEs and larger industries operate, providing significant benefits in terms of efficiency, productivity, and product quality.

Furthermore, all of them are potentially transformative, have commercial implications, and are used in various industries. It is also necessary that the adoption of the I4.0 paradigm is a clear part of the strategic evolution of companies.

The existing literature has established that all of these technologies are present less in small-medium enterprises (SMEs) than in large companies. They are also present more in manufacturing rather than in the service sectors.

Many studies suggest that Industry 4.0 innovations and the detailed analysis of its components will play a critical role in shaping the future of industries. There is also a growing consensus that Industry 4.0 will be a temporary phenomenon and will soon be succeeded by the next industrial revolution, originating from advancements in biotechnology and nanotechnology (Ostemel and Gustev, 2020)

Despite widespread recognition and acceptance of Industry 4.0 and its technologies, there are still many unanswered questions that require further investigation. This includes the impact of digital transformation on businesses, the economy, and business processes, as well as the role that enabling technologies play in employment, growth, competitiveness, and productivity. To ensure that the human factor doesn't become a hindrance to digital development, it's crucial for training institutions and companies to parallel the evolution of technology with an update in the soft skills of their employees through targeted training programs. This way, human skills can be used as an asset to enhance technology's value.

The introduction of new technologies in the workplace within companies represents change. This change starts with the individual end users since they are the ones that have to use the new tools and technologies. Previous research pointed out that one of the important components of a high level of digital maturity is the Human Factor.

However, introducing new technologies within companies is not a synonym of acceptance and adoption by the employees. More recently, there has been a growing number of publications focusing on digital maturity assessment tools.

Furthermore, much of the research to date does not investigate the interrelationships between the adoption of new technologies by the workforce and the overall level of digital maturity of a company. Further research might explore how the technology has been adopted by the workforce. Usually it is known if a certain technology is or isn't within a certain firm but we don't know how deep the technology has been absorbed/adopted by the workforce. It could be very interesting to know if a certain technology is only present or it is fully adopted by the workforce.

From the existing literature it is clear that for a comprehensive understanding of I4.0 phenomenon an holistic and an interdisciplinary approach are essential to the development of Industry 4.0. It is also important to understand that I4.0 is not only about new technologies.

It has been observed that the Guvernamental initiatives are necessary for supporting the digital transformation.

As indicated in the literature review, the future of manufacturing is poised to be characterized by increased intelligence, flexibility, adaptability, autonomy, unmanned systems, and the incorporation of sensors (aligned with Industry 4.0 standards). There is a growing trend towards the integration of augmented reality in production processes, which is likely to result in a shift in the human workforce. Further research is needed to explore these developments and their implications. Additionally, the future of manufacturing systems will likely extend beyond Industry 4.0 standards and move towards fully automated and unmanned systems that feature robots with human-like behaviors.

Moreover it is essential to promote a (lifelong) learning culture within companies at every level of organization. The role of the guvernamental institutions is fundamental to foster new investments in enabling technologies and to raise awareness of Industry 4.0.

The evolution of work has led to a greater emphasis on human skills, which are those intangible qualities that are integral to our personal and professional growth. As the nature of work continues to change, it is evident that empathy, curiosity, and resiliency are increasingly important in maintaining positive relationships, promoting effective leadership, and fostering innovation. These human skills have the power to transform individuals, organizations, and society as a whole.

Further investigation is needed to assess the influence of the digital revolution on businesses and the economy, and to understand its effects on business operations, the labor market, and the necessary skill sets. It is also crucial to evaluate the effectiveness of various policies in fostering the acquisition of new skills, utilizing them for advantage, and promoting alternative forms of employability.

Take away Concepts and Final Remarks

I4.0 technologies are changing in primis the manufacturing sector. These changes not only have technological implications, but also versatile organizational consequences.

Therefore, a shift from product orientation to service orientation is also expected in traditional industries (Lasi *et al.,* 2014).

Industry 4.0 technologies have the potential to revolutionize not only the industrial sector, but also a wide range of other industries and sectors, including:

Healthcare: The use of advanced technologies, such as telemedicine, wearable devices, and big data analytics, to improve patient outcomes and streamline healthcare processes.

Agriculture: The use of precision agriculture techniques, such as sensor-based monitoring, machine learning algorithms, and drone-based imaging, to optimize crop yields and reduce waste.

Energy: The integration of renewable energy sources, such as solar and wind power, into the energy grid, using technologies such as the Internet of Things (IoT) and big data analytics to optimize energy generation and distribution.

Transportation: The development of autonomous vehicles, smart transportation systems, and connected infrastructure to improve safety, reduce congestion, and increase efficiency in the transportation sector.

Retail: The use of advanced technologies, such as augmented reality (AR) and artificial intelligence (AI), to enhance the customer experience, personalize offerings, and optimize supply chain processes.

Construction: The integration of advanced technologies, such as building information modeling (BIM), drones, and robotics, to improve the efficiency, safety, and sustainability of construction projects.

Education: The use of virtual and augmented reality technologies, online learning platforms, and artificial intelligence to enhance the teaching and learning experience, improve access to education, and personalize learning paths.

Overall, Industry 4.0 technologies have the potential to drive significant improvements and efficiencies across a wide range of industries and sectors, beyond just the traditional industrial sector.

There is still no agreed definition of I4.0 concept in literature nor in the practical world. Often I4.0 and the 4thIR are used as interchangeably terms. And there is an unanimous belief that I4.0 represents the Fourth Industrial Revolution in chronological order.

Abbreviations

The following abbreviations are used in this essay:

IoT	Internet of Things
I4.0	Industry 4.0
4IR	Fourth Industrial Revolution
CPS	Cyber-Physical System
Cobot	Collaborative robots
AR	Augmented Reality
VR	Virtual Reality
AM	Additive Manufacturing
SMEs	Small and Medium Enterprises

Appendix 1 - *The role of the Centres of Competence*

Competence Centers (CC) are one of the pillars of the Industry 4.0 Plan that the Government has planned to support and accompany companies in the process of digital transformation. One of the main objectives of it is to support companies in their innovation and digitalization process and in the adoption of enabling technologies.

The Competence Centres are public-private partnerships whose task is to carry out business orientation and training activities on Industry 4.0 as well as supporting the implementation of innovation, industrial research and experimental development projects aimed at the realization of new products, processes or services (or their improvement) through advanced technologies.

With the Industry 4.0 plan, the path to the creation of competence centers, the eight centers of excellence for Industry 4.0, was started, in February 2019, in Turin. They are:

1) CIM 4.0 - Competence Industry Manufacturing 4.0

2) Made - Competence Center Industria 4.0

3) BI-REX - Big Data Innovation-Research EXcellence

4) CYBER 4.0 - Cybersecurity Competence Center;

5) START 4.0 - Security and optimization of Strategic Infrastructure Industry 4.0;

6) SMACT Competence Center;

7) ARTES 4.0 – Industry 4.0 Competence Center on Advanced Robotics and enabling digital TEchnologies & Systems 4.0;

8) MedITech Competence Center I 4.0

They will have to provide a service to companies that is developed on three guidelines:

1. *Training*, with the aim of promoting and disseminating skills in Industry 4.0 through classroom training activities, on the production line, and on real applications, using, for example, demonstration production lines and development of use cases, in order to support the understanding by the user companies of concrete benefits in terms of reducing operating costs and increasing the competitiveness of the offer;

2. *Orientation,* especially for SMEs, through the preparation of a series of tools aimed at supporting companies in assessing their level of digital and technological maturity, following the criteria established in annex G (Technology Readiness Levels) of the Horizon 2020 Work Program 2018-2020 (October 2017)[30]

[30]https://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2018-2020/annexes/h2020-wp1820-annex-ga_en.pdf

3. *Implementation of innovation*, industrial research and experimental development projects, proposed by companies, including those of a collaborative nature between companies, and the provision of technology transfer services in industry 4.0, also through actions to stimulate the demand for innovation by companies, in particular SMEs.

In the first years of activity the CC provided a total of about 150 training events including courses, webinars, etc[31]

According to the OECD Survey of Training in SMEs, there are three major barriers that prevent SMEs from further investing to up and re-skilling their workforce: the lack of a learning culture in these firms, their relative inability to identify skills gaps and attract appropriately skilled workers, and their high sensitivity to the cost of training.

SMEs must be accompanied by the introduction of technological innovation tools that allow them to advance the skills of enterprises. Centres of Competence can help the adoption of KETs withi companies.

In a significant study, International Data Corporation (IDC) points out that implementing digital transformation projects for companies and manufacturing sectors requires more than technologies. IDC has called soft skills such as interpersonal communication, negotiation, and change management *the silent heroes of digital transformation.*[32]

The recent pandemic of Covid-19 challenges the status quo regarding the economy, health, and employment in the coming years. The black swan arrived when most of the companies were still defining their digital transformation strategy (Wuest *et al.* 2020). In this new scenario people and organizations have to deal with many challenges.

During the lockdown, many of the activities of CCs were online. Several Covid measures such as social distancing, travel restrictions and remote work were introduced, and many companies and factories have struggled to remain operational and competitive. Due to digital technologies, we have continued to work, to study, and to keep our social interactions. A recent study conducted by Excelsior-Unioncamere pointed out that the pandemic has intensified the need for soft skills (Unioncamere 2020) which are considered crucial to maintain the motivation of people and to secure the success of the companies when interpersonal relationships are limited. The same research shows that soft skills have become increasingly complementary to digital skills. On the other hand, many observers agree that the Covid-19 accelerated digital transformation.

[31] https://www.mise.gov.it/index.php/it/incentivi/impresa/centri-di-competenza

[32] Developing a Soft Skills Strategy for Digital Transformation, Ott 2017 - IDC Perspective, Doc # US43104617

For example, McKinsey Global Survey (2020) of C-level executives found out that their companies have accelerated the digitization of their supply- chain interaction and of their operations by three to four years and the use of the more advanced technologies, as well.[33]

Due to the pandemic caused by Covid-19, in 2020 *Fondo Nuove Competenze* (The New Skills Fund) was set up. Its first objective was to combat the economic effects of the virus. The FNC refunds the cost, including social insurance contributions, of the hours of work intended for the attendance of the programs of competencies development by workers. The plan provides EUR 730 million (2020-2021) used to refund employees. The project for the development of skills identifies the learning objectives in terms of competences, the beneficiaries of the project, the provider, the charges, the methods of carrying out the learning path and its duration.[34]

The FNC strument is an important labour market policy that can foster a culture of learning among SMEs in Italy. Furthermore, the majority of SMEs lack awareness of the existing policy instruments such as Tax Credit on Training 4.0, The New Skills Found etc.

In this perspective the CCS should provide mentoring and coaching activities to raise the awareness of the policy instruments in support of the initial investment in training.

The future of the workforce, especially in the industrial sector will certainly depend on the measures and the policy taken by the government, starting from local and regional to the national level, in particular it needs to ensure that the I4.0 technologies are beneficial for employees, for companies and for society.

Appendix 2 - *The Impact of the Highly Improbable: digital transformation in time of Covid-19*

The COVID-19 pandemic has had a profound impact on the global economy, leading to widespread disruption and significant shifts in the way that businesses operate. In response to these changes, many organizations have accelerated their efforts to adopt digital technologies and transform their operations, in order to remain competitive and continue to meet customer needs.

One of the key drivers of digital transformation in the time of COVID-19 is the shift to remote work and virtual interactions. The widespread implementation of remote work policies has placed a premium on digital tools and technologies that facilitate remote collaboration and

[33] The online survey was in the field from July 7 to July 31, 2020, and garnered responses from 899 C-level executives and senior managers representing the full range of regions, industries, company sizes, and functional specialties.

[34] Anpal Fondo Nuove Competenze – FNC (2020).

communication. For example, video conferencing platforms, such as Zoom and Microsoft Teams, have seen a significant surge in usage as organizations seek to maintain virtual meetings and remote collaboration (Gartner, 2020).

Another important factor driving digital transformation in the time of COVID-19 is the need to quickly pivot and adapt to new customer needs and changing market conditions. Many organizations have adopted new digital technologies, such as e-commerce platforms and mobile apps, to facilitate contactless sales and service, as well as to reach customers in new and innovative ways (McKinsey, 2020).

In addition to these drivers, the COVID-19 pandemic has also highlighted the importance of data-driven decision making and the need for organizations to quickly access and analyze real-time data in order to respond effectively to changing conditions. Big data analytics and artificial intelligence (AI) technologies have become increasingly important as organizations seek to understand and respond to changes in customer behavior and market conditions (IBM, 2020).

Despite these efforts, the COVID-19 pandemic has also exposed the significant challenges that organizations face in digital transformation. For example, many organizations have struggled to ensure the security and privacy of their digital assets, as well as to manage the increased complexity and costs of maintaining multiple digital systems and platforms (PwC, 2020).

Overall, the COVID-19 pandemic has accelerated the pace of digital transformation across many industries and sectors, leading to a widespread adoption of new digital technologies and a renewed focus on digital innovation. While there are significant challenges to overcome, it is clear that digital transformation will continue to play a critical role in shaping the future of business in the post-COVID-19 world.

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CHAPTER II

Digitalization in Small and Medium-Sized Enterprises: Enablers and Barriers[35]

Abstract

Digitalization remains a tricky issue at industrial and firm level and it is still a hot topic in the agenda of practitioners and scholars.

Firms are affected by the digital transformation phenomenon in many ways. Some companies manage digitalization and benefit from the use of modern technologies. Many small and medium-sized enterprises (SMEs) however are unable to face and tackle the opportunities related to the digitalization process even though technological breakthroughs are offering unprecedented opportunities, Decision-makers in SME remain unsure about how to digitalize and therefore often do not apply it to a necessary extent. This qualitative research study therefore targets to explore the enablers and barriers of digitalization adoption and the performance outcome of digitalization via in-depth interviews with managers of SMEs. The results show that a variety of factors simplify digitization in SMEs, such as the presence of suitable technologies and digital skills. There are also elements that are barriers to digitization, such as a risk-averse culture of SMEs and the usage of legacy systems. Findings generally indicate that effective digitization can only happen when the right combination of elements comes into play. This study provides insights into the nature of digitalization, assesses digitalization adoption factors and evaluates the performance outcome of digitalization in the SME context.

Keywords: Digitalization, SMEs, digital orientation, digital transformation, business performance, digital technologies, digital skills.

[35] In collaboration with Dr. A. Kallmuenzer and Dr. A. Mikhaylov (2022)

Introduction

The integration of modern technologies is greatly impacting business organizations, as they undergo a rapid transformation in response to digitalization (Collin, 2015). Some businesses are able to adapt and reap the benefits of technology, while others that resist or struggle to adopt risk falling behind in the market and facing financial consequences (Becker & Schmid, 2020). Despite the potential of technology to improve business operations, enhance efficiency and provide new opportunities (Kasych et al., 2019), many small to medium-sized enterprises (SMEs) are lagging behind in their digital transformation journey (Eller et al., 2020).

Therefore, the phenomenon of digitalization is still a topic of interest for research and practice (Barkema et al. 2002; Biggiero 2006; Dalenogare et al. 2018; Parviainen et al. 2017; Lee et al. 2015).

The importance of Information Technology (IT) application in business management continues to grow and digital technologies are driving digitalization (Bouncken et al. 2021)

For instance, Legner et al. (2017) and Tilson et al. (2010) argue that digitization refers to the adaptation and utilization of digital technologies in an organizational setting (Lau and Höyng, 2022). These technologies transform traditional processes into digital ones within organizations (Bouncken et al., 2021). In this regard, Pascucci et al. (2023) claim that most enterprises, especially SMEs, are still in the second stage of Verhoef et al. (2021) three stages of digital transformation (DT): digitisation, digitalization (which describes how IT or digital technologies can be used to change and improve existing business processes (Li et al., 2016; Verhoef et al., 2021)) and DT. Hence, companies can implement digital technologies to improve or innovate internal and external processes and integrate them into new business models (Bouncken et al., 2021).

Although numerous digital technologies are available for business use in SMEs, managers are often missing out on the opportunity to benefit from adopting these tools; this may be due to a lack of time, a shortage of financial or human resources (Mollet & Kaudela-Baum, 2022), or the absence of a digital strategy. In any case, such companies need to catch up to the current digitalization trends. For an SME to stay viable, owners and managers must adapt their business model, processes, and infrastructure to the new digital reality (Becker & Schmid, 2020).

The literature provides limited understanding of how small and medium-sized enterprises (SMEs) can incorporate digitalization into their business plans to improve their financial performance, customer satisfaction, customer loyalty, productivity, and brand reputation. Despite the growth in digital technologies, there is a lack of information regarding the different digitalization adoption scenarios for SMEs (Eller et al., 2020). This includes the adoption of technology, integration, application of digital skills, and knowledge management. This study aims to address this gap by exploring the phenomena of digitalization in the context of SMEs and providing a comprehensive analysis based on unique data. The findings of this research are expected to be valuable to both practitioners and scholars in the SME community.

This article is divided into seven sections. The following Section (Sect two) presents the theoretical framework of our research. Section three discusses the methodological choices and

the research design. Section four presents the main findings and the discussion of the results, while the conclusions can be found in Section six. Finally, we conclude with the limitations and future research directions (Section seven).

Theoretical Background

The concept of digitalization is a complex and multi-faceted one, with various definitions and interpretations in the literature. To clarify the terminology, it is important to distinguish between the terms "digitization" and "digitalization". Digitization can be defined as the technical process of converting analog information into a digital form (Autio, 2017), or the transformation of physical objects into digital ones (Rijswijk et al., 2020). On the other hand, digitalization refers to the broader socio-technical processes associated with the use of digital technologies and their impact on social and institutional environments, which requires a higher dependence on digital technology (Tilson et al., 2010; Rijswijk et al., 2020).

In the literature, these terms are often used interchangeably, which can lead to confusion (Bloomberg, 2018). Furthermore, the concept of digital transformation is also frequently mentioned in the context of digitalization, which refers to the changes brought about by the widespread adoption of digital technology in all aspects of society (Gray, 2015).

It is important to note that the concept of digitalization is not limited to the technical aspects of digitization, but encompasses the relationships between firms, business-government interactions, and the importance of customers, as well as the socio-technical processes related to the use of digital technologies (Bloomberg, 2018).

The phenomenon of digitalization has been recognized as a multidimensional concept by Eller et al. (2020) and encompasses various aspects, including digital entrepreneurship, digital strategies, digital processes, and digital education (Kraus et al., 2018). The transformation of internal and external interactions, corporate processes, and business models into digital forms, where information is represented in digital form, has been referred to as digitalization (Sahlin, 2019).

Digital transformation is a broader term that encompasses digitization and digitalization, encompassing a wide range of activities in which the use of digital technology and its associated complexities, such as the interactions between technology, institutions, people, organizations, and the environment, and their potential positive or negative impacts on society continue to expand. The implementation of digital technologies often leads to significant social, economic, and institutional changes, making digitization a critical aspect of or step towards digitalization.

Although digital strategy is regularly discussed in the academic literature, currently has no agreed-upon definition of digital strategy among scholars. The words "digitalization strategy," "digital business strategy," "digitization strategy," and "digital transformation strategy" are frequently used interchangeably in the field of digital strategy (Schallamo et al., 2019).

According to the literature, digitization and digitalization are distinct concepts with varying implications. Digitization refers to the transformation of analog information into digital form, while digitalization encompasses the utilization of digital technologies and digitized data to alter business processes, customer and company interactions, and create new revenue streams. Digitization is a fundamental aspect of digitalization, as it serves as a prerequisite. Digitalization enables the use of digital technology for data acquisition and analysis, leading to improved business decisions and the creation of new business models. It is a crucial step in the digital transformation process and has a significant impact on products, services, and people, transforming the way a company creates value and conducts business. Digital transformation, or digital strategy, involves more than just applying technology to existing businesses. It requires the ability to adapt and make intelligent and timely use of technology and information.

Digital Technologies and Digital Skills

The categorization of digital technologies into various groups has been explored by Vial (2019), who grouped them into six categories: (1) social, (2) mobile, (3) analytics, (4) cloud, (5) internet of things (IoT), and (6) platforms. The internet and software are often taken for granted and are not usually viewed as factors that significantly impact a company's development or direction. Companies aim to transform their businesses using digital technologies, such as social media, mobile analytics, and cloud computing, as highlighted by Kane et al. (2015).

It is important to note that digital technologies are constantly evolving, with new tools emerging every year, and the significance of older ones declining over time. For instance, mobile technology has become a crucial technology, providing people with a new level of communication potential, which was previously only possible through fixed digital engagement on traditional personal computers (Kriechbaumer, 2019). The number of mobile internet users has surpassed the number of desktop internet users (Kriechbaumer, 2019). However, it is crucial to understand that each digital technology serves its unique purpose and plays its role. Therefore, it is incorrect to state that one technology is better or worse than the other. Instead, the combination of various digital technologies plays a crucial role in a company's digital transformation (Vial, 2019).

Although the existing digital technologies constitute a necessary basis for innovation and performance improvement, a company's ability to innovate largely depends on its staff's digital skills and competencies (Lanvin & Passman, 2008). Today's workplace necessitates people with a wide range of abilities who can handle more complex and collaborative jobs. Generally, 21st-century talents include (1) cooperation, (2) communication, (3) digital literacy, (4) civic engagement, (5) problem-solving, (6) critical thinking, (7) creativity, and (8) productivity (Voogt & Roblin, 2012). These talents are often referred to as 21st-century skills because they are much more relevant to today's economic and social trends than in the last century, which was defined by an industrial mode of production.

Digital literacy is becoming essential in today's increasingly interconnected world because of the emergence of a global knowledge economy and the fast use of information and communication technology (ICT). In addition, as the labor market evolves, 21st-century abilities like accessing and assessing information, solving issues, communicating information, or creating ideas in a digital setting are becoming increasingly important. These talents go beyond conventional technical annotations. How a person thinks, solves issues, and learns has a stronger influence on a person's capacity to operate in a technologically rich culture than understanding specific software (Ahmad et al., 2013).

2.2 Key Advantages of Business Digitalization

Adopting digitalization offers numerous advantages to business companies, as multiple sources suggest. Jeansson et al. (2017) found and listed eight benefits of digitalization for SMEs, including: (1) understanding the customer, (2) delivering value, (3) establishing touchpoints, (4) exploring new avenues, (5) generating revenue, (6) forming partnerships, (7) handling information, and (8) streamlining resources.

Kraus et al. (2021) further highlight the benefits of business digitalization, such as reduced costs, reduced manual labor, decreased errors, improved financial visibility and control, and data-driven decision making. The adoption of digitalization is expected to streamline company processes, leading to a decrease in human errors (Ionica, 2019).

Digitalization has been viewed as a crucial tool for business success nowadays. The main goal of this construct is to help companies improve the efficiency of their operations and make automation possible (Milani, 2019). The use of modern technologies allows for reducing waste and optimizing the use of resources, thus decreasing losses and increasing staff productivity. Digitalization is also of paramount importance in the process of working with customers (Gorensek & Kohont, 2019).

Digitalization not only influences customer interactions and transactions but also affects business operations. Hybrid work models have rapidly become widespread. Therefore, businesses have to adjust to the new needs and expectations of employees in order to achieve efficient collaboration regardless of the location of staff. This collaboration becomes possible because of the adoption of cloud-based technologies that keep employees connected and centralize information (Verhoef et al., 2021). It should be clarified that digitalization requires a great change in thinking and readiness for the opportunity for disruption (Beijen, 2021).

Analyzing the best practices for digitalizing businesses to help these organizations become more customer-centric and high performing is necessary to investigate the problem of digitalization in small businesses. Taking a strategic view can be regarded as the first step in the process of company digitization (Bogoviz & Ragulina, 2020). Identifying end goals helps

determine how these can be achieved with the help of digitalization. When digitalization is initiated to automate legacy operations, the same problems with performance are highly likely to remain (Bentalha et al., 2019). At the same time, if digitalization is perceived as a tool for improving the ways in which people work and collaborate, digitalization is likely to deliver measurable benefits.

Digitalization and SMEs' Business Models

SMEs play a vital role in the European economy. They are considered engines of economic growth (Gherghina et al., 2020) and often referred to as 'the backbone of the EU's economy' (EU, 2003). SMEs are defined in EU recommendations (2003) as businesses that employ fewer than 250 employees.

As digitalization continues to proliferate in terms of its importance as a marketing tool and for other key communication strategies around the globe, addressing the ways in which digital transformation will need to be at the centre of SMEs' business plans is becoming increasingly important (Becker & Schmid, 2020). Sabatini et al. (2022) argue that one of the most important reasons why SMEs reshape and rethink their business models is the opportunity to embrace new technologies.

Digital Orientation and Digital Strategy

The concept of digital orientation is a significant aspect in understanding the development and interaction of Small and Medium Enterprises (SMEs) with various factors, as acknowledged in the literature review. As noted by Berman (2012), digitalization has brought about numerous transformations in society, the workforce, and business organizations.

The way in which consumers approach products and services has changed significantly with the advent of digitalization, as discussed by Berman (2012). In the contemporary business environment, digital orientation serves as a crucial source of competitive advantage (Quinton et al., 2018). Companies from various industries are exploring the use of digital technologies to stay ahead of the competition and offer high value to customers. However, the mere utilization of digital technologies does not guarantee a digital orientation for a firm.

According to Rha and Lee (2022), a company that possesses a digital orientation prioritizes and integrates digital technologies and tools into various processes. Thus, the adoption of digital technologies in line with the principles of digital orientation has become a worldwide strategy that affects all organizational processes.

The Adoption of Digital Orientation: An Analysis of Impediments

The adoption of digital orientation by organizations has been identified as a critical factor in maximizing performance and delivering high value to customers, as per Kraus et al. (2021). This is achieved by aligning all organizational processes with the underlying philosophy of digital orientation, which leverages digital technologies and tools. However, the implementation of digital orientation may face several barriers.

The success of small and medium enterprises (SMEs) in the digitalized organizational environment is crucial, given their significance in the economy (European Parliament, 2013; Matthews, Hechavarria, & Schenkel, 2012). Digital technology has the potential to bring about benefits such as intelligence gathering, cost reduction, and audience expansion (Borges, Hoppen, & Luce, 2009; Harrigan, Ramsey, & Ibbotson, 2011). However, SMEs may face challenges in adapting to the changes brought about by digitalization, such as a lack of technical or marketing expertise (Nguyen, Newby, & Macaulay, 2015; O'Toole, 2003).

To better understand the factors that contribute to the success of SMEs in the digital organization environment, it is necessary to examine the role of strategic and digital orientation and the conditions that support its development. The organizations' strategic orientation directs the behaviors that are necessary for success in a given market (Theodosiou, Kehagias, & Katsikea, 2012), and acquiring certain assets or capabilities. As such, understanding the best strategic orientation for SMEs to compete in the digital environment and the conditions that support its development is crucial for their success in this realm.

One of the most significant challenges is the inability to experiment quickly, as highlighted by Kamaljeet (2021). Traditional organizations may struggle to adapt to the fast-paced environment of digitalization and to keep up with the changing demands and opportunities. The slow pace of digital innovation, in this case, can impede the process of adopting digital orientation and result in the organization missing out on the competitive advantage offered by digitalization (Kraus et al., 2021).

Quiton et al., (2017) defined Digital Orientation as follow '*DO is the deliberate strategic positioning of an SME to take advantage of the opportunities presented by digital technologies. This positioning includes the attitudes and behaviours that support the generation and use of market insight, proactive innovation, and openness to new ideas.'*

The definition of Digital Orientation (DO) emphasizes the deliberate strategic positioning of Small and Medium Enterprises (SMEs) to take advantage of the opportunities presented by digital technologies. This positioning encompasses the attitudes and behaviors that foster the generation and utilization of market intelligence, proactive innovation, and openness to new ideas (Bharadwaj et al., 2013).

The definition highlights the importance of considering organizational practices and the broader environment in adapting to the ever-evolving digital technology landscape for SMEs. The use of technology and organizational strategy are intertwined, and the implementation of technology should not occur haphazardly or in isolation within the organization (Bharadwaj et al., 2013; El Sawy, 2003).

The role of senior management, particularly the owner-manager in Small and Medium Enterprises (SMEs), is critical in determining the adoption of digital orientation (DO). The owner-manager's level of IT knowledge and belief in the benefits of digital technology adoption are significant factors influencing the adoption of DO (Alshamaila et al., 2013; Chatterjee et al., 2002; Del Aguila-Obra & Padilla-Melendez, 2006; Michaelidou et al., 2011; Peltier et al., 2009).

Furthermore, a positive attitude towards change and risk-taking ability are crucial drivers of a DO (Grant et al., 2014; Jones et al., 2013; Jones & Rowley, 2011). Personal characteristics such as curiosity and open-mindedness also play a significant role in the successful adoption of digital technology (Day, 2011). The owner-manager's age and educational background can also influence the organization's willingness to embrace digital technology and the challenges it brings (Peltier et al., 2009; Peltier et al., 2012).

According to the literature, the prevalence of a risk-averse culture and limited funding are key barriers to adopting a digital orientation. A risk-averse culture, which prioritizes safety and security over potential rewards, can hinder the experimentation and integration of new digital tools that are crucial to a digital orientation (Brodny & Tutak, 2021; Trittin-Ulbrich et al., 2020). In addition, the adoption of new digital technologies often requires a substantial amount of funding, which may not be available for small and medium-sized enterprises (SMEs) (Rachinger et al., 2018; Kamaljeet, 2021). The cost of integrating various digital tools, such as customer relationship management systems, business planning and coordination applications, and AI-powered analytics, can be significant and may pose a challenge for SMEs (Kamaljeet, 2021). Thus, the lack of funding can act as a significant barrier to the adoption of a digital orientation in SMEs.

The adoption of a digital orientation by small and medium enterprises (SMEs) may face several barriers related to their employees, one of which is the insufficient digital competencies and skills among the workforce (Brodny & Tutak, 2021). This encompasses inadequate computer literacy skills, even with the provision of extensive training. To address this challenge, companies with a digital orientation tend to implement stringent recruitment standards to ensure that their employees possess the necessary digital literacy (Trittin-Ulbrich et al., 2020).

Another major barrier to digital orientation is employee resistance to change. The literature highlights that many employees may resist organizational changes, including the implementation of new digital technologies (Kraus et al., 2021). This resistance to change can impede organizational transformation efforts, requiring companies to employ various strategies, such as the appointment of change agents, expanded training programs, financial incentives, and other measures, to overcome it (Trittin-Ulbrich et al., 2020). The presence of employee resistance to change can thus pose a significant challenge to a firm's digital orientation.

Despite the growing popularity of digitalization in academic literature, there remain numerous research gaps related to the topic. The current body of literature lacks a comprehensive understanding of how digitalization can be integrated into the strategies of small and medium

enterprises (SMEs) to enhance their financial performance, as well as other outcomes such as customer satisfaction, customer loyalty, productivity, and brand reputation.

Research Design and Methodology

In this study, the authors aim to understand the adoption of digitalization in small and medium enterprises (SMEs) and its impact on their performance. The authors conduct a literature review to identify the key characteristics and functions of digitalization, including the application of digital technologies and the strategic orientation of SMEs. To gain a deeper understanding of the subject, the authors employ a qualitative, exploratory research methodology. This approach was chosen due to the relative newness and limited understanding of the topic of digitalization and digital strategies in SMEs (Becker & Schmid, 2020). The literature review suggests that qualitative research is better suited for exploring the digitalization journeys of SMEs and 65% of the studies reviewed were qualitative in nature.

The nature of the research aim and research questions is exploratory, as the goal is to understand digitalization processes and situations and their effects on productivity from the individual perspectives of SME managers. The main goal is to describe the patterns of various processes, identify the most critical factors, and explain and interpret the relationships between different factors of digitalization and productivity in the context of SMEs.

Using an inductive method did not mean that theories would be ignored when coming up with research questions and goals. The researcher used existing theories in an inductive method as a guide for developing a research topic. The collected data was examined for resemblances and patterns that was used to draw conclusions. The exploration of the topic was made before moving on to more abstract generalizations and notions. Thought the research, the most prevalent concepts in reasoning were subjectivity and meaning. The types of questions were open-ended and process-oriented (Merriam, 2015).

In establishing the reliability of the data and the credibility of sources, non-random samples were drawn using strict eligibility criteria (purposive sampling). The participants are managers with relevant positions, professionals with years of experience who have been exposed to multiple situations, and those who possess valuable knowledge in the domains of digitalization and productivity. The number of samples is relatively small; seven in-depth interviews were conducted until data saturation is reached (Mariam, 2015). The research aims to collect valuable insights from professionals with substantial experience in the fields of management and digitalization.

Seven in-depth, semi-structured interviews with a moderate amount of control by the researcher were conducted to obtain a better understanding of the whole picture of the phenomenon and gain new perspectives on the topic. The interview guideline was drafted with open-ended questions, to which the answers should either support and supplement or refute and oppose the claims, themes, and ideas derived from the literature review. After the first three interviews, the

interview guideline was slightly revised, as some new, relevant themes and concepts emerged during the initial data collection.

3.1 *Data Collection and Limitations*

For this research, data were collected from a review of relevant literature and from the in-depth interviews. The primary instrument for data collection, semi-structured interviews, offered a structure with its predetermined themes and questions, as well as the freedom to reply to and construct additional questions depending on the responses provided during the interview.

Semi-structured interviews frequently yield results that are useful beyond the immediate confines of the current research subject (Merriam, 2015). Each interview lasted between 30 and 40 minutes, on average. The interviews were conducted either on-site, at the company's premises, or via video calls when traveling seemed problematic for the interviewee or the researcher. Each interview was recorded and transcribed using Descript for Mac software. During all interviews, a guide with open-ended questions was utilized to guarantee direction and consistency in the interview. The interview questions were meticulously developed to guarantee uniformity in the responses. Questions were posed with the intent of eliciting the respondents' perspectives and worldviews, and they were not necessarily asked in the same order in each interview (Merriam, 2015). As purposeful sampling was used, strict criteria for participation were applied. First, the interviewee had to have at least three years of experience managing a SME company or a department in an SME. Second, they must be exposed in one way or another to digitalization within their line of work and must be familiar with the key concepts and relevant definitions of terms.

The Limitations of the in-depth interview data collection method are that they provide data that is indirect in nature, as it represents the viewpoints of the participants. This information is provided in a setting that is different from the natural one, and the presence of a researcher may cause bias (Creswell & Creswell, 2020). It was assumed that the participants would provide truthful answers to the best of their knowledge.

3.2 Interview Process

An inductive logical approach was used to develop the semi-structured interview questions. This approach reflects the overall qualitative research strategy, moving from specific to more general ideas and collecting pieces of the puzzle to create a full picture of the phenomenon.

The interview guideline was drafted with the themes from the literature review embedded in the questions. Follow-up and clarifying questions were asked if the given answer appeared to be indirect or incomprehensible (Kallmuenzer et al., 2018).

The questionnaire started with a focus on specific aspects of digitalization with underlying technologies, such as internal and external digital interactions, digital business processes and functions, and differences from the alternatives available. The next set of questions followed, focusing on the varying consequences of and ideas about probable alternative routes and decisions. This is where questions about the adoption challenges and benefits of digitalization and performance measures were asked. Finally, the participant's perceptions of the strategic role of digitalization were obtained.

Table 1

Interview G*uide*

Themes	Questions/Phases
1. Opening Statement	
1. Questions on the participants' views on digitalization, adopted tools and enterprise technologies, and effects on different organizational units	- Please tell me about your view on digitalization and how you define it.
	- Would you please tell me about the digital technologies that your company is currently using (Vial, 2019)?
	- How exactly did your company come about adopting these technologies (market pull/technology push; Rothwell, 1992)?
	- What are the most effective digital practices and activities that have been adopted by your company's organizational units (e.g., HR, marketing, sales, production, and accounting) **(**Kriechbaumer (2019**)**?
	- Can you say a few words about technology integration and knowledge management (Milani, 2019)?
	- What are the most valuable digital skills for a company's employees (Lanvin & Passman, 2008) ?
2. Perceptions of the advantages of digitalization, obstacles to it, and its impacts on	- Financial (ROI, cash flow, financial results)
	- Internal processes (process automation and alignment, activities per function, individual KPIs)

performance by activity (Hudson et al., 2001)	- Customer relationships (customer retention, customer satisfaction rate, etc.)
	- Education and growth (job satisfaction, employee turnover, training)
3. A big-picture overview of the role of digitalization, digital transformation, and digital strategy in the overall success of the company	- What is the scope (limits) of your company's current digitalization initiatives **(**Kindermann et al.**,** 2021**)**?
	- What are the company's long-term plans and its position in terms of its digital strategy **(**Saunila et al. 2020)?
	- How would you describe the role of digitalization and digital transformation in management's strategic decision making?
4. A closing statement and feedback on the questionnaire	

3.3 ***Content Analysis***

During the course of this research, qualitative data analysis was seen as a process of consecutive phases from particular to general and included several levels of analysis:

Step 1. The data was organized and prepared for analysis. This entailed transcribing interviews and classifying and organizing the data into various categories.

Step 2: The data was read and examined. This initial stage gave an overview of the material and an opportunity to consider its overall significance. The discussed notions, ideas and concepts were identified, and the overall breadth, reliability, and utility of the information were assessed.

Step 3: All of the data was encoded. Coding is the process of arranging data by bracketing chunks and putting a category-specific term in the margins (Rossman & Rallis, 2012). It entailed segmenting phrases (or paragraphs) into groups and identifying those categories with a keyword, frequently based on the real language of the participant.

Step 4. Description and themes were generated, as well as categories for study. Description entails the presentation of information about people, locations, or events in a context in detail. Coding was used to generate a number of topics (themes). These themes are essential findings of the research and were also used as section titles in the Findings sections of this study.

Several viewpoints from the interviewees were presented and supported by various quotations and concrete data. (Creswell & Creswell, 2018). Further investigation was aimed at establishing intricate linkages between themes.

3.3.1 Qualitative Data Analysis Software and Coding

The qualitative data was divided into 154 quotes, with each quote identified by its source (the interviewee), and coded under 39 subcodes - one for each concept - that fit into 12 codes - groups of concepts - and five themes: (1) Digital Orientation, (2) Digital Skills, (3) Digital Technologies, (4) Benefits and Drivers of Digitalization, and (5) Barriers to SMEs Digitalization.

Atlas.ti, a qualitative data analysis application, was used to aid in the data analysis. That software has the ability to incorporate text, data storage, and organization features, the search capacity to locate all text associated with specific codes, interrelated codes to make queries about relationships between codes, and the import and export of qualitative data.

The transcripts, clean and prepared for analysis, were uploaded into Atlas.ti software. Codes and subcodes were created by reading the transcripts. The quotes from the interview were labeled according to these codes. After that, the codes were closely examined to reduce overlap and redundancy. Every code and subcode had to fit into one of the themes in a shared concept.

As a result of data analysis, several first-order codes (subcodes) were identified, which were then grouped into second-order codes that conveyed the primary indicators of the textual data (Kallmuenzer, 2018). The most meaningful direct quotes derived from the transcripts of the interviewees are presented to substantiate the claims made by the researcher. Then, the codes were aggregated into themes for a better organization of findings and analysis. Further, codes and themes were organized into a concept map. (Figure 4 in appendix 1)

3.4 *Limitations*

Qualitative research, despite the researcher's efforts to remain objective, is nonetheless susceptible to bias and personal preferences (Flick, 2014). The data and information obtained through the managers' responses is also a shortcoming of this approach. As a result, broad generalizations should not be drawn from the findings of this qualitative investigation. The participants' prejudices influence the facts, analysis, and conclusion in terms of geography, culture, and location.

4.1 Definition

For a smooth transition from theoretical material to practical information, it was deemed necessary to collect information about the managers' view of digitalization as a phenomenon. The theme of the definition of digitalization is the basis for further research. Similar to the theoretical findings, different interviewees have slightly different views on digitalization.

The majority of owners and managers of SMEs possess purely practical knowledge of digitalization. Unsurprisingly, the interviewed managers of SMEs gave their definitions and perspectives of digitalization based on the functions of this phenomenon and by describing what it does for their company. With such characteristics as speed and efficiency being the top benefits:

"The way I look at it, time is valuable, and digitalization helps us save time, by streamlining our work, mostly by helping us to connect with customers and storing the information" (quote YP1; code "definition of digitalization")

"With digitalization, we automate the process of computing, which speed-ups our operations, and therefore we can concentrate on other things, like quality and strategy. …" (quote SK1; code "definition of digitalization")

Most managers have never heard of the distinction between the terms digitization, digitalization, and digital transformation. However, digitalization is viewed as a process of adoption of digital technologies, which is coherent with textbook definitions:

"For me, digitalization is basically instead of using paper; we use information technology tools like different computer software, the internet to get the job done faster, more efficiently…" (quote PH1; code "definition of digitalization")

During the identification of the view on digitalization as a whole from the perspective of the SME managers, the researcher observed, that the theme of digital technologies was prevalent during the discussion of the digitalization and digital practices of SMEs. To further investigate the technology adoption, it seemed natural to take a closer look at various digital tools and applications and the skills required to be efficient at using these tools.

4.2 *Digital Tools and Skills*

The theme of digital tools includes electronic devices, such as computers or point-of-sale (POS) systems (hardware). It also includes the internet, cloud technologies, applications, such as collaborative tools, cloud-based CRMs, and other software. The described tools have their practical applications in SMEs. The interviewed managers, despite being exposed to digitalization, are not the experts in the field of ICT, and their viewpoints have a purely

hands-on nature. The participants described a variety of digital tools and relevant skills required from workers to be able to use these tools for a specific purpose:

"By staff members, the majority of our employees are salespeople, so they mostly use our CRM system, the marketers use analytical tools, HR manager – the Lucca (HR) software. We all use MS Teams for internal communications. Digital tools are becoming increasingly more specialized" (quote PH2; code "digital tools and applications")

Each company uses a mixture of digital technologies to a different extent, and the managers employ the technologies in combination with each other. Each company uses its own mixture of technologies that is unique and adapted for the needs of its business :

"We use our website to connect to our customers, to display our products, and if we spark their interest, they act, either by leaving a request online, emailing, or calling us. In our company, we use IP telephone, WhatsApp, email, Chat-box, social media to get ahold of the clients […] for the internal communication we use cloud applications" (quote PH3; code "digital tools and applications");

"We use Bitrix24 cloud application for managing our projects; I find it useful for collaboration and brainstorming ideas. This tool allows me to assess risks and get each of our team member's perspective on a given situation…" (quote SK3; code "digital tools and applications")

Two of the SMEs' managers in the hospitality and retail sector are actively using POS systems that have grown to be indispensable for their business:

"Our whole business relies on the POS software; we have our customer database there, we take payments, record transactions, manage our stock and inventory with this software." (quote AP7; code "digital tools and applications")

Even microenterprises in the non-IT sector make use of digit tools; here is the quote from a small café owner:

"We don't have departments in the conventional sense; we have a kitchen, dining hall, and a delivery guy. Our computer with the specialized software on it makes communication and record-keeping extremely easy and fast […] For clients, the software helps to make price quotations, invoices, and bills […] for our workers; the same software takes care of the inventory[..]For me[…] I can track the popularity and profitability of specific products, and based on that make business decisions." (quote YP6; code "digital tools and applications")

In connection with the used technologies, the interviewees spoke about their own and their employees' skills required to be able to use the digital tools effectively:

"We hire lots of young people who are familiar with the technology. It means that you can use a phone, you can use a computer, then know how the internet works, how the search engines work. So it's like a basic knowledge required to work in our company. Almost everyone is required to know how to create, store, manage files, using spreadsheets and other applications…" (quote PH4; code "digital skills")

A lack of digital skills may be a severe barrier for someone looking for employment, even in a small company. Learning may be a lengthy process for someone unfamiliar with the technologies:

"Being a small company, however, we cannot hire people who don't know how the software works. One can learn, of course, but we cannot provide computer literacy training here…" (quote SK4; code "digital skills")

Digital skills are viewed as a necessary supplement to the worker's specialization, acquired through education and professional experience:

"As we hire salespeople, for example, the main criteria for successful candidates is the relevant work experience, then it may be a diploma, and then the skills, which can be divided into soft skills, like sales ability, assertion, ability to learn, presentation skills […] and hard skills or technical skills, which will include digital skills" (quote AP4; code "digital skills")

Surprisingly, the managers indicated the importance of a personality of an employee that uses digital technology for communication on behalf of the company:

"The services of our company are presented online, through our website. So, when we use ICT to connect to our customers, we don't see them, they don't see us, they don't know who we are[…] An important role here plays in winning trust in our company in the eyes of the clients. That can only be gained by the trustworthiness of our staff, if they, as workers, and we, as a company deliver on our own promises" (quote PH6; code "digital skills")

The idea of accountability goes deeper when international trade is involved:

"We serve clients from all over the world, and we are constantly looking for potential customers; with the use of ICT, it is easier and harder at the same time. It is easy to locate a potential client, but convincing him to make a deal is much tougher. We need to be able to evoke trust." (quote SK6; code "digital skills")

Even in small companies, there is a variety of specializations of employees who use different digital tools and focus on different activities:

"We have salespeople, marketers, managers, accountants. They all use different software, as they do different tasks. These different tasks also require different skills." (quote EA6; code "digital skills")

It was revealed that workers have different abilities, and the tasks should be aligned with the employees' talents, abilities, and aspirations:

"We hire interns for the positions that will allow them to fully utilize their abilities, and tasks are given according to their preference. We believe, if the person likes what he or she is doing, they will be much better at the given task" (quote PH7; code "digital skills")

However, in microenterprises, the roles are not specialized and more blurred:

"In our company, only one person is in charge of [digital] Community Management, on top of other responsibilities, so he is unable to create frequent high-quality posts. I take care of the organizational elements" (quote RA5; code "digital skills")

The researcher collected qualitative data about the tools and skills necessary for each company's successful digitalization. Next, it was imperative to explore how exactly the given company came about the adoption of the described tools.

4.3 Technology Adoption

As an integral part of digitalization, technology adoption plays the role of change and learning mechanism for the entire company. The interviewed managers view the technology adoption process as a difficult but necessary process for the overall success of their companies. As the companies that were observed were small and medium-sized, naturally, the adoption came about through a market pull process (Rothwell, 1992):

"In this company, we cannot create the need, we are a small company, we can only satisfy the need, that is already there" (quote EA2; code "technology adoption – market pull ")

The market pull technology adoption process comes primarily from the customers:

"When the potential customers are looking for the products of their interest, the first Google search it, and then we should appear, […] the clients want their information fast, and presented nicely, they also want reactivity, they became demanding and knowledgeable. If they send us a request or a question, they expect us to reply within an hour or so[…] The current technologies allow us, most of the time to respond quickly and accurately" (quote RA6; code "technology adoption – market pull ")

"Many of our customers use the newest technologies and expect us to do the same from our end. For example, making cryptocurrency payments, or authorizing smart contacts […] we cannot do that yet, we do not have the means" (quote PH9; code "technology adoption – market pull ")

The market pull process can come from the competitors as well:

"We are always looking at what our competitors are doing, and trying to do the same, but better […] The competition is strong […]. We regularly schedule competitive research activities, so we can compare the quality of competitors' services, such as website functionality and presentation, good pictures, etc.…" (quote PH8; code "technology adoption – market pull ")

There are certain limits to the extent of technology adoption due to the size of the company:

"As much as we would love to, we cannot afford custom-made CRM software that would be perfect for us,[…] so we have to use the cloud platforms, so we use Birix24, it is far from perfect, but it helps a lot nevertheless.." (quote SK7; code "technology adoption – market pull ")

Global technological development regularly produces new, improved versions of IT systems and solutions. However, the managers often find it challenging to quickly adopt new technologies, citing a lack of time and resources. As a consequence, they prefer to continue using the legacy systems:

"There are new programs and computers released each year; I don't want to invest in a new computer when the old one works just fine." (quote YP7; code "technology adoption – market pull ")

4.4 Digitalization Effect on Performance

The question about the effect of digitalization on the company's performance came out to be slightly confusing for the participants. Every single respondent in the current study, however,

cited a positive effect of digitalization on a company's performance. It was challenging for them to distinguish and articulate a direct link between digitalization and performance.

Digitalization is viewed as a set of helpful tools and practices that drive the performance of an enterprise. However, the managers of the studied SMEs' have made emphasis on the key benefits of digitalization, which were congregated into three main groups: (1) connection to customers, (2) streamlining internal processes, and (3) managing external stakeholders.

4.4.1 Connection to Customers

The current study shows that for SMEs' managers, the key benefit of digitalization these days is the ability to market their products effectively and to create a good reputation among the potential clients:

"Our CRM system is the main tool that we use to get in touch with the clients, even if it is a one-way connection through our website [..] With available digital tools, we are able to scale customer management process […] We categorize clients, we keep all the data about them, so we can use this data to more effectively engage them […] We can also make personalized quotes, as our salesmen use back end tools to modify the website" (quote AP8; code "client connection")

Social Media platforms play a key role in customer connection for the SMEs:

"Imagine I send somebody a piece of information, a promotional text, or an image; usually it is both, and that somebody looks at it. Now, Social Media allows us to send such information to a very large public. It is mind-blowing to realize that thousands of people are reading our Instagram posts…" (quote RA12; code "client connection")

Online presence and online reputation have become one of the most important factors when the client is facing a choice between companies who provide similar services:

"Our firm has 4.8 stars on Google reviews, and it is often the first thing that we hear when the customer shows up at the door of our business…" (quote RA13; code "client connection")

Digital technologies, like websites and Social Media, provide companies with an exceptional ability to present their products. At the same time, a wrong message can make a devastating impact on the company's online reputation:

"These days we have to be very careful what we post, we want to create a strong message, but at the same time, we don't want to offend anybody…" (quote LP6; code "client connection")

A number of analytical tools allow managers to draw their customer's persona and present personalized services:

"We have to admit, most of the social media engagement comes from younger people, so we send our messages to them, using appropriate language and images" (quote LP7; code "client connection")

4.4.2 Streamlining Internal Processes

In addition to the effective connection to the customers, the respondents highlighted the benefit of digitalization in automating and rationalizing various processes inside the company. Some managers believe that transparency of internal information is essential for understanding the company and, as a result, individual worker's productivity:

"Every salesman and marketer has access to the same database of information about our clients, about the products that we offer, and even about the sales figures. This way, as we make all this information accessible for almost everyone in the company, we embrace transparency and allow our employees to learn about the company as a whole…" (quote PH12; code "streamlining internal processes")

Such a level of internal transparency requires a high level of trust from the management and a high level of accountability from the employees:

"We are a small company, and we don't have secrets from our workers. On the contrary, I think that the more our workers know, including cross-department knowledge, the better they understand how our business works, so they can clearly see their own roles and importance in the company.." (quote PH13; code "streamlining internal processes")

The managers are employing different collaborative tools, like MS Teams, Zoom, or other applications, to streamline and organize information flow and communication within the company:

"Effective communication is extremely important; we constantly exchange messages, and we use different software for different purposes; for example, a short question can be asked through Teams, if someone needs to talk to somebody in the company – they make a video call. For sharing files, we use MS Outlook (email). Everyone can also edit the client information for other team members' reference in our CRM system".." (quote EA10; code "streamlining internal processes")

Covid 19 pandemic was one of the strongest drivers for the acceleration of digitalization of internal processes; more specifically, the remote work became much more existent than before:

"During Covid, we had to work from home, which was quite unusual at the time. Soon, however, we adopted to the new reality, and, with time, we actually improved on our overall performance, especially in the communication domain…" (quote PH14; code "streamlining internal processes")

"So, you can work from anywhere in the world; you don't need special software, just the browser and internet connection" (quote PH15; code "streamlining internal processes")

For the company's internal organization, it is imperative that everyone is working on their tasks and that every team member is responsible for a particular part of the work. On top of that, under the proper management, with the correct tools, the efforts can be multiplied, yielding excellent results:

"Synergy is the word; we try to utilize everyone's talents here. Our company has been growing considerably in the last years […] It is all thanks to our workers and the spirit of cooperation […] Unlike some large companies, we don't promote aggressive competitiveness between our employees. We have a friendly, helpful atmosphere of support and encouragement" (quote AP14; code "streamlining internal processes")

The technologies allow the managers to collect and analyze data related to the performance of departments and individual employees:

"I can regularly check how much every salesman brings to the company, and make my conclusions […] There are, of course, other factors, but still, I can see the big picture" (quote EA12; code "streamlining internal processes")

4.4.3 Managing External Stakeholders

The participants of this study view customers as the most important external group, with whom effective communication can dramatically increase the company's performance. However, the company's digitalization can improve communication and engagement with other external stakeholders, such as suppliers, banks, regulatory agencies, and competitors (Verbeke & Tung, 2013).

The companies are able to exchange complex information with the suppliers efficiently:

"Our company has access to the database of the suppliers, the latest information about the price and availability of components helps us improve on the production process" (quote RA12; code "managing external stakeholders").

Communication with financial institutions was mentioned as a major benefit of digitalization:

"I understand that online banking is not a new thing, but it is worth mentioning, because it saves much time with sending and receiving payments, tracking down expenses […] I don't remember last time I went to the bank" (quote YP11; code "managing external stakeholders").

The accessibility of the information makes it possible to carry out robust competitive analysis and benchmarking:

"All the offers [product description, prices, conditions] are online, and we can see them in real-time. Then we compare them to what we have to offer and try to do better [than the competitors]. Either lower the price or improve quality and presentation" (quote PH17; code "managing external stakeholders").

The information accessibility, such as price transparency, brings SME businesses to a highly competitive atmosphere:

"The clients can see and compare all the prices from different vendors online, and we often cannot match the competitors' offers. Sometimes, the margins are so low that it becomes pointless for us to sell these items. At the same time, if I see that our price is much lower, I adjust the price to increase the margin" (quote RA21; code "managing external stakeholders").

4.5 Barriers to Digitalization

The collected data suggests that digitalization practices if applied correctly, bring substantial benefits to the company. However, there are numerous obstacles on the way to digitalization in SMEs. Lack of financial resources is cited as one of the major barriers:

"We sell our products through our website, and how we present these products is a decisive factor for the customers. I wish we could afford high-end technologies like VR, which could improve customer experience[…] as a small company, and have to work with what we have" (quote EA21; code "barriers to digitalization adoption").

The insufficiency of necessary digital competencies and skills among employees were mentioned as one of the major hurdles to digitalization:

"Sometimes it is hard to believe that there are people out there who apply for a job but don't know how to use a computer. Digital literacy and basic knowledge of software are the essential skills for all of our employees." (quote AP18; code "barriers to digitalization adoption").

For some businesses among SMEs, the conservative, non-risk approach is prevalent, as managers continue with the old ways, as long as these practices produce the results:

"My philosophy is simple: If it works, there is no need to fix it; I don't want to spend money on something that may or may not improve our business." (quote YP19; code "barriers to digitalization adoption").

4.6 Strategic Role of Digitalization in the Overall Success of SMEs

The interviewed managers stated that, in their view, the role of digital in the internal organization of the company would most likely continue to grow :

"For our business use, as we went from [using] pen, paper and calculators to Excel spreadsheets, stored in the cloud; it seems that more digital tools will appear in the future, and we'll have to adapt." (quote AP21; code "strategic outlook to digitalization").

"Twelve years ago, we just had our website, with our products displayed there, a company email, and phone line, that was all. It has become more complex now: we use our CRM system to manage the clients, our site uses a chat box, and we use business WhatsApp. Customers expect us to have all of that [to be able to connect to them]. Now, many clients want to use cryptocurrency for payments, and we are thinking about adopting this technology." (quote PH20; code "strategic outlook to digitalization").

The importance of digitalization in external communication will likely develop as well:

"More and more people use the internet, and before coming to our store, customers conduct their online investigation about us. How we present ourselves online is a dealbreaker for us, so we'll continue to improve our image on the internet" (quote RA22; code "strategic outlook to digitalization").

The scope of digitalization is limited due to the size and capabilities of SMEs. The disadvantages of SMEs, such as limited financial and human recourses, shape the extent of digitalization strategy (Wuest & Thoben, 2011).

"Of course, I consider digitalization as the new reality of how business is done, but my company is small, and it is not my priority to fully digitalize the operations…" (quote YP18; code "strategic outlook to digitalization").

When discussing the scope of digitalization, more specifically, the application of digital in communication, managers emphasized the importance of the balance between digital and traditional communication methods:

"Our company employs forty-seven salespeople, that includes interns. We could have made the sale process fully automatic like it is on Booking.com or when you buy a plane ticket online. [However] We came to the realization that a real human can radically improve the chances of a successful sale. Customers need to talk to a real human and maybe experience an emotional connection. That is also why there are emojis in messengers [applications]…" (quote EA21; code "strategic outlook to digitalization").

"For a small company using digital, it is a great opportunity to communicate to a large audience, we can, basically, scale the communication, but for higher levels of coordination, human, face-to-face contact is vital. The information can be expressed with a gesture, a smile or a smirk, the tone of voice, or the look of a person. The message, sent through digital, on the other hand, can be lost, misinterpreted or ignored ..." (quote RA23; code "strategic outlook to digitalization").

For successfully managing internal processes, the idea of creating a balanced combination of digital and human capabilities was expressed:

"We try to automate our daily tasks as much as we can, but some responsibilities require purely human qualities: creativity, imagination, even intuition in some instances" (quote AP23; code "strategic outlook to digitalization").

5 Discussion of Results

The research question of digitalization adoption and the effect of digitalization on the performance of SMEs came out to be a rather complex problem for a few reasons. First, no agreed-upon conceptual structure for the notion of digitalization was found. Second, a multitude of concepts, themes, notions, and terms in the domain of ICT often overlap, and different experts have varying viewpoints and often use different terminology when describing the same subject. Third, different types and levels of exposure to digitalization produced a large congregation of ideas coming from researchers and business practitioners.

Nevertheless, the available publications allowed the author to create a foundation for further research, build on the existing progress and develop the ideas that are already published in the literature. The fundamental notions of the current research were broken down into several

smaller topics; these topics were further deconstructed to even more minor elements of the phenomena. During the data collection phase, these smaller pieces were identified, collected, and put back together, this time with the idea that the interviewees represented their own outlook as managers of SMEs.

5.1 Conceptualization of Digitalization in SME Context

Similar to the available publications, the managers interviewed for this research could not provide a unanimous, exact definition of this phenomenon. However, similar to the data from the literature review, the collected data suggest that digitalization is perceived as a process of Information and Communication Technology adoption. On the other hand, the majority of participants in this research did not mention digital orientation when providing a definition of the phenomenon of digitalization. This may be due to the fact that small companies do not generally prioritize digital transformation and rather use the available technologies only when there is a strong need for them. In addition, SMEs are known to have relatively traditional cultures, are hesitant to experiment, and are very careful with their financial resources and investments. Nevertheless, the managers are well aware of available digital solutions, and their definition of digitalization orbited around the functionality of digital tools. In other words, the managers looked at what digitalization could do for their company and used their own descriptions to define the phenomenon.

5.2 Application of Digitalization

The available literature about digitalization provided several structured descriptions of modern digital technologies. Many of these technologies, such as AI, blockchain, IoT, 3-D printing, VR, are described as the most innovative and promising (Cennamo et al., 2020). However, these technologies were mentioned in the interviews as merely the probable future solutions for SMEs. Some of the participants just merely heard of the existence of these technologies. These digital tools are rather expensive for SMEs to adopt and are yet to get widespread acceptance among managers. Moreover, some of these technologies have yet to be practical use in small, specialized companies.

5.3 The Human Factor in Digital Transformation

The significance of human factor in the context of digitalization was emphasized by the managers who participated in the study. They acknowledged that while computer literacy is essential for employees, it is not sufficient for successful technology integration and operation. The participants emphasized the importance of soft skills such as creativity, teamwork, adaptability, and problem-solving abilities in addition to hard skills. The participants also emphasized the importance of aligning digital and soft skills with the specialty of the employees, especially in the case of larger companies that employ marketers and salespeople. In smaller companies, however, one person may have to handle multiple digital tasks, which can limit their outcome. The study also highlights the importance of human, face-to-face communication and the role of integrity and accountability in building trust with customers.

The findings complement the existing literature by highlighting the need for a human touch in digital communication and the importance of trust and trustworthiness in digital transactions.

5.4 Digitalization Strategy of SMEs

As we discussed the digital tools and the required skills to adopt these tools effectively, we move on to the question of the strategic orientation of a company. The literature suggests that digital strategy is one of the main components for successfully adopting digitalization. Despite the fact that the interviewed managers of SMEs stated that they do not have a specific digital strategy, they were able to name their strategic outlook on digitalization. The managers realize the scope of their digitalization practices and the limit of their digital capabilities. In addition, the data suggests that digital coordination and configuration are perceived as important factors in the digital strategy of SMEs. These findings align with the conclusions of Kindermann et al. (2021) about the digital orientation domains. According to these findings, every company has its own unique way of digitalization and configuration.

A multitude of factors, such as the size of the company, the industry that the company operates in, and the viewpoint of the owner or manager, decide how and to what extent the company will adopt digitalization.

5.5 Benefits and the Effective Formula for Digitalization

The benefits of digitalization for business enterprises of any size have been extensively presented in the available literature. From the many advantages described in the literature, the interviewed SME managers were mostly focused on the benefit of the improved connection with the clients. That enhancement ultimately leads to customer satisfaction, which is also one of the most cited performance metrics. Another less prominent benefit is the streamlined communication with various internal and external stakeholders.

Every single participant in this study mentioned that digitalization, as a phenomenon, positively affects the company's performance in various activities. The stated activities were grouped into three main themes: (1) internal processes, (2) managing external processes, and (3) connection to the clients. The accurate and unique combination of the tools and skills, plus the digital initiatives of the management, will make digitalization effective and capable of the significant improvement of the performance of SMEs. Managers can easily observe the performance progress of the company by detecting higher customer satisfaction rates, increased ROI, and the amount of time saved while completing regular tasks by the improved and rationalized processes (Hudson et al., 2013).

5.6 Barriers to Effective Digitalization

On every level of digitalization in the SME context, several barriers were revealed (Figure 4, appendix 1). Lack of funding was the most mentioned factor both in the literature and by interviewed industry professionals. SMEs are often characterized as entities with limited

resources, both human and financial (Lee et al., 2012). On the level of technology adoption, the most significant barrier is the widespread usage of legacy systems, both hardware and software. It was observed that managers often refuse to innovate as long as the technology in place is functional. The continuous use of outdated technology is tied up with obsolete digital skills. As many SMEs managers do not prioritize digital elements in their operations, both the current skills and old technology dramatically slow down the digitalization of certain SME companies. The strategic outlook of the managers is also often not in favor of digitalization. Many SMEs adopt risk-aversive culture (Brodny & Tutak, 2021), making it extremely difficult to invest in digital innovations. The data also suggests that sometimes, managers view digitalization as merely a set of digital tools that allow performing certain activities. Most of the interviewed managers are unwilling to overhaul their entire business model to improve performance through digitalization.

6 Conclusion

In today's business landscape, digitalization has emerged as a critical topic for professionals and academics alike. The rise of digital companies and availability of digital products and services have highlighted the potential benefits of digitalization for organizations that embrace it. However, for small and medium-sized enterprises (SMEs), the adoption of digital technologies presents unique challenges such as affordability, simplicity of technology adoption, and the availability of specialized digital tools.

While there are various factors that can facilitate the adoption of digitalization in SMEs, including the presence of the right technologies and digital skills, there are also significant barriers that can hinder the process. For effective digitalization to take place, a careful balance of different elements is necessary.

Studies have demonstrated that implementing digital tools and applications can significantly enhance the performance of SMEs by streamlining internal processes, managing external stakeholders, and strengthening relationships with existing clients. Digitalization has also been found to promote customer focus and innovation, resulting in more productive operations.

To achieve these benefits, it is recommended that SME managers take a strategic and comprehensive view of digitalization and adopt digital technologies that align with their business goals. This can be achieved by staying up-to-date on existing and relevant technologies, educating their employees, and collaborating with others to gain a full understanding of the phenomenon of digitalization. By doing so, SMEs can formulate favorable digital strategies and establish sustainable growth practices within their organizations.

7 Limits and Possible Expansion of the study

This study utilizes a qualitative, exploratory research design to provide insights into the impact of digitalization on small and medium-sized enterprises (SMEs). While the study was limited by time constraints and a relatively small sample size, the use of purposive sampling allowed for a comprehensive understanding of the topic. However, a larger sample size could have resulted in greater data saturation.

Furthermore, due to the exploratory nature of the study, it was not possible to examine personal characteristics or nuances of individual skills and digital technologies in-depth. This study serves as a foundational work for future research, which could explore topics such as the relationship between digitalization and customer engagement, or the connections between contemporary skills and technology. Additionally, further research could focus on identifying barriers to digitalization and understanding their dynamics within SMEs.

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CHAPTER III

Brainport Eindhoven is a region in the Netherlands that is known for its strong high-tech industry and innovative businesses. The region is home to several major technology companies, universities, and research institutes, making it a hub for cutting-edge technology development.

In the context of Industry 4.0, Brainport Eindhoven has been a leader in the development of new technologies and innovations in the field. The region has a high concentration of patents related to Industry 4.0, including patents for digital technologies, robotics, and automation (Brainport Monitor, 2020)[36]

Many of these patents are held by major companies and research institutes in the region, and they reflect the region's commitment to developing innovative solutions for the challenges of Industry 4.0. Brainport Eindhoven has become a leading hub for Industry 4.0 research and development, and its continued investment in this area is likely to result in continued growth and success in the field.

The area is home to a large number of international knowledge workers. This is due to the region's reputation as a hub for high-tech innovation and its thriving technology sector, which attracts highly skilled professionals from all over the world (Brainport Monitor, 2019)

The region is home to several major technology companies, universities, and research institutes, which provides a wealth of opportunities for international knowledge workers in a variety of fields, including engineering, technology, and research and development. Additionally, the region's strong economy and high quality of life make it an attractive destination for international workers.

As a result, Brainport Eindhoven has become a melting pot of different cultures and expertise, which has contributed to its dynamic and innovative atmosphere. The presence of international knowledge workers has also helped to create a diverse and cosmopolitan community in the region, which has further enhanced its reputation as a hub for high-tech innovation and a great place to live and work.[37]

The next chapter aims to investigate the impact of COVID-19 on the well-being and retention intentions of International Knowledge Workers (IKWs) in the high-tech cluster of Brainport Eindhoven.

[36] https://issuu.com/brainporteindhoven/docs/brainport_monitor_2020_en
[37] https://brainporteindhoven.com/int/discover/quality-of-life/living-in-the-netherlands

Examining the Effect of COVID-19 on the Well-being and Retention Intentions of International Knowledge Workers in the High-Tech Cluster of Brainport Eindhoven[38]

Abstract

The covid-19 pandemic has strongly influenced the life and well-being of people across the globe. International knowledge workers ' well-being strongly influences their intention to stay or leave their country of residence. This paper explores the impact of the pandemic on the well being of the IKWs in Brainport Eindhoven. Further, it explores how their changed well-being influences their intention to stay or leave the region. Our population includes IKWs who lived

in Brainport Eindhoven or who had left the region during the pandemic. Given the exploratory nature of this work, we use a qualitative method based on semi structured interviews. Our findings show that the pandemic and the related measures had highly impacted the well-being of highly skilled workers in the region. Further, reasons related to the pandemic influenced the intention to leave all but one of the respondents who left the region. Moreover, this study found that IKWs'trust in the government had strongly decreased during the pandemic.

Finally, by looking at how covid influence the well-being of IKWs, this article adds to the literature on migration and well-being and the literature on IKWs and well-being, and global talent management.

Keywords: International Knowledge Workers (IKWs)s; Covid-19; well-being, Netherlands, Brainport Eindhoven, intention to stay, intention to leave.

1. Introduction

Demographic changes as the ageing and the decline of the population have contributed to the shortage of skilled labour in European countries. In this framework, the Netherlands, as other EU countries have, has started to develop policies and strategies to attract and retain Highly Skilled Migrants (HSMs) (Tarique and Schuler, 2010, Suutari et al., 2014; SEO, 2015; Cerna & Czaika, 2016; Shirmohammadi et al., 2018, Spadavecchia & Yu, 2021).

With working sectors and technologies ranging from Energy, Integrated Photonics, Automotive Industry, Printing, and Additive manufacturing to Foodtech and Medtech, the

[38] In collaboration with C., Spadavecchia (2022)

Eindhoven Region - known as Brainport Region - represents the high-tech industrial hub of the Netherlands. Fifteen years ago, the region started attracting highly qualified employees from every corner of the world (OECD, 2013). Over the last five years, the number of HSMs in the region has risen quickly (Spadavecchia, 2021). As a result, big corporations and Small Medium Enterprises (SMEs) are now focusing on attracting and retaining more HSMs.

Nevertheless, a recent study shows that attracting, retaining, and developing international talent (namely, HSMs) are the core global talent management (GTM) challenges faced by those companies (Spadavecchia, 2021). Furthermore, the same study showed that HSMs retention in the region depends on several well-being-related factors connected to their working and private lives. For instance, family well-being, sense of belonging, and economic and career well-being (including career advancement possibilities and work-life balance) are crucial for migrants' intention to stay in Brainport Eindhoven (Spadavecchia, 2021).

However, currently, no literature has explored how the well-being of HSMs in the region has changed during the pandemic.

Furthermore, due to the recent Covid-19 pandemic, most countries have introduced measures such as social distancing, travel restrictions, and remote work that affected individuals and society in several ways. After the healthcare systems, the labour market is one of the most harmed sectors by the pandemic (ILO, 2021).

Some studies have examined the role of migrants among 'key workers', their role in delivering essential services, and their vulnerabilities (Anderson et al., 2020; Fasani & Mazza, 2020). Nevertheless, research on HSMs during the pandemic is still scant (e.g., Gerber & Ravazzini, 2021; Maekawa et al., 2022).

Further, international migrants often leave their families (e.g., parents, spouses, and children) in their country of origin (Démurger, 2015).

Being unable to leave their host country due to travel restrictions, many migrants who have left their loved ones in their country of origin have faced loneliness (ILO, March 2020). Further, HSMs have started to work from home due to pandemic-related measures. Several studies have identified loneliness, ineffective communication, and work-home interference factors that have impacted the well-being of those who work from home (Deutrom et al., 2021; Wang et al., 2020; Taser et al., 2021).

On March 12, 2020, the Dutch government decided national lockdown restrictions and announced a stay-at-home order. In addition, the government introduced restrictions on all non essential travel from and to non-EU countries (Groeniger et al., 2021), which in some

cases lasted until 2022. Furthermore, until March 23, 2022, a ban on entry into the EU has been in place for people from countries outside the Schengen area.

A growing body of literature has investigated the well-being of migrants (Liem et al., 2006; Wiseman & Brasher, 2008; Safi, 2010; Graham & Markowitz, 2011) and highly skilled migrants (Spadavecchia & Yu, 2021). For example, a study by Gerber & Ravazzini (2021) investigated the life satisfaction (LS) of HSMs in Switzerland during the pandemic. In addition, Maekawa et al. (2022) investigated the impacts of sudden departures due to Covid-19 on HSMs workers in three countries in Micronesia. Nevertheless, no research has been found investigating the well-being of HSMs during the pandemic and its impact on their intention to stay or leave the region of residence.

Against this background, this research explores how the well-being of HSMs living in Brainport Eindhoven has changed during the pandemic. Further, it looks at how these changes have influenced HSMs intention to leave or stay in the country.

The main research question guiding this study is: How has the well-being of HSMs in Brainport Eindhoven changed during the pandemic, and how have those changes influenced their intention to leave the region?

To answer this question, we explored several aspects of HSMs' well-being (e.g., career, economic, social, health, and community well-being), and in general, we looked at their LS. This research is connected to a previous study on HSMs' well-being in the Eindhoven region and how their well-being influences their intention to stay (Spadavecchia, 2021). This article is divided into five sections. The following section presents some of the literature at the core of this study. Section three discusses the methodological choices and the research design. Finally, section four presents the main findings, while the conclusions can be found in the last section (five).

2. Some literature at the core of this study

2.1 Well-being

Literature on well-being is extensive. Huppert (2014) defines well-being as a primary human goal, as we all desire for our life to go well, which means that we all wish to feel good and function well (Hupper, 2014:1). At the same time, well-being is considered crucial for creating and maintaining "healthy" and functioning societies (Das et al., 2020). Further, well-being can be used to identify subjective and so-called objective experiences. While subjective well-being refers to how individuals experience their lives, objective well-being

refers to the factors influencing people's lives. Governments and public and private bodies usually measure aspects influencing objective well-being to improve the well-being of their members (Hupper, 2014; Das et al., 2020).

2.1.1. Well-being models and indexes

Over the years, several indexes and indicators have been developed to measure objective and subjective well-being. Measures of objective well-being include, among others, income, literacy, and life expectancy. In contrast, subjective well-being is traditionally measured through the perception of individuals on specific aspects of their life (Huppert, 2013). Rath & Harter (2010) defined well-being as 'the combination of our love for what we do each day, the quality of our relationships, the security of our finances, the vibrancy of our physical health, and the pride we take in what we have contributed to our communities' (Rath & Harter, 2010: 4). Further, they argue that it is not only about those elements but how those elements are in balance. According to some, social relationships represent the strongest predictor of well-being (Dolan et al., 2008; Powdthavee, 2008; Hupper, 2014). Further, the research found that the relationship between the family members and the partner is the most critical element of well being (Kapteyn, Smith, and van Soest, 2010, Hupper, 2014). Social trust and trust in the community and governments are also associated with LS (IOM, 2013). In addition, Hupper (2014) states that participation in leisure activities positively influences subjective well-being. Finally, scholars found a strong relationship between volunteering and well-being (Plagnol & Huppert, 2010; Hupper, 2014). Against this background, this study looks at the well-being of highly skilled migrants in Brainport Eindhoven during the covid-19 pandemic. Furthermore, this study is based on the well-being model by IOM (2013) and is strongly informed by the previous study conducted by Spadavecchia and Yu (2021) on HSMs' well being in Eindhoven. The IOM report (IOM, 2013) made use of a well-being model elaborated by Gallup scholars, which includes five dimensions: career, social, community, health, and financial well-being. We argue that it is pertinent to explore those dimensions of well-being for HSMs. Nevertheless, to dive deeper into personal emotions, we argue that it is of most importance, especially during the covid-19 pandemic, to look at emotional health and how it has been affected. Besides building on literature on HSMs, this research explores other dimensions not theorized in the model mentioned above by giving the respondents the possibility to talk about the factors influencing their LS.

2.2 Covid-19 and well-being

The recent pandemic of Covid-19 challenges the status quo regarding health, work, and life in the coming years, and it influences every aspect of people's living conditions. All people worldwide have been affected in different ways (Blundell et al., 2020; IOM, 2020; Barron et al., 2021). Several studies have indicated that international migrants represent one of the least protected and most affected groups by the pandemic (IOM, 2020, Guadagno, 2020; IFRC, 2020; ILO, 2020). Factors such as job insecurity, risks of contagion, discrimination, and psychological distress, have severe impacts on the well-being of migrant workers (Wang et al.,2020). There is an increasing recognition that the Covid-19 pandemic caused stress, anxiety, and depressive symptoms in migrant workers (Molino et al., 2020; Bell et al., 2021; Guadagno 2020; Kumar et al., 2020). Moreover, due to restrictive measures such as border closures, many migrants have been trapped in their host countries, making it impossible to return home (ILO, 2020). In many cases, they were isolated with limited social interaction and, in some cases, without the possibility to communicate with friends and family (Guadagno, 2020; Rai et al., 2020). In his recent literature review on articles addressing people's mental health during the pandemic in several countries, Rajkumar (2020) found that anxiety, depression, and self reported stress symptoms were associated with disturbed sleep in response to the pandemic. In addition, results showed that characteristics that contributed to mental stress and psychological morbidity were unpredictability, uncertainty, the severity of illness, misinformation, and social isolation.

Furthermore, several studies show that many international migrants have faced great difficulties due to language barriers in accessing the health care system in host countries and a lack of quick access to documentation (UN ECLAC 2020; IOM 2020, Liem et al. 2020; ILO, 2020). Finally, a recent study conducted in Switzerland by Gerber & Ravazzini (2021), on the LS of transnational skilled migrant families, before and during Covid-19 found that the pandemic remarkably harmed highly skilled migrants' LS. Further, their results show that women in transnational relationships with their partners reported significantly lower LS in 2020 than men in the same household (Gerber & Ravazzini, 2021). However, the same study also found that, in general, family members separated from each other are more resilient than families living close by. Thus, according to them, proximity to families does not affect their subjective well-being during this global pandemic.

2.3 Measures against Covid-19 in the Netherlands

During the covid-19 pandemic, EU member states adopted and agreed on a joint and coordinated approach to restricting the free movement of people to limit the infection cases (EU, 2020). In March 2020, the European Commission communicated to all EU member states, recommended temporary restrictions on *non-essential travel,* and discouraged outbound travel. Following the European recommendations, in the Netherlands, on March 15, 2020, the first 'intelligent lockdown' began. In order to implement it, the authorities have appealed to the people's sense of responsibility and 'self-discipline' (Kuiper et al., 2020). The first Dutch relatively mild measures allowed freedom of movement of people, as long as they kept a distance of 1.5 m from each other. In the Netherlands, people were allowed to leave their homes for a walk or workout independently and did not need proof of essentiality to be outside. (Kuiper et al., 2020).

The European Union extends the ban to travellers from outside the EU until June 15, 2020 (EU, 2020). Nevertheless, travellers from and to "non-EU high-risk" countries were not allowed in the Netherlands for several months still in 2021.

In January 2021, the Dutch government applied several new measures, such as staying and working from home and non the closure of non' essential activities until March 2021. The closure of the restaurants and catering activities remained until June 2021. The government has decided to lift all the measures starting from June 2021.

In December 2021, due to the Omicron variant, the Dutch government implemented a new lockdown from December 19 until January 14, 2022.

2.4 Definition of Highly skilled migrants

The Dutch institutional setting for entering as knowledge migrants (HSMs) requires an employer functioning as a sponsor and a minimum salary that changes according to the age stage of the applicant. Using the salary threshold and sponsorship criteria to define HSMs, the government excludes all highly qualified people who entered the Country for non-job-related purposes (Spadavecchia & Yu, 2021). In this study, we use the education criterion to define HSMs. Thus, we consider highly skilled people who hold at least a bachelor's or college degree when entering the Country. Thus, we challenge the non-inclusive definition of HSMs proposed by the government (Aure, 2013; Spadavecchia & Yu, 2021).

2.5 Intention to stay

Several studies have been looking at the factors influencing the intention to stay of migrants in the host community (SEO, 2015). Literature has shown that most HSMs intend to stay in the destination country for about five-six years (SEO, 2015; ICP, 2016; CBS, 2020). Batista & Cestari (2016), in their studies on transnational migrants, found that the social connections with people in the home country had a strong correlation with the intention to return within five and ten years, which ties in the destination country had no influence on. According to Barbiano di Belgiojoso (2016), attachment to the host country, in terms of economic, migratory status, social connections, and sense of belonging, positively influence the length of stay of migrants. Bijwaard et al. (2011) argue that some people migrate to accumulate savings before returning home, while others may migrate to improve their skills that are highly rewarded in the source country. Further, they state that return migration is expected to occur relatively soon after arrival in the host country if these mechanisms are in place. Finally, Bijwaard (2010) found that labour migrants and students are more prone to leave than family migrants.

3. Methodology

Considering the study's exploratory nature, we used a qualitative method to look at what factors influenced the well-being of HSMs in Brainport Eindhoven during the covid pandemic. A qualitative research design is required to explore the differences in the experienced well-being during the pandemic of the HSMs (Ramos and Martín-Palomino 2015). Our study involves in depth interviews with HSMs who left the region and HSMs still living in the area.

3.1. Research design

The research is deductive as semi-structured interviews had been prepared for the two groups of participants around crucial dimensions of well-being, referring to findings from existing literature on HSMs and well-being. Nevertheless, it also has some inductive elements, as we also included open questions about the respondents' LS over the last three years. In this respect, all respondents were asked to rate their LS from 0 to 10 for the following years, 2019, 2020, 2021, and 2022. Besides the LS and the factors impacting it, questions were formulated around the Gallup model of well-being (2012), also used by IOM (2013) and Spadavecchia and Yu (2021). The dimensions include economic well-being (financial satisfaction, occurred changes over the pandemic), job and career well-being (job satisfaction,

organisational support before and during the pandemic, remote work experience during the pandemic, career track, and how if so that has changed over the pandemic), community well-being (including elements such as safety perception, volunteering experiences, trust in the government, sense of belonging), social well-being (including the social connections both in the region and in other relevant countries, the changes in terms of social connections during the covid-19 measures) and health related well-being. For this last dimension, we added two significant parts to the model proposed by IOM (2013), which included only physical health, namely emotional health and trust in the health system (and how all those factors changed during the pandemic) (Spadavecchia & Yu, 2021).

Additionally, to understand how the covid-19 had influenced respondents' well-being and intention to stay, all these dimensions were also explored concerning the pandemic. Furthermore, by asking people about their LS and the factors influencing it, we found other elements that are not always included in these macro dimensions of well-being. In this regard, we challenge research not to focus only on a pre-determined well-being model (Spadavecchia & Yu, 2021).

3.2. Sample strategy and composition

The selection criteria used for this study are holding at least a Bachelor's degree obtained in a Third Country and having lived in Brainport Eindhoven for at least six months before the pandemic started (2019). Further, for HSMs who left, "*having left the region during the pandemic* (2020-2022)" was used as an additional criterion. As control variables, we looked at gender (male or female), origin (EU/non-EU), and parenthood (yes/no). Those variables are selected as they proved to be highly relevant to the well-being experience of HSMs (Spadavecchia & Yu, 2021; Spadavecchia, 2021, Aure, 2013, Riaño, 2011). Based on the selected variables (Gender) 2x (Parenthood) 2 x (Origin) 2, we reached the need for eight respondents for each group.

Therefore we interviewed 16 HSMs who, at the time of the interview, were living (group 1) or had left the region (group 2). Respondents were retrieved through purposive and snowball sampling. Interviews took place between February 15 and April 18, 2022. Each interview lasted between 45 and 60 minutes and was held in English. The average age of the respondents is 37 y.o., with the youngest being 29 and the oldest 67 y.o. All respondents, but two are currently working, and four are self-employed. All the self-employed respondents are currently living in Brainport Eindhoven. In terms of gender, six out of 16 are males, and 10 are females. In terms of origin, seven out of 10 are non-EU, nine are EU, and one

self-identifies both EU- and non EU, given her parents' background and her personal life experience. Specifically, respondents come from India, Colombia, Brazil, Nepal, Romania, Portugal, Spain, and Italy. Most of the respondents who left Eindhoven moved back to their origin country, even if living in different cities, one moved to Amsterdam, and another moved to Canada. Nine out of 16 do not have kids, one is single, and another is in a short-term relationship. Regarding reasons to move to Eindhoven, the most important reasons for our respondents were work, joining their partner, or studying.

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Table 1. Respondents IKW's characteristics

	Age	Gender	Kids (yes/no)	Origin (EU/ non EU)	Currently living in Eindhoven (Yes/ No)	Working status
INT 1	35	Female	No	Non EU	Yes	Entrepreneur
INT 2	45	Female	Yes	Non EU	Yes	Entrepreneur
INT 3	37	Female	Yes	EU	No	Employed
INT 4	42	Female	Yes	EU	Yes	Entrepreneur
INT 5	36	Female	No	EU and Non EU	No	Employed
INT 6	39	Male	Yes	EU	Yes	Self employed
INT 7	31	Female	No	EU	No	Employed
INT 8	40	Female	Yes	Non EU	Yes	Entrepreneur
INT 9	32	Male	No	Non EU	No	Employed

INT 10	34	Male	No	Non EU	No	Not working
INT 11	32	Male	No	EU	Yes	Employed
INT 12	33	Male	Yes	Non EU	Yes	Employed
INT 13	35	Female	No	Non EU	No	Employed
INT 14	31	Female	No	Non EU	No	Employed
INT 15	29	Female	No	EU	No	Employed
INT 16	67	Male	Yes	Non EU	Yes	Retired

Source: Authors, 2022.

3.3 Research quality indicators

To enhance the trustworthiness of the research (Nowell et al., 2017), the researchers took specific measures. First, all the interviews were recorded, transcribed, and carefully analysed. Then, the analysis was organised into three stages: selective, open, and axial coding. Data collection triangulation and researcher triangulation have been used to address credibility. Both researchers were present during the interviews, and both took and exchanged notes afterward. The first author prepared the interview script, discussed it with the second author, and tested with two persons having all the characteristics required before starting the interview process. The main author prepared a migration grid that was then used during the interview. To ensure confirmability, the study is based on substantial literature and models of well-being found in research and uses a script and migration grid (Nowell et al., 2017). Finally, the questions had an open character to avoid performativity and desirable answers by interviewees. Moreover, to further mitigate desirable answers, the anonymity of the interviews was guaranteed.

4. Findings

Our findings show that the pandemic and the related measures had highly impacted the well being of HSMs in the region. Moreover, most of the respondents who left the country did leave for reasons directly related to the pandemic. Only one respondent from outside the EU had to leave the country because his working contract ended, and he

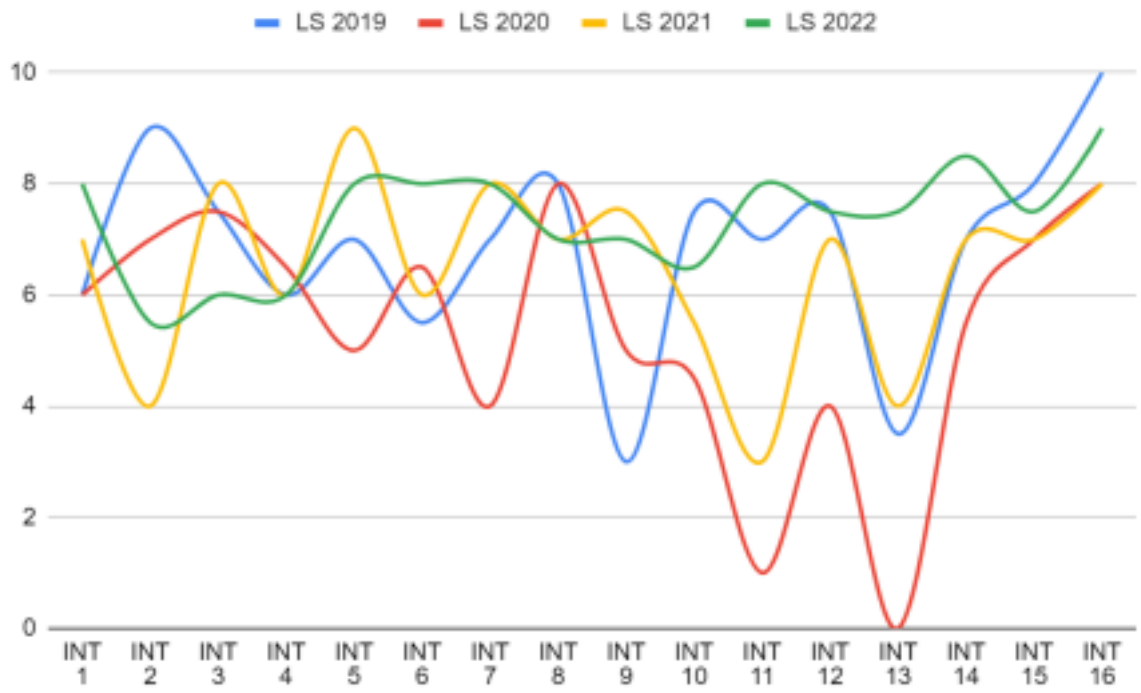
could not renovate his visa. Among respondents who stayed, two of them had thought or are planning to leave the country given the management of the pandemic by the Dutch government, and two will leave when getting older as they do not trust the health system.

Further, the results show that people who left have done so for a combination of factors to which the pandemic served as an extra pushing factor. This also holds for people who intend to leave.

In the following subsections, we present the main findings related to the areas of well-being explored, plus other areas that emerged related to LS and intention to stay or leave.

4.1 Life satisfaction changes over the last three years

The LS of all the respondents has gone through significant changes over the last three years. A relevant decrease in LS was encountered in 2020 when the average LS dropped from 6.8 in 2019 to 5.3 in 2020. A slight increase in LS was registered in 2021 when the average LS was 6.5. Further, respondents were more satisfied with their life in 2022 when the average LS level increased to 7.3.



Graph. 1. Life satisfaction of the respondents between 2019-2022

Further, we notice a clear difference in the LS for the two groups, especially during the first year of the pandemic (2020) and the year of the emigration of most respondents in the second group (2021). In 2020 the LS was significantly lower for those who decided to emigrate than those who stayed (4.8 for group 2 versus 5.8 for group 1). On the other hand, in 2021, the year of the emigration of most people, the LS of group 2 was significantly higher (7 versus 6 of group 1) than the LS of the second group.

Interestingly the LS of the two groups converged in 2022, even if, on average, group 1 had a slightly higher LS (7.5) than Group 2 (7.2). Further, the current average LS for both groups (7.3) is higher than in 2019 (6.9). Nevertheless, it is significantly much higher for people who emigrated than for those who stayed. This is consistent with the fact that most respondents feel that their expectations in terms of LS after their emigration had been met.

4.2 Well-being of the respondents during the covid-19 pandemic

The covid-19 pandemic had strongly impacted almost all the explored dimensions of the well being of most respondents. Moreover, for almost half of the studied population, these impacts resulted in their emigration decision.

The following subsections present findings related to the well-being dimensions explored and other emerging factors.

4.2.1 Job and career wellbeing

The respondents' work and career had been impacted differently, depending on their kind of job.

For instance, entrepreneurs' work had been significantly impacted by the covid-19 measures. To some extent, all the entrepreneurs' businesses require interaction with other people, which was banned for several months between 2020-2021.

Three out of the five entrepreneurs started their businesses in 2019, so they could not get them properly started.

INT. 6, for instance, mentioned that uncertainty about when things would end, and he could start working was the most challenging part.

It was the uncertainty of when is this going to end? I decided to work with companies. And then I was talking with companies in February or in March and then none of us knew when we could do things. We were constantly wondering when this is going to end

when it's going to be possible to work again. The uncertainty surrounding that, I think, was the most difficult part. (INT. 6)

On the other hand, none of the employed participants lost their job due to the pandemic. Some of them had changed their job over the last three years, but for a personal choice. Nevertheless, the work-from-home policy had strongly impacted both negatively and positively the well being of several respondents and their partners.

4.2.2. Work from home policy and impact on respondent' well-being

Most respondents mentioned that the work-from-home policy strongly impacted their way of working. Respondents with kids mentioned their difficulty in balancing their parenthood and work-related duties. Some mentioned feeling overwhelmed by not having clear boundaries between work and family life.

Nowadays, with Covid and everything online, there is no limit between your job and your life; everything goes on continuously, and people text you at 11 at night. And also, there was no way to have a proper holiday. So I felt like I was working 24/7, and meanwhile, I had to take care of my husband who was sick, and the household. (INT 2).

Nevertheless, two respondents mentioned that they were already working at least partially from home, so that did not impact them substantially.

Several respondents mentioned being tired of being on screen all day, and some mentioned experiencing so-called *zoom fatigue.*

Furthermore, respondents, especially those living alone, mentioned missing the interactions with colleagues, mainly because there was no social interaction in other aspects of their lives. Nevertheless, working from home had been experienced as a positive experience by most respondents. Most people mentioned that besides the initial struggle, working from home was beneficial to their family, as being together brought them closer.

It was difficult in the beginning, but then it made us feel more connected (INT. 6)

On the positive side, my husband started working from home so I was like, happy... yeah, and when he started going to work at least once or twice a week, that was challenging for both of us. (INT. 1)

Moreover, several respondents mentioned that they or their partners initially did not believe that they could work from home. However, in the end, they did, and they were happy with it. Also, some realised that they could continue working from home while

living in another country (see 4.3.3). Consequently, when asked to go back to the office, many interviewees and their partners started negotiating with the company about the possibility of continuing to work remotely. However, when companies were not supportive in that respect, they started to look for other jobs in companies allowing remote work.

4.2.3 Financial wellbeing

The financial security of employed interviewees hadn't been negatively impacted by the pandemic.

*Especially in the last three years [the economic situation]was pretty much linear. (INT.*11)

Moreover, most respondents could increase their savings as they haven't been spending money on leisure activities, clothes, and travelling.

[Covid]made me more rich because I did not spend any money on coffee outside or dinners outside or drinking outside; it was all at home. So you save a lot of money. I saved more money during Covid than at any time in my life, which is crazy. (INT.13)

Nevertheless, all the respondents who had their businesses had been impacted by the pandemic related measures to a certain extent.

Very greatly [impacted]. It was devastating. The business, which was focused on connecting, networking events, cultural activities, it was yeah, we were really struggling. (INT. 2)

Furthermore, the respondents who left the country, but kept their Dutch contract and salary, were highly satisfied with their financial situation. They receive a higher salary than the average salary in their destination countries and could benefit from a lower cost of living. Moreover, one of the respondents could also benefit from the tax reduction for HSMs returning to their country. On the other hand, respondents who left the Netherlands and found a job in the new destination country mentioned having a worse economic situation than before.

4.2.4 Trust in the government

The Dutch government's pandemic management strongly impacted HSMs' trust in the government. Twelve out of 16 respondents mentioned that their trust in the government had substantially decreased during the pandemic.

The main complaints regard the long-lasting non-mandatory use of face masks, the continuous lockdowns, and the fast elimination of all measures in June 2021, which led to a new lockdown right after summer 2021.

People never wear them [face masks] in supermarkets. I mean, closed spaces sometimes didn't have basic things like alcohol ... The government, basically. They implied, you know, we have these requirements, these are not rules, these are just general guidelines, you know? (INT 6)

No, in the beginning, when it was not mandatory to wear a mask. (INT. 1)

I mean at the beginning of the pandemic they were not encouraging the use of masks. And I found that unreasonable (INT. 3)

Several respondents mentioned the clear division between Dutch and internationals in terms of face masks usage.

And then, of course, we took our precautions, you know, even if the government said that I don't need to wear a mask in the supermarket, I always wear a mask it, we always wear a mask in indoor spaces, you know, and I noticed that with a lot of internationals, I noticed that internationals took a lot more care during Corona than Dutch nationals. (INT. 6)

Complaints also refer to the lack of economic support provided by the government to small businesses. This, for instance, is the main reason influencing INT.2's decision to leave the country.

We were really struggling with how the pandemic was handled in this Country. And the lack of support, the rules there were for, for business for entrepreneurs. Big companies were supported, but the common ordinary entrepreneurs, for us it was impossible. So I'm, yeah, I'm, I'm done. […] yes, sure, we will leave. Not tomorrow, but in a couple of years when my kid finishes the school (INT. 2)

Other measures were also seen as directly impacting the businesses:

The way it was handled with the QR codes with the mask, with all these protests. I didn't understand how some things were not mandatory. People not vaccinating or not giving the booster affect us. Because then our shop, our business had to close down because the numbers were increasing, people were not vaccinated, and it was not possible to make it mandatory. (INT 2).

Nevertheless, respondents were generally satisfied that they could still get out of the house and walk-in nature during the lockdowns.

It is relevant to point out that most respondents' perception of how the Dutch government managed the situation was impacted by the information they were reading about how their or other countries were dealing with the pandemic.

For instance, INT 10 says:

Oh, gosh, no, I mean, my Country handled the pandemic quite badly. So in comparison, the Netherlands had fewer deaths. But if I look at Japan, they had substantially fewer cases. And I think that at least their communication, actually… there were mass guidelines and use of antimicrobial gels and things like that. I felt like the Japanese government was more consistent in its approach. And that I feel it would have had a more positive effect in the Netherlands too (INT .10)

On the same line, another respondent said that she has felt safer in the NL than she would have been in her Country:

In [non-EU Country] the new rules and regulations are not as fast as in the Netherlands. It was very different. We felt safer here (INT.1)

In addition, the travel ban constitutes another highly relevant element that impacted the trust in the government. This had been very tough for people from non-EU countries that had a much longer travel ban regarding EU citizens (see 4.3.1).

4.2.5 Volunteering

More than half of the respondents did some volunteering jobs or activities in Eindhoven. For most of them, volunteering had good outcomes in terms of well-being. It increased their sense of meaning, accomplishment, and community, strengthening their social relationships.

We did [volunteer] on weekends. So even if it is a weekend, I don't mind going out and yeah being with them. And the others I've met during the past volunteering, they are like a community. (INT. 1)

I joined a group that was involved in montage cleanup. And then we went around and took care of that…I felt like it was my city, like I belong to Eindhoven. (INT. 10)

I'm a volunteer at [cultural organization]. That definitely helps [the sense of belonging] and connections. (INT 9)

Nevertheless, during covid all their volunteering jobs closed so they actually felt

isolated. *4.2.6 Sense of belonging*

Experiencing a sense of belonging positively influences the well-being of respondents. Nevertheless, only two out of 16 respondents feel a sense of belonging to Eindhoven and the Dutch culture, and another person mentioned feeling "adjusted". This means that 13 out of 16 people do not feel that they belong to Eindhoven. Furthermore, the language and the different lifestyles and cultures are the elements negatively impacting belonging.

I don't feel like I belong. In terms of language and culture and connections, I don't feel I belong. (INT. 8)

For those who left, the lack of sense of belonging and the need to feel that they belong played a relevant role in their decision to emigrate.

We felt that we were not part of this society somehow. Of course, part of this was the language, as we do or do not speak Dutch. And most of our friends were internationals, and we did not feel like we belonged there. And the lifestyle was completely different. And you are aiming to have a place where you can say that it's my home apart from home. (INT. 14) *In Eindhoven, I always felt a little bit out of place. I never felt like I belonged there.* (INT.13).

Furthermore, all respondents who left experience a sense of belonging to their new destination, and this positively influences their wellbeing.

For instance, INT 5 who moved to Spain, says:

The cultural aspect, like, here in Spain, I do feel that, culturally, I'm more like home. So I really enjoy the culture of going a lot outside of you know, being very loud and spontaneous. And all, like, the culture here makes me feel more at home than the Dutch culture, for instance, there (NL), you know, the dynamics of their relationships are a little bit different. And also, you know, the way they [Dutch people] enjoyed the days and activities is different, which is good, but I had to make a bigger effort to belong and to cope, than than here. (INT. 5)

4.2.7 Sense of safety

Fourteen out of 16 respondents mention that Eindhoven is a very safe city, and for most people living in the town, this safety influences their intention to stay.

I mean, I feel very safe. Very safe country and Eindhoven is a safe city, even if people sometimes try to paint it as a dangerous place [...]. Of course, that helps in our decision to stay. Oh, better, it doesn't give us any reason to leave. (INT. 6)

A couple of respondents mentioned that Eindhoven has become less safe after the covid-19, and one person said it became a bit less safe than it was ten years ago.

For instance, an entrepreneur who had her business seriously affected by the protests against the measures, said:

I remember the one day that there were these disturbing protests in Eindhoven and my shop is in downtown, and we were scared and crying like it never happened in my country. And here it felt like, "Oh, my God, I can lo0se everything". (INT. 2)

Nevertheless, for most respondents, the region's safety had not been impacted by the covid-19. Further, safety has not been seen as a reason to leave but more as a reason to stay, especially for respondents having kids.

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4.2.8 Social well-being

The covid-19 and the related measures have substantially impacted the respondents' social relationships with people living in the region.

Most respondents, especially those living alone, had been strongly impacted by the lack of social contacts, especially at the beginning of the pandemic, when they felt that they had to be strict in not meeting people.

Further, given the restrictions, during the pandemic, most respondents selected the friends to meet. They had to make a choice, so they chose to meet only the closest friends, while meeting the others online or in sporadic occasions and outdoors.

In the beginning we didn't meet with many people. But yeah, just to meet a few people was already enough for all of us…So, on a regular basis, there are very limited people we meet. (INT. 1)

In some cases, people felt less stressed to keep up with constant meetings. For instance, INT. 8 mentioned that she also started using covid to get out of meetings' request:

Suddenly, maybe I was using Covid as an excuse. So, it was nice to take a break. And then now, Yeah, again, like today, we went out with friends and all. So, in a way it was nice also, but I can't go back to have the full weekend constantly planned with meeting with friends. I will I'll never go back to that one. (INT.8)

In other cases that made people felt even more isolated as they were not part of any inner circle of friends:

And especially with Covid, you saw that only if you were part of the inner layer, you actually like kept in touch with people, all the other superficial layers were like sort of

socially cut off, like, you know, people that would normally invite you for a coffee or a drink after work, just stopped inviting you. Only the essential circles were basically having contact. And we weren't close friends to anyone. (INT.13)

The lack of a deep relationship influenced the intention to leave of few respondents.

4.2.9 Opinions about the Health system

Thirteen out of 16 respondents are not satisfied with the Dutch health system. Most complaints concern the health insurance costs, the lack of a proper prevention system, the GP bottleneck to see a specialist, and the long waiting lists.

'This is my main complaint in this country [...]Because I had bad personal experiences. The doctors not treating you is a huge problem, and in terms of prevention, they do not do any kind of prevention in the health system. (INT. 11)

I didn't really like the health system in the Netherlands, but luckily, we had the opportunity to go either to Belgium or to Germany for extra appointments or something we needed. We should be able to see a specialist whenever we want, but it is not possible here. (INT. 3)

So for making the appointment with the GP. I need to wait for some time or I need to call early in the morning. Otherwise, I will not get an appointment or wait for two or three days. And especially for my son's eye appointment it took eight months. That's really long. (INT. 12)

Further, the lack of trust in the health system is seen by some as a reason to leave:
So, health system-wise, I would say that's a definite reason to leave the Netherlands. (INT. 13)

No, I don't [trust the health system]. Actually, the only complaint I have about this country is about the health system and how it works, their superficiality, and everything is about money. I know at least I can go to Romania.. [here] they don't want to send you to a specialist and give you all the paracetamol, so this makes me feel unsafe…Yes, it influences our intention to leave as we get older. (INT. 4)

4.2.10 Physical health

The respondents' physical health had not significantly changed over the last three years, and neither the covid nor the related measures impacted their health.

4.2.11 Emotional health during covid-19

The pandemic impacted the emotional health of almost all respondents. Particularly most

respondents mentioned that the state of uncertainty they had been living in triggered some forms of anxiety and stress.

So, I mean, I never was depressed or anything but it took us down. And then in the second lockdown, because of the uncertainty, I think that was the main, the main factor; it was the uncertainty of when is this going to end? (INT. 6)

Yeah, I think the uncertainty about the future is like their unstable life right now because Covid is still around. (INT.14)

Okay, so I think in general, what affected this number was the level of anxiety that I had during that year, right, because it was so unexpected, it was a lot of uncertainty. (INT.5)

Because of the economic pressure, I have to pay bills, and there is no income because everything is cancelled. So that, that, that kept me awake at night and...those two I think, I, yeah, I think the social is the social parties. Okay, I still have my friends, I still get, yeah, I got in contact with my family but I see myself exhausted, exhausted emotionally. Okay, okay, so is enough. Is enough, is enough fight. I have fought enough. (INT 2)

Almost all respondents with teenegaer kids affirmed that the pandemic had strongly affected them.

It impacted my son quite hard. He started having bad grades and not feeling like going out (INT. 4)

Nevertheless, the majority of respondents also mentioned several positive impacts of the pandemic on their well-being.

Most people with kids mentioned that having the family constantly living together was challenging but also increased the bonding between family members (see 4.3.3). Further, more than half of the respondents mentioned that they liked to slow down a bit and enjoy the small things in life:

I've realised things that you didn't realise before. You get to understand that what is more important, all small things and the appreciation to them has they come…like we've lost so many relatives because of Covid…so many things have happened, which you just start appreciating small things in life. (INT. 8)

A significant number of respondents mentioned that they became more resilient and self conscious.

I had more time to face my fears, and to get rid of them.I discovered another part of me that before I was scared off, I'm proud of how I am now. (INT. 4)

I learned a lot. So for example how to be satisfied only by myself. (INT. 11)

Further, six out of sixteen respondents mentioned that they went more often out in nature during the pandemic and realised how important it was for their well-being.

One really fun thing that I began to do during the pandemic was I took a long walk in the park, I would just go out and watch the same trees every day. And just watch the leaves come out of these trees. And that it was an amazingly peaceful experiment (INT.10)

4.3 Main factors that impacted the respondents' intention to leave

The pandemic had strongly impacted the LS and the respondents' well-being and, therefore, their intention to leave. The main reasons people left or intend to leave are the covid-19 measures, the lack of sense of belonging, and the need to stay close to the family of origin.

4.3.1. Travel ban policy and the intention to leave

The travel ban had a significant impact on the well-being and the LS of the respondents. In several cases, this had also been directly influencing their intention to leave:

For instance, INT 15 and INT 5 mentioned that the travel bans strictly impacted their concept of distance from their family, which impacted their intention to move back.

I would say the main reason was Covid and not Covid by itself, but the impact it had on my own life. Before Covid, there were flights from Eindhoven to my city, at least one per day, if not two, and I knew I was not flying back home too often. But I knew that if I had the necessity, I could do it. With Covid, the Eindhoven airport was almost closed, and we're not any more direct flights through them. If I wanted to go back to (home place), I should have gone to Amsterdam or flown with KLM and spent more money. The tests were mandatory at the time. So I think I spent almost 400- 500 euros just for one trip to my country and that really changed the perspective I had about distance. (INT. 15)

I always had the impression that they [family] were not as far away, right, because I could take a plane and come to [city] and stay with them, which was still the same. But after Covid, we experienced that the distance was, you know… perceived as a longer distance than shorter because we couldn't make a plan so easily; even today, right, we need to do all these tasks and formularies and everything. So I think that really impacted the way I cope with the distance. So I think after experiencing covid, I do appreciate being able to be in the same city as my family. (INT. 5)

Again INT 15 says that covid 19 strongly influenced not only her idea to move but to

move back to her country:

Initially, it was to move somewhere, but then after Covid, it was going back to my country. So from this perspective, like before, I would have considered another country. But then, after Covid, it was now I wanted to go back to my country and be closer to my family. (INT. 15)

4.3.2 Having a supportive network

The importance of having a supportive network has been seen as a crucial factor for people who moved, not only for those having kids but also for those planning to have a family in the future. For instance, for INT 7, having a family close by that can help them with their future family strongly impacted her intention to emigrate.

Because I think for us to have the, let's say, a family network is important for our hypothetical future family. (INT. 7)

To have a bigger support network, like grandparents and family, godparents, uncles, everything in case we needed something. (INT. 3)

4.3.3 Work from home policy as a trigger to leave

The remote work policy had been a trigger for people to leave Eindhoven.

They [the company] have a completely remote work lifestyle. So I can work from anywhere. I don't need to be in Eindhoven. I don't need to be anywhere specific. And then, luckily, [the partner] also found a remote job. So we realised that neither of us work in Eindhoven anymore, and we don't have very deep connections. So we decided to leave. (INT 13)

People who liked to work remotely when companies started to ask people to go back to work started a conversation with the companies about the possibility of keeping working remotely. In several cases, companies were supportive of this request.

In the case of INT 3, she was granted the possibility to work from Portugal, but her husband wasn't given the same opportunity, so he changed the company.

Before the pandemic, my partner always thought that he couldn't work from home; he thought that he wouldn't be able to concentrate. But then he had no choice when the pandemic came… and then he really liked it; he liked it so much that he didn't want to go back to work. And then I think it was more or less around September that his company started asking people to come back to the office. And he didn't want to. […] His company said that it wouldn't be possible for him to work remotely… then he started

looking for a new job. And he got one quite quickly... and, and I also spoke with my company, and I told them, okay, this is going to happen, and they were supportive. (INT. 3)

For three out of seven respondents, the possibility of continuing to work for a Dutch company and enjoying the Dutch working culture and labour conditions was crucial. They explicitly mentioned that they did not want to work for a company in their destination country. This is also the intention of their partners and the partners of one respondent.

I think that the factor that really pushed us to really move is that our companies kind of agreed with us working remotely in a permanent manner because none of us were really happy with the idea of having to work for Spanish companies and culture. (INT.5)

The partner of INT 7 also decided that working from home with a Dutch contract is an essential condition for his emigration to Spain. Nevertheless, his company was not supportive, so he decided to stay in Eindhoven while looking for other remote work possibilities.

He was already negotiating with a company about working remotely from Spain for like forever. Yeah, so the plan was like he would move to Spain, but finally, the company didn't accept his request, and so he stayed, and he is looking for another job that will allow him to work from home. (INT. 7)

Other respondents expected to have the worst working conditions back in their country, but they decided to take the risk and move back.

So I know that workwise I would have found a harder environment in my country, but I wanted to go anyway. (INT.15)

In addition, eight of 16 respondents mentioned that the weather is crucial for their well-being. Further, five out of seven people who left affirmed that the weather played a role in their decision to leave. They all expressed a higher sense of well-being by being in countries with better weather conditions.

The weather, having long days, even in winter; that we have lighter days until six o'clock in the afternoon. That really impacts my happiness, in the level of energy that I have as well. So I think having more light, not per se only the sun, but just in general, more light does affect my energy level. (INT.5)

Finally, the respondents' intention to leave resulted from several factors. In particular, rather than being the main element impacting their intention to emigrate, for many the pandemic functioned as a final trigger for their decision to leave.

4.3.4 Expectations

All respondents but one said that their expectations regarding their life in the new country had been met.

For instance, INT 13, a young woman who decided to move to Amsterdam, said:

So far, yes [expectations are met]. I don't know. I don't know if it's because I've also started travelling more. And you know, I have the perfect balance of living in Amsterdam, which is beautiful, and travelling, which is also really exciting. So, I think so far, it has been great. (INT. 13)

INT 5, who moved to Spain with her husband, says:

Yes, I think they [the expectations] were met and actually exceeded our expectations. I think for both of us. We really enjoy being here, and our level of happiness, in general, has really increased. (INT. 5)

INT 15 affirmed that she had to adjust to her country's work environment but that she was prepared for that, so all her expectations were met:

I know that I would have found a harder environment workwise…In terms of positive expectations, I expected life, let's say more similar to the one that I knew from the time I was living here, meaning …having the shops open until eight or walking in the streets and hearing people speaking in my language, or going to a bar and the bartender saying "Bella, how are you?" like this kind of human connection? That's something I kind of missed in the Netherlands. In these terms, I would say my expectations are fulfilled. (INT. 15)

The only respondent who did not have a strong opinion about it was the one who left because of his job contract's expiration. He specifically said that he had no clear expectations because being back in his country is just a temporary matter.

One respondent mentioned that her expectations were not completely met because their house was not ready yet, so they had to move with the inlaws, and that had led to family interference in the upbringing of their child:

Exactly. So, um, yeah, if we would have the house we expected to be ready, the expectations like our LS would be higher, for sure…we had a conversation with her [grandpas] that they can be a bit more flexible with, with our daughter because, I mean, of course, each grandparent has his style or his personality. But we told [them] that they can be a bit more flexible with our child, that we are the ones responsible for the education. (INT. 3)

5. *Conclusion and discussion*

This study looked at how covid-19 influenced the well-being of the IKWs in Brainport Eindhoven and how their (changed) well-being impacted their intention to stay. Our findings show that Covid-19 strongly impacted the well-being of IKWs in the region. Further, Covid-19 had influenced the intention to leave of almost half of the respondents. Moreover, the life satisfaction of all the respondents significantly decreased during the pandemic, especially in 2020. The group that, on average, had the lower LS in 2020 is the group that left.

Furthermore, this group had a significantly higher LS in 2021, right after their emigration. Their LS in that year was also higher than the LS of the group who remained. Nevertheless, in 2022, the life satisfaction of the two groups converged to a level slightly higher than their LS in 2019.

5.1 Discussion

Besides physical health, which has not been strongly affected by the pandemic, all dimensions have been impacted.

The findings show that the pandemic had not negatively impacted the financial well-being of those employed; actually, most could save more money than usual. This finding contrasts with findings on the negative economic impacts of covid-19 on labour migrants (Guadagno, 2020; IFRC, 2020; ILO, 2020, Wilson et al., 2020).

An explanation for that is that our group is composed of migrants working mainly in stable and highly remunerated positions.

Nevertheless, those running their own business had a substantial financial setback. This, for one of them, resulted in the intention to leave in the next couple of years. Further, the career possibilities of those employed have not been significantly impacted by the pandemic. Nevertheless, the work-from-home policy affected the well-being of many, both in positive and negative terms. In general, adverse outcomes are related to the invasion of the work on private time and space and the so-called "zoom fatigue". Other scholars found an increase in symptoms related to technostress (e.g. feelings of exhaustion) as well as eye-related symptoms during the pandemic (Molino et al., 2020; Majumdar et al., 2020; Rump & Brandt, 2021).

For those living alone, working remotely, and not being able to meet people triggered a

sense of loneliness (Deutrom et al., 2021; Wang et al., 2020; Taser et al., 2021).

In addition, uncertainty on how long the pandemic would last impacted the work of the entrepreneurs.

Further, working from home had both positive and adverse outcomes for those living with their partners or families, as also found by (De Filippis et al. 2021 and Xiao et al., 2021). On the one hand, respondents struggled to combine work and family life; on the other hand, they could strengthen their bonds with the other family members. Similar results have been found by Arntz et al. (2020) and Bouziri et al.(2020).

Nevertheless, several respondents found that they like to work from home. When asked to go back to the office, they started negotiating the possibility of working remotely on a permanent base. When the employers did not grant this possibility, they started looking for other jobs. Several people decided to finally leave only when they knew that they could continue to work from home for their Dutch employer. This is because they prefer the Dutch conditions regarding salary, benefits, and work-life culture. For them, the covid-19 pandemic functioned as a pushing factor to fulfill all their job and personal life needs.

Further, *trust in the government* had been significantly impacted by the pandemic. In this respect, most respondents, who initially trusted the Dutch government, have lost their trust after seeing the government's pandemic management. These findings contrast with the previous studies on the well-being of migrants in Brainport Eindhoven (Spadavecchia & Yu, 2021; Spadavecchia, 2021). This is because the previous studies were conducted before the covid-19 pandemic. Further, Groeniger et al. (2021) registered a sharp decrease in trust in government between December 2019 and early March 2020 (Groeniger et al. 2021).

Specifically, several are complaints about the government's management of the pandemic. Respondents' complaints relate mainly to not making mandatory the use of face masks for several months and to the lack of consistent communication. In this respect, Sibley et al. (2020) found that a solid and cohesive national response to exceptional circumstances increases people's trust in politicians and scientists.

Further, another highly shared complaint is about the extended travel bans towards and from non-EU countries. The prolonged ban substantially impacted the respondents' well-being, especially non-EU citizens. Several could not see their family for a long time, even when their relatives or parents fell sick or passed away.

A critical issue emerged from the lack of financial support for the small entrepreneurs,

which led to the intention to leave one respondent. Even if the Dutch government adopted a package of financial measures designed to support entrepreneurs and companies during the pandemic

(Government of the Netherlands, March 17, 2020), they did not seem adequate for small entrepreneurs.

Finally, people complained about the continuous lockdowns given to the weak measures taken. Nevertheless, some people from countries with a high infection rate felt safer in the Netherlands.

The sense of belonging has been highly significant for the respondents' well-being. However, even if many have strong connections to some specific communities (e.g., volunteering groups) or friends, most respondents do not feel a proper sense of belonging in the Netherlands. This influenced several respondents' intention to leave. Barbiano di Belgiojoso (2016) found that the sense of belonging is strictly related to the intention to leave.

On the positive side, almost all respondents feel safe in the region, and their safety perception has not changed during the pandemic. In addition, their sense of safety strongly influences their intention to stay (Spadavecchia & Yu, 2021; Spadavecchia, 2021).

Further, most people do not trust the health system, and three will leave in the future because of that (Spadavecchia & Yu, 2021; Spadavecchia, 2021). Nevertheless, HSMs' opinions about the health system were not impacted by the pandemic.

Finally, the pandemic strongly impacted emotional and social well-being, and both elements influenced some people's intention to leave. Many have seen uncertainty as a trigger for their anxiety, stress, and in some cases, depressive symptoms (Molino et al., 2020; Bell et al., 2021; Guadagno, 2020; Kumar et al., 2020).

Further, worrying about one's own and far away family members' health has a considerable impact on the well-being of people. It has been established that concerns about other people's health increase the risk of anxiety (Bell et al., 2021).

The impossibility of going back home and seeing the family frequently also changed the idea of distance "from home," which influenced two respondents' intention to move "back home." Nevertheless, Covid-19 also had a positive impact on the lives of many respondents. For instance, several reported an increased resilience and self-consciousness. Furthermore, during the lockdowns, people could enjoy a renewed connection with nature. For example, Killgore et al. (2020) found that people's resilience

was higher among those who tended to go outdoors more often and engage with nature. In addition, Williams and Hall (2014) found a strong relationship between the natural environment and well-being.

Moreover, the pandemic also changed the way of meeting friends. Due to the restriction, most people start selecting friends to meet. They choose to meet only their closest friends and see other people online. Some people felt relieved not to have to participate in social activities constantly. Finally, several people mentioned that one factor influencing their intention to leave or positively impacting their well-being in their new destination country is the weather. The relationship between weather and well-being has also been discussed by Feddersen et al. (2016).

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CHAPTER IV

Exploring the Intersection of Virtual Teams and Transformational Leadership through an Integrative Literature Review and Identifying Avenues for Future Research[39]

Abstract

The advent of digitalization has caused a paradigm shift in the workplace, including new forms of communication within teams. With the onset of the COVID-19 pandemic, exclusively virtual communication has gained even more relevance and accelerated the need for leaders to transition from a physical to an entirely virtual work environment. In a face-to-face setting, transformational leaders are able to motivate their followers by setting an example. However, with the rise of virtual teams, there is a growing interest in studying the role of transformational leadership in this context.

In this study, we conduct a literature review that integrates virtual teams and transformational leadership, identifying team, leadership, and motivation factors from the existing research. Our paper challenges the traditional leadership model under exceptional economic circumstances and reveals gaps in the literature related to team dynamics, leadership approaches, and motivational factors. Given the growing impact of virtual working environments on the future of work, this study serves as a starting point for further research on the influence of transformational leaders in virtual teams.

Keywords: virtual teams; transformational leadership; motivation factors

Introduction

Within a hierarchically organized team, leaders influence, train, and guide followers through change (Bass, 1999). By changing external circumstances, the transformational leadership theory introduced by Burns (1978) enables teams to help each other reach a higher level of motivation. Transformational leadership describes an approach whereby leaders motivate followers to align with the organization's aims and interests to achieve performance that exceeds expectations (Grošelj et al., 2020). Transformational leadership can be defined based on its impact on followers through charisma, inspiration, intellectual stimulation, or individualized consideration (Bass, 1999).

Furthermore, these four factors are the main characteristics of transformational leaders, as described by Bass and Avolio (1994). Siangchokyoo et al. (2020) argued that no matter the positive results associated with this leadership construct, a leader is not truly "transformational" unless the followers are transformed. Mysirlaky and Paraskeva (2020) pointed out that leaders

[39] In collaboration with N. Greimel and D. Kanbach (2022)

who express transformational leadership behaviors can help a virtual team improve its performance. Yukl (2010), cited in Adriani et al. (2018), describes the transformational leadership style as effective in any situation and culture.

The core of transformational leadership is creating and communicating a vision beyond one's self-interest, which naturally evolves through verbal and non-verbal communication in a face-to-face environment (Zigurs, 2003). The motivation dynamics of transformational leaders and their followers is a broad research field in a face-to-face working environment (DeChurch & Marks, 2006). However, leveraged through digital transformation, the forms of interaction and communication within teams are changing (Bresciani et al., 2021b). Under working conditions that involve communicating through a technological medium, the virtual working environment provides a wide range of opportunities for interaction and ways of connection. A team under the leadership of a transformational leader is amenable to adapting to changing circumstances and a growing field of interest in computer-mediated communication environments (DeChurch & Marks, 2006).

The pandemic triggered social distancing and, thus, the necessity of remote working (Prin & Bartels, 2020). As an international health and economic crisis, it forces employees and corporations worldwide into a virtual working environment (Bouziri et al., 2020). In order of magnitude, since March 2020, over 3.5 billion individuals worldwide have been forced to stay at home, and several million are working solely with virtual communication methods (Bouziri et al., 2020). The COVID-19 pandemic affected every company and business routine in many ways (Kraus et al., 2020) and drastically changed organizations, family dynamics, and teamwork (Feitosa & Salas, 2021).

This change brought on by the pandemic has challenged the activities that virtual teamwork requires, such as relationship interactions (Whillans et al., 2021). Within a team, leaders can have formal and informal extended relationships (Malik et al., 2015). For instance, leaders built solid and trusting relationships with only a portion of team members (Ansari et al., 2007; Bauer & Erdogan, 2015).

A virtual team is a group of people from different geographic locations and possibly different time zones (Garro-Abbarca et al., 2021). Jarvenpaa and Leidner (1999) described virtual teams as teams working in virtual environments where members are temporarily and geographically dispersed and rely on information and communications technologies (ICT) to work and communicate. It can be seen that the main characteristics are virtuality and the use of information and communication technologies. Since research on virtual teams directed by transformational leadership is an evolving field (Hambley et al., 2007), unexpected economic circumstances indicate the importance of having a closer look at a proven leadership theory and challenging it within an exceptional situation. Motivating a virtual team, which solely communicates through a technological medium, provides an opportunity to integrate existing literature (Zigurs, 2003). Working exclusively in virtual teams and being additionally stressed due to a pandemic situation requires a precise inspection of the existing theory, underlying models, and potential research gaps. Faced with the aftermath of the COVID-19 pandemic and simultaneously hovering in a transition situation between face-to-face and computer-mediated communication working conditions, practitioners and researchers will be interested in motivating a virtual team through a transformational leader who assists their followers in

reaching a higher level of motivation (Burns, 1978). Leadership effectiveness plays a key role in the success of virtual teams.

In their recent study, Mysirlaki and Paraskeva (2020) showed that transformational leadership mediates the relationship between leaders' emotional intelligence and team effectiveness in a virtual team. In the same way, researchers agree that effective leadership is a key factor in the success of virtual teams (Bell & Kozlowski, 2002; Hoch & Kozlowski, 2014) and an important factor in overcoming the challenges of virtual teams and realizing their potential benefits (Liao, 2017).

It is commonly agreed that there is a need for a better understanding of transformational leaders and virtual teams and how transformational leaders motivate their followers in a virtual team setting (Zigurs, 2003; Pitts et al., 2012; Dulebohn & Hoch, 2017).

This paper integrates literature analyzing the dimensions of virtual teams and transformational leadership to date. The discourse starts with the theoretical background and definition of leadership in a virtual environment and continues with a description of narrowing down the target literature. Based on the identified literature, the paper analyzes and synthesizes the delimited research field in a structured approach, providing a new, holistic perspective on motivating virtual teams guided by transformational leadership. Based on the breakdown of the literature, the identified gaps in the literature are stated as an outlook for further research.

Theoretical background

Building on the outlined discussion and relevance of the topic as well as providing a basis for our further analysis, the following section portrays both the theoretical background and a delimited definition of virtual teams, transformational leadership, and leadership in a virtual environment.

2.1 *Virtual Teams*

Planned changes and the integration of advanced technologies in daily work routines are part of the digital transformation (Bresciani et al., 2021b) and have enabled new forms of collaboration, communication configurations, and work arrangements (i.e., telework) (Gilson et al., 2021). Thus, the concept of a physical work environment has been transformed, and organizations are increasingly becoming more flexible in how, where, and when work is performed (Harris, 2016; Palvalin & Vuolle, 2016). For instance, in geographically dispersed teams, members rely on technology to collaborate virtually within the team (Hill & Bartol, 2016).

In virtual teams, collaboration enabled by IT solutions is vital for communication and working methods within a team (Hollingshead, 2004; Lilian, 2014; Lipnack & Stamps, 2000; Townsend et al., 1998). The causes of virtual team interaction got new visibility and self-perception during COVID-19 and beyond since regulations led to physical distancing and related guidelines (e.g., wearing face masks) (Wendt et al., 2021). As a result, teams that were not geographically or organizationally dispersed across time zones found themselves unexpectedly unprepared to collaborate via computer-mediated communication (Lilian, 2014).

In general, team interaction is affected by the medium of communication, and virtual working entails more possibilities to interact and connect, which are interrelated with and can be

influenced by the geographical location of the team members (Balthazard et al., 2009; Kraus et al., 2022). Therefore, the team members' geographical location impacts the forms of communication. For example, being geographically dispersed within a team for various reasons limits face-to-face contact and encourages many computer-mediated communication possibilities. Therefore, not being able to meet and communicate face-to-face with one's team colleagues makes the team reliant on technology solutions for communication (Jarvempaa & Tanriverdi, 2003).

In principle, Lilian (2014) defines the form of collaboration within a virtual team as "effective communication and information diffusion across time and space." For our analysis, we focus on virtual teams that communicate solely through a technological medium, excluding the occasional face-to-face contact (Hambley et al., 2007), as informal meetings between colleagues took place primarily in a virtual setting during the COVID-19 pandemic (Viererbl et al., 2022). For instance, Hill and Bartol (2016, cited in Liao, 2017) highlight the importance of virtual collaboration in virtual teams, as tasks and jobs are mostly carried out through virtual channels. Collaboration in virtual teams refers to interactions and tasks to achieve common goals (Morrison-Smith & Ruiz, 2020).

Numerous computer-mediated communication forms exist, are constantly evolving, and can be classified and distinguished by the richness of the communication. For instance, videoconferencing or teleconferencing is a richer form of communication than chat-based interaction (Cascio & Shurygailo, 2003; Hambley et al., 2007). Furthermore, collaboration tools are not limited to one form of communication, meaning one tool can simultaneously entail different forms and intensities of communication or be time-shifted.

Given recent events and the prospect of an unpredictable future development, the rationale for and definition of virtual teams in the literature must be reconsidered and revised. The literature to this day entails a profound basis in the theoretical framework and scientific research to understand the phenomenon of virtual teams (Bell & Kozlowski, 2002). Although the role of virtual teams within organizations has grown in the last two decades, the reasons for a team to interact via a technological medium are changing (Hertel et al., 2004; Lipnack & Stamps, 2000). Lilian (2014) defined a virtual team as a team that is dispersed over different time zones. A primary reason for the geographical team dispersion and interaction over computer-mediated communication is to overcome separations while simultaneously reducing costs (Lilian, 2014).

2.2 *Transformational Leadership*

Burns (1978) introduced transformational and transactional leadership as mutually exclusive concepts in his descriptive speech. In its ideal form, transformational leadership enables leaders and their followers to help each other reach a higher level of morale and motivation (Burns, 1978). Unlike transactional leadership, which emphasizes the self-interest of leaders and their followers operating in an existing culture, transformational leadership enables followers to become leaders and creates value by changing the culture within a social system's organization (Burns, 1978). Transformational leadership can be defined based on its impact on followers and can be characterized by factors like idealized influence, intellectual stimulation, or

individualized consideration (Bass, 1999; Bass & Avolio, 1994). The interplay between leaders and employees defines how a team harmonizes and performs, which is crucial for initiating change. As defined by the people who make decisions in their daily work, the way whole organizations and team units operate depends on leadership. The impact of transformational leadership is well observed and discussed in a face-to-face working environment. Leadership studies outline a positive connotation between transformational leadership style, motivation, and meaningful work (Bailey et al., 2019). A transformational leader outperforms a transactional leader in empowerment, group cohesion, and perceived group effectiveness when operating in a face-to-face setting (Jung & Sosik, 2002).

Ruggieri (2009) analyzed the effects of transformational and transactional leadership on virtual groups and evaluated the perception of the style adopted. The results showed that a transformational leadership style is more satisfying than a transactional one, and a transformational leader is evaluated better than a transactional one (Ruggieri, 2009).

Al-Husseini et al. (2021) have explained that transformational leadership is an important and influential factor in innovation and knowledge management systems.

Bogoviz et al. (2018) found that a transformational leadership style is best suited for knowledge-intensive companies, mainly because of its orientation toward the continuous development of individual employees and the company. On the same line, the research of Rafique et al. (2022) revealed a positive impact of transformational leadership related to employee engagement, knowledge sharing, and the creation of an environment of trust.

Although the initial transformational leadership theory can be divided into measurable characteristics with a broad field of existing research in a face-to-face environment, the study is not limiting itself to well-known and established concepts to keep an open mind to converting transformational leadership in a virtual environment. In this treatise, the main focus rests upon a transformational leadership personality: leading by example, being open to innovative change within the organization, and being committed to employee wellbeing, independent of constant comparison to transactional leadership characteristics.

2.3 *Leadership in a Virtual Environment*

The literature analysis and implications for the practice of transformational leadership theory in virtual teams are scarcely comparable to those in a face-to-face environment (Zaccaro & Bader, 2002). Because virtual working is a relatively new phenomenon in leadership research, leadership characteristics and team motivation in a face-to-face environment have been primarily studied.

As nonverbal communication must be freshly thought about in a virtual working environment, proven transformational leadership characteristics must also be challenged (Purvanova & Bono, 2009). Because a technological medium replaces physical interaction, we cannot simply transfer the findings from face-to-face into a virtual environment (Zigurs, 2003). Moreover, typical transformational leadership interaction, led by example, tends to be more emotionally driven, often transmitted to followers through nonverbal communication (Kirkpatrick & Locke, 1996). Therefore, leadership in a virtual environment is an evolving human resource development topic in the literature that gained new relevance due to the digital transformation

and was accelerated by the COVID-19 pandemic and its work-from-home consequences (Bertello et al., 2021).

Since a transformational leader model can be a strong motivator in a face-to-face environment, we aim to integrate the existing literature to provide a basis for a solid leadership model in a virtual working environment that can adapt to changing circumstances.

Methodology

The methodology of Torraco (2005) is used to integrate the existing literature as a basis for further research while considering the external and evolving circumstances. An integrative literature review is put together by topic and relationship, not chronologically (Torraco, 2005).

The research design of an integrative literature review is a suitable approach for a new perspective on a current topic that is still evolving in the literature (Snyder, 2019; Kraus et al., 2022). For instance, integrative literature reviews were published on evolving topics like contingent work and new employment relationships, new forms of organizations, and training concepts (Burke-Smalley & Hutchins, 2007; Easterby-Smith, 1997; Kalleberg, 2000; Liker et al., 2003; Scully-Russ & Torraco, 2020).

Moreover, journal publications have indicated that an integrative literature review is a valuable approach for human resource development-related topics that entail the investigation of team dynamics and leadership (Scully-Russ & Torraco, 2020; Torraco, 2005; 2016).

For the content analysis of the literature, we applied an inductive qualitative approach to concept development, as described by Gioia et al. (2013). The grounded theory approach, which starts with data collection and not hypothesis building, is suitable for generating new concepts and ideas (Gioia et al., 2013).

We first identified target articles in the data selection process. Afterward, we systematically developed a concept from the literature, as outlined below.

3.1 *Data Collection*

With the data collection approach, 13 target articles were identified (see Table 1 below). To narrow down the literature sample size for the subsequent analysis, the data collection and selection process for the target literature to be included in the study was conducted in three sequential steps: (i) searching the pre-selected databases with keyword combinations, (ii) executing a quality threshold, and (iii) screening the literature manually and analyzing the content (Figure 1 below).

We reviewed the databases with a list of keyword combinations such as "virtual teams" and "transformational leadership," and then we ensured that the detected articles either contained the keywords in the title or described the phenomenon in the abstract. Furthermore, we aimed to ensure that all target articles included keyword combination strings in their core analysis. In the first step, we used the electronic databases “EBSCOhost” and “EBSCOhost Integrated Search” to encompass various databases with access to external and internal sources. We received results in various research fields, including business, strategy, and management topics, publications in human resource management, organizational behavior, applied psychology, and

human-computer interaction. The initial literature search was not limited to a time frame, but due to the set criteria of "virtual teams," the search results only went back approximately 25 years. Moreover, we did not restrict our search to articles but mainly received results published in academic journals. Furthermore, since the topic is a broad field within different research areas, including different angles of perspective, we did not limit our search to articles in business and management academic journals.

Since it indicates a reasonable re-citation rate and, therefore, the scientific relevance of the academic journal, we solely included articles from academic peer-reviewed journals in our analysis with a Journal Citation Report ≥ 1.5 and ranked in VHB ≥ C. After the initial literature review, we conducted a quality threshold. First, we aim to focus on the significant research results of peer-reviewed studies and do not include conference presentations or books. Secondly, we decided to concentrate on empirical work and primary research and make some cross-checks with secondary research. Thirdly, we ensured that all peer-reviewed primary research journals were listed on the Web of Science. The Web of Science, which examines recently published literature, is a database that entails the Social Science Citation Index and the Science Citation Index (Li et al., 2018). All Social Science Citation Index journals published by Thomson Reuters are used to generate a journal impact factor, which reflects a journal's relevance within its field (Li et al., 2018). The calculated Journal Impact Factor, used as a proxy for the annual average number of citations of articles released within two years in a stated journal, is published yearly by Clarivate and listed in a Journal Citation Report (Li et al., 2018). As our journal quality threshold for our target journals, we used the Journal Citation Reports 2020, released with the reference year 2019, and the VHB ranking. Since not all of our target journals entail a VHB ranking, we used a conversion table of leading academic journal rankings by Kraus et al. (2020) to supplement our threshold analysis.

Following the literature search approach defined by Webster and Watson (2002), we identified the articles defined by search criteria and quality thresholds as leading articles. In the following step, we aimed to ensure that our literature search led to meaningful results and executed a profound content analysis and manual literature search. To ensure that we gain a holistic understanding of the topic of interest and close possible literature gaps, we conducted a backward and forward search based on the leading articles (Webster & Watson, 2002). In the first step of a systematic backward search to study the origins of the theory, we reviewed the citations of the articles (Webster & Watson, 2002). In the second step of the forward search, which helped expand knowledge on the topic, we identified articles citing the key articles marked in the previous steps (Webster & Watson, 2002).

Insert Table 1 here

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3.2 *Conceptualization of the Literature*

After identifying a phenomenon of interest and defining the relevant set of data, an analysis process explained by Gioia et al. (2013) was applied. The results were outlined using the labeling methods of "first-order categories," "second-order themes," and "aggregate dimensions" in a systematic data tree (Figure 2 below).

In the first step, 96 items of "first-order categories" were identified by scanning the target literature with an open mind to all relevant concepts within the target literature. In a second step, the unstructured "first-order categories" were named and marked with the letters of the related target article for orientation. Discovering similarities within the data, the 96 "first-order categories" were grouped into 12 "second-order themes." After developing and analyzing the "second-order themes," three emerging "aggregate dimensions" were identified.

The three developed overarching theoretical dimensions, (i.) team perspective, (ii.) leadership perspective, and (iii.) motivation factors, are indicators for the relationship within the pre-defined categories and themes. Going through the evaluated literature's conceptual framework, we identified that some variables were less well presented. Based on the conceptual and systemic analysis of the target literature, we outlined that the lack of research on some variables constitutes an interesting pillar for further research. Since the subject of interest is relatively new and emerging, we could benefit from a profound literature analysis and a conceptualization of the literature, as outlined within the subsequent chapter (Torraco, 2005).

Integration of literature

Following the conceptual framework of Gioia et al. (2013), three dependent dimensions were discovered. The interrelation between the dimensions becomes more apparent by looking closely at the developed matrix (Table 2).

Based on the literature and interrelationship analysis, we identified fields and blind spots within every dimension. Aside from motivation factors, which are at least partially researched, all three perspectives reveal a dearth of research on demographic leadership factors. More precisely, a lack of interrelation was discovered for the variables of demographic leadership factors, motivation, trust, and team location (Figure 3 below). Therefore, a potential research question could lead to a closer examination of the underrepresented variables and their interplay. The literature analysis's main findings are discussed for every dimension, considering the interrelationships within the dimensions, and subsequently synthesized (Torraco, 2005).

4.1 *Team Perspective*

In the following, we look closely at the team perspective variables and their representation within the target papers. Within the dimension of team perspective, we discovered a strong interrelation between team performance, communication, and atmosphere (Figure 3 above) and a lack of research on team location. Moreover, the three most represented variables within this

dimension interplay more with the leadership perspective than motivation factors (Figure 3 above).

Team location is essential for virtual team settings, only relating to team performance, communication, and leadership characteristics. Since the target literature rarely deals with the topic and there is no interrelation with the dimension of motivation factors, the research on geographical team location and dispersion and the effect on virtual interaction and transformational leadership can potentially be a field of further research.

From the team perspective, it becomes apparent that there are still contradictory statements regarding a transformational leadership style and the form of communicating with and motivating a team. For instance, one study shows that transformational leadership is more effective with written communication tools, while another paper outlines that transformational leadership is less effective in highly dispersed teams. As a result, the team's perspective gains the possibility of additional research to obtain a clearer picture of the influencing variables.

4.1.1 Team performance

To measure the success of a virtual team, another important field within the analyzed literature is performance. Team performance can be found with different nomenclatures in literature like "team performance," "group performance," or "team outcome" (Eisenberg et al., 2019; Hoyt & Blascovich, 2003; Kahai et al., 2012; Kelloway et al., 2003; Maduka et al., 2017; Purvanova & Bono, 2009). On the one hand, the literature suggests that a transformationally led team is less effective when highly dispersed (Eisenberg et al., 2019). On the other hand, the target literature outlines that transformational leadership has a more substantial effect in virtual than in face-to-face team interaction (Purvanova & Bono, 2009, p. 343).

Like in a face-to-face environment, performance can be measured by different methods. Another measurable variable is individual performance, which indicates the individual's success within the team and can be added to team performance (Balthazard et al., 2002; Kelloway et al., 2003). Performance can be measured by numbers and quantitative performance indicators or by qualitative performance factors that cannot be easily measured by figures (Hoyt & Blascovich, 2003). Like in a face-to-face environment, virtual teams that transformational leaders lead show a decrease in quantitative performance but increases in qualitative performance (Hoyt & Blascovich, 2003). Quantitative performance indicators, which interact with transformational leadership style and the communication medium, are factors like task performance, task interdependence, time performance, and task time (Hambley et al., 2007; Kahai et al., 2012; Sosik et al., 1998; Strang, 2011).

Adding up quantitative and qualitative performance factors provides a holistic picture that can display the mood within a team. To measure performance with quantitative figures misses out on qualitative performance factors that, for instance, describe the group dynamic within a virtual setting better (Hoyt & Blascovich, 2003).

Group efficacy, collective efficacy, and group effectiveness can be used to measure qualitative team success, which favors transformational leadership (Hoyt & Blascovich, 2003; Kahai, Sosik & Avolio, 2003; Kahai et al., 2012; Sosik et al., 1998; Sosik et al., 1997). However, efficiency in a virtual team setting has no performance effects on the leadership style (Hoyt & Blascovich, 2003). Also, group potency and effectiveness do not affect project scope quality or

time performance in a virtual team setting guided by transformational leadership (Sosik et al., 1998; Strang, 2011). One qualitative success factor of an individual team member within the group can be self-efficacy (Hoyt & Blascovich, 2003). Further qualitative factors of team performance can be indicated as group potency, project scope quality, and decision quality (Kahai et al., 2012; Sosik et al., 1997; Sosik et al., 1998; Strang, 2011).

To summarize, transformational leadership in a virtual setting has a similar impact on team and individual performance in many ways.

4.1.2 *Team communication*

Within the literature, the form of communication in a virtual team setup is measured with different communication variables. The terms “team interaction” and “team interaction style” contain different forms of characteristics like constructive, defensive, passive, and aggressive (Balthazard et al., 2009; Hambley et al., 2007). A virtual team environment can be distinguished from a face-to-face environment by group setting and team type (Hoyt & Blascovich, 2003; Purvanova & Bono, 2009).

Team interaction styles are dependent and can be defined by the frequency of participation and the initiation of ideas (Balthazard et al., 2009). Within virtual team interaction, the activity level of team members, especially in written communication, favors transformational leadership (Balthazard et al., 2009).

In general, the range of media richness can be spread between richer communication mediums, such as videoconferencing, and poorer communication mediums, for instance, written communication in the form of instant messaging or chats (Balthazard et al., 2009; Hambley et al., 2007; Kahai et al., 2012). As outlined before, the nomenclature of team communication depends on the communication medium and interacts with transformational leadership (Eisenberg et al., 2019; Hambley et al., 2007; Kahai et al., 2012). On the one hand, the literature indicates that transformational leadership greatly influences teams working with computer-mediated communication, and the more precise influence is dependent on and can be distinguished by media richness (Ben Sedrine et al., 2020; Purvanova & Bono, 2009). On the other hand, Hambley et al. (2007) state that the impact of transformational leadership on teams working in richer or poorer communication mediums is marginal. In the field of written communication, linguistic quality plays a significant role and interplays with transformational leadership (Balthazard et al., 2009). Also, the effect is marginal; differences depend on media richness; for instance, team cohesion is higher in videoconferencing than in chat teams (Hambley et al., 2007).

Transformational leadership is more effective when the communication medium becomes more anonymous (Hambley et al., 2007, p. 5). Dependent on the form of virtual communication and especially in written communication, anonymity and anonymous interaction, distinguished from identified interaction, play an essential role in team communication and interplay with the transformational leadership style (Hambley et al., 2007; Kahai et al., 2003; Sosik et al., 1997; Sosik et al., 1998).

To sum up, since the form of communication is an important topic in virtual teams led by transformational leadership and is consciously evolving, there is an immense potential for further research.

4.1.3 Team atmosphere

The team atmosphere is an essential topic within a virtual working environment and cannot be seen independently from motivation factors. It is outlined in the target literature that an increase in team cohesion will increase team commitment within a transformational-led team (Hambley et al., 2007). Research shows that the form of communication has an important effect on team interaction styles and cohesion (Hambley et al., 2007). Group atmosphere can measure how the team is united and connected, which in a virtual environment is dependent on social presence, which is distinguished from and contrary to social loafing and consensus (Hambley et al., 2007; Kahai et al., 2003; Kahai et al., 2012). Moreover, the way the team sticks together can be defined by team cohesion, group cohesiveness, and operational group cohesion (Ben Sedrine et al., 2020; Hambley et al., 2007; Hoyt & Blascovich, 2003; Kahai et al., 2012).

Although team atmosphere is a topic of discussion within virtual teams, the long-term effect of virtual working on how a team sticks together and the interaction with motivation factors can be a broad field for future research.

4.1.4 *Team location*

As per the initial definition of virtual teams, the location of the team members plays a vital role in remote working.

Literature indicates that a transformational leader can reduce the adverse effects of dispersion in teams (Eisenberg et al., 2019). In highly dispersed teams, transformational leadership is less effective since it is difficult for leaders to facilitate team communication (Eisenberg et al., 2019). This contradicts the point that transformational leadership is stronger with written communication tools. The team location, which in the initial definition is a reason for virtual interaction, influences all the outlined factors of team communication, performance, and atmosphere. To summarize, a team's location or geographical dispersion is related to transformational leadership (Eisenberg et al., 2019).

Given the required virtual working situation during the COVID-19 crisis and a future trend toward a more individual choice of working from any location, the choice of location within teams has the potential to be a broad research topic.

4.2 *Leadership Perspective*

Since a transformational leader leads by example, personality traits and external circumstances play an important role in motivating a team. The leadership perspective entails the two dimensions of leadership characteristics and demographic leadership factors that are interrelated (Figure 2). While leadership characteristics are represented in the literature, demographic leadership factors are underrepresented. It is a common approach to research transformational leaders by their characteristics, an evolving trend that is also accelerated by a

more flexible and virtual work setup. Moreover, since there is less correlation with motivation factors, transformational leadership characteristics and backgrounds entail the possibility of further research (Figure 3).

Having elaborated that there is a lack of research analyzing the variety of demographic factors of leadership within our target literature and considering that virtual working provides more flexibility for leadership, it would be interesting to know how demographic factors interact with each other and the outlined variables.

4.2.1 Leadership characteristics

Leading by example, a transformational leader can be characterized as high-level and having a more detailed look at personality traits. Our defined literature shows that leaders who increase their transformational leadership in virtual teams are more successful (Purvanova & Bono, 2009). This contradicts our previous findings, which outlined that more face-to-face contact strengthens transformational leadership.

The primary literature describes the transformational leadership style and its characteristics in a virtual team setting, often distinguishing it from the transactional leadership style (Hambley et al., 2007; Hoyt & Blascovich, 2003; Kahai et al., 2003; Purvanova & Bono, 2009; Sosik et al., 1997; Sosik et al., 1998). When it comes to transformational leadership characteristics in a virtual setting, a leader's personality and attributes influence team performance and atmosphere (Balthazard et al., 2009; Strang, 2011).

It is outlined in the target literature that the type of communication medium influences emotional stability (Balthazard et al., 2009). Moreover, when leaders were asked to describe themselves, the five highest-ranked characteristics were transformational leadership attributes (Balthazard et al., 2009). Leadership attributes and personality characteristics that interact with the communication medium are examined for transformational leaders in our target literature as variables of extraversion, conscientiousness, agreeableness, openness to experience, emotional stability, interpersonal justice, continuity, commitment, and solution originality (Balthazard et al., 2009; Kahai et al., 2003; Kelloway et al., 2003). Besides the more general leadership personality characteristics, there are attributes related to a transformational leadership style, like idealized influence or charisma, inspirational motivation, intellectual stimulation, and individualized consideration (Kelloway et al., 2003; Purvanova & Bono, 2009).

The literature describes that transformational leadership occurs less often in virtual than face-to-face project teams (Purvanova & Bono, 2009, p. 345). Knowing that transformational leadership characteristics help leaders and their followers to be motivated, there is a potential for further research on transformational leadership characteristics in a virtual working environment.

4.2.2 Demographic leadership factors

A leadership personality evolves and sustains an individual leadership style through characteristics and personality. It would be helpful to know more about the lead person to learn more about the roots of leadership characteristics and how they develop. Literature indicates that demographic factors influence the transformational leader; for instance, female leaders

tend to act more transformationally (Balthazard et al., 2009). The leadership personality and related characteristics are shaped by demographic factors like age, gender, ethnicity, or level of education (Balthazard et al., 2009).

Since a virtual working environment can also influence flexibility within a job and the hiring market, and since there is a lack of research on demographic leadership factors, it is an open field for further research.

4.3 Motivation Factors

A transformational leader has the goal of motivating the team by example. Therefore, we have to take a closer look at the motivation factors of a transformation leader in a virtual team.

While motivation factors and underlying variables strongly interrelate with team and leadership perspectives, we discovered less interplay of the variables within the motivation factor dimension and demographic leadership factors (Figure 3). Two variables that stand out by nearly not interacting with each other are motivation and trust (Figure 3).

The lack of interrelation and research of the variables motivation and trust calls for an opportunity to conduct research measuring the mood and atmosphere of team and leadership interaction in a virtual setting.

4.3.1 Satisfaction

For a transformational leader in a virtual team, satisfaction is the basis for motivating a team. The identified literature demonstrates that a transformational leadership style leads to higher supervisory satisfaction (Kelloway et al., 2003). The satisfaction of every team member in a virtual setting is contingent on supervision and leadership satisfaction (Hoyt & Blascovich, 2003; Kahai et al., 2012; Kelloway et al., 2003).

According to our findings, team project satisfaction is the same whether face-to-face or virtual (Purvanova & Bono, 2009). The satisfaction of every team member is also correlated with the variables of job satisfaction, project satisfaction, and satisfaction with the task (Kahai et al., 2003; Kelloway et al., 2003; Purvanova & Bono, 2009).

Since satisfaction has a high potential to change, it is helpful to measure satisfaction continuously and when ways of working are changing. Therefore, satisfaction is a broad potential field for further research.

4.3.2 Rewards

Monetary or other rewards are an essential component of the motivation factors. Rewards can never be seen as independent of other motivation factors. Literature studies the effect of individual and group rewards on the variables of transformational leadership style and anonymity (Kahai et al., 2003). Factors that influence the motivation of the team members can be rewarded on an individual and group level (Kahai et al., 2003).

As one pillar within motivation factors, rewards need to be considered for further research regarding a virtual team led by a transformational leader.

4.3.3 Feedback

A transformational leader is open to change and willing to adopt an individual leadership style. Therefore, continuous feedback is a valuable indicator for adjusting motivation and leadership style.

In a virtual setting using instant messaging, the transformational leadership style is influenced by constructive feedback (Kahai et al., 2012). Another critical motivator is to receive and provide positive feedback from the leader and the peer team (Kahai et al., 2012). Since feedback in a virtual setting can have different channels, it is an important field for further research.

4.3.4 Purposefulness

In a virtual working environment, setting a vision and leading by example can give a team a sense of purpose.

Our predefined resources outline how transformational leaders can establish a sense of purpose within virtual teams by setting goals and developing agendas to achieve them (Purvanova & Bono, 2009). Purvanova and Bono (2009) identify a sense of purpose as an essential motivator for the team and each individual in general, particularly in daily tasks.

The sense of purpose can have a different meaning in a virtual setting since it is, for instance, independent of going to a work location every day. The sense of purpose can be guided by a transformational leader and has the potential for further research.

4.3.5 Motivation

One driver in a virtual setting is the motivation of each individual within a team setup.

Literature predicts that higher motivation will lead to better individual and group performance in virtual settings with a transformational leader (Kelloway et al., 2003). The team's performance and atmosphere depend on the individual's motivation within a virtual team (Kelloway et al., 2003).

Knowing that the motivation of the individual has a high impact on the motivation of the group, the interplay of individual and group motivation gains potential for further research.

4.3.6 Trust

In a relationship between leaders and their followers, trust plays a vital role in sustaining and building new relationships.

As the literature demonstrates, trust plays an important mediational role for a virtual-led team (Hoyt & Blascovich, 2003). Not only for team interaction and atmosphere but also for the relationship between leaders and their followers, trust is a crucial indicator (Hoyt & Blascovich, 2003). Since trust is an underrepresented research variable in the relationship between transformational leaders and virtual teams, it gains the potential to be more precisely defined in further research.

Taking all three perspectives into account and knowing that team motivation is important in a virtual setting, we investigated which factors, in particular, warrant further investigation.

Discussion

After outlining our findings in detail, we will reflect on them in light of existing literature and discuss similarities and differences. A wide-open academic research field could be the dispersion of teams interacting with a new type of leadership embedded in a working environment of motivation and trust, regardless of distance by location. As outlined before, the lack of interrelation within and between all three dimensions entails a variety of research opportunities.

Being renowned as a standard form for synthesizing literature, within the following chapter, the results of the literature analysis are discussed in an outlook for further research (Torraco, 2005).

5.1 Geographical Team Dispersion

We discovered a lack of interrelationship with a team atmosphere and all of the outlined motivation factors after taking a closer look at the interrelationship variables of team location. Based on this observation, a potential research field could be how team location influences the team atmosphere and motivation factors in a team setting.

More precisely, factors like how team location influences not only the place but also the space of working, for instance, working in a home office setting, are possibilities and fields of interest for further research. Moreover, within virtual and hybrid settings, how the team is located and geographically dispersed affects the virtual interaction and opens a field of research that can be explored in more detail.

Assuming a global job market or hiring process entails a range of holistic choices of location for the candidate and the hiring organization, the intercultural diversity within a team can be influenced and determined by demographic factors like, for instance, ethnicity. Considering that candidates can be restricted to a particular home location for various reasons, applying for a job independent of the location can influence the decision to apply for the job and the variable motivation.

Besides considering compliance and federal legislation, virtual working methods and team dispersion can allow organizations to hire talent worldwide. In today's global job market, data analytics is becoming increasingly important in human resources-related topics (Korherr & Kanbach, 2021). Only occasionally meeting one's team or the client face-to-face brings a whole new dimension of job opportunities and flexibility for organizations, leaders, and employees.

5.2 Leadership Diversity

A diverse leadership setup shapes a company's culture (Korherr et al., 2022). Analyzing the interrelationship behavior of the variable demographic leadership factors opens up research possibilities in team perspective and motivation factors. Since geographical team dispersion is a topic of interest, a potential research field could be how team location relates to demographic leadership and various motivation factors.

Since it is part of a worldwide diversity debate, institutional and organizational challenges for women in a changing workplace considering different ethnicity and minority factors could be a potential focus topic for further research (Cho et al., 2017). Analyzing the leadership perspective, we recognized a lack of research on various demographic factors characterizing and forming transformational leaders in virtual team settings. Diverse ways of leading should be considered in a world that favors diverse ways of working. Therefore, demographic factors like age, gender, ethnicity, or level of education could be the focus of further research and analysis.

Demographic leadership factors can include a wide range of diverse factors such as work experience, age, function, gender, and ethnicity, opening our minds to a broad field of diversity. Investigating demographic leadership factors and their impact on team interaction can be a profound indicator of the variable's motivation and trust.

Since diversity encompasses a wide range of factors, it should not be limited to leadership characteristics and should also include the diversity of team members and diversity within a team, as well as cooperation and organization.

5.3 Motivation and Trust

We detected potential research opportunities in all three dimensions after taking a closer look at the motivation factors of individual motivation and trust. Considering the lack of research on team location and demographic leadership factors, an analysis including the variables of motivation and trust can be a potential research area.

Furthermore, motivation factors are only an opportunity to conduct research measuring the mood and atmosphere of the team but also a possibility to discover new and various facets within a motivation factor. Having discovered that there is a lack of research in particular on singular motivation factors like trust, for instance, the variable of reliability could be a new facet of the motivation factor.

Because leaders and followers rely on virtual communication tools to stay connected, they must outperform already critical skills such as good communication and empathic relationship building to form and maintain a trustful relationship based on motivation. Studies revealed that sought-after competencies like relationship building are superior in diverse management teams mixed by age, gender, and cultural background (Zenger, 2020).

Leaders and followers should be equipped with skills and competencies that provide respite from their daily work routine in a work environment that requires life-long upskilling, training, and learning. Assuming that not only competencies and hard skills related to a job can be learned but also soft skills like motivation and trust can build relationships and bring a team's dynamics to a new level.

Conclusion

Staying connected solely through virtual communication not only opens a global job market and hiring process but also allows for intercultural diversity within a transformational-led team that can form and maintain a trusting relationship based on motivation. In our integrative literature review, we discovered literature gap variables within motivation factors and

demographic leadership factors that entail the potential for various research fields and facets in the megatrend areas of a global job market, diversity, and upskilling. The results are based on the interrelation and interplay of the three methodologically discovered angles of (i) team perspective, (ii) leadership perspective, and (iii) motivation factors.

Besides the contribution to research, this study provides managerial implications. Since the labor market is changing after the COVID-19 pandemic, there is a lack of qualified workforce, it is difficult to retain and attract employees across all sectors, and there is less time to search for qualified staff due to cost pressure and workload, making it even more important to keep employees satisfied. Therefore, having cognizance of motivation factors can help companies attract and maintain talent.

The study has some limitations due to a limited number of researchers and papers, as well as the lack of an existing theoretical framework for virtual teams and transformational leadership. Due to our approach of solely focusing on the defined terms of virtual teams and transformational leadership, we believe that, despite any limitations, our literature review provides useful guidance and a good starting point for a variety of detailed academic research in the outlined field.

Therefore, promising avenues for further research are to intensify the research on the identified research gaps with a larger sample size and more data after the COVID-19 pandemic. Furthermore, the identified factors could also be distinguished depending on the form of remote and hybrid communication.

Concluding, since a virtual working environment is a concept of a sustainable future and transformational leadership skills and personalities are a proven approach to motivating a team, our work entailing an outlook for further research and discussion not only opens the door for further academic research but can also be beneficial for opportunities and implications in practice.

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FIGURE 1

Literature Search Approach

n= number of publications

FIGURE 2
Applied Conceptual Framework of Gioia et al. (2013)

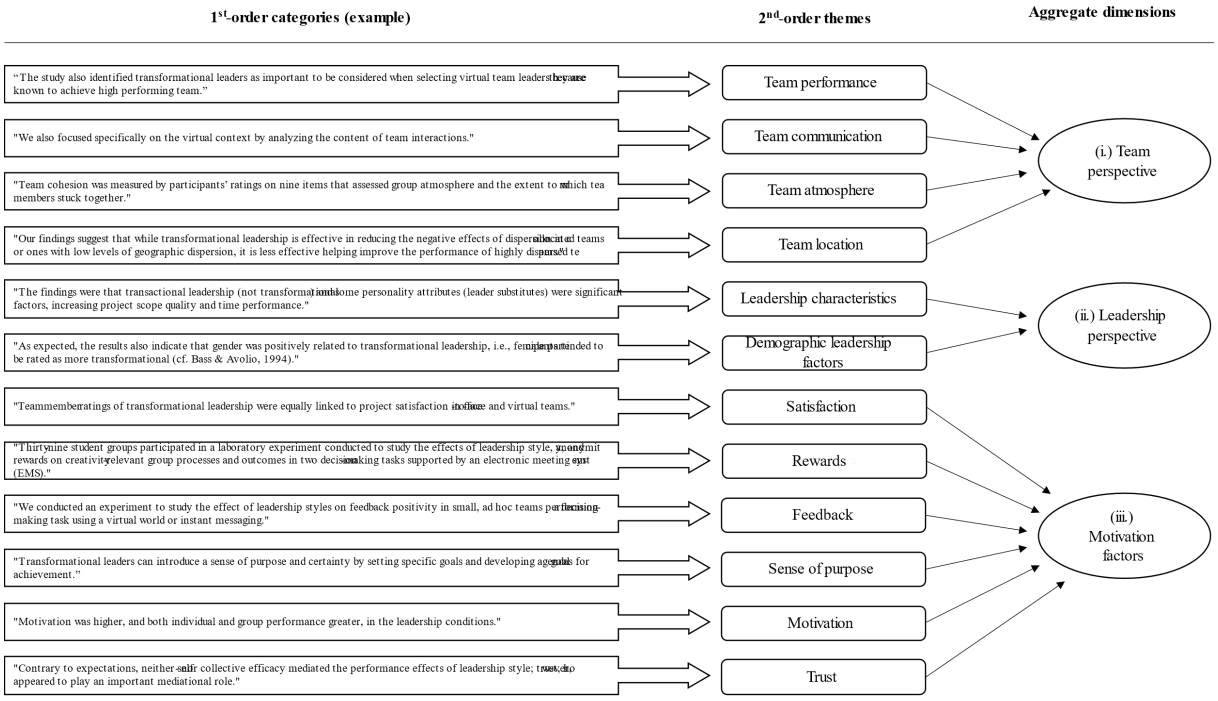

TABLE 1

Target Articles resulted from the Literature Search

Target Articles resulted from the Literature Search

Author(s) and year	*Title*	*Journal*	*Empirical study (primary research)*	*Quality threshold (JCR ≥ 1.5 and VHB ≥ C)*
Balthazard et al. (2009)	Predictors of the emergence of transformational leadership in virtual decision teams.	The Leadership Quarterly	Yes	Yes
Ben Sedrine et al. (2020)	Leadership style effect on virtual team efficiency: trust, operational cohesion and media richness roles.	Journal of Management Development	Yes	Yes
Eisenberg et al. (2019)	Team Dispersion and Performance: The Role of Team Communication and Transformational Leadership.	Small Group Research	Yes	Yes
Hambley et al. (2007)	Virtual team leadership: The effects of leadership style and communication medium on team interaction styles and outcomes.	Organisational Behaviour & Human Decision Processes	Yes	Yes
Hoyt & Blascovich (2003)	Transformational and transactional leadership in virtual and physical environments.	Small Group Research	Yes	Yes
Kahai et al. (2003)	Effects of leadership style, anonymity, and rewards on creativity-relevant processes and outcomes in an electronic meeting system context.	The Leadership Quarterly	Yes	Yes
Kahai et al. (2012)	Interaction Effect of Leadership and Communication Media on Feedback Positivity in Virtual Teams.	Group & Organisation Management	Yes	Yes
Kelloway et al. (2003)	Remote transformational leadership.	Leadership & Organisational Development Journal	Yes	Yes
Maduka et al. (2017)	Analysis of competencies for effective virtual team leadership in building successful organisations.	Benchmarking: An International Journal	Yes	Yes
Purvanova & Bono (2009)	Transformational leadership in context: Face-to-face and virtual teams.	The Leadership Quarterly	Yes	Yes
Sosik et al. (1997)	Effects of leadership style and anonymity on group potency and effectiveness in a group decision support system environment.	Journal of Applied Psychology	Yes	Yes
Sosik et al. (1998)	Computersupported work group potency and effectiveness: the role of transformational leadership, anonymity, and task interdependence.	Computers in Human Behaviour	Yes	Yes
Strang (2011)	Leadership substitutes and personality impact on time and quality in virtual new product development projects.	Project Management Journal	Yes	Yes

Conclusion and final remarks

The central emphasis of Industry 4.0 lies in the automation of processes aimed at reducing human involvement in the production process.

In conclusion, Industry 4.0 represents a major shift in the way businesses operate, and it is increasingly important for small and medium enterprises (SMEs) to embrace this change in order to remain competitive. The role of international knowledge workers will be critical in helping SMEs navigate this transformation, as they bring a wealth of expertise and experience to the table. As the world moves towards Industry 5.0, it is essential that SMEs continue to adapt and evolve in order to stay ahead of the curve. By leveraging the expertise of international knowledge workers and embracing Industry 4.0 technologies, SMEs can position themselves for success in the rapidly-changing business landscape of the future.

Given what we have found in the first chapter, a question arises: Can we be confident that everything has been presented to us accurately?

Advanced Manufacturing Solutions: We have found that the integration of collaborative robots have the potential to augment the capabilities of both robotic and human elements within the system, leading to increased process efficiency and adaptability to change.

But is digital transformation really limited to just key enabling technologies? For instance, even agriculture is undergoing digitization.

For instance Big Data - they don't have to be large, they need to be smart. The size doesn't matter, but the insights that can be obtained from analytics do. If the data is smaller, it can be analyzed more effectively. They need to be fast, not manually written but automatically extracted by machines. The data must be prepared and processed in a way that supports decision making. In order to utilize the data, the organization must have the technical capability for real-time access and the infrastructure to facilitate necessary data processing and seamless information delivery.

3D Printing: Is it truly one of the core technologies of Industry 4.0? In reality, it is only necessary in two scenarios: prototyping and production of specialized products on demand. In other cases, it is not useful, especially since printing farms are available.

Augmented Reality: It only makes a significant impact in specific fields such as training and telemaintenance (but it must be determined if the conditions are favorable for it to work, such as bandwidth). In all other cases, it has limited utility.

Industry 4.0 (and also Industry 5.0) has an impact not only on technology and people, as commonly mentioned in literature, but also on Business Models (BM) due to the emergence of new intelligence generated from interconnected products that produce data and information.

How are Business Models Changing? We have observed that organizations can no longer grow solely through their products, except in cases where new technologies are introduced to new or niche markets. Rather, growth is achieved by introducing a commercial or service innovation to the market, rather than a product innovation.

From a product-focused sales model to a solution-driven service business model: customers' unique and sometimes diverse needs are no longer primarily met by products, but by individually customizable data-based services that combine both in-house and externally sourced products (such as predictive maintenance).

The ability to tailor services to meet the customer's specific requirements leads to more efficient service delivery and strengthens the relationship between the customer and the service provider, allowing for the establishment of a long-term partnership.

Thus, Industry 5.0 is envisioned as a collaboration between human experts and advanced machinery, bringing back a human touch to manufacturing. It aims to merge the speed and accuracy of machines with the critical thinking of humans to achieve mass personalization and increased efficiency. This collaboration will allow for rapid production and improved quality by assigning repetitive tasks to robots/machines while reserving tasks requiring critical thinking for humans.

Additionally, while Industry 5.0 claims to prioritize the individual, there has been a marked increase in dissatisfaction with one's job. The sharp rise in voluntary resignations across advanced economies has garnered attention from scholars and raised concerns among human resources managers. An increasing number of workers are choosing to leave their current jobs in search of more fulfilling opportunities, a trend that Professor Anthony Klotz of the University of Texas referred to as the "Great Resignation" when it emerged dramatically between April and September of 2021.

Further research is needed to understand this apparent contradiction and to explore how Industry 5.0 might play a role in managing the Great Resignation.

Developing policies and regulations to support the transition to Industry 5.0. The findings of this study can contribute to the development of a more sustainable, equitable and human-centered digital future. It is expected that this research will contribute to a deeper understanding of the interplay between technology and human values and provide a roadmap for future innovation and development in this field. The integration of advanced technologies and human values will not only improve productivity and efficiency but also lead to a more fulfilling and meaningful life for all stakeholders involved in the process.